EKA University of Applied Science

Tatjana Tambovceva, Jelena Titko

INTRODUCTION TO CIRCULAR ECONOMY

EKA UNIVERSITY OF APPLIED SCIENCE

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PREFACE

This book is developed within the framework of the International project „Online Master Programme for Circular Economy (CIRCECO)”. Project coordinator – European University – Skopje (R. of Macedonia), project partners – Zelena Infrastruktura, Green Infrastructure Ltd. (Croatia), Fakulteta za komercialne in poslovne vede (Slovenia) YES Foundation (Macedonia) and The University of Economics and Culture (Latvia). Project period – December 2017 – January 2020. CIRCECO is financed and supported by the European Commission, Erasmus + Programme, Key Action 2 – Strategic Partnership (grant agreement No. 2017-1-MK01-KA203-035392).

CIRCECO project’s specific goals are as follows:

- Circular Economy joint research – conducted in collaboration with participants from the business sector, researchers, experts, professionals and students in order to analyse economic indicators and potential benefits and risks of transitioning from linear to circular economy.
- Support and implement models for effective and practical learning through raising awareness and inspiring students to rethink the economic future from the viewpoint of circular economy; establish innovative educational practices and training platforms so as to speed up the transition from linear to circular economy; provide the latest information, insights, and views implemented in the Master Study Program for circular economy needed to accelerate the transition; foster innovation, creativity and entrepreneurial skills.
- The support and development of innovative business models focused on a renewable and self-sustainable economy, and employ innovations resulting from the circular economy and the cooperation with the business sector; implementation of a comprehensive business initiative for circular economy and support throughout the implementation stage; strengthening the knowledge-transfer infrastructure.
- Creating an Online platform, enabling the setting up and implementation of an on-line study programme, allowing students and staff to log in, upload and download learning materials, forum discussions, as well as providing an option for live consultations and lectures.
- Promoting the benefits of the innovative Online Master Study Programme for Circular Economy and raising awareness through relevant electronic and press media, in order to inform about the latest findings, reports and achievements in the field of circular economy and exchanging views of all interested parties.
- Increased awareness in the importance of circular economy, not only among the business sector, but for the wider audience as well.

The main goal of this book is to increase students' awareness about the significance of circular economy. The learning book is designed to provide a comprehensive overview about the global issues our society is facing nowadays, solutions suggested by world, European and national organizations, and specifically emphasizes the role of the circular economy to deal with environmental, economic and social problems.

This book will help students to be acquainted with the new terminology, to understand the relationships between various associated concepts and models, and to generate ideas about their own research in the field of circular economy.

The book "Introduction to Circular Economy" consists of 11 chapters. Its structure was used as a basis for developing an online course "Introduction to Circular Economy" within the framework of the project. The questions for individual studies at the end of each chapter will help students to systematize knowledge and to fulfil the tasks within the course.

ABOUT THE AUTHORS

Tatjana TAMBOVCEVA (Dr.oec.) is a Professor at the Riga Technical University (Latvia). She has more than 25 years' experience in lecturing both at the undergraduate and graduate levels. Her research interests focus on circular economy, green production and consumption; change of consumer behavior; corporate social and environmental responsibility; sustainable building, real estate management, project management and use of ICT in many areas. She has published more than 150 articles in national and international academic journals. She is an author to a number of specialized books and reports on Management, Sustainable development and Project Management. She is a member and an expert in a number of international Societies, Councils and Foundations. She is the Managing Editor of the Scientific Journal "Economics and Business" and Head deputy of the Department of Civil Construction and Real Estate Economics and Management at the Riga Technical University in Latvia.

Jelena TITKO (Dr.oec.) is an Associate Professor at the EKA University of applied Sciences (Latvia); she also holds an administrative position of a Vice-Rector for Science and International Cooperation. She is an expert in the fields of Education and Economics and Entrepreneurship of the Latvian Council of Science; an author of more than 60 scientific papers in the field of economics, business, management and education; an expert representing Latvia in the Eurydice study "Digital Education at School in Europe". She is an Editor-in-Chief of the journal "Economics and Culture" and a member of a scientific board of the journal "Business, Management and Education".

CONTENTS

INTRODUCTION

Modern economic realities require a fundamentally new approach to the implementation of economic activity, since commodity producers are currently experiencing serious restrictions, caused by a shortage of natural resources and unprecedented degradation of ecosystems. In order to ensure sustainable development, which presupposes economic progress, environmental safety and improvement of the quality of life of the population, today a different development paradigm is needed.

In the world, at the moment, the traditional model and the economy are gradually being revised, and a new development paradigm, based on the concept of a green economy, is gaining more and more resonance. The Organisation for Economic Co-operation and Development (OECD) officially adopted an economic policy of "green" growth as a strategic direction for the development of all its members in 2009. It was adopted for the long-term period, i.e. up to 2030, as well as up to and beyond 2050. The main advantage of a circular (green) economy is that it not only saves nature, but also ensures further economic growth without increasing consumption (and landfill growth), as well as increases the number of jobs. Since the main task of this economy is to ensure maximum efficiency of each step and process in the particular product or service life cycle, one of its priority directions is concentrated on waste reuse.

Many countries have a linear economic model based on the principle of "take, make, dispose". For this reason, the traditional economic model is being reinterpreted, and more and more attention is being paid to the concept of a circular economy, based on the principle of "take, make, reuse".

Most experts believe that a closed-cycle economy (or a closed-loop economy, a cyclical economy, a circular economy) is a way to find harmony between the economy and the environment. For many years, nature and the economy have been in conflict; moreover, it is impossible to give priority to one of the parties of this conflict without detriment of the other.

The economy of a closed cycle becomes the subject of a wide range of studies not only in European countries, but also throughout the world. Experts consider it as a potential strategy for the development of society, which can improve well-being, while weakening the dependence of states on raw materials and energy. Many entrepreneurs see cyclical economy as a way to boost economic growth and increase profits. Many governments are actively involved in discussing the issues of attractiveness of the transition to a closed-cycle economy, its impact on the number of jobs, economic growth and the environment. Circular economy can become a key tool in the fight against pollution, biodiversity loss, climate change and growing inequalities. But to do that, the causes of the current problems need to be looked at, remembering that local activities can influence global change. Consequently, there is a need for cooperation at the level of governments, society, companies and individuals, which can serve as a common basis for the implementation and development of the circular economy.

Circular economy can also bring significant economic, social and environmental benefits on a global scale, becoming a paradigm for new economic development. Circular economy envisages a change from the current model based on 'end-of-life' concepts to the new model of production and consumption. The new model aims at reducing resource consumption, recycling and reusing various products and materials in all production, distribution and consumption processes. Circulation promotion aims to accomplish sustainable development, because the circular economy is linked to many of the United Nations' endorsed 17 Sustainable Development Goals (SDGs).[1]

A circular economy is a regenerative or regenerative production system. It is also often possible to find other names for this approach, such as green economy, closed-loop economy, and non-waste economy. This approach provides for replacing the concept of "end-of-life" repair, shifting the interest towards the use of renewable energy sources, completely eliminating the use of toxic chemicals that interfere with product reuse, and waste elimination through the improvement of design, materials, products and, as a result, the entire business model.

A wasteful lifestyle, mainly in industrialized countries, has led to a decline in ecosystems, limited resources and an increasingly unstable climate. At the same time, population growth and the much-needed increase in per capita income in low-income countries put additional pressure on resources. Business circles often see the environmental policy development as a threat to competitiveness, but there is reason to consider resource efficiency as an opportunity.

The current economy is built on the principle of "quick turnover". The faster the consumptions items are replaced, the better it is for manufacturers. As a result, the Earth's resources are managed very inefficiently. The transition to a circular economy through reuse will bring many benefits.

In the 1981 Report of the European Commission "Jobs for tomorrow: the potential for substituting manpower for energy" (Stahel & Reday-Mulvey, 1981) it is said, that the circular economy, in contrast to the production of new goods, will create local jobs and reduce resource consumption, greenhouse gas emissions and waste. The findings presented in this report have remained relevant also nowadays.

The economic effect of introducing the concept of a circular economy is expressed in reducing the consumption of raw materials and energy resources, and as a result – in reducing demand for them and price volatility in resource markets; as well as an increase in the number of jobs due to the formation of new sectors of the circular economy (Van Buren *et al.*, 2016). The acceleration of urbanization leads to an incentive for the state to promote the development of a circular economy. The advantages for enterprises are expressed in the strengthening of relationships with partners along the entire value chain, increasing innovation and customer loyalty, the emergence of additional competitive advantages and new sources of profit (Firnkorn & Muller, 2012; Shafiee & Stec, 2014), and for consumers – in the consumption of environmentally friendly products and, in some cases, a decrease in their cost.

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[1] United Nations. *Sustainable Development Goals.*

The circular economy provides the direction of material resources for reuse within the existing production cycle, which leads to a number of positive and negative consequences. It was found that despite the presence of negative effects, the benefits from the development of the circular economy are significantly higher.

Along with the long-term benefits of the transition to a circular economy, the following challenges exist:

- the difficulty of promoting systemic changes;
- economic challenges (a circular economy may be unprofitable in the short term);
- imperfect markets (lack of necessary products and infrastructure, competition, knowledge and / or incentives in the market);
- imperfect regulation (imperfect legislation and / or implementation);
- social factors (insufficient knowledge and skills related to the circular economy);
- difficulties in obtaining adequate funding;
- lack of harmonized procedures in various fields.

The introduction of a circular economy requires transformations that facilitate the identification and use of reserves in the chain of use of material resources throughout the "product cost cycle", which is possible only with complex changes, not so much technological as economic and organizational.

The transition to a circular economy is accompanied by attracting investments in the engineering and design service sectors, which will take into account recycling opportunities at the product design stage, waste processing technologies and processes, modernization of existing industries to increase resource efficiency and the ability to work on secondary raw materials, and the development of biotechnology-based products.

For the development of a circular economy and the creation of conditions that stimulate the attraction of investments in it, it is suggested to:

- carry out work to improve the methodology for identifying industries or activities related to the circular economy sector;
- develop quality standards for secondary raw materials to increase the level of their involvement in the economy and strengthen the confidence of producers on their part;
- improve the reliability and availability of data in the field of waste, which would contribute to better comparisons;
- create a public information platform that will allow to not only monitor the development of a closed-type economic system, but also to share information with all participants in this sector.

1. CIRCULAR ECONOMY AS A RESPONSE TO GLOBAL ISSUES

The Industrial Revolution, which started in the 18th century, was not only the transition from hand production methods to manufacturing, but also the starting point for huge transformative processes within the society. Unprecedented population growth and technological innovations led to increased consumption that, in turn, considering the limited resources, caused the global challenges mankind is facing now. World population reached 7.7 billion people in 2019 (Figure 1).[2]

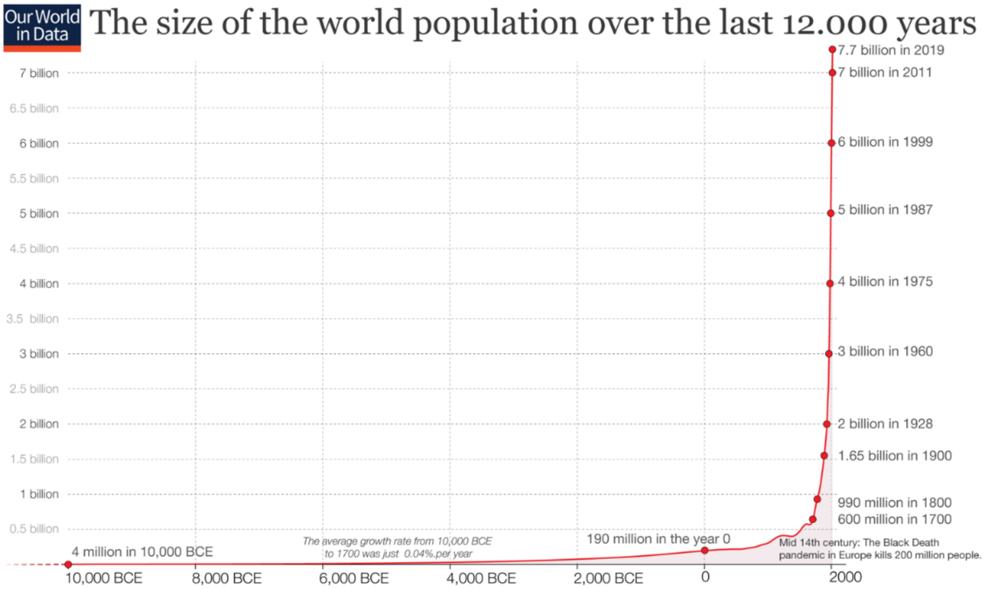

Figure 1. World Population Growth from 10,000 BC to today
(Source: Our World in Data, 2019)

The most visible effects of the growing population are an increase in thr usage of natural resources, environmental pollution and land use changes like urbanisation. According to the forecasts of *The Global Material Resources Outlook to 2060*, the use of global materials will rise double to those of today (Figure 2). According to Angel Gurría, OECD Secretary-General “Growth in materials use, coupled with the environmental consequences of material extraction, processing and waste, is likely to increase the pressure on the resource bases of our economies and jeopardise future gains in well-being”.[3]

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[2] Our World in Data, 2019.
[3] OECD, 2018.

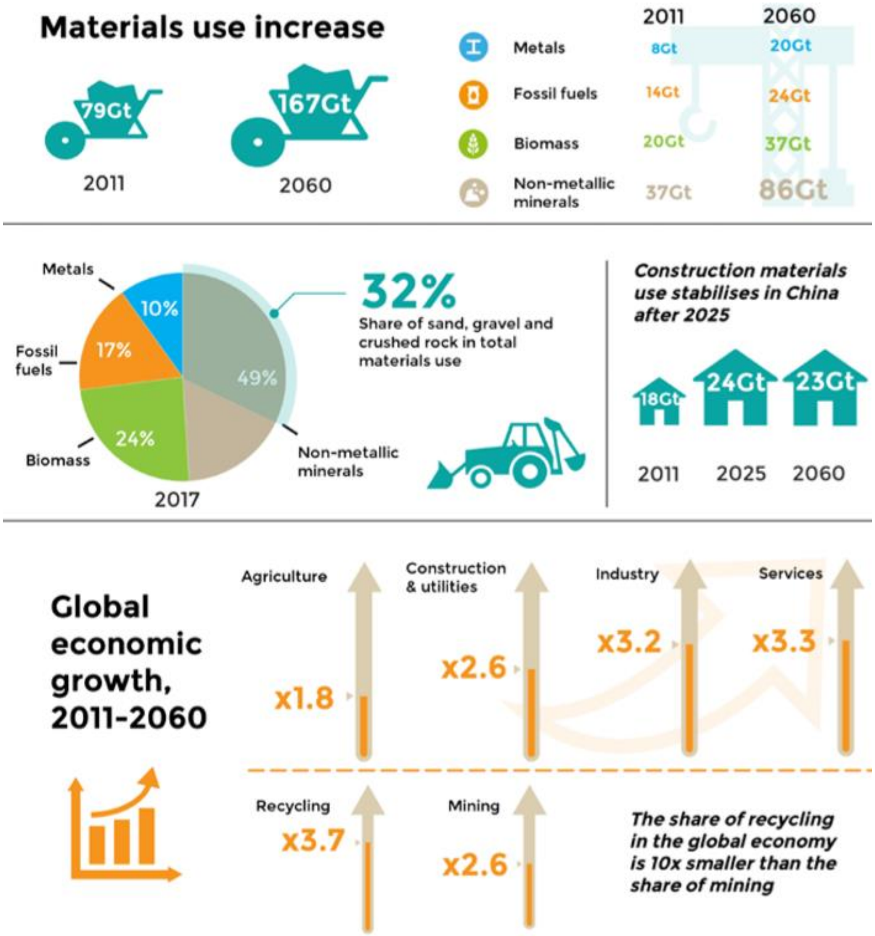

Figure 2. Key facts and projections from the OECD Global Material Resources Outlook to 2060 (Source: OECD, 2018)

The World Economic Forum, which took place in 2016, determined that one of the global risks, that, for the next ten years will mostly concern people and economies, will be the water crisis. Two thirds of the world's population currently lives in areas that experience water scarcity for at least one month a year.[4] According to the World Health Organisation (2019) data "in least developed countries, 22% of health care facilities have no water service, 21% no sanitation service, and 22% no waste management service. By 2025, half of the world's population will be living in water-stressed areas".[5]

Eurostat collects data on total waste in all European countries. According to 2016, the total amount of waste generated by all economic activities and household production, reached 2,538 million tons; of which hazardous waste accounted for 4.0%

[4] World Water Assessment Programme (WWAP), 2017.
[5] World Health Organisation, 2019.

of the total, i.e. 100.7 million tons.[6] Global waste, as forecasted, will grow to 3.40 billion tons by 2050 (Kaza *et al*., 2016).

The growth in population and the increase in the amount of waste generated leads to aggravation of global environmental problems. Statistics on water, land and air pollution are depressing. Worldwide, over 80% of all wastewater returns to the environment without being treated.[7] World Water Assessment Programme (WWAP) in 2017 analyzed the situation in different income countries and got to know, that high-income countries treat about 70% of the wastewater they generate, upper middle-income countries treat about 38% and lower middle-income countries about 28%. In addition, in low-income countries, only 8% of industrial and municipal wastewater is treated in any form.[8] Cumulative carbon dioxide (CO_2) emissions in the United States increased to 400 billion tons, which is 13 times more than in the same year of the previous century. The value of the indicator increased 1000! times for a 100 year period in China (Figure 3).[9]

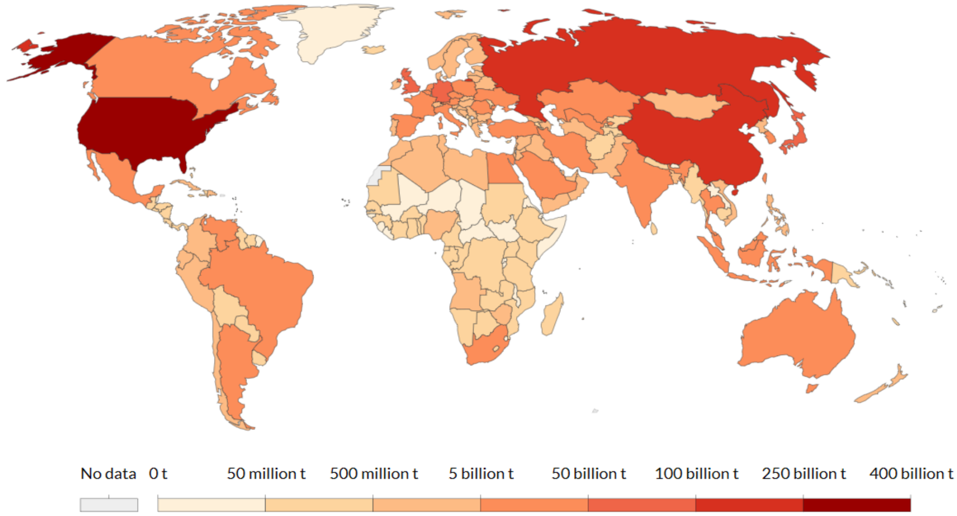

Figure 3. Cumulative carbon dioxide (CO_2) emissions (total sum of CO_2 emissions produced from fossil fuels and cement) (Source: Our World in Data, 2017)

Environmental pollution, in turn, resulted in land degradation (soil erosion), forest degradation, biodiversity reduction and climate change (global warming). The cause of environmental pollution, to a greater extent, is industrial production. The Industrial Revolution has led to the creation of a production system that results in billions of tons of toxic materials being released into water, air and soil, destroying the

[6] Eurostat, 2016.
[7] World Water Assessment Programme (WWAP), 2019.
[8] World Water Assessment Programme (WWAP), 2017.
[9] Our World in Data, 2017.

ecosystem and reducing biodiversity. The absence of universally implemented environmentally neutral technologies causes pollution of the atmosphere, water bodies, as well as an increase in waste generation. Therefore, ecology needs to be seen as a complex scientific direction that collects and synthesises data on interactions between the environment, people and society as a whole, energy substances and processes in these systems.

Circular economy is restorative and regenerative by design. It can be a response to many challenges we are facing now through strategies, such as recirculating a larger share of materials, reducing waste in production, extending the lifetimes of products, and deploying new sharing-based business models.[10] Finally, it will have a positive economic effect.

Circular economy is an economic model that functions more like a natural ecosystem with some changes.[11] Comparing the economic model with the ecosystem is possible because there is no waste in the ecosystem, and there is no waste in the circular economy, and all materials can be reused. Circular economy is an economic activity aimed at energy saving, regenerative environmentally friendly production, circulation and consumption. The circular model is the most successful way to save resources and materials, and constant economic growth.

Based on the report of the European Investment Bank[12], there are three fundamental drivers of circular economy:

1. Resource constraints: Global demand for resources is rising very rapidly, resulting in ever-increasing shortages of critical raw materials and water.
2. Technological development: The introduction of new technologies enables the development and introduction of new CE business models. Without the development of new technologies and the development of innovative approaches, recycling, block replacement and re-use of resources, as well as the application of new IT technologies, will not be possible.
3. Socio-economic development: Circular models play a very important role in the context of increasing urbanization. Urban areas can easily develop, implement and maintain systems that can collect and return a variety of goods, materials and other resources, and which will also be cost effective.

In turn, the opportunities offered by circular economies for companies include: (i) de-risk/ hedge future commodity supply uncertainty and price volatility; (ii) reducing manufacturing costs, (iii) avoided costs and new revenue streams, and (iv) new business opportunities and new markets.[13]

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[10] Material Economics, 2018.

[11] *Towards the Circular Economy: Accelerating the scale-up across global supply chains*. World Economic Forum, 2014.

[12] European Investment Bank, 2019.

[13] ibid.

The experts from McKinsey in their 2016 report "The circular economy: Moving from theory to practice"[14] concluded that:

- By adopting circular-economy principles and integrating new technologies and business models, Europe could achieve "growth within".
- A growth-within model would create better outcomes for the European economy, generating annual benefits of up to €1.8 trillion by 2030.
- The circular economy could produce better welfare, GDP, and employment outcomes than the current development path.
- A circular economy could benefit the environment while boosting competitiveness and resilience.

Based on the viewpoint of the experts from the World Business Council for Sustainable Development[15], circular economy can deliver significant benefits for businesses, such as increased growth; innovation and competitive advantage; cost reduction; reduced energy consumption and CO_2 emissions; increased supply chain and resource security.

The most important result that can be achieved after the transition to a circular economy is reduced consumption of natural resources. This will help both the environment through reduced environmental impact and the economy, such as achieving security of supply through reduced dependence on imports of natural resources (Potting & Hanemaaijer, 2018). Circular economy offers the opportunity to "make better use of the materials already produced, and so reduce our need for new production,… through strategies such as recirculating a larger share of materials, reducing waste in production, light-weighting products and structures, extending the lifetimes of products, and deploying new business models based around sharing of cars, buildings, and more".[16]

CONTROL QUESTIONS AND QUESTIONS FOR INDIVIDUAL STUDIES

1. What are the main challenges people are facing now? What are the cause-effect relations between them?
2. What is the situation in your country? Find statistics on main social and environmental indicators to describe.
3. How do you understand the term "Circular economy" after reading this chapter?
4. What benefits can be captured by businesses and society, moving to the circular economy?

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[14] McKinsey&Company, 2016.
[15] World Business Council for Sustainable Development, 2017a.
[16] Material Economics, 2018, p. 3.

2. CONCEPTUAL FRAMEWORK FOR CIRCULAR ECONOMY

2.1. EMERGENCE OF THE CONCEPT AND CURRENT DEFINITIONS

The concept of circular economy gained the extreme popularity among the academicians during the last decades. To show the progress in the number of studies devoted to circular economy issues, a small research has been conducted. Figure 4 demonstrates the exponential growth of the number of CE-related papers, published in different issues indexed in SCOPUS and Web of Science databases – the largest and the most valuable in the academic world databases of peer-reviewed literature.

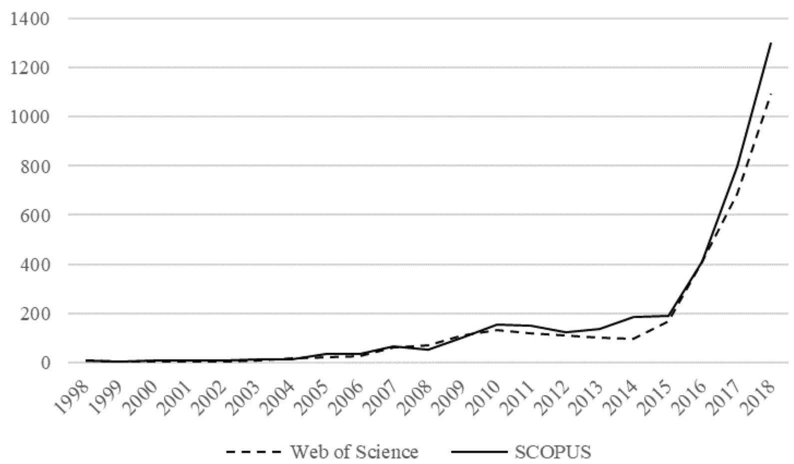

Figure 4. Results of the search in Web of Science and SCOPUS data bases, using the key words “circular economy” (Source: Authors’ compilation)

The idea of the circular economy appeared several decades ago. Back in the 1960s, economist Kenneth Boulding (1966) wrote about the “ideal economy”. He argued that it was necessary to manage the available resources as if being in a spaceship: there was no way to hope for fresh produce, and nowhere to store waste and garbage. Boulding introduced the terms of two alternative forms of economy: 1) cowboy economy, i.e. the open economy of the past, and 2) spaceman economy, i.e. the closed economy of the future.

In 1969, Otto Schmitt introduced the terms of biomimetics/ biomimicry to describe a “more technical approach of imitating models, systems and elements of nature specifically for the purpose of synthesizing sustainable products through artificial mechanisms which mimic natural ones” (Schmitt, 1969).

Back in the 1970s, many scientists, ideological leaders, and also some companies began to speak out in support of a closed-cycle economy, but until recently this model remained only an idea.

The increased amount of waste and the scarcity of raw materials, in turn, fostered to consider waste as a resource and to implement the principles of re-using and recycling. In 1989, a new research field of "Industrial ecology" emerged (Frosch & Gallopoulos, 1989). Industrial ecology facilitates the transition from open material and energy cycles to closed ones, thus reducing the wastage of the industrial process (Kronenberg, 2007).

The term "Circular economy" was introduced by Pearce and Turner (1990), who developed a new economic model, applying principles of the laws of thermodynamics. The idea was explained later by Čiegis and Čiegis (2008).

To date, the active advocates of the cyclical economy are the international consulting company McKinsey&Co. and the World Economic Forum (WEF), while international companies like Unilever, Cisco Systems and Philips implement the principles of cyclical economics.

The concept of the circular economy takes its origin from many theories and scientific schools, but all of them are, in one way or another, connected with overconsumption of natural resources. The current concept of the circular economy is based on the foundations of industrial ecology, the environmental economy and the green economy. These concepts have been developed to balance the environmental burden in industrialised countries (Murray *et al.*, 2017; Ghisellini *et al*., 2016). Due to its comprehensive and multidimensional nature, the concept of circular economy is related to many other concepts. This leads to considering it as a quintessential concept to describe socially- and environmentally- responsible human activities within the production cycle and consumption.

In recent years, circular economy in the world has become increasingly popular, emphasizing that resources and their effectiveness are crucial for economic and business prosperity and the achievement of sustainable development goals.

The impetus for the introduction and popularization of the ideas of a cyclical economy occurred in 2010, when the former yachtswoman Ellen MacArthur created a foundation under her own name, promoting this approach.[17] Circular economy (CE) is a paradigm for economic development and a policy initiative. It is developed to respond to the unsustainable, conventional and linear "take, make, dispose" economic model. Circular economy is defined as "an industrial economy that is restorative by intention; aims to rely on renewable energy; minimises, tracks, and eliminates the use of toxic chemicals; and eradicates waste through careful design".[18]

In the 2013 report "Towards the Circular Economy: Economic and business rationale for an accelerated transition" an overview of several schools of thought about circular economy was developed by the Ellen MacArthur Foundation.[19] The "historical evolution" of the concept is visualized in Figure 5. For sure, this "evolution" is just illustrative. The predecessors of the circular economy were economists working in

[17] Ellen MacArthur Foundation, 2017a.
[18] Ellen MacArthur Foundation, 2013a, p.22.
[19] Ellen MacArthur Foundation, 2013a, p. 26-27

the late 1800s and in the beginning and middle of the 19th century. The years assigned to the concepts and schools of thought illustrate the period of the "emergence". Sometimes the most significant contribution was made much later after emergence.

