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## THE DEVELOPMENT OF THE PRODUCTION PROCESSES IN AN ACTIVE CIRCULAR ECONOMY SYSTEM, A VIEW OF RECIRCULATION

Elena Simina LAKATOS, Laura BACALI, Ligia Maria NAN, Alina Maria DANCIU,  
Matthew GREENLEY

*Abstract:* The purpose of this article is to present the advantages of secondary recycling in the production processes of the important component of the circular economy. The fierce growth of resource demand by industry over the last decades has prompted the competent authorities to come up with measures to support the sustainable development of resources on our planet. We have reviewed an array of circular economy literature incorporating into it the concept of recirculation. Following the grounded theory procedure we have analysed 59 papers in the field of circular economy published between 1998 and 2018 so as to see the current state of knowledge regarding the recirculation dimension of circular enterprises.

*Key words:* Circular economy, recirculation, production, industry

### 1. INTRODUCTION

Nowadays, the economic consumer model based on the phrase "buy, use, throw away", which implies the availability of large quantities of cheap, raw materials, is about to reach its physical limits of sustainability. Circular economy is an attractive and viable alternative, and major international companies and large interstate organizations and fora have already begun to consider and explore the concept [1].

According to the Ellen McArthur Foundation, the circular economy is a restorative and regenerative one that aims to keep products, components and materials at their greatest utility and value at any given time. The concept calls for technical cycles where components are used and reused very effectively without negative effects. In view of the concept of circular economy is a continuous cycle of positive development that preserves and enhances natural capital, optimizes resource efficiencies and minimizes the risks of inventory management system by finite and renewable flows. It works efficiently on every scale. It is an opportunity to re-think and redistribute the way we do things. A change in perspective where we

can re-design the way our economy works, manufacture the products that can be "made to be made again" and power the system with renewable energy. It challenges us to reach a restorative economy through creativity and innovation [2].

In a circular economy, the value of products and materials is kept as long as possible; waste and the use of resources are minimized and resources do not leave the economic flow once they have reached the end of their lifetime but are reused and create value. This model can generate safe jobs, promote innovations that offer a competitive edge and provide a level of protection for people and the environment. It can also offer consumers more sustainable and innovative products and, consequently, monetary economy and better quality of life [3].

The EU Action Plan for the Circular Economy outlined a set of both general and material-specific actions.

While some obstacles to a circular economy are generic, different sectors and materials face specific challenges due to the particularities of the value chain [4].

It is a gratifying fact that the EU has already taken measures in this regard. Waste has been

hierarchized, giving priority to reducing and recycling waste.

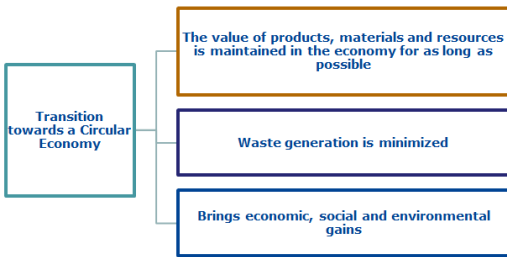


Fig. 1. Closing the loop, an EU action plan for the Circular Economy [5]

The Chemicals Policy seeks to phase out very toxic high-risk substances. Projects related to the circular economy are supported by European funds. Public authorities' initiatives on green public procurement stimulate greener demand for products and services and encourage firms to

make similar choices. Likewise, the Eco-design Directive for energy related products helps companies develop innovative products with low environmental impact. And according to the new legislative package on the circular economy L150, promulgated by the European Parliament on June 14, 2018, it is necessary for the EU to recycle 70% by 2030 to all the packaging and 65% by 2035 to municipal waste [6].

Another important component of the circular economy is related to the fact that it also contributes to the creation of new jobs, aspect highlighted by a lot of data and studies of European Commission concerning the positive effects of these strategies; for example, that for each percentage point of reduction in consumption of virgin raw materials, it could create about 600 thousand places of work [7].

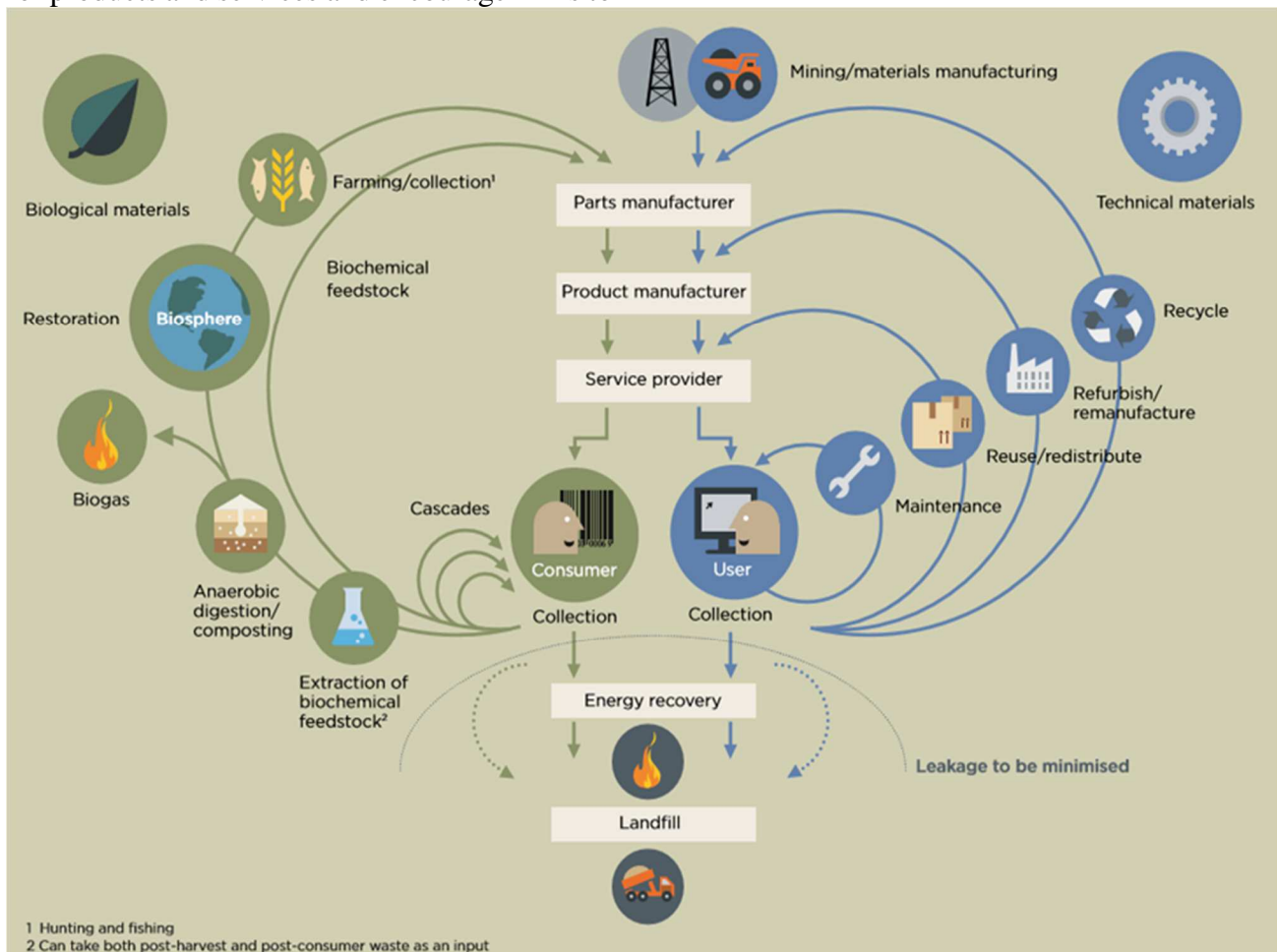


Fig. 2. The circular economy—an industrial system that is restorative by design [10]

Starting from the above, the article aims to support the advanced use of the substance and energy by using circular active development

based on closed manufacturing cycles or closed technologies. A fundamental way of acting in this direction is the reintegration of secondary

materials (waste), issues that will be presented in the following sections.