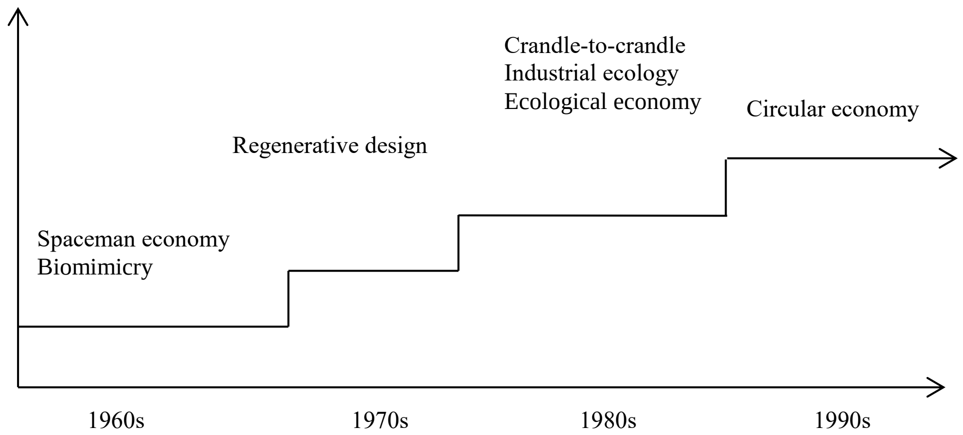

Figure 5. Schools of thought contributed to the development of the Circular economy concept (Source: Authors' compilation)

For instance, Walter R. Stahel firstly used the term "cradle to cradle" (Hebel *et al*., 2014, p.11). However, the authors of the current concept of cradle to cradle are William McDonough and Michael Braungart (2002). Main contributors to the development of the conceptual predecessors of circular economy and other related schools of thought are listed in Table 1.

There are plenty of scientific publications with an attempt to make a comprehensive overview of definitions of the circular economy concept. Kirchherr *et al*. (2017a) with an analysis of 114 definitions and Rizos *et al*. (2017), who reviewed not only the definitions, but also the circular economy processes and impacts, both can be mentioned as an example.

Table 1. The main contributors to CE-related schools of thought
(Source: Authors' compilation)

Concept / school of thought	Year	Contribution
Performance economy	1986	Stahel, W.R. "Hidden Innovation, R&D in a Sustainable Society"
Green Economy	1989	Pearce, D.W., Markandya, A., Barbier, E.B. "Blueprint for a Green Economy"
Industrial ecology	1989	Frosch & Gallopoulos "Strategies for Manufacturing"

Concept / school of thought	Year	Contribution
Regenerative Design	1994	Lyle, J.T. “Regenerative design for sustainable development”
Biomimicry	1997	Benyus, J.M. “Biomimicry: Innovation Inspired by Nature”
Bioeconomy	1998	Enriquez, J. “Genomics and the World's Economy”
Cradle-to-cradle	2002	McDonough & Braungart “Cradle to Cradle: Rethinking the Way We Make Things”
Blue economy	2010	Pauli, G. “10 years, 100 innovations, 100 million new jobs”

Several up-to-date definitions of the concept, proposed by different authors and organisations in 2015-2019, are summarized in Table 2.

Table 2. Definitions of the concept of Circular economy
(Source: Authors’ compilation)

Author(s)	Definition
Korhonen *et al*. (2018)	“Circular economy is an economy constructed from societal production-consumption systems that maximizes the service produced from the linear nature-society-nature material and energy throughput flow”.
Kirchherr *et al*. (2017a)	“A circular economy describes 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”.
Association of Cities and Regions for sustainable resource management (2015, p.3)	“The notion of circular economy aims at finding a new economical paradigm integrating environmental preoccupations (particularly, dwindling of certain resources), and therefore makes way for “new business models”, i.e. a deep transformation of production and consumption models.”
Deloitte Central Europe (2017, p. 27)	“The circular economy presents a development strategy that allows economic growth while optimizing the use of resources, deeply transformed patterns of production and consumption chains, and designs for new industrial systems”

Author(s)	Definition
World Business Council for Sustainable Development (2017a)	"The circular economy is a new way of looking at the relationships between markets, customers and natural resources. It leverages innovative new business models and disruptive technologies to transform the linear economic model"
Ellen MacArthur Foundation & McKinsey Center for Business and Environment (2015, p. 23)	"...an economy that provides multiple value creation mechanisms which are decoupled from the consumption of finite resources"
European Investment Bank (2019, p. 3)	"...a new economic model that represents sustainable progress towards efficient green growth, moving from a consumption and disposal-based linear model to extending the life and use of products and materials and minimising wastage"

Rizos *et al.* (2017) state that the two basic approaches to the interpretation of the notion "circular economy" are:

1. resource-oriented definitions/ interpretations, emphasising the need to create closed loops of material flows and reduce the consumption of virgin resources;
2. interpretations that attempt to move beyond the notion of management of material resources and incorporate additional dimensions.

In turn, the circular processes – recycling, remanufacturing etc. – are classified into three categories: 1) using less primary resources, 2) maintaining the highest value of materials and products and 3) changing utilisation patterns.

One can select any definition that is the most clear for them. The most important is to be aware of the principles and activities within the circular economy. One of the simplest ways for understanding definitions of the concept of circular economy is provided by the quarterly journal *Government Europe:*[20]

> *The circular economy is a regenerative system in which resource input, waste, emission, and energy leakage are minimised by slowing, closing, and narrowing energy and material loops; this can be achieved through long-lasting design, maintenance, repair, reuse, re-manufacturing, refurbishing, recycling, and upcycling.*

[20] Government Europe, 2018.

2.2. Circular economy and the related concepts

"These concepts [circular economy, green economy, sharing economy, steady-state economy, bioeconomy] contribute to form companies' sustainability visions and strategies by providing shared grounds for discussion on current issues with multiple stakeholder groups" (D'Amato et al., 2019)

"To become more sustainable, companies need to go from traditional, linear business models based on "take, make and dispose" to circular business models based on reuse, resource efficiency, the sharing economy and closed loops" (Jørgensen & Pedersen, 2018)

In these statements several notions and terms that are usually associated with (sustainable, sharing economy, green economy, closed loops) or matched against (linear business, "take, make, dispose") the term "circular economy" can be found. The understanding of these related concepts can help to get a deeper awareness about the concept of circular economy itself.

Circular economy and Sustainable development

In 1987, the World Commission on Environment and Development defined sustainable development in the report *Our Common Future*, as following:

"Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs". [21]

Since the emergence of that definition, many actors still are struggling to find viable solutions to achieve sustainable development. However, it is a complicated process affected by various external factors. The world's population is increasing, along with the average gross domestic product. The middle class is expanding and is predicted to increase with three billion people over the coming decade. Even though these external factors are favourable to economic growth, they are simultaneously imposing limits to it, as they are the key drivers of resource demand.[22] This rising global affluence creates a demand that many non-renewable resources cannot keep up with.

Sustainable development refers to approaches and methods that minimize our impact on the environment, promote development, based on social justice and equality. Three pillars of sustainability are **economic, environmental** and **social** sustainability. It is only achieved when there is balance or a trade-off between these three aspects.

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[21] World Commission on Environment and Development, 1987, p.41.

[22] *Towards the Circular Economy: Accelerating the scale-up across global supply chains*. World Economic Forum, 2014.

The principles of sustainable development contain only a concept, but do not contain specific solutions or implementation tools for achieving sustainable development, which is a complex fundamental task. An important issue in the implementation of the concept of sustainable development, especially since it is often viewed as evolving, was the identification of its measurable indicators, which could reflect the economic, social and environmental aspects of the sustainable development of society and link them together. An additional issue was the creation of various methods and approaches for the implementation of the concept of sustainable development in life in various fields and industries.

Therefore, at the United Nations Sustainable Development Summit in 2015, world leaders adopted the 2030 Agenda for Sustainable Development.[23] The Agenda includes a set of 17 Sustainable Development Goals (SDGs) to be met by 2030 (Figure 6), which are accompanied by specific targets – 169 in total.[24] All goals relate to the global challenges the planet is facing, including those related to environmental degradation and climate change, poverty, inequality, peace and justice.

Figure 6. Sustainable development goals[25]

Dr. Patrick Schröder at the Institute of Development Studies (IDS) has identified the key targets amongst the Sustainable Development Goals (SDGs) that are crucial for a transition to a circular economy (Table 3).

[23] United Nations, 2015.
[24] United Nations. Sustainable Development Goals.
[25] Sustainable Development Working Group, 2015.

Table 3. Key SDG targets crucial for circular economy
(Source: The top 10 priority targets for the circular economy[26])

SDG targets	Description
TARGET 2-4	By 2030, ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production.
TARGET 3-9	By 2030, substantially reduce the number of death and illnesses from hazardous chemicals and air, water and soil pollution and contamination
TARGET 6-3	By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally
TARGET 7-3	By 2030, double the global rate of improvement in energy efficiency
TARGET 8-4	Improve progressively, through 2030, global resource efficiency in consumption and production and endeavour to decouple economic growth from environmental degradation, in accordance with the 10-year framework of programmes on SCP, with developed countries taking the lead
TARGET 9-2	Promote inclusive and sustainable industrialization and, by 2030, significantly raise industry's share of employment and gross domestic product, in line with national circumstances, and double its share in least developed countries
TARGET 11-6	By 2030, reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management
TARGET 12-2	By 2030, achieve the sustainable management and efficient use of natural resource
TARGET 12-5	By 2030, substantially reduce waste generation through prevention, reduction, recycling and reuse
TARGET 14-1	By 2025, prevent and significantly reduce marine pollution of all kinds, in particular from land-based activities, including marine debris and nutrient pollution

The researchers and public authorities recognize a strong interconnection between sustainable development and circular economy, both on the theoretical (conceptual) and the practical level.

In the report of the Economic Research Institute for ASEAN and East Asia "Towards a Circular Economy: Corporate Management and Policy Pathways", it is stated that

[26] SB Insight, 2019, p. 10.

sustainable development requires a balanced and simultaneous consideration of economic, environmental, technological, financial, and social aspects of the country-, sector-, firm-level process, as well as interaction among different stakeholders. In that context, circular economy is seen as a new business model, expected to lead to a more sustainable and harmonious society (Anbumozhi & Kim, 2016).

Shaharia (2018) in his paper "Circular Economy: The Beauty of Circularity in Value Chain" states that circular business models and sustainable business models are focusing on the same values – creating sustainable value, stakeholder management, and long-term perspective. The supporting activities in the circular value chain "are mostly the same as the linear value chain, but sustainable procurement and practicing sustainability in supporting activities are added" (Shaharia, 2018, p.588)

> *"The link between circular economy and the Sustainable Development Goals is thus evident. A circular economy improves resource efficiency and can therefore increase economic growth in a long-term sustainable manner" (2019 report "The Nordic Market for Circular Economy").*[27]

The concept of sustainable development has a direct economic and technological substantiation, the essence of which can be described by the so-called "5R" principle of a closed-cycle economy:

- Restriction of energy and material consumption
- Replacement of non-renewable resources by renewables
- Recovery of the necessary components from recycled waste
- Recycling
- Reuse of products

Lehmann, Leeuw and Fehr, representing the World Resources Forum, state that a circular economy is "the basic requirement for achieving a sustainable economy and a future-compliant society" (Lehmann *et al*., 2014). In their brochure "Circular Economy Improving the Management of Natural Resources", the authors also presented their vision of circular economy within the framework of other sustainability concepts (Figure 7).

[27] SB Insight, 2019, p. 9.

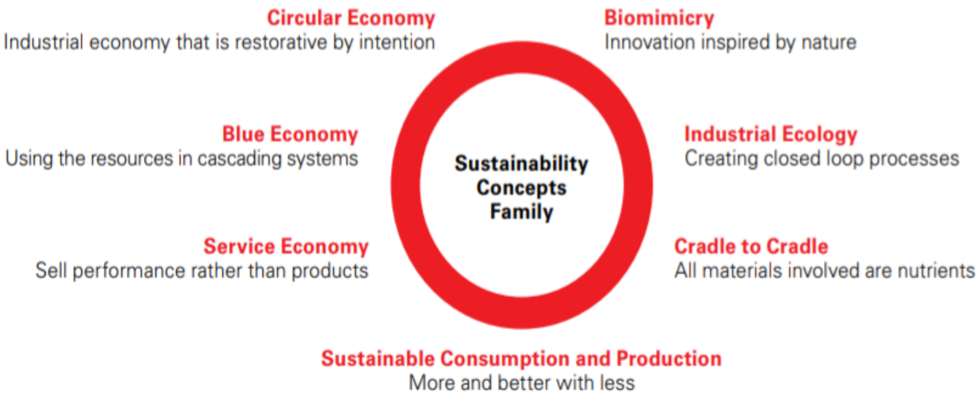

Figure 7. CE within the framework of other sustainability concepts
(Source: Lehmann *et al.*, 2014)

Circular economy versus Linear economy

The Industrial Revolution created a linear model for a rapid and an efficient production of products — more often with built-in service life – without regard to environmental consequences. Historically, manufacturers often took environmentally unsustainable resources, manufactured goods, and disposed of the remaining materials in ways that were harmful to the environment.

The linear economy is based on a linear process. Usually, the process is optimized to make it as efficient as possible, with high throughput and lower production costs based on the availability of various inputs at relatively low cost. The typical process is based on the "take – make – consume – dispose" model and consists of a series of steps: resource extraction, production, distribution, consumption and disposing of products at the end of their life cycle.

A linear model of value creation "begins with extraction and concludes with end-of-life disposal. Resources are acquired, processed using energy and labour, and sold as goods – with the expectation that customers will discard those goods and buy more".[28]

Circular economy is an alternative model that assumes an endless flow of raw materials, product life-cycle extension and incorporates the principle "reduce, re-use, recycle" instead of the principle "take, make, dispose".

> *"In a circular economy, products are designed for durability, upgradeability, reparability and reusability, with a view to reusing the materials from which they are made after they reach the end of their life".*[29]

[28] McKinsey & Company, 2016.
[29] European Commission, 2019a, p. 4.

Shaharia (2018) defines a circular value chain as "a process and activities by which organizations retain and regenerate values to an article from secondary raw materials through reverse logistics and propose regenerative value by practicing sustainability in supporting activities: human resources, procurement, technology, and firm infrastructure". A simplified illustration of both a linear and a circular economy is presented in Figure 8.

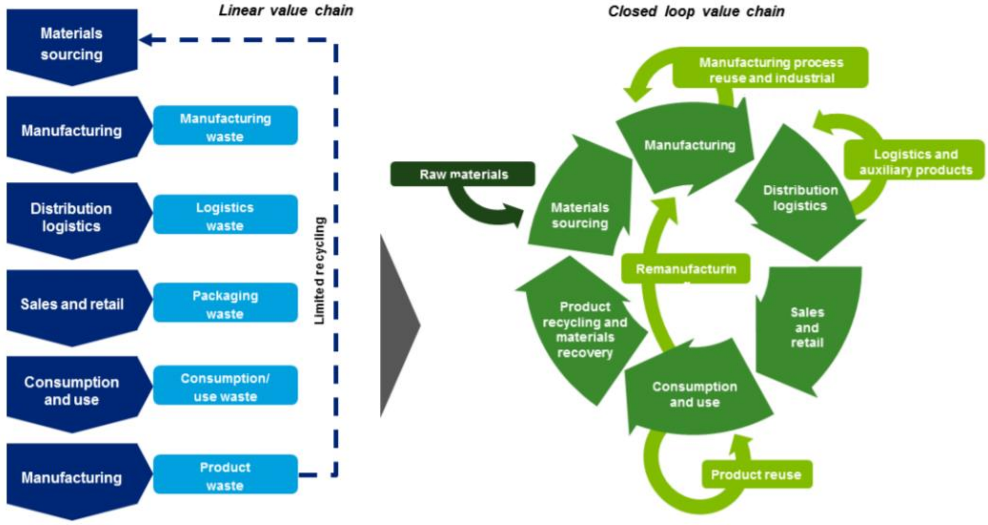

Figure 8. Simplified illustration of a linear and a circular economy[30]

A key difference between the linear economy and the circular economy is the fact that circular economy is eco-effective instead of eco-efficient.

> *"The goal [of eco-effectiveness] is not to minimize the cradle-to-grave flow of materials, but to generate cyclical, cradle-to-cradle "metabolisms" that enable materials to maintain their status as resources and accumulate intelligence over time (upcycling)" (Braungart et al., 2007, p.1338)*

This creates a positive correlation between the economy and the ecology.[31] Circular economy is a response to not only ecological problems. Along with the positive environmental impact, benefits from the transition to a circular economy include:

- Resource benefits: improving resource security and decreasing import dependency;

[30] Deloitte Sustainability, 2016.
[31] SB Insight, 2019.

- Economic benefits: opportunities for economic growth and innovation;
- Social benefits: sustainable consumer behaviour and job opportunities.[32]

Moreover, "the circular economy is compatible with the inherent interests of the corporations, as it is aligned with the competitive and the strategic frameworks and it is capable to enrich the contract between the consumers and the producers". (Sariatli, 2017) The properly applied principles of circular economy can deliver companies "cost benefits today and some striking longer-term strategic opportunities as well as new profit pools in reverse cycle services".[33]

> *"Transitioning to a circular economy does not only amount to adjustments aimed at reducing the negative impacts of the linear economy. Rather, it represents a systemic shift that builds long-term resilience, generates business and economic opportunities, and provides environmental and societal benefits".*[34]

Circular economy and Green economy

The term "Green economy" was coined in 1989 in the "Blueprint for a Green Economy" report (Pearce *et al*., 1989).

In 2008, the United Nations Environmental Programme (UNEP) launched a Green Economy Initiative (GEI). GEI's aim was stated as "to demonstrate that investing in green sectors – such as energy efficient technologies, renewable energy, public transport, sustainable agriculture, environment friendly tourism, and sustainable management of natural resources including ecosystems and biodiversity".[35]

European Environmental Agency defined green economy as

> *"…results in improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities".*[36]

A comprehensive overview of the literature on green economy "A guidebook to the Green Economy" was provided by Allen and Clouth (2012).

D'Amato with co-authors in their paper "Green, Circular, Bio economy: a comparative analysis of sustainability concepts" stated that "Green Economy acts as an 'umbrella' concept, including elements from Circular Economy and Bioeconomy concepts (e.g. eco-efficiency; renewables), as well as additional ideas, e.g. nature-based solutions" (D'Amato *et al*., 2017).

According to the European Environmental Agency (2016b), the circular economy is a relevant part of the green economy (Figure 9), which deals also with the human

[32] European Environment Agency, 2016a.
[33] Ellen MacArthur Foundation, 2013a, p. 10.
[34] Ellen MacArthur Foundation, 2017b.
[35] Chief Executives Board Secretariat, 2016.
[36] European Environmental Agency, 2016b.

welfare (i.e. lifestyles and consumption models for an extensive and inclusive well-being) and the ecosystems resilience (i.e. natural capital and ecosystem services preservation).

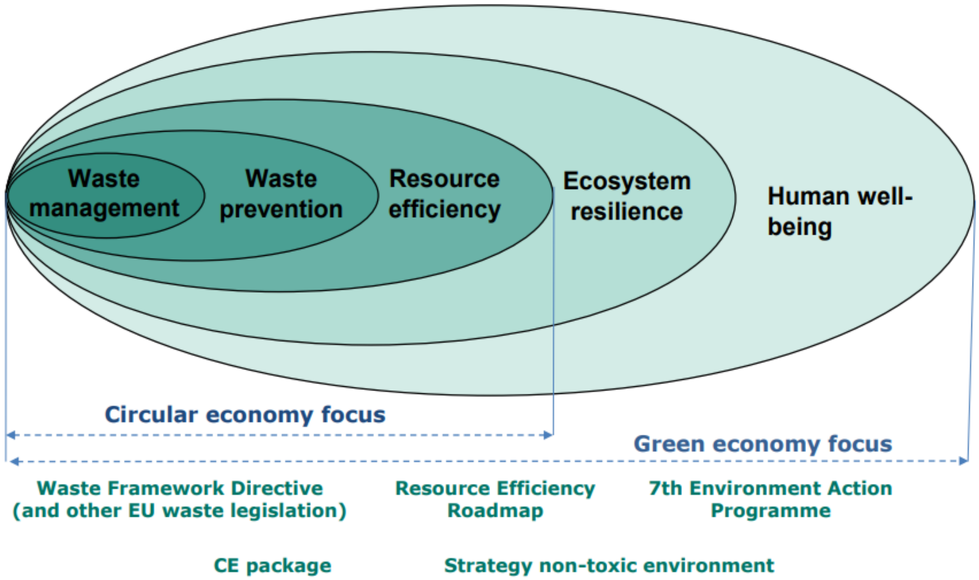

Figure 9. Circular economy and Green economy
(Source: European Environment Agency, 2016a, p. 31)

Circular economy and Corporate Social Responsibility

Corporate social responsibility (CSR) “refers to companies taking responsibility for their impact on society” (European Commission, 2017).

Speaking about circular economy business models, the link with the concept of CSR becomes obvious. Researchers (Turoń & Czech, 2016; Esken *et al.*, 2018) and business practitioners investigate circular economy practices and the economic impact of CE-based activities in line with the CSR strategy.[37]

> *“A holistic approach to circular economy is the one that merges the mission-driven approaches of CSR, social enterprise, and social entrepreneurship with the ecological potential of circular economy for social good” (Soufani et al., 2018).*

Based on Ordaz & Vargas-Hernández (2017), “Circular Economy model emerges as a system that seeks the manufacture of more resistant products or the collection of

[37] Deloitte Sustainability Consulting Central Europe, 2017.

raw materials through recycling for its reutilization, which represents a way of sustainable development that maintains the Social Responsibility from companies".

To understand the close relationship between circular economy and CSR or vice versa, one can read any CSR report prepared by the organizations. The reports include sections, such as "waste management", "greenhouse gas reduction", "product energy efficiency", "water stewardship" – all of which are the core activities of circular economy (Intel Corporation 2019; Starbucks Corporation, 2006).

In some reports CSR activities are mentioned as instruments for moving towards circular economy goals:

"I am pleased with our sustainability and corporate responsibility performance in 2017, particularly the progress we made in the areas of energy performance, climate action and circular economy" (President and CEO of Ericsson, Sustainability and Corporate Responsibility Report 2017).[38]

"Groupe PSA has long deployed an eco-design approach. It is actively involved in the circular economy through managing its products' end-of-life cycles" (GROUPE PSA, Corporate Social Responsibility Report 2018).[39]

"XPO Logistics Europe supports the move towards a circular economy by reducing the amount of waste generated by our operations and by ensuring that as much waste as possible is sorted and recycled" (XPO Logistics Europe, Corporate Social Responsibility Report 2018).[40]

"We need to move away from linearity and embrace circularity. Through careful design and innovative business models, technical and biological materials can flow continuously within the economy, rather than be used once and discarded, safeguarding valuable stocks and decoupling growth from finite natural resources" (Chris Dedicoat, Executive Vice President of CISCO, Corporate Social Responsibility 2016 Report).[41]

CONTROL QUESTIONS AND QUESTIONS FOR INDIVIDUAL STUDIES

1. How do you understand the term "Circular economy" after reading this chapter?
2. Form your own list of key words associated with circular economy.
3. Select 2-3 CE-related concepts and explain the interrelation between them.

[38] Ericsson, 2018, p. 4.
[39] Groupe PSA, 2018, p. 17.
[40] XPO Logistics Europe, 2019, p. 20.
[41] CISCO, 2017, p. 18.

3. CIRCULAR ECONOMY ACTIVITIES

3.1. GLOBAL INITIATIVES TOWARDS CIRCULAR ECONOMY

The United Nations Environment Programme (UN Environment)

UN Environment is the leading global environmental authority that sets the global environmental agenda, promotes the coherent implementation of the environmental dimension of sustainable development within the United Nations system, and serves as an authoritative advocate for the global environment.[42]

United Nations Global Compact (UN Global Compact)

UN Global Compact is the world's largest corporate sustainability initiative. The strategy of the UN Global Compact is to drive business awareness and action in support of achieving the Sustainable Development Goals by 2030.

UN Global Compact guides companies to do business responsibly, committing to and incorporating its 10 principles on human rights, labour, environment and anti-corruption into strategies and operations.[43]

The Ellen MacArthur Foundation

It was launched by Ellen MacArthur in 2010 to accelerate the transition to a circular economy. Its work focuses on six areas:[44]

1. Learning. The Foundation provides insights and resources to support circular economy learning, and the systems thinking required to accelerate a transition.
2. Business. The Foundation works with its Global Partners to develop scalable circular business initiatives and to address challenges to implementing them.
3. Institutions, Governments and Cities. The Foundation works with governments and institutions with the aim of informing policymakers and supporting public-private co-creation mechanisms.
4. Insight and Analysis. The Foundation continues to widen its understanding by working with international experts, key thinkers and leading academics.
5. Systemic Initiatives. The Foundation is bringing together organisations from across value chains to tackle systemic stalemates which organisations cannot overcome in isolation.
6. Communications. The Foundation communicates CE ideas and knowledge through digital media and *Circulate*, an online information source dedicated to the issues of circular economy and related subjects.

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[42] United Nations Environment Programme. About UN Environment.
[43] United Nations Global Compact
[44] Ellen MacArthur Foundation, 2017a.

World Health Organization (WHO)

WHO started its work in 1948 and now all the members of WHO represent 194 of the world's countries.[45]

WHO bases its work on the Sustainable Development Goals (SDGs). The currently implemented strategical programme is the *Programme of work 2019 – 2023*.[46] Its vision: "A world in which all people attain the highest possible standard of health and well-being".

WHO supports countries to implement the drinking-water quality guidelines.[47] The organisation works closely with UNICEF on water, sanitation, and hygiene in health care facilities.[48]

UN-Water & UNESCO

Members of UN-Water are UN (United Nations) agencies, programmes and other UN entities dealing with water-related issues, including sanitation and natural disasters. UN-Water provides coherent and reliable data and information on key water trends and management issues and coordinates the United Nations international observances on freshwater and sanitation.[49]

The flagship programme of UN-Water – UNESCO World Water Assessment Programme (UNESCO WWAP) – was founded in 2000. It coordinates the production of the UN World Water Development Report (WWDR), with an aim to report on the status of global freshwater resources and the progress achieved in reaching the Millennium Development Goals related to water. UNESCO WWAP seeks to equip water managers and key decision-makers with the information, data, tools and skills necessary to enable them to effectively participate in the development of policies.[50]

The Food and Agriculture Organization (FAO)

FAO unites 194 member states. Its goal is to achieve food security for all and make sure that people have regular access to enough high-quality food to lead active and healthy lives. To meet demands and challenges in agricultural development, FAO has identified five key priorities:[51]

1. Help eliminate hunger, food insecurity and malnutrition.
2. Make agriculture, forestry and fisheries more productive and sustainable.
3. Reduce rural poverty.
4. Enable inclusive and efficient agricultural and food systems.

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[45] World Health Organization. Who we are.
[46] World Health Organization, 2018.
[47] World Health Organization, 2011.
[48] World Health Organization, 2019.
[49] UN-Water. What we do.
[50] UNESCO. World Water Assessment Programme (UNESCO WWAP).
[51] Food and Agriculture Organization. What we do.

5. Increase the resilience of livelihoods to threats and crises.

World Meteorological Organization (WMO)

WMO was established in 1950 and now is an organization with 193 member states and territories.

WMO collects data to produce weather, climate and water-related forecasts and coordinates and organizes international research programmes to improve weather, climate, water and environmental observations, prediction, service delivery and scientific assessments of regional and global environmental conditions.[52]

World Bank Group

World Bank Group is a partnership of institutions: The International Bank for Reconstruction and Development (IBRD), The International Development Association (IDA), The International Finance Corporation (IFC), The Multilateral Investment Guarantee Agency (MIGA) and The International Centre for Settlement of Investment Disputes (ISCID) working for sustainable solutions that reduce poverty and build shared prosperity in developing countries.