## 2. RECIRCULATION OF SECONDARY MATERIALS INDUSTRY

The systematic approach appreciates the organization as a system in which there are complex interactions between the component elements, so that the intervention on a particular element of the organization affects the organization as a unitary and dynamic one. They must be able to anticipate both desired and undesirable effects that might arise from the adoption and enforcement of decisions [8].

The manufacturing industry often produces hazardous waste materials, which their subsequent treatment or disposal often requires additional resources or materials and can result in harmful emissions. Such cases are quite common in the chemical industry, the pharmaceutical industry, the plastics industry, even if the process or component is obtained in an environmentally friendly environment. In the past years, the responsibility of manufacturers has already taken the first steps to meet expectations and advance to sustainability. Of course, reducing waste or eliminating it, aspiring producers to reduce the environmental impact of economic benefits is a sensitive point and even the social impact is under consideration.

The secondary material is the material which, for technological reasons, results as auxiliary material – companion of the primary one. In some situations, it can be exploited by reintegration using the 3R technologies (recirculation, recycling and regeneration) [8].

Recirculation is the process by which secondary materials are reintroduced into previous sequential streams, typically as raw material substitutes [9].

Quantitative recirculation is the most important way of re-incorporating secondary materials into industry and it is less expensive than recycling.

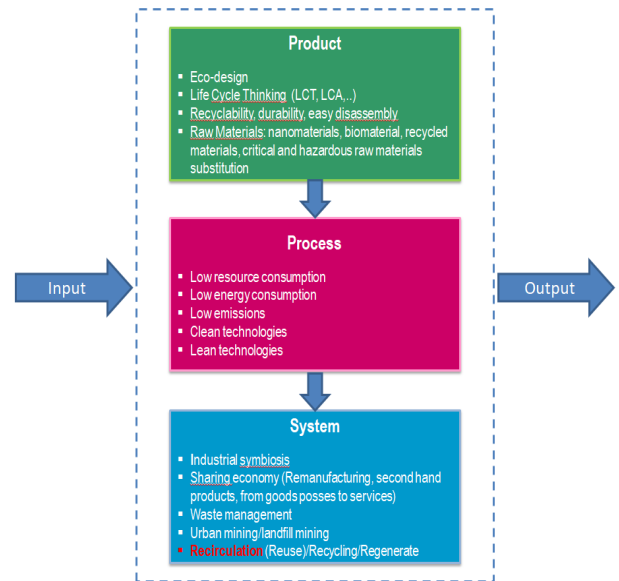


Fig. 3. Criteria to be considered in circular active production flows

The industrial cycle of production, alike the cycles of various substances in nature, represents the path of a material: natural capital zone -> industrial processing - recycling (secondary valorification): -> industrial processing -> natural capital zone [8] aspect that are presented in figure no. 3.

For example the recirculation of steel in the form of scrap metal is a specific case in metallurgy, given the large quantities of material that is the subject of such an operation.

In the specialized literature (technological or economic), the definitions of some notions that work on the steel market produced mainly from the old iron in metallurgical furnaces (the LD converter or the electric arc furnace) are not yet defined. This is the reason why some suggestions are made in the following.

In the figure no.2, the circular economy—an industrial system that is restorative by design is explained the evolution from where we are now, a central linear spine, into where we should be going to: a circular economy where we see the world from a dual perspective: biological and technical nutrients flowing endlessly within our economy [10].

The use of the component of recirculation as described above leads to a very important series of assessments on the production activity under conditions of sustainable development [8, 11]:

- methods that improve the environmental indicators of secondary material are the same as

the ones that improve its purity in terms of impurities; this means that pretreatment or advanced treatment of this material will have positive effects by environment quality;

- the best solutions in terms of minimum costs and best environmental performance, are not necessarily those that are currently being implemented the most; Indeed, the best solutions require optimizing the entire recycling circuit, going beyond the business boundaries;

- also, solutions that lead recirculation to a good level of purity of secondary materials (level of impurities) are the best; moreover, recirculation means energy - technological additions - labour and capital and therefore it should be minimized, the best solution being a single technology (aggregate); this latter rule is far from being obvious for most of today's operators.