World Bank operates in accordance with its environmental and social policies, which provide a framework for consultation with communities and for public disclosure. These policies require the borrowing governments to address certain environmental and social risks in order to receive World Bank support for investment projects.[53]

Platform for Accelerating the Circular Economy (PACE)

PACE is a public-private collaboration platform and project accelerator. PACE aims to accelerate action towards the circular economy by driving projects, capturing & disseminating learnings and leveraging leadership for scale.[54]

3.2. European initiatives

In 2005, the European Commission proposed a Strategy on the Sustainable Use of Natural Resources [55,56] within the 6th Environmental Action programme (6 EAP). This was an initial stage for development current European strategies towards circular economy. In 2011, the Resource Efficiency Roadmap[57] was developed to "illustrate what will be needed to put Europe on a path to resource efficient and sustainable growth".[58]

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[52] World Meteorological Organization. *What we do*
[53] World Bank. *Environmental and Social Policies.*
[54] Platform for Accelarating the Circular Economy (PACE). *Public Overview.*
[55] European Commission, 2019b. *Sustainable Use of Natural Resources*.
[56] European Commission, 2003.
[57] European Commission, 2011a.
[58] European Commission, 2019c. *The Roadmap to a Resource Efficient Europe*.

The current EU policies on circular economy express the commitments of EU to United Nations' 2030 Agenda for Sustainable Development [59] and Paris Agreement.[60] In 2015, the European Commission presented a circular economy package – the key EU policy initiative on circular economy.[61,62] It contains EC communication "Closing the Loop - An EU action plan for the Circular Economy"[63], an action plan with concrete actions, measures and timetable, and legislative proposals on waste management.

The EU action plan for the Circular Economy aims to support the transition to a circular economy in the EU. It contains a set of actions, such as:[64]

1. A European EU Strategy for Plastics in the Circular Economy.
2. Communication about how to deal with the interlinkages between chemical, product and waste legislation.
3. A monitoring Framework on the progress of the transition towards circularity, both on the EU level and on a national level.
4. A report on critical Raw materials.

The guidance for EU's environmental policy till year 2020 is the 7th Environment Action Programme.[65] The Programme sets up a 2050 vision of 'living well within the limits of the planet'. Its key objectives are:

- to protect, conserve and enhance the Union's natural capital;
- to turn the Union into a resource-efficient, green, and competitive low-carbon economy;
- to safeguard the Union's citizens from environment-related pressures and risks to health and wellbeing.

Circular economy Action plan is complemented by a set of strategies, such as:

- The Bioeconomy Strategy launched in 2012 and updated in 2018.[66]
- Eco-innovation Action Plan.[67]
- The EU Biodiversity Strategy to 2020.[68]
- The Plastics Strategy adopted in 2018.[69]

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59 Transforming our world: the 2030 Agenda for Sustainable Development
60 United Nations Climate Change, 2015.
61 European Parliament, 2016.
62 European Commission, 2019d. *Green growth and circular economy.*
63 European Commission, 2015.
64 SB Insight, 2019.
65 European Commission, 2014a.
66 European Commission, 2019e. *The Bioeconomy Strategy.*
67 European Commission, 2011b.
68 European Commission, 2011c.
69 European Commission, 2018a.

- a modernised Common Agricultural Policy (CAP) proposed in 2018 for the next long-term EU budget 2021-2027. [70]

A comprehensive overview of the EU programmes towards circular economy, as well as the recommendations for the EU institutions are provided in the discussion paper prepared within the European Policy Centre's project "Digital Roadmap for Circular Economy" (Hedberg *et al*., 2019).

The overview of CE activities in EU28 countries is provided within the 2019 report "Circular economy update: Overview of circular economy in Europe" prepared by the European Federation of Sustainable Business.[71] The report "Circular economy strategies and roadmaps in Europe: Identifying synergies and the potential for cooperation and alliance building", developed by the European Economic and Social Committee, provides a comprehensive list of national strategic documents on circular economy, elaborated in 14 European countries.[72]

CONTROL QUESTIONS AND QUESTIONS FOR INDIVIDUAL STUDIES

1. What are the main organizations promoting the transition to a circular economy?
2. Which organization are engaged into the circular economy activities in your country?

[70] European Commission, 2018b.
[71] Ecopreneur.eu, 2019.
[72] European Economic and Social Committee, 2019, p.13.

4. PRINCIPLES AND BUILDING BLOCKS OF THE CIRCULAR ECONOMY

4.1. PRINCIPLES OF THE CIRCULAR ECONOMY

Over the past few years, circular economy has significantly raised interest and continues to gain momentum. “Circular economy”, “circular principles” and related concepts are frequently mentioned in academic literature and the reports of various involved organisations. Some definitions were provided in the second chapter of this book. The definitions of “circular economy” varies widely depending on the problems to be solved, the audience or the lens through which the author looks at the world. For some organizations, circular economy means managing material resources and resources to close material cycles. For others, this means new business models and far-sighted organizational strategies, or innovative products and design strategies.

Without a clear understanding of the circular economy, there is a huge missed opportunity to effectively link the topic with the existing framework. For example, it is difficult to answer the questions: What aspects of a circular economy are related to sustainable development goals? How to close the emissions gap and attain the Paris agreement reached at COP21? Which initiatives are better to use in various sectors for sustainable development? Which political initiatives must be developed in different countries of the world?

Development of the environmental protection and sustainable development concept towards the circular economy have gone a long way in more than 60 years, starting almost from scratch, gradually developing to present day (Figure 10).

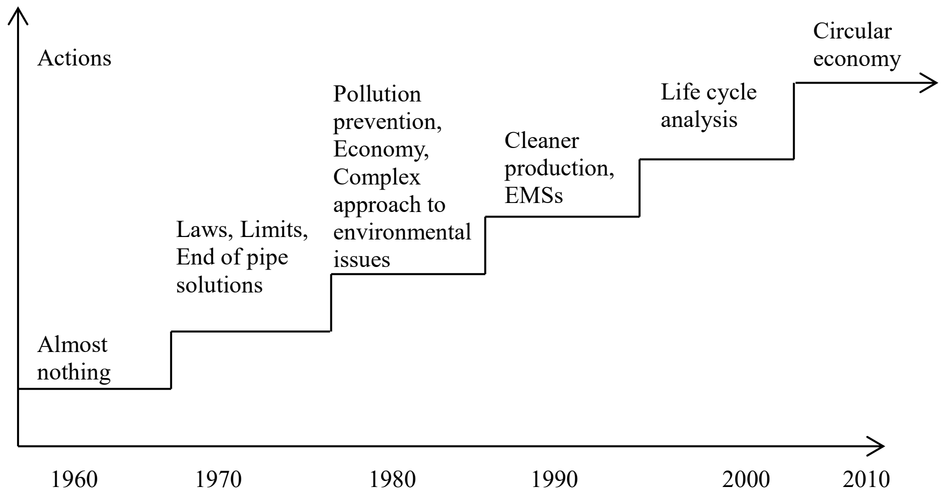

Figure 10. Development of the environmental protection and sustainable development concept towards the circular economy (Source: Authors’ compilation)

The concept of a circular economy has origins that are deeply rooted and cannot be directly connected to any single author or date (see Chapter 2). However, in accordance with international studies of the circular economy, two fundamental approaches can be identified:

- resource-oriented, implying a closed flow of materials, energy and waste, which can be achieved through reuse at the product level (repair or restoration), at the component level (reuse in production) and at the material level (recycling);
- economy-oriented, according to which the circular economy is an economic system based on the reuse of materials and the conservation of natural resources, focused on creating values for people and the economy in each part of the system.

The notion *Circular Economy* gained traction in 2010 when the Ellen MacArthur Foundation was established. Combining the previously mentioned two approaches and the most cited one, is the definition given by the experts of the Ellen McArthur Foundation. According to this approach, "a circular economy is one that is restorative and regenerative by design and aims to keep products, components, and materials at their highest utility and value at all times, distinguishing between technical and biological cycles".[73]

In 2014, the World Economic Forum in collaboration with the Ellen MacArthur Foundation, and McKinsey & Company created a report "Towards the Circular Economy: Accelerating the scale-up across global supply chains", where the following five main principles of the circular economy have been identified:[74]

- ***Design out waste**:* By designing out waste, both environmental and operational improvements can arise. The aim is to reduce waste by designing products for disassembly and refurbishment to fit within biological and technical material cycles.
- ***Build resilience through diversity**:* A diverse system built on features such as modularity, versatility and adaptively makes the system less vulnerable to external shocks.
- ***Rely on energy from renewables:*** As great amounts of energy are typically used during production processes, using renewable resources should be the ultimate aim for manufacturing systems.
- ***Think in systems:*** The concept of the circular economy is inspired by living systems, where systems rather than components are optimized. The ability to understand how different parts of the system influence each other is therefore crucial.
- ***Waste is food:*** Technological and biological nutrient-based products and materials should cycle through the economic system through different

73 Ellen MacArthur Foundation, 2015a, p.2.

74 *Towards the Circular Economy: Accelerating the scale-up across global supply chains*. World Economic Forum, 2014.

applications before they finally reintroduce their nutrients into the biosphere.[75]

> *"A circular economy refers to a model in which we keep resources in use as long as possible to extract the maximum value from them whilst in use, and then to recover and regenerate products and materials at the end of their service life".*[76]

To date, there are more than a dozen visualizations of the circular economy model, while all of them have a similar structure. However, the model of the circular economy based on the development of the Ellen MacArthur Foundation, which is presented in Figure 11, is the most widespread and comprehensive model today.

Linear economy is presented as a vertical process in the middle of the figure, from resource extraction and production, to landfill. The figure also shows two cycles in a circular economy - biological substances on the left and technical substances on the right.

- **The technical cycle** involves the management of finite resources. Usage replaces consumption. Technical materials are recovered and mostly restored in the technical cycle.
- **The biological cycle** encompasses the flows of renewable materials. Consumption only occurs in the biological cycle. Renewable (biological) nutrients are mostly regenerated in the biological cycle.[77]

In this report, it is claimed that value is created in a closed loop system. Unlike biological materials, technical materials are not connected in series with other applications, but the functionality, integrity and value of the energy contained in them, is maintained by means of modernization, reuse, dismantling, repair and rehabilitation works. Three features of the circular economy are also highlighted:

- enhanced control over the reserves of natural resources and the observance of a sustainable balance of renewable resources for preserving and maintaining of natural capital at an inexhaustible level;
- optimization of consumption processes developing, using and distributing such materials, components and products that could be recycled and reused as much as possible;
- identification and prevention of negative external effects of current production activities in order to increase the efficiency of economic and environmental systems.[78]

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[75] *Towards the Circular Economy: Accelerating the scale-up across global supply chains. World Economic Forum, 2014.*
[76] *Closing the loop: risk or reward?*
[77] Ellen MacArthur Foundation, 2015a, p.7.
[78] Ellen MacArthur Foundation & McKinsey Center for Business and Environment, 2015.

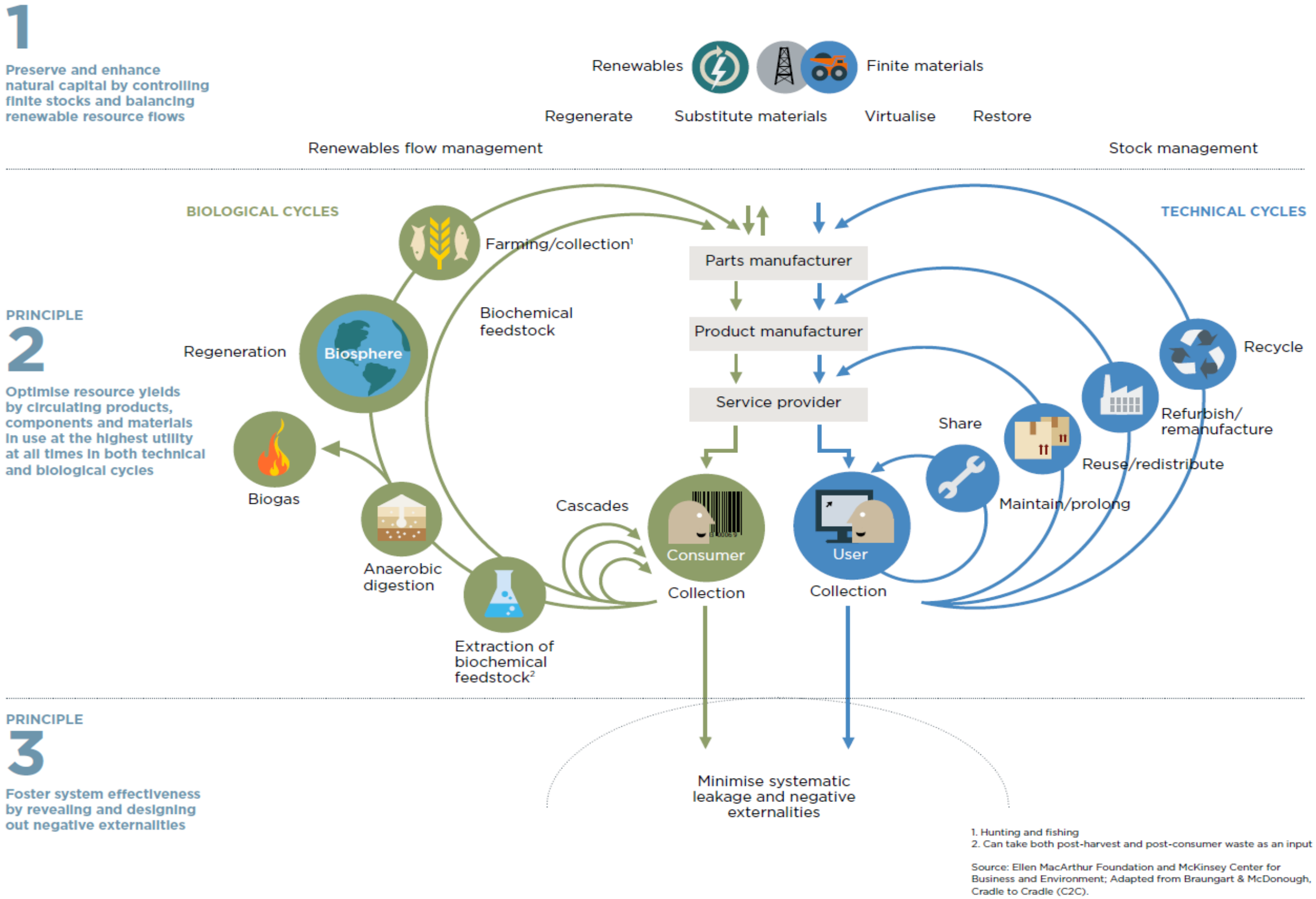
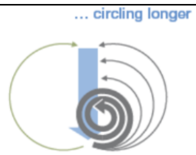
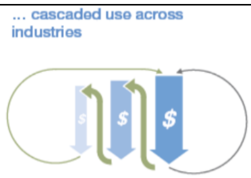


Figure 11. Outline of a circular economy (Source: Ellen MacArthur Foundation, 2015a, p.6.)

The basis of the circular economy is formed by closed supply chains. They combine conventional direct supply chain processes with reverse logistics processes, which range from product recovery, remanufacturing, disassembly and reuse of individual parts. The ultimate goal is to preserve the value of products consumed and used by consumers, with the possibility of reducing the environmental impact of the entire supply chain.

Value Creation is happening using four different principles, i.e. inner circle, circling longer, cascading, and pure input (Table 4). These principles offer ways to take advantage of the price difference between used and virgin materials.

Table 4. Sources of value creation for the circular economy
(Source: Authors' compilation, based on Ellen MacArthur Foundation, 2015a)

	**Inner Circle** – Minimising the use of comparative materials, through re-use. The tighter the circle, the less it has to be changed to be returned to use (with higher savings).
	**Circling Longer** – Maximising the number of consecutive cycles of reuse, to avoid production of a new component.
	**Cascading** – Diversified re-use across the value chain, substituting previously used virgin materials with existing materials (including symbiosis).
	**Pure inputs** – Avoidance of contaminated materials to increase collection and re-use efficiency whilst maintaining quality.

So, circular economy describes an economic system based on business models of the reuse, processing and extraction of materials in the production and consumption of goods, works, and services. The concept of a circular economy requires a rethinking of the value chain.

Circular economy can benefit companies and municipalities. This may be due to increased efficiency in the use of resources, reduction in waste management needs, and reduction in environmental pollution. In addition, circular economy has the potential to create social and economic benefits, i.e. new jobs, give opportunities and improved welfare in low-income households etc.[79,80] (Ghisellini *et al*., 2016; Lazarevic & Valve, 2017).

A key element of sustainable production is the materials used. Such materials have to come from sustainable sources and have to be reusable and recyclable. The energy used to produce and process materials have to be highly efficient and come from sustainable sources. Materials have to be produced with high energy efficiency and with minimal waste or residue. Materials have to be moved back and forth throughout the entire life cycle of the products.

Another important element is the conversion of waste into value. Waste is designed out of the production and consumption cycle. It means that waste is kept to the very minimum or there is simply no waste at all. Material and industrial residues are used as a resource for something else, their value being preserved, and goods with an expired service life are disassembled and recycled.

In addition to materials and waste, product design is also important. That is a design that allows you to use materials for a long time and maintains the high quality of materials after recycling. Products are designed to be modular, versatile and adaptive. In addition, the service life of the product is increased due to the maintenance, repair and upgrade schemes.

During many years, also nowadays, the concept of thr 3Rs is very popular. It was developed based on the “waste hierarchy” and shows the particular sequence of priority of actions to be taken for reducing the amount generated waste, and for improving the general waste management programs, projects and processes. This concept of the 3Rs is as follows: Reduce, Reuse, Recycle.[81]

All three principles are not hard to implement. All that is needed is a small change in our daily lifestyles to reduce waste, so that less of it goes to landfill, reducing our carbon footprint. But, of course, the current understanding of the concept of 3Rs goes beyond just reducing, reusing and recycling, and takes on a much broader 'umbrella'. Usually it means to build the economy based on the life cycle approach.

1R – Reduce. The main idea is to reduce the amount of produced waste. It is possible by starting with the inspection of what materials, details and products are being used, and finishing with the examination of the purposes for their usage. It could be done using many different approaches, for example:

– Limiting the number of purchases.
– Purchasing durable goods with a longer warranty, which usually have a longer lifespan. Additionally, reducing the amount of waste at the landfill.
– Avoiding buying products that are over-packaged and use too much plastic, foil or paper.

[79] Ellen MacArthur Foundation, 2015a.
[80] Wijkman & Skånberg, 2016.
[81] Srinivas, 2015.

- Using electronic means of communication rather than paper- based documents.
- Reducing paper wastage by printing on both sides of the paper.
- If one no longer wishes to receive messages, removing your contact data from mailing lists can decrease the delivered paper materials.
- Avoid the usage of disposable tableware or other items.[82]

2R – Reuse. The main idea is to reuse something, any item as much as possible before replacing it. Things that somebody wants to throw away can be transformed into something useful. Learning to reuse items or re-purpose them, for another than their initial use, is essential in waste hierarchy. Again, many activities should be done to reuse as much as possible. Some examples of items that can be reused are:

- Waste paper: it can be collected and sent to recycling companies or used for notes and sketches.
- Newspaper: Old newspaper can be used to pack items in boxes for moving or storage. It can also be used as a decor element, for example, for wallpaper or framed pictures.
- Old clothes: Unwanted clothes or shoes can be donated to specific individuals or charity institutions. Additionaly, they can be repurposed into new clothes, accesories or interior design elements.
- Used wood: The main usage for used wood is fire; however several crafts can also be done with it.
- Tyres: These can be sent to recycling stations or used to make a tyre-swing.
- Old pots and jars: The main use of these can be storing items in the kitchen, garden etc.
- Compostable materials: A compost bin can be built to use these for composting. The compost will return to the garden to help your plants grow better. For this purpose all biological materials, as well as tea bags and coffee grounds, can be used.[83]

3R – Recycle. Recycling (and composting) is done for ensuring that items or their components are put to some new purpose as much as possible. To recycle something means that it will be retransformed into raw materials that can be converted into a new item. Instead of throwing items in landfills of certain types like, glass, paper and tin cans, they should be recycled, thus transforming them into something useful and reusable. There are very few materials on Earth that cannot be recycled. One of the issues facing communities that want to become more involved with the recycling effort is that, while the relying collection and sorting process may be affordable to

[82] E-CSR, 2019.
[83] ibid.

implement, there still has to be a facility to receive and transform the discarded waste into raw materials. More progress is being made towards uniting recycling plants with industries, which can process the waste material, through agreements and incentive credits.

To put efforts in recycling, several actions can be taken:

- Carefully selecting products that can be recycled i.e. that are made from recycled materials.
- Buying products that have been made from recycled materials.
- Buying non-toxic products if it is possible. Purchase non-hazardous materials whenever possible, as they may be difficult to recycle.
- Inventing new ways to recycle different items, and etc.[84]

All developed countries have used a wide variety of initiatives and schemes, and there are companies that use or benefit from all or one of the 3R initiatives.

Additionaly to the three basic Rs, sometimes the fourth R of "rethink" or "recover", is added. In the case of 'rethink' it should be put in first place, meaning that first and foremost the environmental impact of our actions should be considered. Conversely, if 'recover' is used, it will be treated as the last R, because it refers to the practice of using waste products again. For example, decomposing garbage produces methane gas (one of the greenhouse gases), which some landfill sites recover and burn for energy, rather than letting it dissipate. In this case, the concept of 4Rs (reduce, recycle, recover, and reuse) is usually discussed.

However, the concept of the 3Rs developed further, evolving into the 5Rs concept: Refuse, Reduce, Reuse, Recycle and Recover (Matevosyan, 2014; Tan *et al.*, 2016), then the 6Rs: Reinvent/ Rethink, Refuse, Reduce, Reuse/ Repair, Recycle, Replace/ Rebuy (Avalero, 2013; Jawahir & Bradley, 2016), and the 7Rs: Refuse, Reduce, Reuse, Recycle, Recover, Repair and Re-gift (Van Ree, 2016; Golden Plains Shire, 2016).

8Rs also offers an expanded version of the 3Rs. The 8R adds a philosophical question on consumer behaviour, which sounds like "do I need it in the first place?" 8R adds the process of re-thinking the purchase of goods by consumers (Lyngaas, 2017).

The last of the known concepts is the 9R model. The 9R model shows the hierarchical levels between the linear and circular economy. The highest level describes the circular economy and the cell 'refuse'. It means, that the products become not or no longer needed or useful, or replaced by a completely different product. The lowest level describes the linear economy and the cell 'recovery'. On this level waste is burned and this process produces energy and heat for further use (Figure 12).

[84] E-CSR, 2019.

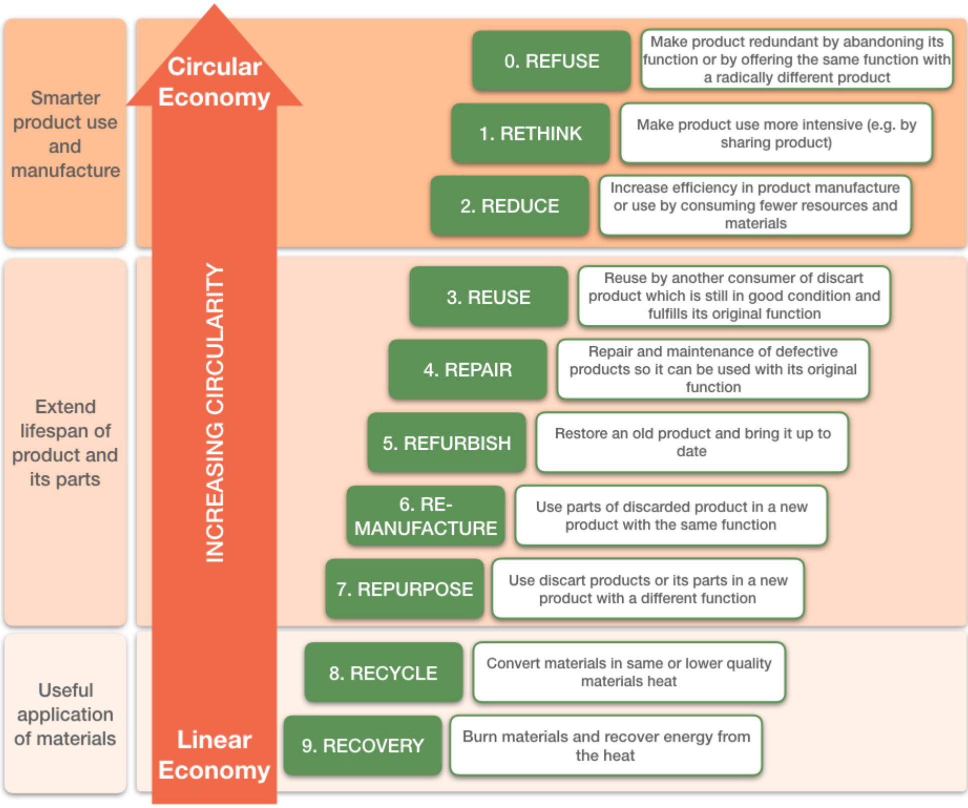


Figure 12. The 9R model for circular economy (Source: Lankester, 2018)

The 9R model tries to describe the way from linear to the circular economy. The different step-by-step R strategies, presented in the middle part of the model, show the best activities to move from a linear to a circular economy.

4.2. Circular economy building blocks

Over the last two decades, increased attention to the concept of business model has been observed, especially in entrepreneurial, business strategy and management scholars.

Business models are widely acknowledged as "a system-level, holistic approach towards explaining how firms do business". Accordingly, a business model has been widely considered as a new unit of analysis of the company, which is centred on the focal firm and its activities, but with wider boundaries than those of the firm (e.g. relationships with its partners and suppliers) (Zott *et al.*, 2011).

A business model could be defined by three main elements (Figure 13).

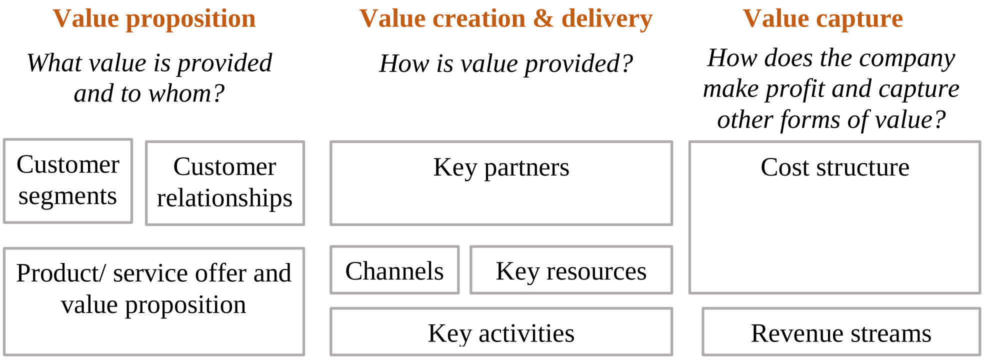


Figure 13. A conceptual business model framework
(Source: adapted from Richardson (2008))

In today's increasingly globalized and competitive market, business model innovation has become one of the most important means of staying competitive in the market. The sustainability of any business model remains unclear, as the constantly changing market environment (new technologies, competitors, regulations, customer need changes, etc.) can quickly make existing business models obsolete or less profitable.

At a conceptual level, adopting circularity in business seems to be an intuitive business case: closed loop supply chains enable the company to reduce its dependence on increasingly scarce and costly natural resources, and to turn waste into additional sources of revenue and value. But the practical implementation of circularity is not so easy. The main reason arises from the fact that most of the companies are simply not built to capitalize on the opportunities of a circular economy. Their strategies, structures and operations are deeply rooted in the linear approach to growth. Moreover, many traditional business models are still viable today only because of mispriced resources and other market distortions which make them more competitive than they would otherwise be (Clinton & Whisnant, 2014).

Over the last years, as the concept of circular economy has been receiving more interest from businesses, the topic of a circular business model has been increasingly discussed in scholars and white papers through different lenses (i.e. typologies, archetypes, business model innovation framework).

Nußholz (2017) describes a circular business model as "how a company creates, captures, and delivers value with the value creation logic designed to improve resource efficiency through contributing to extending useful life of products and parts (e.g. through long-life design, repair and remanufacturing) and closing material loops". Nußholz puts the emphasis on the interconnection between the business value creation logic and the two types of resource efficiency strategies: on the one hand, downstream value chain activities aim to preserve the embedded value of products and to maximize their use (i.e. extension of the useful life) and on the other hand, upstream value chain activities substitute primary material input with secondary materials (i.e. closing materials loops).

Mentik (2014) describes a circular business model as “the rationale of how an organization creates, delivers, and captures value with and within closed material loops”.

Bocken *et al*. (2016) think that circular business models enable “economically viable ways to continually reuse products and materials, using renewable resources where possible”.

Despite the growing amount of literature around the concept, there is neither unique definition nor understanding of the business model, but rather various perspectives. Through an extensive review of business model literature, Wirtz (2011) identifies three main approaches: technological, strategic and organization-theoretical.

All definitions emphasize the importance of addressing business models having circularity in mind. While scholars agree on established business model concepts (“the value creation logic” and the business rationale on “how an organization creates, delivers and captures value”), they offer various perspectives on what resource efficiency strategies entail.

As a developer of the idea of circular economy, the Ellen MacArthur Foundation[85,86] published a report identifying the following four essential building blocks of a circular economy:

1. Circular economy design.
2. New business models.
3. Reverse cycles.
4. Enablers and favourable system conditions.

Block 1. Circular economy design

To facilitate product reuse, recycling and cascading, companies need to build core competencies in circular design. The design of circular products plays a key role for extending the product life-span and closing material loops, as new design strategies are thought to address durability, maintenance and repair ability, as well as upgradability or compatibility. Circular product (and process) design requires sets of information, often new working methods and advanced skills. For using circular designs in an economically successful way, it is necessary to pay attention and operate in the following areas: material selection, standardised components, design for easy end-of-life sorting and recycling, i.e. easier separation or reusage of products and materials, and design-for-manufacturing, taking into account possible useful applications of by-products and waste.

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[85] Ellen MacArthur Foundation, 2013b
[86] Ellen MacArthur Foundation, 2017c

Block 2. New business models

The shift to a circular economy requires innovative business models that either replace existing ones or seize new opportunities. Here the most important role belongs to the companies. Companies having significant market share and possibilities to create and develop innovations could play a major role in driving circular economy.

Business models of circular economy are based on not only manufacturing, but also the usage of new economy approaches, such as redistribution, maintenance and sharing. Remanufacturing predicts the maintenance and refurbishment of product components and used parts with a view to sell them again. Redistribution means resell and buy-back business activities. Maintenance is mostly oriented on performance rather than products. In this case, ownership of the products remains with the service provider. In contrast, sharing provides access to the item, product or service and possibility to use it, but does not provide ownership.

However, new business models could be created not only on the production side, but also on the consumer side, as new purchasing models. Usually the following three types of models are used: access- or usage- based, performance-based and result-based models.

Access- or usage-based purchasing models are focused on the purchase of goods and products for a specified period of access and/ or use. Conversely, performance-based models purchase certain services or performance that are not product-specific. In comparison, result-based models focus on a defined service result.

If business models and initiatives are profitable, other market players will also use them, which will allow expanding these models more widely.

Block 3. Reverse cycles

To introduce reverse cycles, cascades and the final return of materials back into the industrial production system, or to soil, it is necessary to create and learn new and additional skills. These skills are connected to the delivery chain logistics, sorting, warehousing, risk management, power generation, and even molecular biology and polymer chemistry. It is necessary to create new, better-quality collection and treatment systems, and also an effective segmentation of end-of-life products. All such systems must be cost-efficient and environmentally friendly.

Block 4. Enablers and favourable system conditions

This block mostly focuses on education and policy making. For wider reusage of materials and rooting of this habit, as well as achieving higher resource productivity, market mechanisms must play a dominant role. But for the implementation of their plans, the support of politicians and educational institutions, as well as opinion leaders, should be enjoyed. Following examples can be mentioned:

- Collaboration.
- Rethinking incentives.

– Providing a suitable set of international environmental rules.

– Leading by example and driving up scale fast.

– Access to financing.

By implement the above mentioned four principles; companies can better follow the development of a circular economy. The purpose of it is to restore any type of capital, i.e., natural, social, human or financial. This will certainly benefit all and contribute to the sustainable development of the economic system (Fonseca, 2018).

In an effort to define a common language for a circular economy, various terms and definitions used by more than 20 organizations – NGOs, government agencies, academia, consultants, etc. that work on the elements of this topic, have been outlined. After interpreting and grouping these various terms, seven key elements emerged, defining most of the terms related to the circular economy (Figure 14).

Figure 14. Seven key elements of circular economy[87]

1. *Prioritise Regenerative Resources*. Ensure that renewable, reusable, non-toxic resources are utilised as materials and energy in an efficient way.
2. *Preserve and extend what's already made*. While resources are in-use, maintain, repair and upgrade them to maximise their lifetime and give them a second life through take back strategies when applicable.
3. *Use Waste as a Resource*. Utilise waste streams as a source of secondary resources and recover waste for reusage and recycling.
4. *Rethink the Business Model*. Consider opportunities to create greater value and align incentives through business models that build on the interaction between products and services.

[87] *Making Sense of the Circular Economy: The 7 Key Elements*

5. *Design for the Future*. Account for the systems perspective during the design process, to use the right materials, to design for appropriate lifetimes and for extended future use.
6. *Incorporate Digital Technology*. Track and optimise resource use and strengthen connections between supply chain actors through digital and online platforms, and technologies that provide insights.
7. *Collaborate to Create Joint Value*. Work together throughout the supply chain, internally within organisations and with the public sector to increase transparency and create joint value.[88]

Later, in the Circularity Gap Report 2019[89], these seven elements were slightly modified and named as the DISRUPT model, also consisting of seven elements, which describe the entirety of the relevant circular strategies, accordingly:

D – Design for the Future;

I – Incorporate Digital Technology;

S – Sustain & Preserve What's Already;

R – Rethink the Business Model;

U – Use Waste as a Resource;

P – Prioritise Regenerative Resources;

T – Team Up to Create Joint Value.

It is important to note that the development of any business solution to cover all round opportunities should not follow the "one size fits all" approach, but should prefer individual solutions that integrate local socio-cultural habits and use locally available materials. In addition to this principle of diversity, any business activity done must be based on renewable energy sources.

CONTROL QUESTIONS AND QUESTIONS FOR INDIVIDUAL STUDIES

1. How can you describe the term "circular economy" after reading this chapter?
2. What are the main principles of the circular economy?
3. How can you describe the 3R concept?

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[88] *Making Sense of the Circular Economy: The 7 Key Elements*
[89] *The Circularity Gap Report 2019.*

5. ACTION AREAS OF THE CIRCULAR ECONOMY

5.1. KEY ACTION AREAS OF THE CIRCULAR ECONOMY

The circular economy model works on the basis that materials for new products come from old recycled products, which means that the products must be made to be more durable and fit for recycling and reuse. As far as possible, everything is reused, ex works, recycled, used as a source of energy, or at a last resort disposed of (Figure 15).

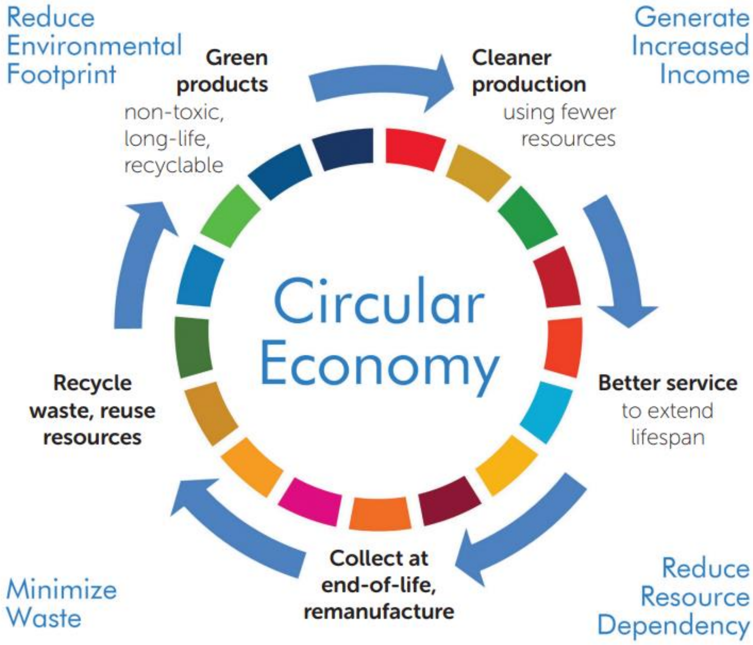

Figure 15. The key components of the circular economy concept (Source: UNIDO, 2017)

The 7th Environment Action Programme set a long-term vision of where the EU wants to be by 2050: "In 2050, we live well, within the planet's ecological limits. Our prosperity and healthy environment stem from an innovative, circular economy where nothing is wasted and where natural resources are managed sustainably, and biodiversity is protected, valued and restored in ways that enhance our society's resilience. Our low-carbon growth has long been decoupled from resource use, setting the pace for a safe and sustainable global society".[90]

Europe faces two challenges:

1. stimulating and securing growth that promotes well-being and provides jobs for all,
2. quality assurance of growth that will ensure a sustainable future.

[90] European Commission, 2013.

In the EU, an Action Plan for the development of a circular economy has been implemented since December 2nd of 2015 [91], establishing a set of measures that cover the entire product life cycle: from production and consumption to waste management and the secondary raw material market.[92] Later it was updated to a newer version, i.e. on March 4th of 2019. The European Commission adopted a comprehensive report on the implementation of the Circular Economy Action Plan.[93]

The measures identified in the Action Plan focus on measures at the EU level that provide high added value to create a circular economic model. The measures included in the Action Plan provide synergies between the environment and business agendas. Realization and implementation of circular economy, however, will require long-term participation at all levels – the European Union, the Member States, regional and local, as well as from all stakeholders.

Measuring the progress towards a circular economy is carried out in five ways: production, consumption; waste management; secondary raw materials; competitiveness and innovation. Indicators of circular economy, included in the monitoring structure, have been developed in the indicated directions (Figure 16).[94]

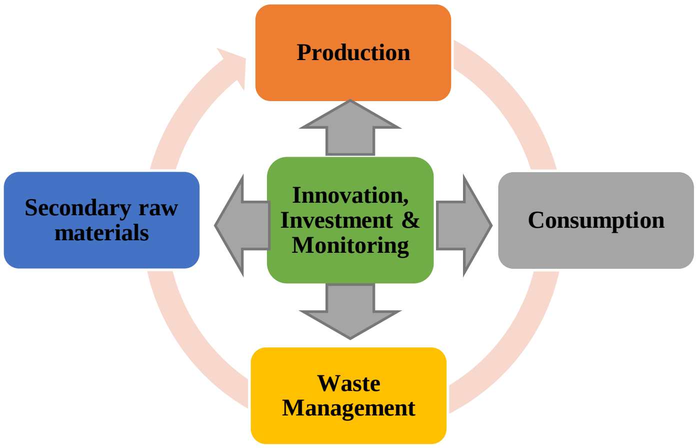

Figure 16. Key action areas of Circular economy
(Source: Authors' compilation based on European Commission, 2015)

The figure shows that the Plan of Action of the circular economy covers the entire product life cycle. In order to ensure a balanced movement of each stage of the cycle, it is necessary to act at all of the interconnected stages of the product life cycle. Therefore, the needs and limitations of other stages must be taken into account.

[91] European Commision, 2015.
[92] Eurostat, 2019.
[93] European Commision, 2019f.
[94] European Commision, 2015.

Among the key EU indicators for the period up to 2030 to reduce waste are the following: the disposal of 65% of municipal waste; the disposal of 75% of packaging waste; the recovery of 75% of construction waste and waste as a result of the demolishing of buildings.[95]

Currently, the level of disposed municipal waste in the EU is 46.4% (2017), packaging waste - 67.2% (2016), and the level of recovery of construction and demolition waste of buildings exceededs the planned figure, reaching 89% in 2016.[96]

The objectives and key actions of all areas of a circular economy are provided in Table 5.[97]

The Action Plan also contains an Annex, which lists all the measures that the Commission intends to take as part of its current mandate, with relevant measures and appropriate timelines.

Table 5. Objectives and key actions of areas of circular economy
(Source: Authors' compilation based on European Commission, 2013)

Key area	Objectives	Key actions
Production	• Provide incentives to boost circular product design. • Innovative and efficient production processes.	• Reparability, durability, and recyclability in eco-design (e.g. TV screens). • Best practices for waste management and resource efficiency in industrial sectors. • Industrial symbiosis.
Consumption	• Repair and reuse of products to avoid waste generation. • Provide consumers with reliable information on environmental impact of products.	• Encourage reuse activities (e.g. waste proposal). • Eco-design: availability of spare parts. • Guarantees and action on false green claims. • Circular Economy criteria in Green Public Procurement. • Independent testing programme to assess possible planned obsolescence. • Better labelling: EU Eco-label, Environmental Footprint.

95 European Commision, 2018c.
96 Eurostat, 2018.
97 European Commission, 2013.

Key area	Objectives	Key actions
Waste management	• Improve waste management in line with the EU waste hierarchy. • Address existing implementation gaps. • Provide long-term vision and targets to guide investments.	• Legislative proposals on waste. • Work with Member States to improve waste management plans, including to avoid overcapacity in residual waste treatment (incineration and mechanical-biological treatment). • Ensure coherence between waste investments under EU Cohesion Policy and the waste hierarchy.
Market for secondary raw materials	• Increase the use of secondary raw materials. • Increase the use of recycled nutrients and the reuse of treated wastewater. • Safely manage risks of chemicals of concern. • Improve knowledge of material stocks and flows.	• Quality standards for secondary raw materials. • EU regulation on fertilisers. • Legislative proposal on minimum requirements for reused water. • Analysis on the interface between chemicals, product, and waste legislation. • EU-wide electronic system for cross-border transfers of waste.
Innovation & Investment	• Create the right environment for innovation and investment.	• Horizon 2020 initiative launched on 'Industry 2020 in the Circular Economy' (EUR 650 million). • Pilot 'innovation deals' to address potential regulatory obstacles for innovators. • Targeted outreach of EU funding, as Cohesion Policy Funds and for SMEs. • New platform for financing Circular Economy with European Investment Bank and national promotional banks.

Previous studies in the field of circular economy revealed that the above mentioned areas of circular economy (production, consumption, waste management and development support) differ significantly, depending on the level of business models of individual business entities, and mechanisms for regulating the environmental and economic status of urbanized territories and regions.

In particular, the implementation of the concept of a circular economy at the micro level involves the consideration of environmental aspects in the development of production processes and products (eco-design), the organization of a clean production with low emissions, and the introduction of waste prevention systems by manufacturers, as well as the strengthening of consumer responsibility - through the introduction of eco-labelling systems and green state procurement.

The introduction of the circular economy practice at the meso-level includes the development of eco-industrial parks[98] and agricultural ecological systems (agroecosystems)[99], complemented by an environmentally friendly design and efficient waste management.

At the macro level, the introduction of circular economy practices are aimed at creating eco-cities, eco-communities and eco-regions (Ghisellini *et al.*, 2016; Heshmati, 2015).

An important condition for ensuring an effective implementation of the concept of a circular economy and smoothing out existing barriers is the availability of support in the form of initiatives by governmental and non-governmental organizations, covering all areas of production, consumption and waste management, at three levels of aggregation: micro-, meso- and macro-.

5.2. PRIORITY AREAS OF CIRCULAR ECONOMY

Comprehensive consultations were held with various stakeholders, based on which the following five priority sectors were identified. All these sectors have their own problems and barriers on implementation and development. These problems can be resolved by adjusting the EU legislation and policy instruments. The action plan provides specific measures to address these issues (Figure 17).[100]

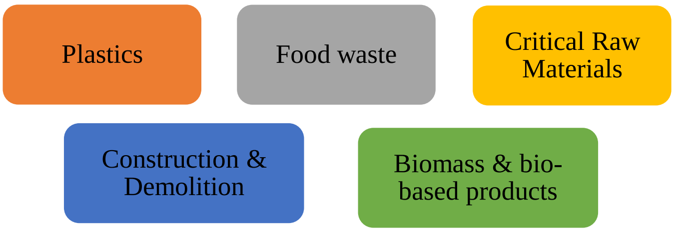

Figure 17. Five priority areas of circular economy
(Source: Authors' compilation based on European Commission, 2015)

[98] An association of producers of goods and services wishing to improve the economic and environmental situation by jointly managing natural resources (energy, water and materials) and the environment. Moreover, production is carried out in a closed system similar to natural ecosystems, i.e. waste or by-products in the production chain are raw materials for another production chain.
[99] A community of cultivated plants and animals and their environment, artificially created in the process of human economic activity, in which the balance of the biogeochemical cycle of nutrients is ensured by introducing them into the soil in amounts that compensate for the annual alienation from the crop.
[100] European Commision, 2015.

Table 6. Objectives and key actions of priority sectors of circular economy
(Source: Authors' compilation based on European Commission, 2015)

Priority area	Objectives	Key actions
Plastics	• Increase recycling efficiency - less than 25 % of plastic waste collected is recycled, and about 50 % is landfilled.	• Adopt a specific strategy to reduce plastic waste, including marine litter. • Set a more ambitious target for the recycling of plastic packaging in the framework of a new legislative proposal on waste.
Food waste	• Reach the Sustainable Development Goal (SDG) to halve food waste by 2030 – today around 100 million tons of food are wasted every year in the EU.	• Develop an EU methodology to measure food waste. • Create a platform for the SDG on food waste and share best practices and the achieved results. • Clarify the EU legislation on waste, food and feed, and encourage food donation. • Improve the use and understanding of date marking along the food chain (e.g. 'best before' label).
Critical raw material (CRMs)	• Increase the efficient use and recovery of CRMs.	• Encourage recovery of CRMs, and draft a report on best practices and options for further action at the EU level. • Encourage action by the Member States.
Construction and demolition	• Identify and increase recovery of valuable materials.	• Ensure recovery of valuable resources and adequate waste management in the construction and demolition sector, as well as facilitate assessing the environmental performance of buildings. • Put in place pre-demolition guidelines to promote high-value recycling, and voluntary recycling protocols.
Biomass and bio-based products	• Support an efficient use of wood and bio-based products. • Increase recycling of bio-waste.	• Promote an efficient use of bio-based resources through series of measures, including promoting the cascading use of biomass and support bioeconomy innovation. • Set a new target for recycling wood packaging and a provision to ensure the separate collection of bio-waste.

For a broader value assessment European Commission published *COM(2014)398* – Communication: "Towards a circular economy: A zero waste programme for Europe"[101], where it underlines that "Moving to more circular economic models promises a much brighter future for the European economy". This document sets out how to establish a framework to promote circular economy. In addition, the document mentions how to move the EU towards a zero-waste economy, through:

- new innovations in markets for recycled materials;
- new business models;
- eco-designs, and
- industrial symbiosis.

It is possible to achieve this goal by using a combination of smart regulation, market-based instruments, incentives, information exchange, and support for voluntary processes.

All circular economy key actions in priority sectors are based on the statement that waste is a resource and waste has an economic opportunity, if it is collected and treated correctly. It is directly connected with the waste management hierarchy, suggested by the UNEP[102] in the Green Economy Report. Recognition that waste is a resource accounts for a shift towards greater recycling and recovery.

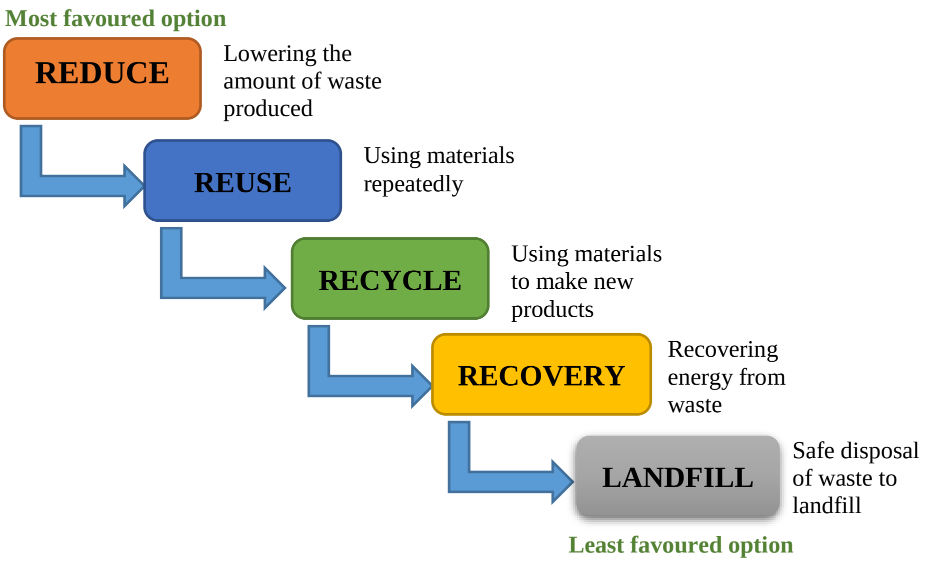

Figure 18. Waste Management Hierarchy (Source: Authors' compilation)

[101] European Commission, 2014a.
[102] UNEP, 2011.

The above mentioned hierarchy informs and shapes the EU waste policy, as well as sets out the most favourable to least favourable options for waste management. According to it, reduction and reuse are the most favoured options, which fit for the concept of circular economy.

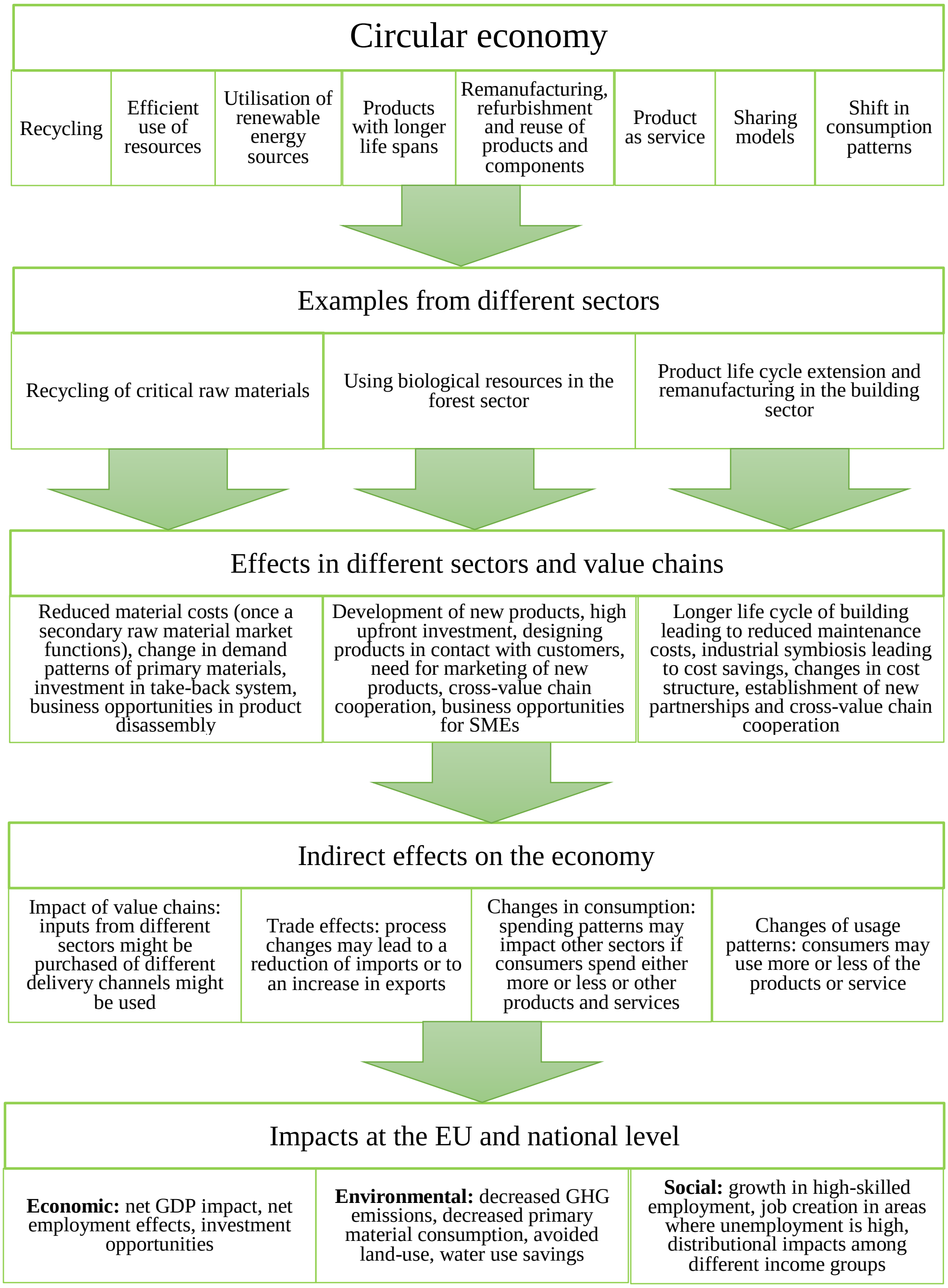

Figure 19. Circular economy effects on sectors and impacts (Source: Rizos *et al.*, 2017)

During the last years, many targets were set for waste management. However, very often, after its assessment, it became clear that many countries and regions have great difficulties reaching the landfill target, considering their current waste management situation. Therefore, the European Commission proposes to amend Directive 1994/62/EC[103] on waste to introduce an overall recycling target for all packaging waste for 2030 at 75% and for 2025 a target of 65%.

5.3. Assessment of the circular economy

The transition to a circular economy concerns not only certain materials and sectors, but covers the entire economic system. Evaluation of the progress along this path should mainly contribute to understanding trends in maintaining the economic value of goods and resources, as well as in the generation of waste. Since no indicator can reflect the complexity and diversity of the transition to a closed economy, the best solution is to use a set of indicators.

There are many indicators related to the environment and resources which have already been proposed by several organisations. A thorough review of specific indicators which may be relevant to the circular economy are summarised in Table 7.[104]

Table 7. Indicator sets relevant to the circular economy (Source: EASAC, 2016)

Indicator set	Advocated by	Characteristic/ data source	Number of indicators
Sustainable Development Indicators	UNEP	Major global environmental issues	10
Sustainable Development Goals	UNDP	End poverty, fight inequality and injustice, and tackle climate change	17
Corporate sustainability	Global reporting initiative (GRI)	Sustainability-relevant indicators for organisations	>100
Environmental sustainability index (ESI); environmental performance indicator (EPI)	Yale and Columbia universities	Environmental indicators	21 (ESI)* 20 (EPI)
Little Green Data Book	World Bank	Environment and sustainability	50
Green Growth Indicators	OECD	Environment, resources, economic and policy responses	25-30
Economy-wide material flow accounts EW-MFA	Eurostat Wuppertal Institute	Focused on material flows	6
Circular economy indicators	Ellen MacArthur foundation (EMF)	Indicators currently available	7

[103] European Parlament, 1994.
[104] EASAC, 2016.

Indicator set	Advocated by	Characteristic/ data source	Number of indicators
Resource efficiency	EU Resource efficiency scoreboard (EURES)	Eurostat, EEA and others	32
Raw materials	European Innovation Partnership (EIP)	Raw Materials Scoreboard European Union Raw Materials Knowledge Base (EURMKB)	24 4

**The 21 indicators were in the areas of air quality, biodiversity, land, water quality, water quantity, reducing air pollution, reducing ecosystem stress, reducing population pressures, reducing waste and consumption pressures, reducing water stress, natural resource management, environmental health, basic human sustenance, reducing environmental-related natural disaster vulnerability, environmental governance, ecoefficiency, private sector responsiveness, science and technology, participation in international collaboration efforts, greenhouse gas emissions, reducing transboundary environmental pressures.*

In order to assess the level of development of circular economy in literature in recent years, special indices have been used, which allow interested parties to determine how consistently the process of formation of the circular economy is going on. Such indices include the following: The Material Circularity Indicator (MCI)[105]; The Regional Circular Economy Index System (Jia & Zhang, 2011); The Circular Economy Performance Index (Ruiter, 2015); A Circular Economy Index for the Consumer Goods Sector (Verbeek, 2016). A detailed analysis of the listed and other indices available in the literature is beyond the scope of this book. It needs to be noted that these indices, representing scientific and practical interests, are at the same time characterized by certain incompleteness in assessing the totality of elements and processes taking place in a circular economy. In addition, some of them show elements of subjectivity. For example, The Circular Economy Performance Index is calculated using the key performance indicators (KPI), widely known in management, and at the level of individual companies, based on the data obtained during their survey. However, it remains unclear what criteria should be followed when choosing a KPI and when selecting companies for interviews.