### 3. METHODOLOGY

The current paper, entitled “The development of the production processes in an active circular economy system, a view of recirculation” aims at identifying the recirculation process perspective from industry in a circular economy by means of content analysis of most influential publications in the field.

In order to approach recirculation process perspective from industry we analyse content published in circular economy studies. The goal is to examine how recirculation process is perceived in relation to circular economy and to identify the direction towards where it moves. In the following sections details of methods employed to identify and analyse published works in the field are provided.

We have performed a systematic review according to a predefined search strategy respecting the process stages as suggested by Kitchenham [12]: (1) planning – justification and protocol; (2) conducting the review - identification of research, selection of primary studies, study quality assessment, data extraction & monitoring and data synthesis; and the final stage (3) reporting the review. The selection procedure is similar to that followed by Mainela et al. [13] in their review and research agenda pertaining to the concept of international opportunity in entrepreneurship. We propose the

following protocol for relevant literature identification that is presented in table no.1.

**Table. 1.** Protocol for circular economy literature identification

Criteria	Reasons
(1) <b>Publications in the field of SE</b>	We search ISI Clarivate Analytics Web of Science databases for papers on circular economy; We select works in circular economy related subject categories such as: recirculation, production and industry. We add industry related subject categories (engineering, science technology, computer science, material science, robotics etc.) so as to examine the role of circular economy in industry. We search for works with the following keywords in their title: circular economy/ manufacturing/ production/ secondary production/ reuse/ ecotechnologies to ensure a wider approach of the concept.
(2) <b>Publications between 1998-2018</b>	We set the starting point of our research so it correspond with the development of the concept of circular economy;
(3) <b>Publications in peer-reviewed journals</b>	We select only the works published in journals with an ISI-impact factor ranking;
(4) <b>Publication at full-length journal article or review</b>	We exclude book reviews and conference proceedings papers;
(5) <b>Incorporation of innovation concept</b>	We record the occurrence of recirculation concept in abstracts, keywords and/or content of papers; We analyse the contexts of the concept

Secondly, we have selected from them only such materials published in journals with ISI-impact factor in the ranking, so as to ensure the quality of materials and of the review process. Out of 51 works matching the impact factor criterion, only 21 were approaching the concept of recirculation within their content and therefore they were retained for further analysis.

We have deliberately chosen to select only articles, refraining from extending our search to books and book chapters, as a wider literature area would affect the quality of the content analysis and also, because of accessibility of the articles published in journals.

For the content analysis we propose three types of coding: (1) open coding; (2) axial coding; and (3) selective coding to construct our theories. Firstly, we have identified and sorted the relevant literature in the field. Secondly, we have extracted information-directly-related paragraphs from the materials to be coded according to typical methodology. Finally, we have formulated a research agenda for the future.

The analysis was developed using the content analysis procedure that belongs in grounded theory [15]. As noted, we have analysed our materials using three types of coding: open coding, axial coding and selective coding.

Open coding allowed us to break the data into pieces and label all relevant data regarding our subject. We have discovered codes describing specific phenomena (properties) that were gathered under a category.

The next step has been axial coding, aimed at refining and differentiating categories which had resulted from the open coding Flick [14]. The methodology used is that originated by Strauss and Corbin [15] as it allowed us to discover and establish structures and relationships between all types of data labels (phenomena, concepts and categories). The coding paradigm model is represented in figure no 4.

We continued our coding procedure with selective coding. Selective coding represents a prosecution of axial coding at a higher level of abstraction. At this point, the development and integration of axial coding is compared to other groups that focus on possible concepts or variables of interest. It might imply search for further examples and evidence for core categories that will help at the development of case stories [14].

#### 4. RESULTS OF THE REVIEW

The analysis reveals that early stage of circular economy literature tends to approach recirculation as it had been referred to before 2003, when the concept of recirculation or circular economy was absent in high impact journals. Out of 51 selected articles, 14 were published between 2003 and 2018, followed by the rest of 7 which had been published between 1998 and 2012.