In 2015, the EC, in the Perspective Work Plan for the Circular Economy, expressed its intention to create a simple and an effective monitoring system.[106] The set of indicators for the development of the circular economy proposed by the EC takes into account and complements the previously developed Resource Efficiency Scale[107] and Raw Material Scale.[108] The main criteria for choosing indicators were as follows: a) the ability to reflect the basic elements of a circular economy; b) data availability; c) thematic relevance, acceptability, ease of use, etc.

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105 Ellen MacArthur Foundation, 2015c.
106 European Commision, 2015.
107 European Commision, 2019g.
108 European Commision, 2018d.

The monitoring system includes ten indicators, which are part of four blocks:

- production and consumption;
- waste management;
- secondary raw materials;
- competitiveness and innovation.

Each of the blocks characterizes either a certain stage of the life cycle of resources, products and services, or an aspect of the development of a circular economy. The Production and Consumption block covers four indicators related to the EU self-sufficiency in raw materials, public procurement of goods and services in the green economy, waste generation, and food waste. At the same time, a methodology for calculating the indicators "state purchases of goods and services in the green economy" and "food waste" is under development. The level of waste processing, both aggregate and by their individual types, is presented in the "Waste Management" block. The "Secondary raw materials" block is devoted to two aspects - assessing the share of secondary raw materials in the total volume of demand for raw materials and the intercountry trade in raw materials to be recycled. Investments, employment, gross value added in the circular economy, as well as patents related to processing and secondary raw materials, are considered in the block "Competitiveness and Innovation".

As mentioned earlier, the basic concept of a circular economy depicts a production and consumption system that is based on the following principles - recycling, reusage, restoration, repair, sharing of goods and services, changing consumption patterns and using new business models and systems.

There is no single indicator for measuring circular economy, but there are a number of indicators that can help to measure the effectiveness of individual areas that directly or indirectly contribute to the development of a circular economy. These indicators can be displayed into the following groups:

- *Sustainable resource management*. Using these indicators, it is possible to evaluate the performance of the transformation of the EU member state economies towards circularity. This can be achieved by reducing the demand for resources, thus, increasing resource security and reducing the environmental burden within the country and abroad.
- *Societal behaviour*. Using these indicators, it is possible to assess the awareness of citizens and their engagement and participation in the circular economy. Social norms, behavioural change and citizen engagement are an integral part of the success of the transition to a circular economy. People need to be involved in the disposal, reusage and new forms of consumption of goods. Disposal in this case means the separation of waste streams and the delivery of waste to the sorting and processing sites. Re-use requires a change in the mind-set regarding the repair and refurbishment of goods. While, new forms of consumption mean product-service systems, willingness to pay more for durability, sharing etc.

– *Business operations*. Using these indicators, it is possible to show how eco-innovative activity helps to change and adapt business models with the principles of a circular economy. The transition to a circular economy is impossible without the involvement of enterprises, which are the main driving force of this transition. They foster circularity throughout the entire life cycle of the use of materials, starting with the how and which original materials were used, which is directly related to the quality standards of goods, the environment and health. Especially important for ensuring the possibility of reusage, recycling, re-manufacturing and raising the durability of goods is the design phase. It helps to keep the materials within the economy longer. Additionaly, to expand into circular economy, re-manufacturing and recycling are both very important.

CONTROL QUESTIONS AND QUESTIONS FOR INDIVIDUAL STUDIES

1. What are the key action areas of circular economy?
2. What are the priority areas of circular economy?
3. Which indicators do you know for evaluating the circular economy?

6. CONCEPT OF LIFE CYCLE AND INTRODUCTION TO LIFE CYCLE ASSESSMENT

6.1. CONCEPT OF LIFE CYCLE

Life cycle is among the most widely used concepts in the social sciences. Angela M. O'rand and Margaret L. Krecker analysed and reviewed the history, meanings, and uses of these concepts across anthropology, psychology, economics, and sociology (O'rand & Krecker, 1990).

The product also is to be considered a living entity that evolves like others – conception, birth, maturity, age and death.

The **product life cycle** is an important concept in marketing. From a marketing point of view, the life cycle of a product is the time from the development of the product to its commencement and cessation of sales. It describes the stages a product goes through from the idea, until it finally is removed from the market. Not all products reach this final stage, some continue to grow and others rise and fall. The duration of each stage is influenced by emerging market factors and customer habits.

First referenced in the 1920s, the product life cycle applies biological knowledge to products. In nature, a seed is planted, begins to sprout, becomes a fruit, then eventually withers away and dies. The product life cycle focuses on introduction (seed), growth (sprout), maturity (fruit) and decline (death) phases. Each phase has its own marketing mix strategy and implications regarding product, price, distribution and promotion.[109] However, the product life cycle starts with the product's development and introduction, and then moves toward withdrawal or eventual demise. This progression is shown in Figure 20.[110]

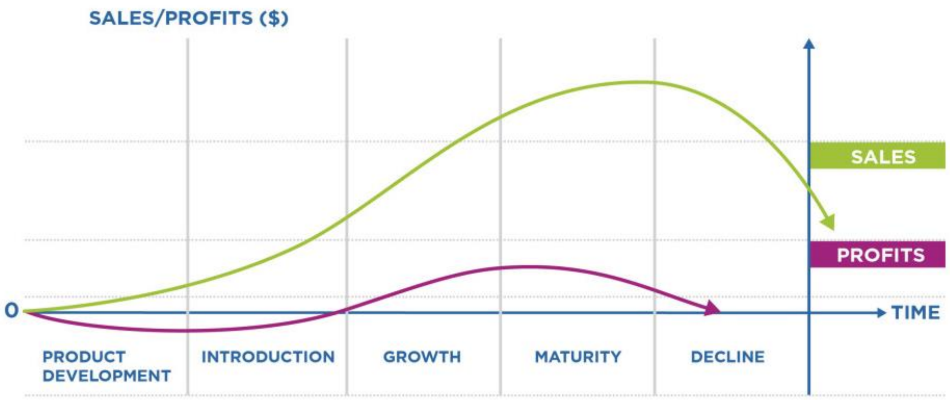

Figure 20. Product life cycle (Source: Lumen, n.d.)

[109] Griffin, n.d.
[110] Lumen, n.d.

Therefore, from a marketing point of view, the product life cycle is mostly about profit and activities related to increasing it, i.e.

- commodities have a limited life on the market;
- there are different stages in the marketing of goods and each one requires different marketing activities;
- profits vary at different stages of the product life cycle.

However, nowadays many people do not only think about profit, but also about the impact of the product on the environment, its protection and reduction of consumption of various resources. To achieve more sustainable production and consumption patterns, the environmental implications of the whole supply-chain of products, both goods and services, their use, and waste management, i.e. their entire life cycle from – cradle to grave, must be considered.

A life cycle perspective includes consideration of the environmental aspects of an organization's activities, products, and services that it can control or influence (Figure 21).[111]

Therefore, **a life cycle is** "*Consecutive and interlinked stages of a product (or service) system, from raw material acquisition or generation from natural resources to final disposal. Life cycle stages include acquisition of raw materials, design, production, transportation/delivery, use, end-of-life treatment and final disposal*".[112]

Figure 21. Life cycle of a manufactured product (Source: Van Kampen, 2015)

The life cycle of a manufactured product consists of a stream of materials passing from process to process. In addition to the flow of materials at each stage of the life cycle, there is also a flow of information. Moreover, there is a continuous interaction

[111] Van Kampen, 2015.
[112] ISO, n.d.

with the environment. Thus, not only material management, but also information management is an important part of product life cycle management (Figure 22).

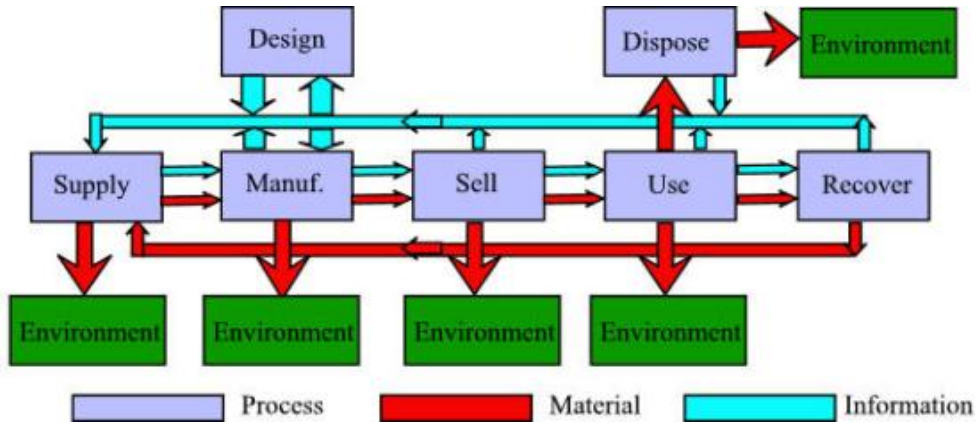

Figure 22. Life cycle of product and different flows (Source: Authors' compilation)

When an organization applies a life cycle approach to its products and services in its work, then the following should be considered:

- the stage in the life cycle of the product or service,
- the degree of control the organization has over the life cycle stages, e.g. a product designer may be responsible for raw material selection, whereas a manufacturer may only be responsible for reducing raw material use and minimizing process waste, and the user may only be responsible for the use and disposal of the product,
- the degree of influence the organization has over the life cycle, e.g. the designer may only influence the manufacturers production methods, whereas the manufacturer may also influence the design and the way the product is used or its method of disposal,
- the life of the product,
- the organization's influence on the supply chain,
- the length of the supply chain, and
- the technological complexity of the product.

The organization can consider the stages in the life cycle which it has the greatest control or influence over, as these may offer the greatest opportunity to reduce resource use and minimize pollution or waste.[113]

[113] ISO, n.d.

6.2. LIFE CYCLE THINKING

Over their life-time, goods and services can impact an environment in different ways. The main purpose of life cycle thinking is to reduce the overall environmental impact. At different stages of the life cycle, impacts may be bigger or smaller. However, care must be taken to avoid transferring problems from one stage to another. For example, if the environmental impact of a product at the production stage is reduced, it can lead to an even greater impact in further stages. Thus, it is necessary to carefully evaluate all the stages and their relationship, as well as the benefits/ costs that each stage will bring.

Life cycle thinking should be used in all sectors that are involved in production chains. This means that all stages of the life cycle should be assessed and comprehensively taken into account when making informed decisions regarding production and consumption models, as well as management strategies and policies.

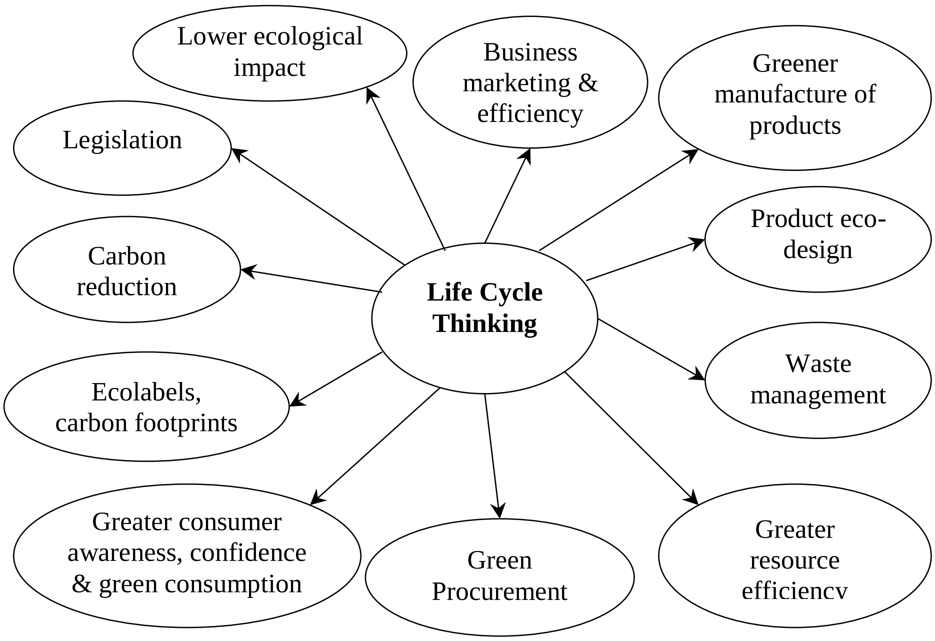

Figure 23. Life cycle thinking instruments and advantages
(Source: Authors' compilation)

Typical first steps for a business can include:

- Conducting a screening of the company's product portfolio to identify those goods and services that contribute most to environmental burdens.
- Identifying which life cycle stages contribute most to the overall environmental impact of particular products.

– Identifying options for improvement, as well as possible “win-win” situations, where reducing the environmental impact of products can come with cost saving opportunities.

6.3. Life Cycle Assessment

Life cycle thinking takes into account environmental impacts throughout the entire product life cycle.

In recent years, environmental issues have become more acute and more people are becoming interested in them. There is an increasing interest in research into the possible environmental impacts of goods and services produced and consumed. In order to better understand and address these effects, the Life Cycle Assessment (LCA) method is used.

There are a number of tools that evaluate various environmental characteristics. But LCA, unlike other methods, provides a holistic approach to assessing environmental performance and takes into account potential impacts at all stages of the product life cycle, i.e. from the cradle to the grave.

So, life cycle assessment is the *factual analysis of a product’s entire life cycle in terms of sustainability*. LCA assesses product-related inputs, emissions, and environmental and human health impacts; appreciates anything that can be attributed to the product in any way. The full life cycle, from the extraction of natural resources to the processing, production, distribution and use of materials; and ending with reuse/ recycling/ energy recovery and disposal of residual waste, is viewed in this method.

The European Commission has developed guidelines for Life Cycle Assessment, which are fully compatible with international standards. These aim to ensure quality and consistency based on scientific evidence when carrying out assessments.[114]

The International Organization for Standardization (ISO) created two LCA standards: the ISO 14040 and ISO 14044. ISO 14040 defined Life Cycle Assessment as “*the compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system throughout its life cycle”.*[115]

ISO 14040 describes the principles and framework for the life cycle assessment (LCA). Following information is described: the LCA definition, goal and scope; description of the life cycle inventory analysis (LCI) phase, the life cycle impact assessment (LCIA) phase, the life cycle interpretation phase, also LCA reporting and critical review, and LCA limitations. The standard also describes the relationship between the LCA phases, and conditions for use of value choices and optional elements. As all ISO standards, ISO 14040 does not describe the LCA technique in detail.

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[114] European Commission. *European platform on life cycle assessment (EPLCA).*
[115] ISO Online Browsing Platform, 2006.

The intended application of LCA or LCI results is considered during the definition of the goal and scope, but the application itself is outside the scope of this International Standard.

According to the ISO standards on LCA, it can assist in:

– identifying opportunities to improve the environmental aspects of products at various points in their life cycle;

– decision making in industry, governmental or non-governmental organizations (e.g. strategic planning, priority setting, product and process design or redesign);

– the selection of relevant indicators of environmental performance, including measurement techniques; and

– marketing (e.g., an environmental claim, eco-labelling scheme or environmental product declarations).

6.4. LCA METHODOLOGY

According to the ISO standards, a Life Cycle Assessment is carried out in four phases. All four phases of LCA framework are shown in Figure 24:[116]

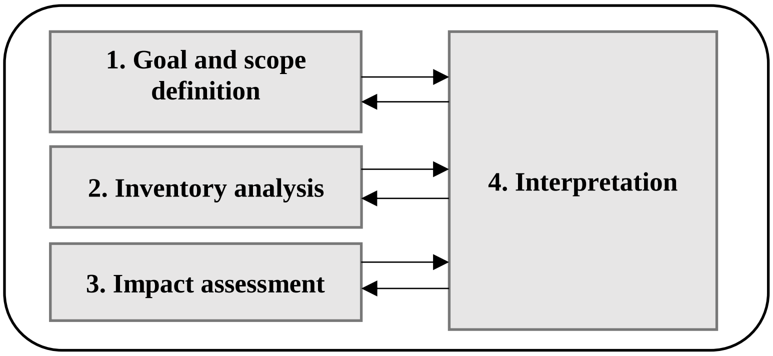

Figure 24. Life Cycle Assessment framework
(Source: ISO Online Browsing Platform, 2006)

Stage 1: Goal Definition and Scoping. Identify the LCA's purpose, the products of the study, and determine the boundaries, i.e. what is and is not included in the study:

To define the **goal**:

– intended application of the study;

– intended audience.

[116] ISO Online Browsing Platform, 2006.

To define the **scope**:

– identify the product system to be studied;
– define the functional unit;
– define the boundaries of the product system;
– identify the assumptions and limitations of the study;
– select impact categories to be included.

Stage 2: Life Cycle Inventory. Quantify the energy and raw material inputs and environmental releases associated with each life cycle phase:

– highly data intensive;
– detailed mass & energy balances performed over life-cycle;
– advantages: measure data & define baseline metrics of life-cycle processes;
– challenges: assumptions made when data is unavailable.

Inventory is collected from multiple sources.

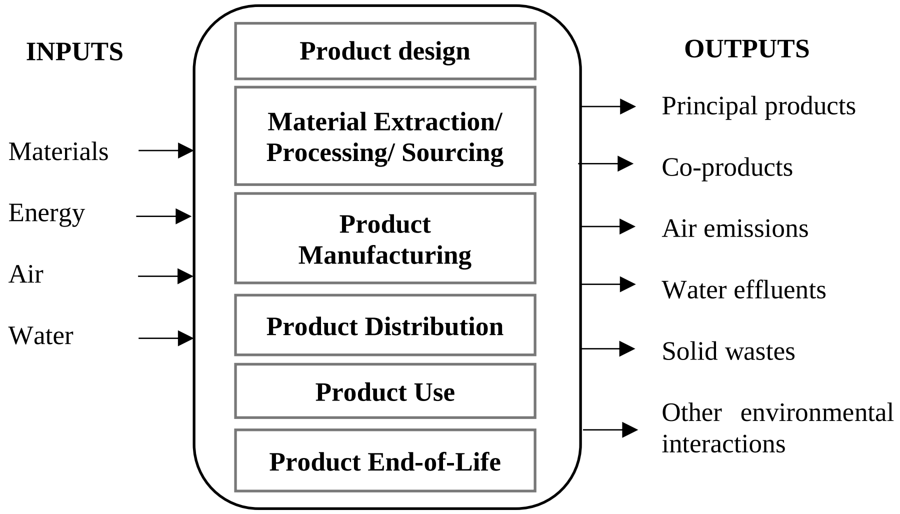

Figure 25. Life Cycle Assessment inputs and outputs (Source: Authors' compilation)

Stage 3: Impact Assessment. Assesses the impact on human health and the environment:

– Converts inventory into impact categories or mid/end points which explain the environmental effect.
– Impact categories may include: carcinogens, respiratory organics and inorganics, climate change, radiation, ozone layer, eco-toxicity, acidification/eutrophication, land use, minerals, fossil fuels.

- Can apply weights to impact categories.

Stage 4: Report Results. Evaluate opportunities to reduce energy, material inputs, or environmental impacts at each stage of the product life cycle.

Life cycle interpretation: findings of the inventory analysis or impact assessment are evaluated in relation to the goal and scope of the study to reach conclusions and recommendations:

1. Identify significant issues.
2. Evaluate results for completeness, consistency, and sensitivity of the data.
3. Draw conclusions & make recommendations consistent with the goal & scope of the study.

LCA can be done for materials, products, buildings, services and supply chains. Typically, LCA studies are conducted in one of the following ways:

- **Streamlined LCA:** A streamlined LCA relies heavily on secondary data and a professional life cycle assessment software to produce rapid results. This streamlined approach can produce results quickly and is therefore useful for initial hot-spotting and testing conclusions before embarking upon a detailed study. Streamlined LCA is useful to determine if a full LCA is needed.
- **Detailed LCA:** A detailed life cycle assessment is required for the maximum robustness, or if the study is comparative and to be released in the public domain.
- **LCA peer review:** To achieve maximum credibility a peer review is recommended. LCA is a detailed field. If an LCA is comparative and to be released in the public domain, the ISO standards on LCA require that an independent peer review is to be completed.[117]

The ISO 14044 (ISO Online Browsing Platform, 2006) standard details the selection of a system boundary for LCA studies. There are four main options to define the system boundaries used (shown in Figure 26):

- Cradle to Grave: includes the material and energy production chain and all processes from raw material extraction through the production, transportation, and the use phase, up to the product's end of life treatment.
- Cradle to Gate: includes all processes from raw material extraction through the production phase (gate of the factory); used to determine the environmental impact of the production of a product.
- Gate to Grave: includes the processes from the use and end-of-life phases (everything post production); used to determine the environmental impacts of a product once it leaves the factory.

[117] Circular ecology, 2019.

– Gate to Gate: includes the processes from the production phase only; used to determine the environmental impacts of a single production step or process.

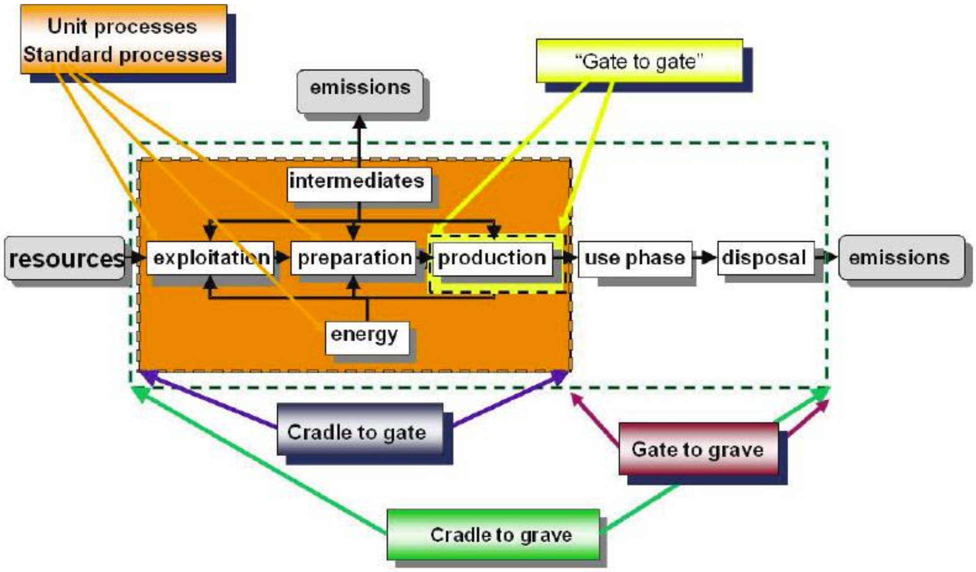

Figure 26. Four main options to define the system boundaries (based on ISO 14044 (ISO Online Browsing Platform, 2006))

To facilitate LCA various software is used. In the past 20 years different software products for the calculation of life cycle assessment, carbon footprint or other indicators such as *Gabi, Umberto, SimaPro, Gemis, OpenLCA* or *ecoMC* were developed.

The best known is the international leading LCA software *SimaPro.*[118] *SimaPro*, has been the world's leading LCA and sustainability software for more than 25 years. It is trusted by the industry and academics in more than 80 countries.

Most LCA software is commercial, but there are three open-source software packages:

- OpenLCA is an open-source software and support database in EcoSpold or ILCD format. It also has free and paid data sources via its Nexus service. IMHO OpenLCA is the best one that is available for free.[119]
- Carnegie-Mellon's EIO-LCA tool uses a different approach to LCA - called Economic Input-Output LCA, which aggregates data on an industry sector

[118] ESU-services, 2019.
[119] OpenLCA, 2018.

level. This method makes a LCA study faster and cheaper, but also less accurate.[120]

- CMLCA from Leiden University is a free tool that is intended to support the technical steps of the life cycle.[121]

Life cycle assessment results may be used for product development and improvement, for strategic planning and public policy planning, as well as for marketing and other purposes.

It can help to integrate environment into core business issues and see it from the systems perspective. It can help to develop and use innovations, and improve efficiency of processes and products and services, also throughout the engagement of different stakeholders – investors, customers, employees. As a result, a better return on investments can occur.

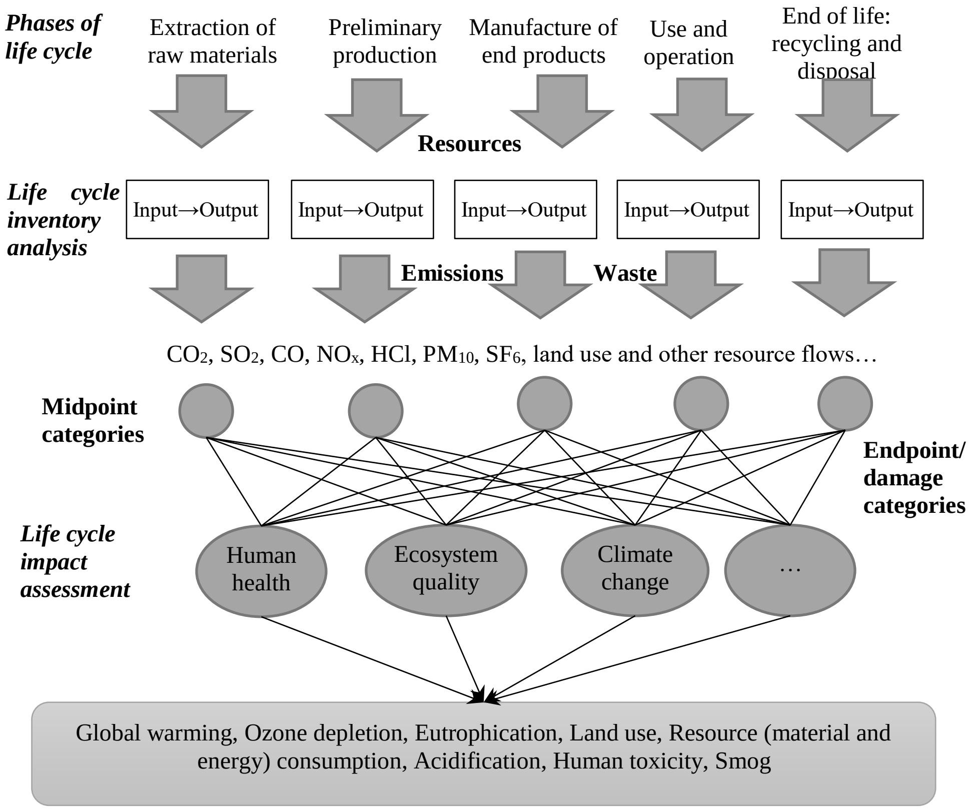

Figure 27. Overview of Life Cycle Assessment (Source: Authors' compilation)

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[120] Carnegie Mellon University, 2018.
[121] CMLCA, 2018.

Environment is not a cost centre for the company, but a business opportunity:

- Look beyond the company's gate.
- Expose trade-offs and opportunities.
- Expand analysis of products, projects, policies and programs – what is the function, what are the boundaries, what are the impacts, where are the opportunities?

By performing an LCA, a company also gains a set of metrics by which it can compare year-to-year performance, together with the performance of suppliers and partners.[122]

CONTROL QUESTIONS AND QUESTIONS FOR INDIVIDUAL STUDIES

1. How do you understand the term "Life cycle" from the environmental point of view after reading this chapter?
2. How many stages are there in a manufactured product's life cycle? Name all of them.
3. How many stages does the Life Cycle Assessment Framework consist of? Name all of them.

   Is there a software/tool that can be used for life cycle assessment?

[122] Network for Business Innovation and Sustainability, 2008.

7. INTRODUCTION TO ECO-DESIGN

"The design process not only gives birth to a product but is also responsible for its life and death" (Ullman, 2009).

"Eco-design is a strategic design management process that considers the full life-cycle environmental impacts of packaging, products, processes, services, organisations and systems. It can identify layers of waste and layers of value" (*Prendeville et al., 2014)*

Nowadays, in the industry, product design and development is a multi-faceted activity, which often takes place in large organizations with involvement from many different departments and specialities representatives. These people are working in Research and Development (R&D), marketing, management and other departments. The most popular way to represent the design process is adapted from Ullman (2003) and it represents the sequence of tests or events with milestones and decisions (Figure 28).

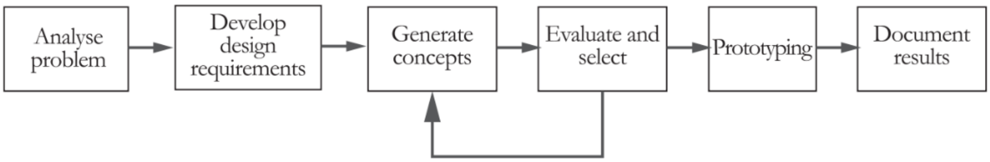

Figure 28. The design process (Source: Ullman, 2003)

For several decades, the consumer society has made profitability its credo - producing and consuming more and always at the lowest price. This tendency is expressed in the over-exploitation of natural resources, increased air and water pollution, the disappearance of plant and animal species and the spread of waste. Breaking this chain means taking immediate action to "produce more with less". In other words, to meet global demand for goods and services while limiting waste and avoiding excess pollution.

Companies have now adopted this approach and incorporated sustainable development into their strategies. This has also become a political issue. In 2000, in Malmö (Sweden), governments around the world issued a call to support sustainable production and consumption, "in order to improve finished products and services, while reducing environmental and health impacts". In short, herald an era of environmental design.

To achieve sustainability, it needs to be looked at the design and product development stage. In this case, sustainability will be justified in the smallest details of the design. There are political documents and various statements, but in the end, specific design problems need to be solved: how to design products and production processes so that materials can be recycled and fully recovered? How to produce safe food, i.e. how to create agricultural systems that do not use pesticides, fertilizers and fossil fuels? How to create wastewater treatment systems that improve rather than harm the surrounding ecosystem? How to design buildings that produce their own energy and recycle their own waste?

Such design problems link traditional scientific and engineering disciplines. They can be solved only if industrial designers communicate with biogeochemists, plumbers with wetland biologists, architects with physicists and farmers with environmentalists. The only long-term approach to building a sustainable world is to redesign the details of products, buildings and landscapes around us. This is a search for the smallest details of a sustainable culture design, based on the textures of daily life.

At every stage of product designing, design plays an important role, which includes not only functionality and aesthetics, but also goodwill. With the growing demand for sustainable products, product manufacturers need to pay more attention to design and product life cycle, with continuous improvement and innovation to create more environmentally friendly and economical resources. However, it is only possible if the customers, manufacturers and designers work together to create a tripartite understanding of the processes in the context of business, production and design.

The everyday world of buildings, artefacts and landscapes is a projected world created by man. Taking this into account, architects, city planners, farmers, chemical engineers, industrial designers, interior decorators and many others are designers to a certain extent. All of them are involved in shaping the physical details of our everyday experience. One of the most important and seemingly simple design principles that developers can use is to make sure that everything they design can be used. This not only increases the likelihood that your customers will choose to buy your solutions, but also increases the likelihood that, once they do, these decisions will actually be used, rather than rejected for something else that might work better. Several principles fall into the category that can help designers and developers create solutions that are more successful. For example, usability, clarity, accessibility and value of each of them contribute to creating more convenient solutions that are more likely to be used for a longer period.

During product planning and designing, producers can greatly influence any phase of the value creation process and material life cycle – a chance to promote ecological innovation. The problems that designers face in the context of their environmental impact have been known for many years, and research in this area was conducted at least fifteen years ago. All that developers do to reduce the amount of materials and energy in their products reduces the amount of resources consumed and the impact on the environment. Systematic reduction of toxic materials, careful designing to reduce the size and weight of the product, as well as the reduction of waste and energy during the production process can significantly improve the sustainability of the solution.

The term "Eco-design" has many synonyms, such as environmental design, sustainable design, green design, environmentally sustainable product design, and design for environment. It has grown its contribution to sustainable manufacturing during the last decades.

Eco-design means "any production process that takes into account environmental considerations (e.g. raw material use, recyclability, end-of-life waste management requirements) at the product design stage" (Monier *et al*., 2014). Consequently, eco-design is the integration of environmental requirements into the product development process. This means that the potential environmental impact of the product (including the service) is already assessed and reduced as much as possible.

Eco-design is the design of products and services to minimize environmental impact throughout the life cycle, while providing the required functionality, quality, cost and aesthetic appearance. Accordingly, eco-design aims to reduce resource consumption, use environmentally friendly materials, optimize production, distribution and use of the product, and ensure its proper management at end-of-life – restoration, treatment or disposal.

Eco-design and eco-innovation are enabling factors of circular economy (Cluzel *et al*., 2014, Benslimane *et al*., 2015; European Environmental Agency, 2016a).

"Eco-design delivers products made with fewer resources, using recycled and renewable resources and avoiding hazardous materials, as well as with components that are longer lasting and easier to maintain, repair, upgrade and recycle".[123]

"Eco-innovation is any form of innovation resulting in or aiming at significant and demonstrable progress towards the goal of sustainable development, through reducing impacts on the environment, enhancing resilience to environmental pressures, or achieving a more efficient and responsible use of natural resources".[124]

Sustainability does not mean deterioration in the quality of life, but a change in the way of thinking and values, seeking a more environmentally friendly way of life. In a sustainable design, it is necessary to use an alternative approach to traditional design, which includes these changes in thinking. In the new design approach, it is necessary to identify the impact of each design choice on the natural and cultural resources in the context of the local, regional and global environment. Long-term design requires understanding of the short- and long-term consequences of any kind of environmental transformation. The product design has been identified as an important life cycle stage in the contribution to the life cycle environmental impacts.

For the first time Eco-design was developed as the Directive 2005/32/EC on Eco-design of Energy-used Products.[125] The current European Union legal framework for the eco-design of energy-using products is laid down in the Directive 2009/125/EC

[123] European Environmental Agency, 2016a, p. 18.
[124] European Commission, 2011b, p. 2.
[125] European Council, 2005.

of the European Parliament and of the Council, establishing a framework for the setting of eco-design requirements for energy-related products.[126]

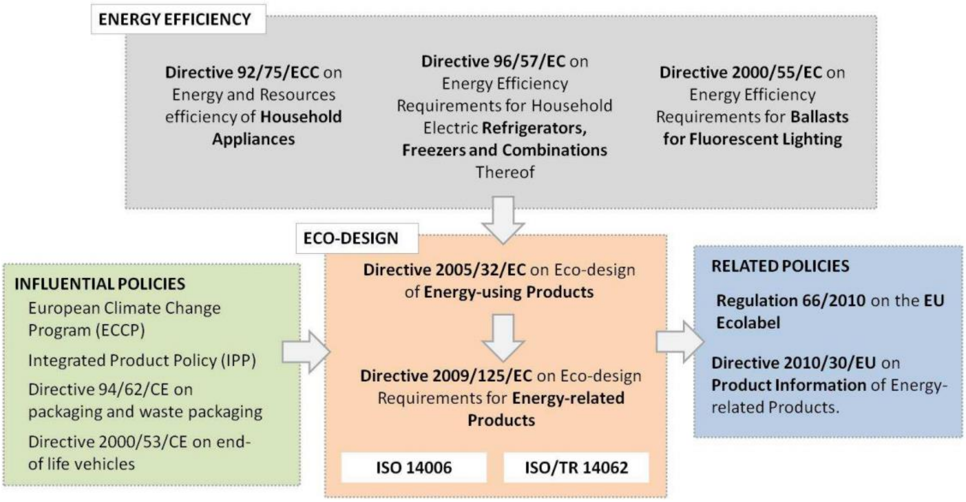

Figure 29. Legal framework of eco-design in EU countries (Source: Sanyé-Mengual *et al.*, 2014)

The EU legislation on eco-design and energy labelling is an effective tool for improving the energy efficiency of products. It helps eliminate the least performing products from the market, significantly contributing to the EU's 2020 energy efficiency objective. It also supports industrial competitiveness and innovation by promoting the better environmental performance of products throughout the internal market.[127] And it also provides both generic and specific eco-design requirements.[128]

Eco-design methods can help prevent and reduce the environmental impact of a product throughout its life cycle, from the production and delivery of raw materials to the production, packaging, delivery, use and disposal of a product. Evaluated impacts – global warming, acidification, resource overflow, biodiversity loss, presence of toxic substances in the atmosphere, indoor air and water, ozone layer depletion, etc. The Eco-design approach implements the principles of sustainable development by preventing pollution, before it has appeared.

A clear description of some of the barriers and drivers of Eco-design was collected by Brezet and Hemel (1997).

[126] European Council, 2009.
[127] European Comission, 2019h.
[128] European Union, 2019.

The historical development of Eco-design has two periods:

1. The first generation of ecological design was based on small-scale experiments with living lightly in place. Many of the technologies and ideas of this generation, such as alternative building materials, renewable energy, organic foods, conservation, and recycling, have been widely adopted in piecemeal fashion.
2. The second generation of ecological design is now on the horizon. This second generation is not an alternative to dominant technology and design; it is the best path for their necessary evolution. The second generation of ecological design must effectively weave the insights of literally dozens of disciplines. It must create a viable ecological design craft within a genuine culture of sustainability rather than being entangled in interdisciplinary disputes and turf wars. It is time to bring forth new ecologies of design that are rich with cultural and epistemological diversity (Van Der Ryn & Cowan, 1996).

The particular function of the Eco-design Directive is to improve design on a product specific level. Eliminating the worst performing products from the market and shifting the economy towards solutions with the least life cycle costs (i.e. total cost of product ownership throughout its lifespan).[129]

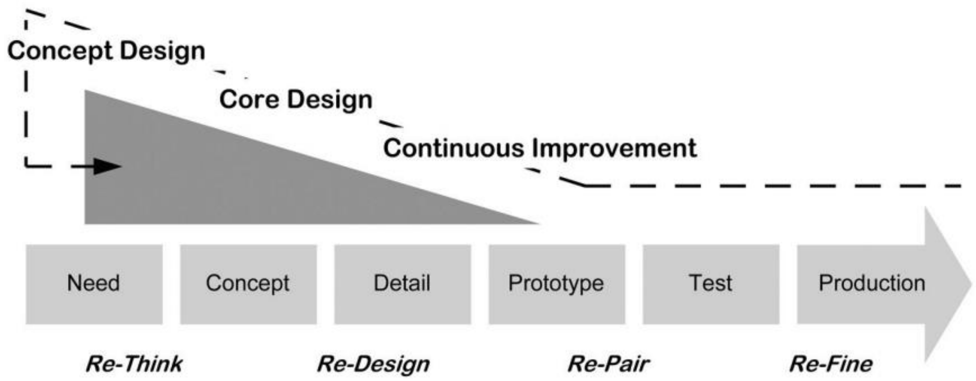

Figure 30. Conceptual and descriptive model of the Eco-design process (Source: Bhamra *et al*., 2001)

All consumer goods, even the “green” ones, have negative repercussions on the environment. They are manufactured using raw materials, energy and water. Then they must be packaged and transported to their place of use, before finishing as waste. Eco-design is a means of minimizing these impacts throughout a product’s life cycle for the same degree of efficiency and utility.

[129] Airedale Air Conditioning, 2019.

The most frequently discussed topic in Eco-design literature is the ‘life cycle principle’. Ecologic design researchers Carolien van Hemel Brezet and Hans Brezet in 1997 offered several eco-design strategies and principles in the Lifecycle Design Strategies Wheel (LiDS Wheel) (Brezet & Hemel, 1997). It is applicable to the design of existing products, as well as to the creation of new and innovative concepts. However, it is equally important to comply with the product's objectives and functions in the manufacturing of any product, in order not to lose its quality. Therefore, in order to better consider all aspects of the environment and alternatives to design, based on LiDS Wheel, Sabine Koklacova (2015) has developed a model that reflects not only the product’s life cycle, but also takes into account the necessary functions and goals.

‘Design for Environment’ (DFE) is an umbrella term describing techniques used to incorporate an environmental component into products and services before they enter the production phase. DFE seeks to discover product innovations that will meet cost and performance objectives, while reducing pollution and waste throughout the life cycle.

Eco-design within a circular economy should create opportunities for repeated reuse and recycling of products based on the use of the latest technologies, knowledge and working methods.

A wide variety of techniques are available, falling into two broad categories:

1. Techniques that are used to identify the environmental impact of a product throughout its life cycle, such as Life Cycle Assessment;
2. Techniques that help designers improve the environmental performance of their products.

Analysis tools can be used to identify broad environmental issues, but improvement techniques are needed in order to solve any of the identified problems.

However, Eco-design can be applied with different goals depending on the product life cycle stage. Therefore, different types of Eco-design were developed:

– Design for remanufacturing focuses on the re-design of an existing product;
– Design for manufacturing and assembly aims to improve the production process;
– Design for disassembly (or “modular design” or “design for repair and redesign”) is a design strategy that considers the future need to disassemble a product for repair, refurbishment or recycling (Erixon, 1996; Kusiak, 2002; Diener&Will, 2010; Kamrani&Salhieh, 2002). It means that products are designed so as to be easily disassembled or separated into individual parts that may either be replaced or repaired to promote long product life (see Figure 31);
– Design for durability means that a product is designed with consideration to how well the materials and the overall product will endure over time. More

specifically, attention is given to how easily different parts of products may wear out; how easily the connections may break; and how individual parts may behave in relation to each other;

- Design for recycling enhances the product recyclability by avoiding end-of-life treatments with higher impacts;
- Design for reusability aims to optimize the lifespan of the product. Product reusage is often viewed as an effective strategy for enhancing environmental sustainability given the potential environmental advantage of reuse over new production (since generally fewer new raw materials are needed when components of 'old' items are reused) (Boyacı *et al*., 2016);
- Design for energy efficiency aims to minimize energy consumption, i.e. to save energy and money, to make the home more comfortable and durable;
- Hazardous material minimization.

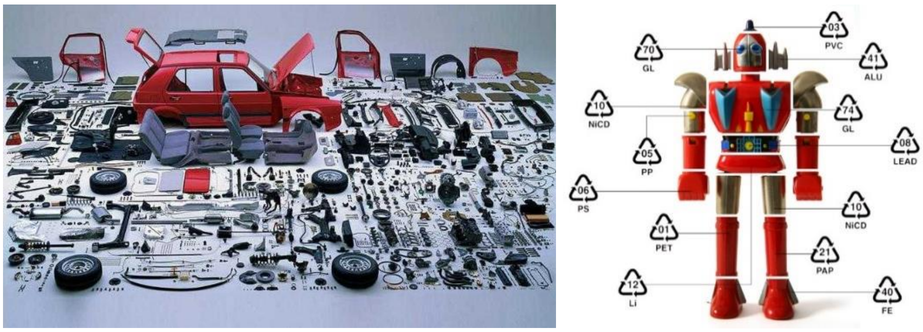

Figure 31. Design for (dis-)assembly (Source: Shedroff, 2010)

Design plays a crucial role in the innovation of environmentally responsible products. That function can take the form of either eco-design strategies or concept demonstrators.

Eco-design strategies are sufficiently broad to be used at the product planning and problem definition stages of the design process. Concept demonstrators, on the other hand, are a tangible vision of the possible product of the future (International Institute for Sustainable Development, 2013).

Any product has a greater or lesser impact on the environment because it must produce and process raw materials, consume energy, be transported and stored.

Product production is only one of the stages of the product life cycle. The life cycle includes the extraction and production of raw materials, the transport, the use of the product, its subsequent disposal, the incineration, and the recycling, if possible, of the recycled material. Eco-friendly goods or eco-products are judged on this whole cycle.

Table 8. Ways how eco-design can minimize impacts
(Source: Authors' compilation based on UNEP, n.a.[130])

Stages	Description	Solutions
1st stage: Raw materials	Manufacturing a product means first exploiting raw materials. Extracting and processing these constituent parts consumes natural resources, uses energy and is a source of pollution.	Reduce quantities, choose the most appropriate materials, transform waste into raw materials, and prefer renewable materials and products that use only one type.
2nd stage: Production	Manufacturing tends to consume large amounts of energy because of the complex processes it involves.	Optimize production processes; assemble products so they are easy to separate into their different components for repair or recycling.
3rd stage: Packaging	Bottles, boxes, cans and other packaging currently account for over half the volume of household waste in developed countries.	Concentrate products; reduce the amount and volume of packaging to make savings along the chain, from manufacturing to waste disposal.
4th stage: Transportation	Relocated production, cost-cutting and liberalized markets all add up to one thing - products travel thousands of kilometres before being used.	Choose manufacturing sites according to the products' final destination, use combined transport and alternative fuels, optimize loads.
5th stage: Use	Using products, operating appliances and maintaining them in working order requires more or less energy, water, etc. Nowadays, designed to be frequently replaced, goods are increasingly fragile and hard to repair, which encourages wastefulness and generates waste.	Design functional, energy-saving or autonomous products that are lasting, safe and easy to maintain or repair.
6th stage: Disposal and recycling	Worn-out or damaged products are more or less easy to recycle. The multiple components, alloys and other combinations of materials from which they are made render disassembling and processing a complex and costly procedure.	Develop reusable or recyclable products and components.

[130] UNEP, n.a.

Eco-design is a possibility to apply for different types of products and for specific sectors. Any product can use an eco-design approach to ensure it is maximizing the use of sustainable materials, is using the least amount of energy necessary, can be recycled or reused at end-of-life.

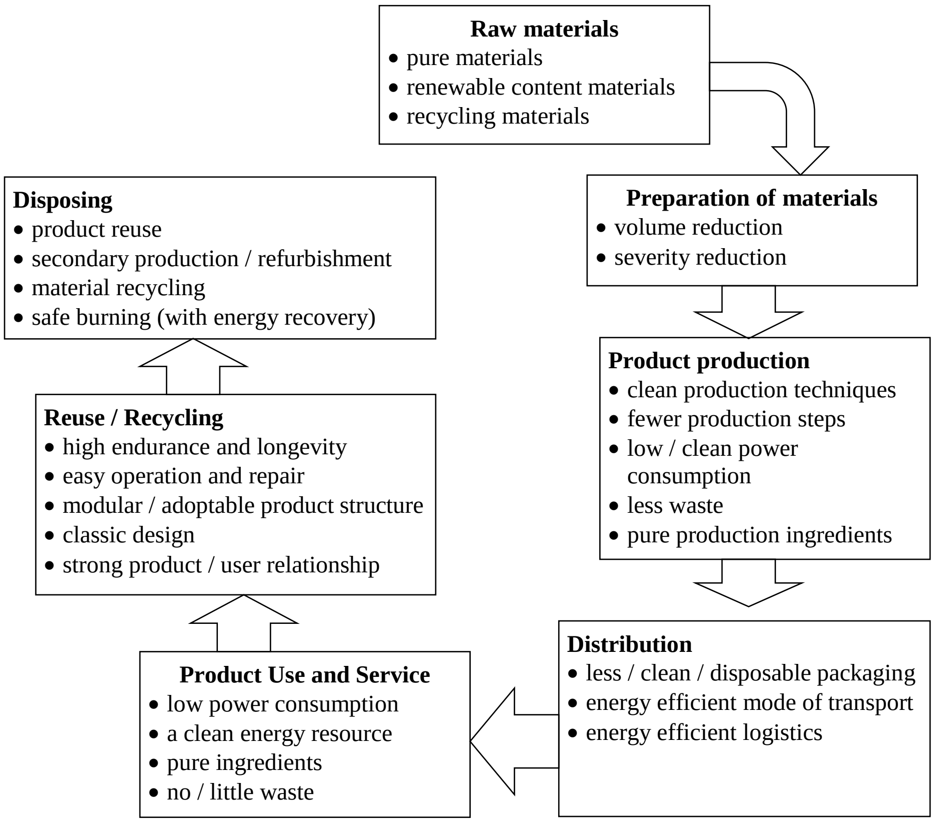

Figure 32. Characteristics of a product in different life cycle stages for eco-design (Source: Authors' compilation)

Many different eco-design strategies exist. The most popular are:

- The product-focused approach - aims to render existing goods and services more economical, more efficient and less harmful to the environment, as well as improving after-sales service, and end-of-life collection and processing.
- The results focused approach - pursues the same objectives from a different angle, for example by selling not the product itself but its use (rental).

- The needs focused approach - studies the needs and expectations that a product or service must fulfil, then looks for the best way to satisfy them using a product, or a service, or both.[131]

Entrepreneurs, technologists and designers can come up with three alternatives – clean materials, renewable materials, and recycled materials – to create environmentally friendly products. The choice of material can also take into account the country of origin or the distance it will travel. Accordingly, the shorter the distance, the more environmentally friendly the eco-design of packaging production is.

At the material preparation stage, one or both alternatives can be considered to create a greener product - reduce severity and/ or reduce volume by selecting lighter materials accordingly, reducing size to maximize resources, but not forgetting the product's required functions or objectives. This stage opens up the possibility of innovation in terms of design and function.

At the production stage, in order to create a greener and more sustainable design, manufacturers of the product can consider alternatives between clean production techniques, fewer production steps, low or clean energy consumption, less waste, or some (clean) production components. Each of the options opens up opportunities for innovative solutions in the production process, as well as the opportunity to reduce not only the resources spent, but also to save money.

In addition, the distribution phase is a way to reduce resource and energy consumption. There is an alternative between less, clean, or reusable packaging, a more environmentally friendly mode of transport, or energy efficient logistics. This is also a sector where it is possible to develop either innovations or innovative solutions in terms of both process and environmentally friendly technologies.

When designing environmentally friendly products, it is also necessary to consider the consumption of resources during their use. It is possible to choose or combine low energy consumption, the use of clean energy resources, the number of components that need to be minimized, the use of clean components and the lack of energy for wasteful use. Accordingly, the convenient use of the product – re-opening, closing, storing, stability, ease of movement, etc., can be considered and developed.

Depending on the product, high durability, easy operation and repair, modular (adaptable) product structure, classic design or strong product (user) relationship can be envisaged.

When considering the release phase during the life cycle, it is possible to see the reuse of the product, secondary production (renovation), material recycling, safe burning (with energy recovery), and safe disposal of product residues.

As an opportunity for further development, moving a product or packaging to the next level of development is the development of a new concept, creating a transition to service delivery, shared product use, feature integration or optimization, for which all

[131] UNEP, n.a.

stages of the life cycle are re-adjusted accordingly. The development of a new concept has the potential to create both innovative products and processes, as opportunities are unlimited, developing environmentally friendly designs or processes. From a business point of view, it opens up opportunities to be a step ahead of competitors, surprise customers with innovations, and the opportunity to create proprietary products, bringing extra profit to the company, besides reducing resources, it can also save money. However, without the help of competent designers, it is impossible.

Prendeville *et al*. (2014) found the relationship between eco-design and circular economy through mutual factors, such as closed loop manufacturing, various methods and tools, cross sector collaboration, business model innovation and resource efficiency (Figure 33).

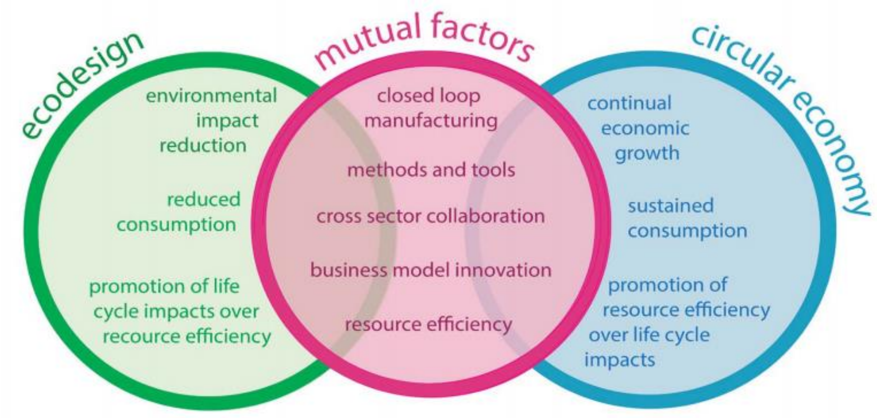

Figure 33. Relationship between Eco-design and Circular Economy
(Source: Prendeville *et al*., 2014)

Dr. Conrad Luttropp suggested 10 Golden Rules in eco-design. All of them are very generic and must be transformed and customised to be at real use in product development work. These 10 rules are following (are not listed in any order of preference) (Luttropp, n.d.):

1. Do not use toxic substances and arrange closed loops for necessary but toxic ones.
2. Minimise energy and resource consumption in production and transport through housekeeping.
3. Minimise energy and resource consumption in the usage phase, especially for products with most significant environmental aspects in the usage phase.
4. Promote repair and upgrading, especially for system dependent products.
5. Promote long life, especially for products with most significant environmental aspects out of usage phase.

6. Use structural features and high quality materials to minimise weight not interfering with necessary flexibility, impact strength or functional priorities.
7. Use better materials, surface treatments or structural arrangements to protect products from dirt, corrosion and wear.
8. Pre-arrange upgrading, repair and recycling through access ability, labelling, modules, breaking points, manuals.
9. Promote upgrading, repair and recycling by using few, simple, recycled, not blended materials and no alloys.
10. Use as few joining elements as possible and use screws, adhesives, welding, snap fits, geometric locking etc. according to the life cycle scenario.

The application of eco-design is influenced by various factors:

- *External:*
  - legislation;
  - market requirements;
  - competitors;
  - suppliers;
  - social responsibility;
  - industry requirements.
- *Internal*:
  - cost reductions;
  - potential for innovation, improvement;
  - higher quality;
  - better reputation;
  - part of the (environmental) management system;
  - employee interest;
  - interest in creating something new and innovative.

The use of energy-efficient and eco-friendly resources is certainly an important aspect, but the concept of eco-design goes beyond this. It is a holistic approach, keeping in mind the environmental, social and economic benefits, as well as an aesthetically appealing and durable design. Eco-design by its nature fosters innovation and promotes behavioural change in producers and consumers towards product-service systems and self-sufficiency. It envisions "ecologically-minded" thinking not as an add-on but as part of the fundamental design process, right from the start. Once it has made the leap from theory to practice, eco-design can help achieve the move towards a circular economy.

"In short, eco-design is good design that benefits people and the environment alike".[132]

Eco-design begins with the idea of a product's production, with raw material extraction, transport, use and waste being taken into account. The whole system should be analysed and each stage needs to be evaluated, where changes or improvements to reduce the overall environmental impact can be made. In order to develop an eco-design, it is necessary to have interdisciplinary and in-depth knowledge and co-operation among all involved parties – product customers, designers, and manufacturers - and active public education that will stimulate demand for environmentally friendly products in the long term. It is therefore necessary to promote cooperation between the parties involved in the development of knowledge, information and innovation transfer points, as well as by promoting cooperation with associations, non-governmental organizations, higher education institutions and research institutes, while at the same time educating society, especially children.

CONTROL QUESTIONS AND QUESTIONS FOR INDIVIDUAL STUDIES

1. How do you understand the term "Eco-design" after reading this chapter?
2. What rules of eco-design do you know?
3. What types of eco-design do you know?

[132] Ecodesing circle, 2019.

8. SUPPLY CHAIN

"The value chain describes the full range of activities that firms and workers do to bring a product from its conception to its end use and beyond. This includes activities such as design, production, marketing, distribution and support to the final consumer. The activities that comprise a value chain can be contained within a single firm or divided among different firms. Value chain activities can produce goods or services, and can be contained within a single geographical location or spread over wider areas" (Gereffi&Fernandez-Stark, 2011, p.4.)

The concept of value chains was developed by Porter as early as 1979 and he described it as decision support tools, which were added onto the competitive strategies paradigm. According to Porter there are two types of value chains: 1) primary activities: Inbound logistics, Operations, Outbound logistics, Marketing and Sales, and Service; and 2) secondary activities: Procurement, Human resource management, Technological development and Infrastructure (Figure 34).