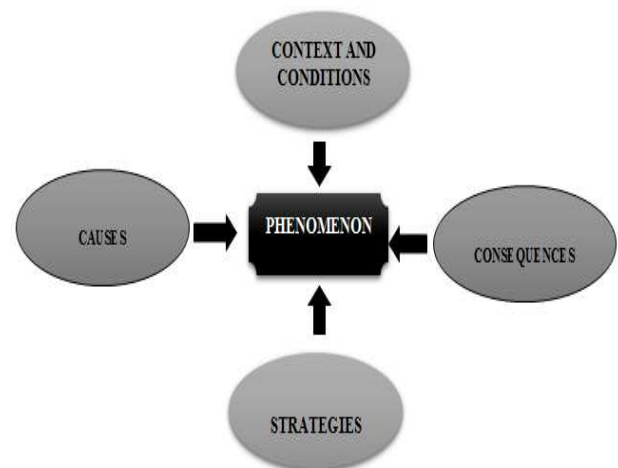


Fig. 4. Axial coding model [16]

The period with the highest number of works in the field of circular economy incorporating the concept of recirculation had been, by far, 2016-2018, with 6 articles.

The reviewed works and their research focus are presented in Table 2 below.

Table 2. The Items reflecting the concern for the environment

Study	Method	Research focus
<i>Blomsma, &amp; Brennan [23]</i>	Conceptual	The emergence and development of the umbrella concept of circular economy with focus on reuse, recycling, and remanufacturing operationalize
<i>Haas et al. [24]</i>	Conceptual Case study	An assessment of material flows, waste production, and recycling in the European Union and the world in 2005
<i>Hahladakis et al. [17]</i>	Conceptual	Improvements in the role of the efficient recovery and recycling
<i>Hu et al. [21]</i>	Case study	The role of legislation promoting a circular economy, a material flow-based evaluation of the circular degree of the Chinese economy
<i>Kirchher, et al. [22]</i>	Conceptual Case study	Conceptualizing the circular economy an analysis of 114 definitions
<i>Lockyer [19]</i>	Conceptual Case study	Present history energetics and in

		conclusion present the primary and secondary production aspects
<i>Nicolae et al. [18]</i>	Conceptual	Eco technologies and waste reintegration for durable-sustainable development
<i>Sherwood et al. [20]</i>	Conceptual	Conceptual model for recirculation, a new concept to drive innovation in sustainable product design for bio-based products

Waste reintegration and environmental problems that describe circularity aspect [18] are often avoided by the profit seeking business sector, leaving room for those whose mission is

not just to gain economic advantages, but also to solve ecological problems through the creating of model for recirculation [20].

The role of legislation promoting a circular economy are engaging social and economic drivers aimed at creating new technology and innovation that will, in turn, generate income sector areas [21].

The different possible combinations of the 3Rs are depicted in Fig. 5, highlighting the recirculation component in the circular active production flows.

Of these, recirculate/reuse, recycle and regenerate (the 3R framework) are the most commonly found in the literature studied.