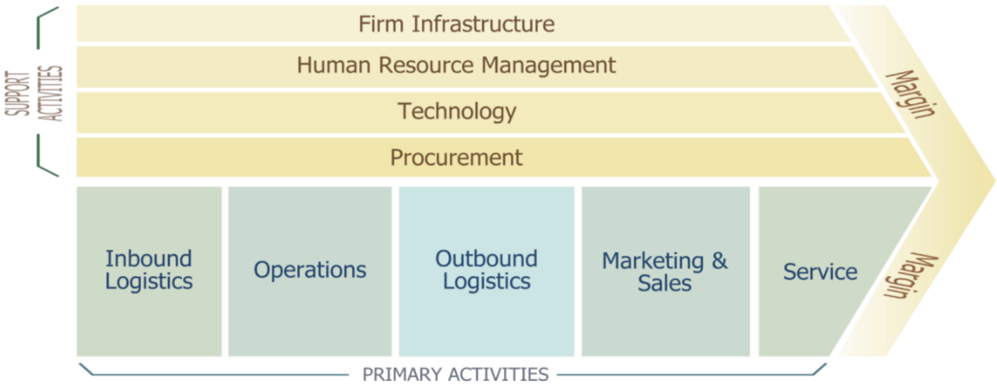

Figure 34. Porter's value chain (Source: Porter, 1985)

- Primary activities:
  - Inbound logistics deal with receiving, storing and distributing inputs.
  - Manufacturing operations convert inputs into finished products.
  - Outbound logistics are concerned with the collection, storage, and distribution of products or services to customers.
  - Marketing and sales involve activities that create awareness among the public regarding the product.
  - Services increase the value of product or services.

- Support activities help the primary activities and include procurement, technology development, human resource management and infrastructure.

Nevertheless, a supply chain is the interconnection of all functions that start from the production of raw materials to the final product, and end when the product reaches the final consumer. It relates to the integration of all activities related to the processes of sourcing, procurement, conversion and logistics.

This network includes different activities, people, entities, information, and resources. The supply chain also represents the steps to get the product or service from its original state to the customer. These two networks help provide customers with quality products at a reasonable price. Most of the supply chain is placed side by side to the value chain.

"The process of planning, implementing, and controlling the efficient, cost effective flow of raw materials, in-process inventory, finished goods, and related information from the point of consumption to the point of origin for the purpose of recapturing or creating value or proper disposal" (Rogers & Tibben-Lembke, 1999, p. 2).

A regular supply chain begins with the ecological, biological and political regulation of natural resources. This is followed by the extraction of raw materials, then several production processes - constructing, assembling and combining components, etc. The transition to the warehouse follows, the size of which is constantly decreasing, and the points of delivery of the goods, which are increasingly more dispersed geographically, and, finally, access to the consumer.

The following activities are included in the supply chain (Surbhi, 2018):

- Integration
- Sharing of Information
- Development of product
- Procurement
- Production
- Distribution
- Services to customer
- Performance analysis.

The basis of the circular economy is a closed supply chain. Closed supply chains maximize the value added over the entire product life cycle with dynamic recovery within relatively long time intervals of values of various types and volumes (Guide & Wassenhove, 2009).

De Angelis *et al.* (2017) analysed a large amount of literature and gave their explanation of traditional, sustainable and circular supply chains. Besides, they discuss the key supply chain challenges being faced by managers, namely: extending the shifting perceptions of value, mitigating risk through structural flexibility, introducing early supplier innovation, more strategic services, and the issue of global vs local distribution of production.

Manavalan and Jayakrishna (2019) analysed a case example in a supply chain organization to meet industry 4.0. requirements and to enable circular economy. They suggest using the 6Rs; as well as various technologies in the supply chain, so that the enterprise is more sustainable in terms of economics, social responsibility, and environmental awareness. They also emphasize that combining the concept of a circular economy with a sustainable supply chain can bring significant environmental benefits. Investing in technology helps organizations increase operational efficiency, which leads to a more skilful implementation of the circular supply chain.

Nowadays worldwide, recycling and reuse of scrapped products have become a very popular topic. Everywhere, entire businesses, which have been created on the sole purpose of reclaiming raw materials from existing goods, can be found.

Modern supply chain enterprises should be prepared to move to a circular supply chain, which includes the entire process of reverse logistics.

By using the principles of a circular economy, it is possible to minimize the costs of biological and technical resources, as well as the generation of waste, which then falls back into the environment. Thus, the extension of the principles of reverse logistics includes two subsystems; the first is related to biological goods (for example, food), and the second to technical goods (products).

Figure 35. Circular Economy and Supply Chains (Source: Ellen MacArthur Foundation & McKinsey Center for Business and Environment, 2014, p.15)

Circular economy today has two main driving forces – large companies and governments.

Since the activities of large transnational corporations cover the entire production chain from the supply of materials to the sale of goods, it is easier and more profitable to implement pilot cyclical projects. In many cases, these projects turn the consumer into a user: the product remains the property of the corporation and, after the end of its service life, is returned to the manufacturer, who can release a new model based upon it or create another product using old materials.

A report on circular economy, released in 2014 by the World Economic Forum, the Ellen MacArthur Foundation and the leading international consulting company McKinsey & Company, predicts that looping production could bring the global economy $ 1 trillion annually by 2025, and in the next five years create 100 thousand new jobs, saving $ 500 million on materials and preventing the emergence of 100 million tons of waste.[133]

With the introduction of a circular economy, supply chains have become multidimensional - new flows and formats are introduced, service networks appear, more common ground appears, and recovery cycles for products and materials appear instead of leaks, i.e. they are "looped". Figure 36 shows some potential flows. Such cyclical use of materials, i.e. willingness to resell, repair, rebuild, or recycle, means rethinking reverse supply chains and packaging design.

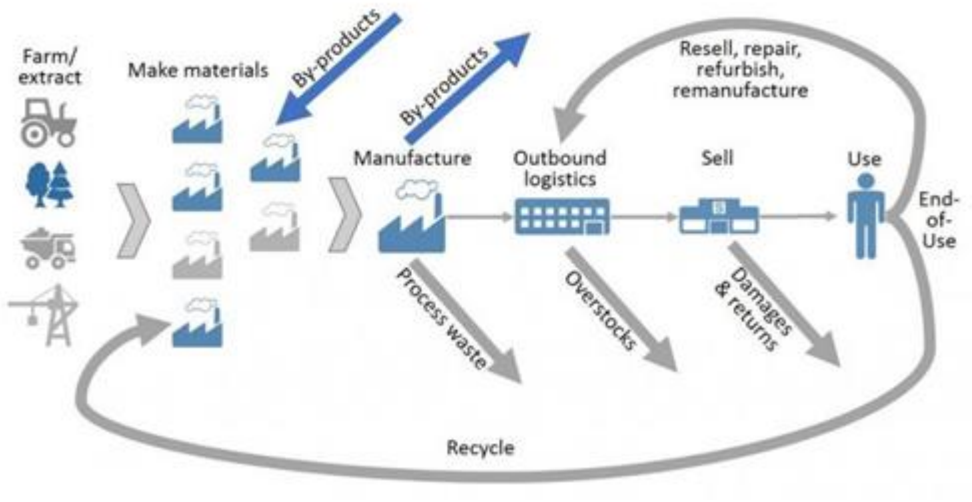

Figure 36. The 'loopy' supply chain (Source: Weetman, 2017)

[133] *Towards the Circular Economy: Accelerating the scale-up across global supply chains*. World Economic Forum, 2014.

A value chain within the circular economy framework is transformed, and innovative solutions may include[134] (1) reducing the quantity of materials required to deliver a particular service (lightweighting), (2) lengthening products' useful life (durability); (3) reducing the use of energy and materials in production and use phases (efficiency); (4) reducing the use of materials that are hazardous or difficult to recycle in products and production processes (substitution); (5) designing products that are easier to maintain, repair, upgrade, remanufacture. (6) incentivising separation, collection systems that minimise the costs of recycling and reuse, etc.

Today's manufacturers produce huge volumes of products that cannot be recycled or reused. Using various methods of real-time data collection and analysis, information can be obtained from various sources in order to increase the overall efficiency of a company. Thus, one of the barriers to a linear supply chain is the lack of cooperation and communication. The collaboration of the various participants in the supply chain needs to be reviewed in order to create a better, cheaper flow of products. Modern supply chain actors must be prepared to use technology to effectively manage and transition from a linear to a circular supply chain. A circular supply chain can be displayed as a web, while a traditional linear supply chains represents a typical flow of goods. They start with suppliers; go to manufacturers, distributors and then consumers. A circular supply chain has many links between each of these parties. For example, consumers can be directly related to the supplier or manufacturer. In this case, the relationship is becoming more complex, and without the use of IT technology, for its tracking and managing, it is almost impossible.

CONTROL QUESTIONS AND QUESTIONS FOR INDIVIDUAL STUDIES

1. How do you understand the term "Supply chain" after reading this chapter?
2. What activities are included in the supply chain?
3. How can a linear supply chain be changed to a circular one?

[134] European Commission, 2014b, p.4.

9. OVERVIEW OF CIRCULAR ECONOMY BUSINESS MODELS

The circular economy is driven by new business models (Kirchher *et al.*, 2017a). The Ellen MacArthur foundation estimated that in Europe, by 2030, a circular economy could create direct primary-resource benefits worth 600 million euros.[135] Unlocking these gains presents great opportunities for businesses.

Business models in the circular economy aim to preserve materials and articles for as long as possible. They need to be used for so long as to get the maximum value out of them. Similarly, the circular economy is about transforming the business and economic system so that waste is "shaped" by the way we live. Business models in a circular economy can offer new commercial opportunities.

There are many types of business models in the circular economy, ranging from converting non-recyclable waste materials into usable heat, electricity or fuel, to product leasing models and new production technologies such as 3D printing (Lewandowski, 2016).

One of the most cited and used circular economy business model categorization is the one developed by Accenture in 2014.[136] Accenture conducted a study analysing more than 120 companies from a wide variety of geographical regions and industries. Most of the companies were from Europe or North America, the most popular industries being the textile, high-tech and clothing industries. Five circular business models were identified from the companies surveyed: 1) Product-as-a-Service (PaaS), 2) Recovery and Recycling, 3) Circular Supply-Chain, 4) Product Life-extension, 5) Sharing Platforms (Figure 37).[137]

All of the above mentioned business models have different characteristics and can be used individually or together throughout the value chain. With the implementation of these circular business models, companies can gain strong competitive advantage - massive resource productivity savings, enhanced customer value and differentiation, reduced cost to serve and own, generation of new revenue, as well as risk reduction.

One of the most effective strategies to implement circular loops is to provide access to the products through a rental service instead of selling them. Keeping ownership of products and their embedded materials enables the business to close the loops more efficiently and opens new business opportunities.

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[135] Ellen MacArthur foundation and McKinsey Center for Business and Environment, 2015.
[136] Accenture, 2014.
[137] ibid.

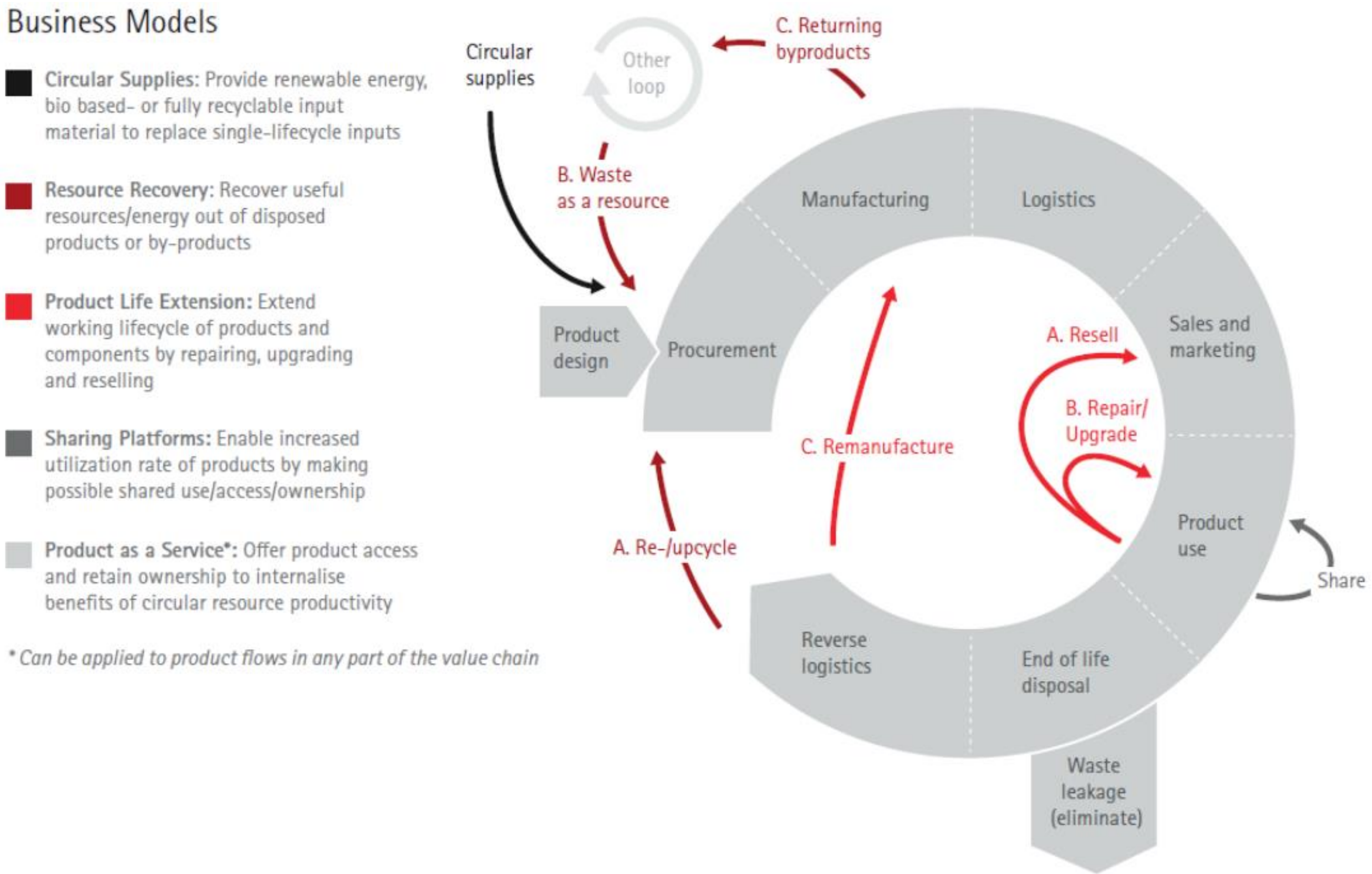

Figure 37. The five circular business models (Source: Accenture, 2014)

By adopting a Product-as-a-Service business model, the retail business focus is shifting from pushing product sales and reducing product costs to enhancing user experience and increasing product quality. In that regard, offering high-quality products starts at the design stage: products must be designed to be used as long as possible, to be easily repaired, remanufactured and recycled. Design is not only about the shape of product but also includes the production process and the selection of raw materials, which should be carefully selected regarding their toxicity and environmental impact. For a retailer, developing a PaaS implies a closer collaboration with the key stakeholders across the value chain, including product manufacturers and designers. On the other hand, when developing a PaaS business model, the business approach shifts from a product-centered approach to a customer-centered one. It means that the focus is not on product features, but rather on the function that the product delivers to its end-users. In other words, technology is considered as an enabler to create and deliver value to the customers. Therefore, the shift to PaaS starts with a deep understanding of the user needs, which enables to explore creative ways to meet them.

Finally, it is important to note that designing a circular business model is not only about turning a product into a service! It requires systems thinking. To design such innovative business models including elements such as take-back models, repair services, upgradability or a sharing system. System thinking implies to consider the characteristics of the business, as well as its interaction with its environment at different levels - at the business level by looking at the material flows and processes, at the value chain level by analysing the interactions between the key stakeholders and at the industrial level by identifying cross industry collaboration (i.e. industrial symbiosis). Therefore, when developing a circular business model, it is crucial to understand the position of the company in the value chain and its relationships with the key partners as well as the implications of circular opportunities.

The Ellen MacArthur Foundation, SUN and McKinsey Center for Business and Environment in their report "Growth within: A Circular Economy Vision for a Competitive Europe" have presented a categorization for six business models (called also the ReSOLVE framework): [138, 139]

- **Regenerate -** refers to shifting to renewable energy and materials.
- **Share -** denotes the sharing and recycling economy, as well as prolonging the life of products.
- **Optimise -** refers to increased efficiency, waste minimization and utilization of information and communications technology (ICT).
- **Loop -** is defined as closing the technical and biological material cycles.

[138] Ellen MacArthur Foundation & McKinsey Center for Business and Environment, 2015.
[139] Ellen MacArthur Foundation, 2015b, p. 176.

– **Virtualise -** deals with direct and indirect dematerialization.
– **Exchange -** calls for the utilization of novel materials and technologies.

Companies use the ReSOLVE framework as a tool for generating growth initiatives and circular strategies. Most sectors have a lot of potential in each of these areas, which is already proven in practice.

Due to the increased attention on the part of the state and interstate bodies, as well as the significant benefits that accompany the application of the principles of the circular economy, many companies are introducing appropriate business models into their practical activities. The classification options for these models, developed by the authors, are presented in Table 9.[140]

Included in Table 9 are the circular business models, corresponding to the theoretical model of a circular economy.

Table 9. Business models of the circular economy (Source: Authors' compilation, based on Ellen MacArthur Foundation, 2015a)

Varieties of business models	Description and purpose	Company Examples
Circular suppliers	Ensures that the supplier delivers biodegradable or fully recyclable resources that underlie the circular production and consumption system	Ford, Fairphone, 3D Hubs, Desso, Toyota, Cisco
Resources recovery	Helps to eliminate resource losses due to waste generation, and therefore to increase profitability of production from mentioned return flows	Coca-Cola, Maersk, Michelin, Philips, Walt Disney World Resort
Sharing platforms	Ensures platforms to promote interaction between individuals or organizations and product users	Patagonia, BlaBlacar, Nearly New Car, BMW, Drivy, Daimler, Lyf
Product life extension	Provides the repair, refurbishment, reconstruction or upgrading of a product and through that the preservation or improvement of a used product.	Bosch, Caterpillar, Volvo, Renault, Apple, BMA Ergonomics, Michelin
Product as a service	Provides the opportunity not to buy the product, but still ensure its use, for example by renting or leasing. This can stimulate the development of durable products with a longer life cycle.	Rolls-Royce, Mud Jeans, De Kledingbibliotheek

[140] Ellen MacArthur Foundation, 2015a.

Thus, circular suppliers are necessary for the development, production and distribution of recyclable materials that prevent the disposal and burning of waste and used products. Resource recovery technologies help to process products and waste into new raw materials and apply them in a new production cycle. The development of exchange platforms allows the reuse of products, and business models related to the extension of the product life cycle, industrial restoration, remanufacturing and repair of used products, their individual components and parts.

The application of the Product-as-a-Service business model allows companies to provide products to its customers for temporary use with a package of services, one of which is maintenance. At the same time, companies can use them individually or in combination to reduce energy consumption, increase resource efficiency, increase consumer value and profit. At the same time, the development of a circular economy depends not only on technological and organizational innovations introduced by companies, but also on measures taken by the legislative and executive authorities to form an institutional environment adequate to these innovative processes. Expanding the size of the circular economy at the global level requires a combination of business models, technological advances and innovations, as well as the joint efforts of stakeholders, business and government representatives.

Table 10. Circular Economy business models' types and sectors, where already applied (Source: Authors' compilation)

	Circular supply	**Resource recovery**	**Product life extension**	**Sharing platforms**	**Product as a service**
Resource efficiency facilitator	Closed material cycles	Closed material cycles	Slow material cycles	Narrow resource flow	Narrow resource flow
Business model sub-type	Cradle to cradle	Industrial symbiosis Recycling Downcycling Upcycling	Direct re-use Repair	Sharing Shared access	Product/ user oriented
Sectors, where already applied	Consumer goods	Metals, paper, plastics	Automotive Electronics	Short-term rent Transport Consumer goods	Transport Energy

Circular suppliers

In the sectors of agriculture, food production and packaging materials, it is possible to use recyclable or biodegradable materials, which underlie the circular system of production and consumption. Companies of the relevant segments should seek and conclude agreements with suppliers of eco-raw materials and materials, to which they could return products or waste for processing. Particularly relevant for consumers is the return to the manufacturer of old or outdated equipment and electronics, cartridges for printing, however, this usually requires special agreements with manufacturers, very often foreign ones.

Resource recovery

Transformation of waste into value is possible through the recovery of embedded value at the end of one product's lifecycle, to feed into another. Treatment methods and reverse logistics allow those materials to get back into the market. These methods are different, but usually include sorting, warehousing, power generation, delivery chain logistics, risk management, etc. With cost-efficient, better-quality collection and treatment systems, as well as an effective segmentation of end-of-life products, the leakage of materials out of the system will decrease, supporting the economics of circular design.[141]

The use of composting and anaerobic digestion in agriculture for the production of fertilizers and energy, as well as the processing of solid waste and products unsuitable for recovery and reuse, are necessary to avoid depletion of resources and increase landfills. Therefore, the development of waste collection and sorting infrastructure in all countries is necessary with the creation of appropriate production facilities.

Reduction and recycling slow down the rates of depletion, but do not stop these processes. Much recycling is "downcycling", because it reduces the quality of a material over time.

For example, when plastic is recycled, it is often mixed with different plastics to produce a hybrid of a lower quality. The original high-quality material is not retrieved, and it eventually ends up in landfills or incinerators.

Product life extension

Product life extension models employ product maintenance and circular design. Products are designed for long life, supported by guarantees and trusted repair services.

By repairing, upgrading, remanufacturing or remarketing products values, that would otherwise be lost through wasted materials, they are instead maintained or even improved. This model can be used for business to business (B2B) segments which are capital-intensive, for example, industrial equipment, as well as for business to customers (B2C) companies, that serve markets, where pre-owned products are common or where a new version of the product adds only partial performance benefits over the previous version.[142]

The remanufacturing industry can be formed in the automotive industry, the production of large household appliances, the aerospace industry and the military industry and, of course, in other industries. Considering domestic investment in new

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[141] Ellen MacArthur Foundation, 2015c.
[142] Accenture, 2014.

technologies, as well as foreign direct investment and technology imports, the interaction of production sites and research centres in the country, a high-tech remanufacturing industry can be formed, the services and models of which are already used by thousands of companies around the world as one of the main elements of circular economy.

An important component of product life extension is a circular design of a product, which should enable its easy disassembly in order to replace an outdated or a corrupted part. This model could be combined with sharing and virtualisation models, as components could be sold or shared on virtual platforms.

Product as a service

An enterprise that works according to the "product as a service" model offers the buyer access to the product, while at the same time retaining ownership of it. This can be implemented via practices of leasing, renting, pay-per-use or performance-based models (Rizos *et al.*, 2017). Such practices can bring great environmental benefits since the company will be interested in operating and repairing the product for a longer period of time.

This business model can be used in the leasing segment of large and small vehicles, agricultural machinery, because instead of buying an expensive product, it is more profitable for the consumer to purchase a package of services. At the same time, the manufacturer has the opportunity to simultaneously saturate the market with their products and make a profit through after-sales service, as well as a service during the usage of the product. As a result, the manufacturer is responsible for the disposal of products at the end of their life cycle, which leads to the formation of a closed supply chain.

Sharing economy

Sharing models are inextricably linked to the circular economy concept since they seek to reduce underutilization of products and thereby support the more efficient use of resources. Sharing models can be applied to products and services among individuals or businesses, but also to sharing of technologies and infrastructure among industry partners.[143]

> *"The sharing economy is an emerging social and technological phenomenon based on developments in information and communications technology (ICT) that implies the collaborative consumption of physical, virtual, and intellectual goods" (Wang & Ho, 2017).*

In the World Economic Forum paper (2013), a sharing economy is defined as "complementary to the circular economy. The circular economy refers to an industrial economy that is, by design or intention, restorative and which focuses on cradle-to-cradle principles and materials sustainability. Resources are used to enable high-

[143] Accenture, 2014.

quality design without contaminating the biosphere. Both the sharing economy and the circular economy focus on efficient and sustainable resource use by individuals, companies, and governments".

A sharing economy can at once reduce resource use and carbon emissions, provide solutions to the global social and environmental problems – the same as a circular economy.

> *"The sharing economy refers to the sharing of goods or other resources by multiple people….Sharing allows existing goods and resources to be used more fully, rather than letting them lay dormant, and depends greatly on either access to goods via a membership (car sharing, resource libraries), or peer-to-peer interaction (AirBnB, ride sharing, clothing swaps)…. The circular economy is more about goods as they are manufactured and as they are taken apart for reuse and reconstruction as new goods. It deals with the raw materials, ensuring that they never become waste or pollution." (Ferguson, 2016)*

Sposato *et al*. (2017) investigated drivers and barriers of a sharing economy, which can affect its effective expansion. They also focused on benefits a sharing economy provides – for instance, the extension of the product's lifecycle, which is also one of the ideas of a circular economy.

According to the Ellen MacArthur Foundation studies, the average European office is only 35-50% in use, even during working hours; about 31% of food is thrown out along the entire value chain, and the average European car is only used 8% of the time, the rest of the time it is parked.[144]

In recent years, many aspects of life have been transformed through a sharing economy. The environment of supply and demand is constantly changing, new approaches and new economic models appear. Sharing is often called "property access", which means that instead of owning things, they can be accessed only when needed. This is especially true for items that are rarely used or are expensive. This model is applicable to various products, such as cars and bicycles, as well as the workplace, various devices and much more.

Instead of buying and owning products, consumers are increasingly interested in leasing and sharing them. Companies can benefit from the trend towards "collaborative consumption" through creative new approaches of defining and distributing their offerings (Matzler *et al.*, 2014).

Exchange and sharing platforms can be created for food products, clothes and shoes, books, etc., which will extend the life cycle of products and their use, will lead to a reduction in the production the number of products and materials, on the one hand, and the volume of waste generated - on the other. A sharing economy can be used to obtain economic, social and / or environmental benefits. Models and platforms of the

[144] Ellen MacArthur Foundation & McKinsey Center for Business and Environment, 2015.

sharing economy can allow you to receive income from asset sharing, i.e. be monetized or allow the exchange or gifting of goods, i.e. not be monetized. Models can also use various technical products, such as car sharing or using mobile apps for sharing. However, models may also be non-technical, such as neighbourhood tool lending libraries[145] (Figure 38).

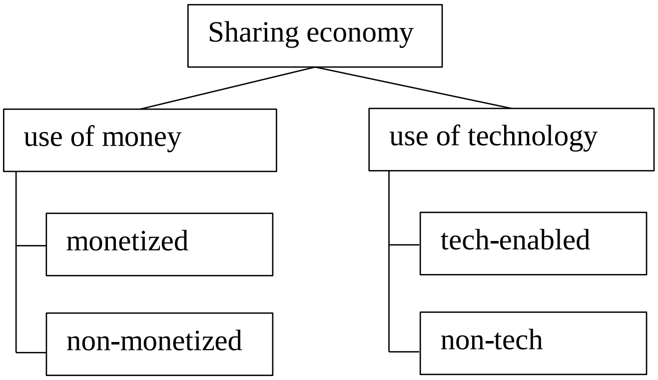

Figure 38. Sharing economy business models (Source: Authors' compilation)

The main stakeholders of a sharing economy are:

- **Providers**. Usually individuals, who share their own resources with users, i.e. the host of an apartment, the owner of a car, etc.
- **Users**. The end users of the product or service provided by the provider, i.e. the guest in the apartments, the person renting a car, etc.
- **Public Authorities**. Governmental agencies, which are responsible for legislative oversight in a specific country, region or city.
- **'Traditional' providers**. Officially registered businesses in different fields and industries.

How can companies create value through innovation in business models, as well as interact with user communities?:

1. Using unused resources and opportunities.
2. Supporting customers in their attempts to resell.
3. Selling the use of goods, not the product.
4. Providing repair and maintenance.
5. By negotiating co-consumption to target new customers.
6. Finding and using new business models based on sharing economy.