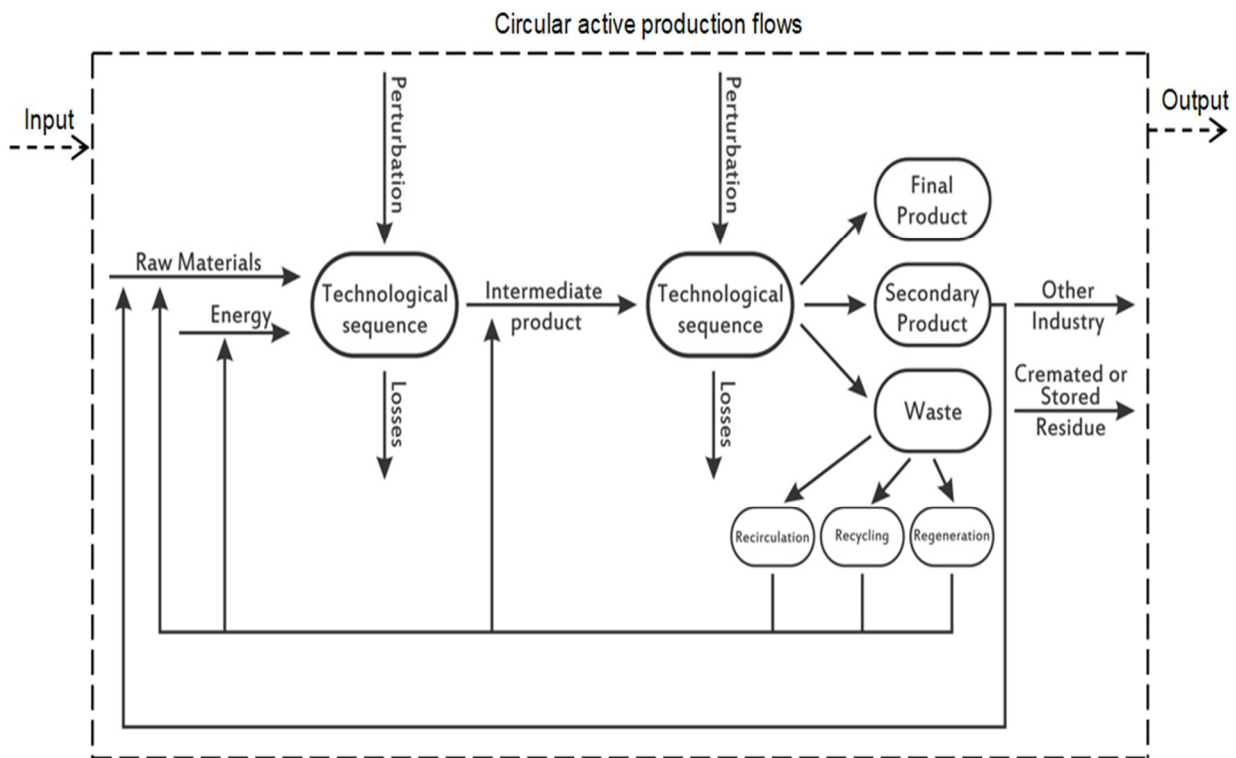


Fig. 5. The recirculation component in the circular active production flows

### 5. CONCLUSIONS

The role of the recirculation concept in this is to clarify the benefit of design for different waste management options, indicating how the value inherent to the materials can be best preserved beyond the lifespan of a single product and to be an commitment to resource recirculation, with an emphasis on inner-loop recycling.

Whilst the calculation of targets this way fits within current legislative reporting requirements and support circular economy objectives of higher material recirculation rates.

Through the legislative package on the circular economy of 14.06.2018 imposing more severe rules on landfill and reduction targets

through incineration, long-term investment decisions have been made that are helping the Europe Union in their progress towards circular economy ideals.

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### **Dezvoltarea proceselor de producție într-un sistem economic circular activ, în vederea recircularii**

**Rezumat:** Scopul acestui articol este de a prezenta avantajele reciclării secundare în procesele de producție a componentei importante a economiei circulare. Creșterea acerbă a cererii de resurse de către industrie în ultimele decenii a determinat autoritățile competente să adopte măsuri pentru a sprijini dezvoltarea durabilă a resurselor pe planeta noastră. Am analizat o serie de literatură circulară care încorporează în ea conceptul de recirculare. În urma procedurii teoretice fundamentate, am analizat 59 de lucrări în domeniul economiei circulare publicate între 1998 și 2018 pentru a vedea stadiul actual al cunoașterii cu privire la dimensiunea de recirculare a întreprinderilor circulare.

**Elena Simina LAKATOS**, Technical University of Cluj-Napoca, siminalakatos@gmail.com

**Laura BACALI**, Technical University of Cluj-Napoca, laurabacali@gmail.com

**Ligia Maria NAN**, Institute for Research in Circular Economy and Environment “Ernest Lupan”

**Alina Maria DANCIU**, Institute for Research in Circular Economy and Environment “Ernest Lupan”

**Matthew GREENLEY**, Institute for Research in Circular Economy and Environment “Ernest Lupan”