One more method that can be used for realization of a circular economy is Virtualization. Technological advancements have enabled virtualization of some

[145] H hotels, 2015.

products, like books or sound carriers, and such virtual products are already accepted by consumers. The products are provided through digital channels instantly, which completely reduce the need for traditional transport. This method also reduces waste creation. Virtualization could lead to resource savings and productivity gains, but it should be noted that there are concerns about the sustainability benefits of such models due to high energy demand of supporting data centres (Rizos *et al*., 2017).

These models are of course not exclusive and are often combined or merged together. Everyone has a role to play in moving towards a circular economy. Depending on the role within the company, there are various circular practices that can be implemented.[146]

CONTROL QUESTIONS AND QUESTIONS FOR INDIVIDUAL STUDIES

1. Which business models of a circular economy do you know?
2. What are the main advantages of using new business models?
3. Consider the five basic business models of a circular economy and outline the prospects for their application in a number of sectors of the economy.

[146] World Business Council for Sustainable Development, 2017b.

10. INDUSTRIAL SYMBIOSIS

The search for compromise solutions, that are beneficial for both the businesses and society living in the same territory, lies at the heart of a circular economy strategy. New technologies and changes in the organizational structure make it possible to transform industrial organizations into flexible and at the same time stable companies that occupy their own special niche due to geographical, cultural, socio-economic, and other prerequisites. Using this principle in building industrial clusters, economic synergy, or "industrial symbiosis", is achieved.

> *"Industrial symbiosis is the process by which wastes or by-products of an industry or industrial process become the raw materials for another. Application of this concept allows materials to be used in a more sustainable way and contributes to the creation of a circular economy".*[147]

In recent years, the term Industrial symbiosis has become more and more popular. The principle of industrial symbiosis is quite simple: instead of being discarded or destroyed, the excess resources generated by the industrial process are collected and then redirected for use as a "new" contribution to another process by one or several other companies, providing mutual benefit or symbiosis. Simply put, industrial symbiosis makes the business world work just like a natural ecosystem, where everything takes place and functions, and nothing is wasted. The concept of industrial symbiosis is based on the principle of cooperation between enterprises of various industries "through the fence" by analogy with the symbiosis of nature, on the principle that allows you to combine economic benefits with environmental ones. This approach is able to ensure the implementation of an effective model for creating an industrial network of cleaner production in the future.

Chertow (2000) proposed one of the most cited definitions of industrial symbiosis as: "The part of industrial ecology known as industrial symbiosis engages traditionally separate industries in a collective approach to competitive advantage involving physical exchange of materials, energy, water and by-products. The keys to industrial symbiosis are collaboration and the synergistic possibilities offered by geographic proximity."

According to Gibbs (2008), "Industrial symbiosis uses metaphors drawn from natural ecosystems to suggest that industrial production can be reconfigured into an 'industrial ecosystem' where firms are interconnected through the exchange of wastes and energy".

Cudecka-Purina and Atstaja (2019) suggest that a step toward a circular economy or such concepts as industrial symbiosis is a good alternative – humans cannot prevent all the waste generated, but can minimize the volumes going to landfills and change their attitude towards waste.

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[147] Industrial Symbiosis (n.a.)

Lombardi and Laybourn (2012) provided their own definition of industrial symbiosis: "Industrial symbiosis engages diverse organisations in a network to foster eco-innovation and a long-term culture change. Creating and sharing knowledge through the network yields mutually profitable transactions for novel sourcing of required inputs, value-added destinations for non-product outputs, and improved business and technical processes".

Summing up all of the information above, it can be said that industrial symbiosis is the sharing of services, utility and by-product resources among industries to increase value, reduce costs and improve the environment. Industrial symbiosis is a subset of an industrial ecology with a particular focus on energy metabolism and material. Although geographical proximity is often associated with industrial symbiosis, it is neither necessary nor sufficient, nor does it pay much attention to the physical exchange of resources. It is more important that the interaction between the participants is active, i.e. be measured by the number of transactions.

Currently, Europe has some EU support networks for industrial symbiosis and European Innovation Partnerships, such as:

- National Programmes, for example the United Kingdom National Industrial Symbiosis Programme (NISP)[148];
- Regional initiatives, for example Swedish Cleantech Östergötland [149];
- Local initiatives, for example, Kalundborg in Denmark [150] or Kujala Waste Centre in Finland [151].

The idea of an industrial symbiosis was first tested in the city of Kalundborg in Denmark, where a whole ecological network of enterprises appeared, developing over a couple of decades. The five major industrial enterprises of the city and the local municipality cooperated by concluding commercial agreements for the exchange of energy and material flows in order to obtain economic and environmental results. The Kalundborg Technology Park was not originally planned as an industrial symbiosis. Its current state of waste, heat and materials separation has developed over a period of 40 years. Previously, the division at Kalundborg tended to include the sale of waste products without significant pre-processing. Each further connection in the system was agreed as an independent commercial transaction and established only if it was economically viable. Thus, it can be said the initial motive for organizing such a system was the desire of entrepreneurs to reduce the cost of production through the use of waste and make more profit. Gradually, the leaders of the enterprises and the municipality realized that along with an increase in the profit of enterprises, the damage of environmental pollution was reduced. The cooperation now covers several dozen projects on the reuse of water, energy and secondary industrial raw materials. They are all based on the philosophy that by-products of one company are valuable

[148] National Industrial Simbiosys Programme. (n.a.)
[149] Cleantech Östergötland. (n.a.)
[150] Kalundborg Symbiosis. (n.a.)
[151] Kujala Waste Centre. (n.a.).

raw materials for others. Saving a huge amount of resources, enterprises receive millions every year only to save customs costs. Industrial symbiosis in Denmark, and now in other countries, has proven that environmental care and business can go hand in hand.[152]

One more example of industrial symbiosis is the ECO3 bio- and circular economy business area – an industrial symbiosis platform initiated in the Kolmenkulma ecoindustrial park in Tampere Region (Finland), centred around the cities of Nokia and Tampere (Figure 39).

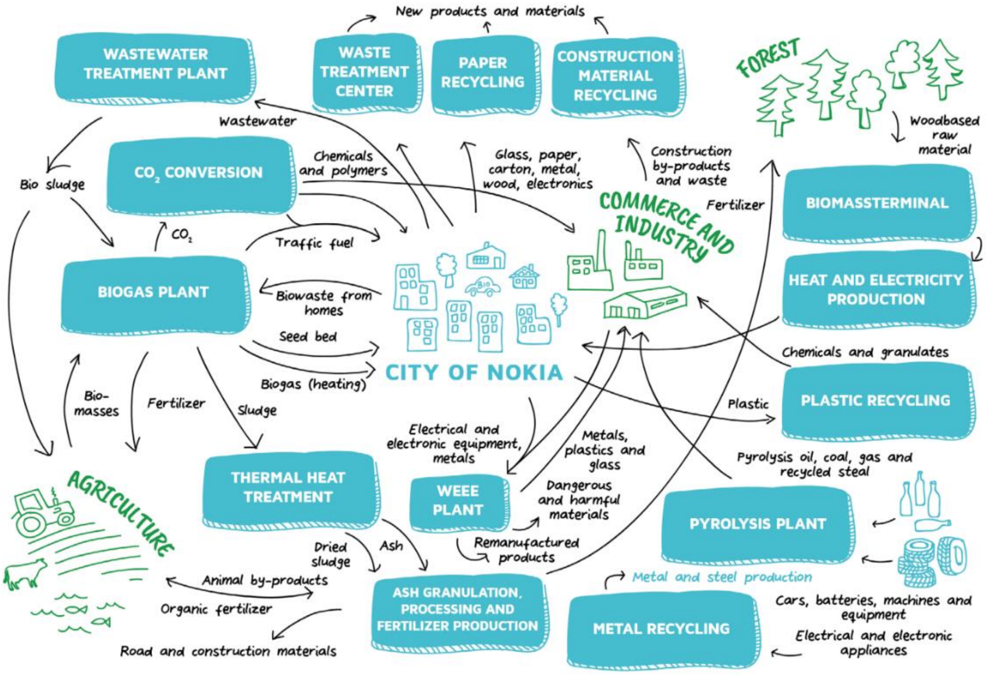

Figure 39. Industrial symbiosis at ECO3. (Source: Nordregio, 2019)

Today the ECO3 industrial symbiosis network comprises 21 partner organisations, from a variety of industries, collaborating on circular resource streams in nutrients, wood and technical by-products, and efficient and sustainable energy production.

The goal of industrial symbiosis is to connect companies of different directions to use the waste of one as a resource for another. “The core of industrial symbiosis is a shared utilisation of resources and by-products among industrial actors on a commercial basis through inter-firm recycling linkages. In industrial symbiosis traditionally separate industries engage in an exchange of materials and energy through shared facilities” (OECD, 2012, p.16.).

Each organization, depending on their role or function, can play a role in moving towards a circular economy. Organizations can apply various cyclic methods,

[152] Kalundborg Symbiosis. (n.a.)

regardless of area and size. Table 11 contains six functions and specific practices, and examples for moving towards a circular economy.

Table 11. Functions and practices for moving towards a circular economy
(Source: Authors' compilation, based on Circular economy practitioner guide, 2018)

Functions/ Department	Practices and examples	
Design (Design, Research or Innovation departments)	• Biomimicry • Cradle to Cradle • Design for disassembly/ deconstruction • Design for flexibility • Design for maintainability/ reparability • Design for recoverability/ recyclability	• Design for the environment (eco-design) • Green chemistry • Integrated design process • Life cycle thinking • Lifetime extension & durability • Regenerative design • Standardization • Systems thinking
Buy (Procurement department)	• Bio-based resources • Biodegradable resources • Compostable resources • Critical raw material substitutes • Rare earth metal substitutes	• Reclaimed resources • Recycled resources • Renewable resources • Reused/ reusable resources • Safe chemicals • Services (not products)
Make (Production and Manufacturing departments)	• Additive manufacturing • Dematerialization • Jidoka (autonomation) • Kaizen (continuous improvement) • Kanban (just-in-time) • Lean manufacturing	• Poka Yoke (error-proofing) • Prefabrication • Refurbishing • Remanufacturing • Resource efficiency • Six Sigma
Sell (Sales and Marketing departments)	• Co-branded services • Digitization and virtualization	• Leasing • Pay-per-service unit • Sharing platforms
Dispose (Waste Management department)	• Cascading • Compatibilizers • Composting • Deconstruction and disassembly • Energy recovery • Feedstock recycling • Industrial symbiosis	• Recycling • Repurposing • Reverse logistics • Secondary material marketplaces • Selective extraction • Take-back program • Waste to Energy

Functions/ Department	Practices and examples
Finance (Finance and Accounting departments)	• Assess creditworthiness risk • Assess environmental, social and governance risk • Assess linear risk • Crowdfunding • Emphasize relationship-based financing • Extend investment time horizon • Factoring • Green bonds • Impact loan • Incentivize end-of-life returns • Integrate circular value in models • Integrated client approach • Natural capital valuation • Prioritize cash flow • Purchase order finance • Stranded asset management • Supply chain financing

Through industrial symbiosis, a network of interconnected enterprises is created that resembles the functioning of ecological systems in which energy and materials constantly circulate and do not generate waste. Thus, the environmental impact of all sectors involved in industrial symbiosis is reduced. It also requires much less virgin raw materials and the amount of waste that can be disposed of, i.e. the number of landfills is reduced. It also allows increasing the value of materials that would not have been used otherwise, thus lengthening the value of materials and using them longer than in traditional industrial systems.

Industrial symbiosis brings together various organizations in a network, to foster eco-innovation and long-term cultural change. It is the culture that determines the attitude of people towards production, an understanding of their role and function in the industrial ecosystem, in the economy as a whole.

The main driving factors of industrial symbiosis for business are profit, reduction of costs and risks, but for regions and Europe it is competitiveness, more jobs and economical growth.

Key benefits of industrial symbiosis are as following:

- *Impact Reduction*. Reduction of environmental impact of waste through recovery, reuse and recycling. Biostabilisation reduces the environmental impacts and risks associated with waste that is sent to landfill.
- *Economic Value*. Cost saving. Creation of economic value from waste material.
- *Cleaner environment*. Reduction of GHG emissions from waste transport and raw material extraction. Reduction of reliance on fossil fuels and decrease of emissions of NOx, SO2, CO2.

– *Knowledge and Skills*. Extension of knowledge and a practical know-how-to of how waste management can be transformed into a sustainable and growth oriented business.

– *New businesses and more jobs*. Creation of new businesses, with the potential to accelerate the creation of new jobs and regional economic growth.

To build a symbiotic chain it is suggested to follow five main steps:

1. An audit / screening. As a result of which a report is created with structured information about the current levels of resource consumption and waste generation at the enterprise.
2. Resource / waste database. A screening report is included in the resource and waste database to examine the potential for symbiotic chain formation.
3. Match & Meet. Organization of a meeting of interested organizations with the potential for industrial symbiosis.
4. Test at Living Lab. Practical testing of ideas of industrial symbiosis in the framework of the Living Laboratory.
5. Industrial symbiosis. The introduction of the technological process in the activities of organizations, the start of the symbiotic chain.

Industrial symbiosis involves traditionally individual industries in a collective approach to competitive advantage, including the physical exchange of materials, energy, water and / or by-products. The keys to industrial symbiosis are collaboration and synergies offered by geographical proximity. With the development of the Internet and virtual capabilities, information exchange is becoming increasingly important. All of these tools can greatly simplify the analysis of potential organizations and the opportunities they might bring.

CONTROL QUESTIONS AND QUESTIONS FOR INDIVIDUAL STUDIES

1. How do you understand the term "Industrial symbiosis" after reading this chapter?
2. What are the main advantages of using industrial symbiosis?
3. Which departments of an organization could be involved in industrial symbiosis and how?

11. BARRIERS TO CIRCULAR ECONOMY

The implementation of a circular economy model could bring many benefits to the economy and business, as well as to solve environmental issues. However, the introduction of a CE model is slow. The main barriers preventing the move towards the circular economy model can be divided into economical (mostly financial), institutional, structural, operational, technological and attitudinal.

A large number of scientific studies regarding the existing barriers (institutional, structural, economic, informational, administrative, etc.) on the way of introducing circular economy practices, confirm the complexity and multidimensionality of this process, which necessitates the implementation of various types of actions at national, regional and local levels depending on the nature of the barrier (Galvão *et al*., 2018).

Ormazabal *et al*. (2018) concluded that one of the main circular economy barriers is the lack of financial resources. Urbinati *et al.* (2017) and Ranta *et al*. (2017) noted the need for institutional support, i.e. policies and regulations, to help companies design and better implement circular economy measures. Garcés-Ayerbe *et al*. (2019) conducted a study of circular economy activity implementation and barriers. For this purpose, the European SMEs and the Circular Economy database were used, which is based on Flash Eurobarometer Survey number 441.[153]

In Flash Eurobarometer Survey, five different internal measures for the circular economy were discovered:

1. minimizing of usage and maximizing of re-usage of water through the planning of the way of using;
2. using of renewable energy;
3. re-planning using of energy for minimization of consumption;
4. minimizing waste through the recycling and reusing waste or selling it to another company;
5. re-designing products and services for minimization of usage materials or use of recycled materials.

During the survey, it turned out that there are companies that have implemented or are implementing at least one of the circular economy measures (7843), such companies were called in-going firms, and there are companies that did not carry out any circular economy measures (2775), being called no-going firms. Additionally, these two groups, despite being named similar, have various barriers that prevent them from putting the circular economy into practice (Table 12).

[153] European Commission, 2016.

Table 12. In-Going and No-Going firm's barriers to circular economy
(Source: Authors' compilation, based on Garcés-Ayerbe *et al.*, 2019)

In-Going firm's	No-Going firm's
Lack of human resources Lack of expertise to implement these activities Complex legal or administrative procedures Cost of meeting regulations or standards Difficulties in obtaining and finding finance	Lack of human resources Lack of expertise to implement these activities Lack of understanding of cost benefits or improvement of work Lack of understanding of required investment Complex legal or administrative procedures Cost of meeting regulations or standards Difficulties in obtaining and finding finance

Kirchherr *et al.* (2017b) also categorized circular economy barriers into four groups: cultural, technological, market and regulatory barriers, underlying that all these barriers are interrelated. Their vision is presented in Figure 39.

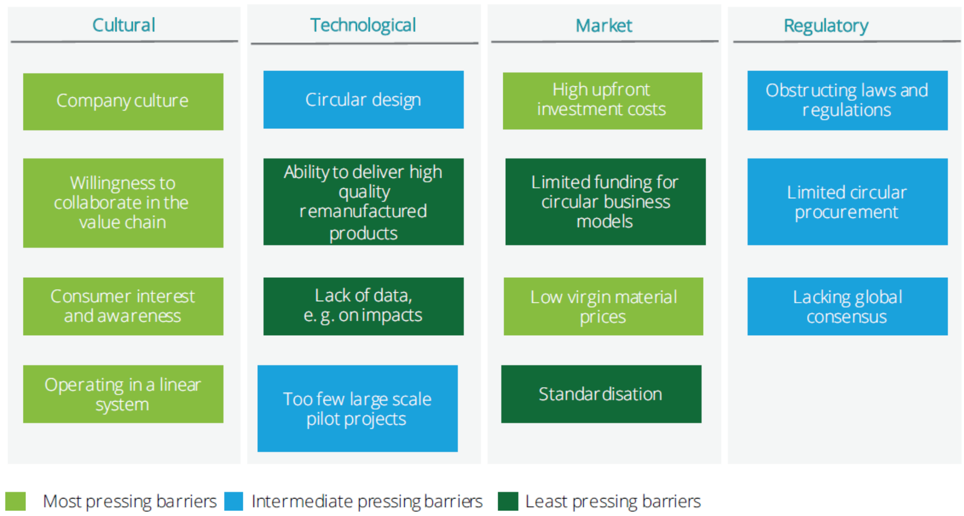

Figure 39. A heatmap of circular economy barriers (Source: Kirchherr *et al.*, 2017b)

After investigating, a key player, that may accelerate the circular economy transition, was mentioned to be the government. "It may become an enabler of CE breaking the current chain reaction towards CE failure" (Kirchherr *et al.*, 2017b).

Economic barriers to a circular economy model. In the current economic system, there are some barriers for the implementation of a circular economy model, such as:

- Social and environmental externalities are not considered in prices, privileging financial market signals, instead of people and nature when economic decisions are made;
- Prices of raw materials are fickle, and at low prices alternative, good quality secondary resources are not competitive;
- Circular economy business models are harder to develop, as most investors are still working under a linear economy logic and sometimes upfront investments are required;
- The demand for circular products and alternatives is still small,
- There is still lack of qualified professionals with technical or 'information and communication technology' (ICT) knowledge.

Institutional barriers to a circular economy model. There are many different barriers in the process of implementing a circular economy:

- The fact that the current economic system is geared towards the demand of the linear economy and is not prepared to deal with circular economy entrepreneurs yet;
- New business models may be challenging to implement and develop because of laws and regulations that are not prepared for these kinds of innovations;
- Plenty of businesses rely on old and/or strong alliances, making it harder to create new alliances and therefore to close loops;
- Many companies still have goals and appraisal systems that focus on short-term value creation, whereas the circular economy model is a long-term value creation model;
- The GDP index does not consider social and environmental externalities, discouraging the creation of value in both these areas.

The Ellen MacArthur Foundation provides a categorisation of potential barriers of a circular economy, as can be seen in Figure 40.

Reducing these types of barriers would address key challenges, which are hindering the development of a more circular economy. Several categories of policy instruments are available to address barriers of a circular economy:

- **Subsidies**. With respect to innovation, positive externalities may exist, and this may be a good reason for subsidies. While many subsidies (e.g. subsidies on fossil fuels) generate externalities and should be abolished, subsidies on innovation may help to overcome barriers in situations where R&D costs borne by private enterprises generate benefits disseminated across the whole economy. Even some infant technologies may be worth subsidizing due to positive externalities stemming from cost decreases arising when the new technology is applied on a larger scale and experience is gathered over time (i.e. learning by doing).

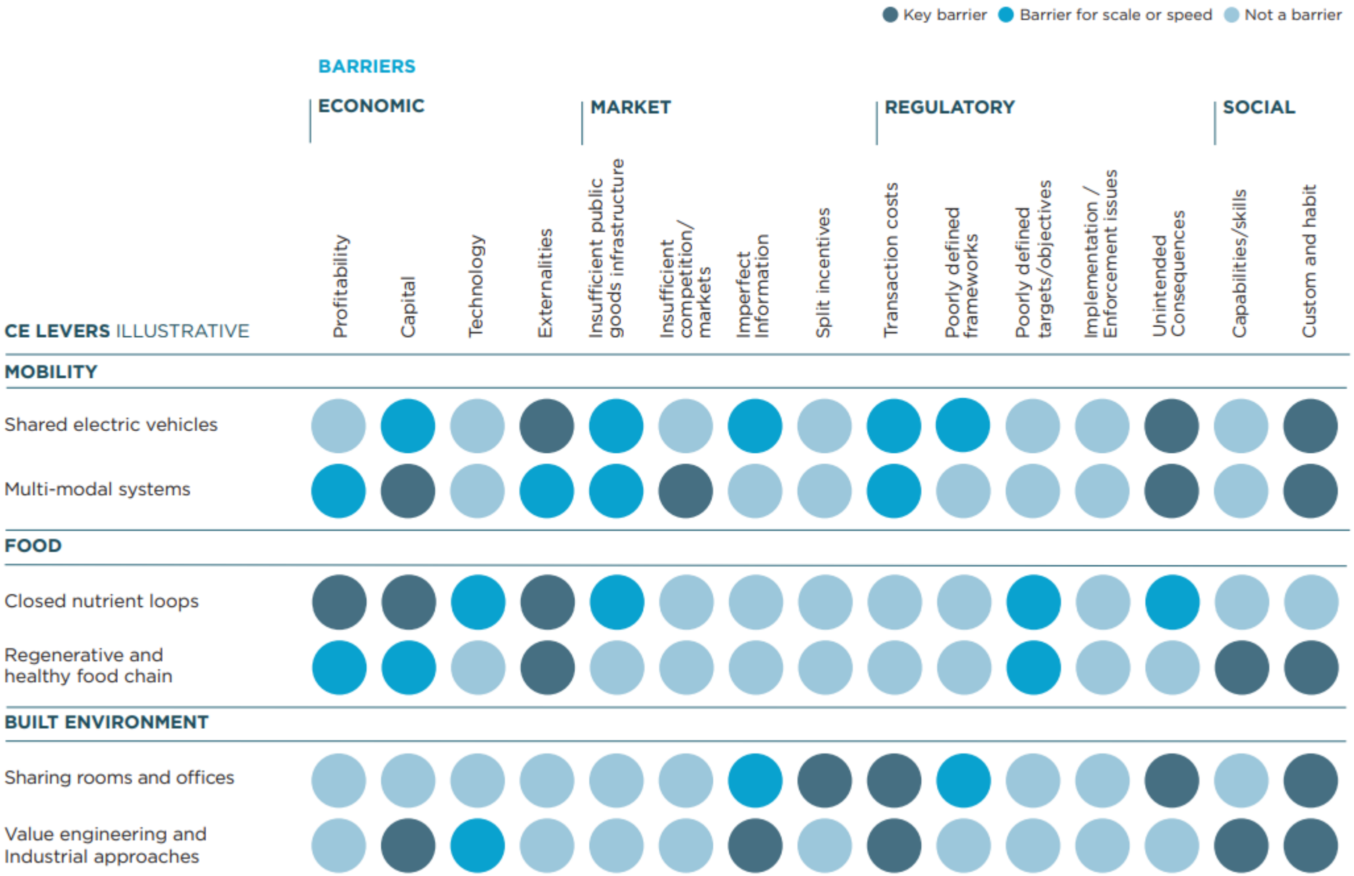

Figure 40. Barriers for implementation of a circular economy
(Source: Ellen MacArthur Foundation & McKinsey Center for Business and Environment, 2015, p.21.)

- **Regulation**. The second category of instruments is an intelligent and targeted regulation. In general, regulations that prescribe specific processes have the risk of lock-in in less efficient solutions. On the other hand, it may be efficient to set restrictions on technologies or externalities that are not consistent with a green economy. For example, governments may set a maximum pollution level or resource-use requirements per unit of output. Governments may set minimum standards for circularity or energy use of buildings, especially if they are floating standards, i.e. standards that adjust to changes of technological knowledge over time. A specific type of regulation is setting responsibility for producers like a minimum guarantee period or mandating they be responsible for paying the costs of recycling after disposal of the product.
- **Infrastructure**. The third category of instruments is infrastructure development. For example, electric cars require an infrastructure of possibilities to charge the cars; public transport requires networks of infrastructure, etc. Providing infrastructure by government, or organising institutions that regulate the provision of infrastructure by private companies, may be important to realise the network that is required for new opportunities to develop.
- **Public procurement**. The fourth category of instruments is green public procurement. Governments are large customers for many products and services. If governments focus on green procurements, innovators may get a market to develop their new products and services. For example, if governments focus on lifetime costs, this may provide benefits both to government and to the sellers of energy-saving or repairable products, or sellers of products as a service.
- **Information**. The fifth category of instrument is the organisation of relevant information for users. This may be through regulations requiring provision of information on energy efficiency or on lifetime costs, or information on environmental sustainability that can be easily compared across products.
- **Coordination**. The sixth category of instrument is coordination of different agents. For example, in the Netherlands, green deals between governments and private agents are made to reach certain green goals and to coordinate activities and adjust legislation when necessary for this purpose.
- **Financing**. The seventh type of instrument is solving financing problems stemming from imperfect information. An example of these may be insurance by government of risks related to new circular opportunities (Woltjer, 2018).

For a successful transition to a circular economy model, the following is needed:

- a tightening and development of an environmental legislation;
- government support in the field of subsidizing companies that are switching to a circular economy model;

- stimulation of research projects related to circular economies;
- cooperation and integration of local companies into global networks of environmentally responsible business;
- preparedness of public consciousness, understanding of society about the harm that the current concept of production does to health and the ecology (the consistent development of society in a democratic way).

Key enabling factors on the way to the circular economy are:

Eco-design: products designed for a longer life; product design based on a sustainable and minimal use of resources and enabling high-quality recycling of materials at the end of a product's life; and substitution of hazardous substances in products and processes.

Recycling: high-quality recycling of as much waste as possible; use of recycled materials as secondary raw materials ; well-functioning markets for secondary raw materials; avoidance of mixing and contaminating materials; cascading use of materials.

Economic incentives and finance: shifting taxes from labour to natural resources and pollution; phasing out environmentally harmful subsidies; internalisation of environmental costs; deposit systems; extended producer responsibility; finance mechanisms supporting circular economy approaches.

Business models: product-service systems rather than product ownership; repair, refurbishment and remanufacture given priority; collaborative consumption; collaboration and transparency along the value chain; industrial symbiosis.

Eco-innovation: technological innovation; social innovation; organisational innovation.

Governance, skills and knowledge: awareness rising about changing lifestyles; participation, stakeholder interaction and exchange of experience; education; data, monitoring and indicators (European Environmental Agency, 2016a).

The transition from a linear economy to a more circular one requires systemic changes, involving a wide range of actors and sectors. Such a large-scale transformation of markets will have impacts on industries, value chains and, in turn, on economies.

A circular economy eradicates problems, reducing our dependence on resources, which reserves are not renewed. It brings economies to a more efficient level, eliminating the possibility of waste generation at the design stage, at the same time saving production, human, social, natural and financial capital. The economic benefit from the transition to such an economic model only in Europe by 2030 is estimated at € 1.8 trillion. In addition to creating jobs and increasing the welfare of the population, the transition provides an excellent opportunity to protect the environment.

Assessing and monitoring your impact on nature and the environment is what ecology explains, hence the importance of ecology in any modern economic system. From how a society relates to the natural world around it, its attitude to production, development — that is, to an artificially constructed infrastructure — depends. How carefully, thoughtfully and responsibly a person interacts with the outside world, manages resources, waste, energy, so much the society is in principle oriented towards development and well-being.

CONTROL QUESTIONS AND QUESTIONS FOR INDIVIDUAL STUDIES

1. Which barriers for circular economy do you know?
2. How can, in your opinion, a circular economy be implemented in practice faster and more effectively?

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