An analysis of European Union's circular economy indicators with focus on materials: implications for the manufacturing industry

R L Păcurariu[1,2,3] , E S Lakatos[1,2], L M Nan[1,2], L Bacali [1,2] and D Seitoar[2]

[1] Faculty of Machine Building, Technical University of Cluj-Napoca, Cluj-Napoca, Romania
[2] Institute for Research in Circular Economy and Environment "Ernest Lupan", Cluj-Napoca, Romania

[3] Corresponding author: roxana.pacurariu@ircem.ro

Abstract. The paper aims to emphasize the contribution that manufacturing industry can have to meet the Circular Economy (CE) scope related to the use of resources. First, we presented the CE concept and the framework in Europe, the monitoring framework and also, we noted some aspects of manufacturing industry related to CE. Then, we performed an analysis of the secondary raw material data, which is one of the representative indicators of CE, in order to see the state of circular economy related to the resources in European Union Member States. The results showed that the resource circularity is lowest in Europe, the states which can be remarked are Germany, Netherlands, and Belgium. Highlighting these aspects, some conclusions were formulated, the most evident is that the manufacturing industry has a very important role on the CE transition, consisting in the resources fact implicated. The manufacturing industry can choose to use secondary raw materials instead of virgin raw materials, can improve resource efficiency through the technologies used in production processes and can address the circularity of a product, being an important CE actor.

1. Introduction

The predominantly linear economic model is no longer sustainable because the resources are fast depleting and this model does not take into account the social and environmental damages [1]. The Circular Economy (CE) is a widespread concept, that is seen as a solution to the classic model of production and consumption called linear economy, and it draws attention both at European and global level as it is an alternative that meets together the economic, environmental and social needs [2]. CE can be seen as a regenerative economic system that replaces the concept of end of life with concepts such as reduction, reuse, recycling and recovery materials in the production / distribution and consumption processes, in order to achieve sustainable development, while creating environmental quality, economic prosperity and social equity, for the benefit of current and future generations [3-5]. From the European Commission perspective, a circular economy maintains the value of products, materials and resources in the economy for as long as possible and minimize the waste generation [6-7]. A key element of the CE is natural resources, for which the aims is to maximize their efficiency, transform waste into resources, recirculating the resources from products at the end-of-life through CE practices as recycling thus conserving natural capital [8].

The first European Commission initiative which aimed the circular economy (resource efficiency) materialized in July 2014 through a communiqué ("Towards a circular economy: a zero waste program for Europe") which established the framework for implementing circularity in the economy [9]; in December 2015, the European strategy for the transition from the linear to the circular economy has taken shape through the launching of an ambitious European Union Plan, named "Closing the loop - an action plan for circular economy"[10]. In order to facilitate the transition to a circular economy, the proposed measures by the European Commission cover the entire product life cycle so that resources remain in the economy as long as possible by closing the loop [11-12]. The action plan was improved in 2018, when was launched a new set of measures for CE monitoring framework [13]. On 11 March 2020, in the New Circular Economy Action Plan is outlined the immediate need for the transition to circularity, which will reduce resource consumption within the planet, accelerate towards a circular rate of material use in the next decade and decreasing dependence on virgin raw materials [14].

In the last years, the development of European framework for the transition to a circular economy determined the intensification of the political, regulatory, technical and scientific activity at the level of the entire European Union, so it appears a stringent need for the transition monitoring framework, which can reflect accurately the reality. Thus, the launched measures at EU level also include a Monitoring Framework for the transition, which is applicable for each Member State of EU. The system of indicators developed allows the evaluation of transition process and it is meant to complete the existing Dashboard on resource efficiency and the Dashboard of raw material resources from the European level, which have been recent implemented by the European Commission. The EU monitoring framework for the circular economy from 2018 includes 10 key indicators, which cover each phase of the product life cycle but also the major aspects of competitiveness [13,15,16]. All indicators are updated regularly, and they can be seen online, on Eurostat site. The taxonomy and the description of the indicators are presented in the Commission' official document, as an annex to the Communication from the Commission to the European Parliament on the monitoring framework for the circular economy [15].

Manufacturing industry faces the current environmental concerns which are addressed through regulation regarding the resources consumption and other issues, that are meant to drive toward the CE [17]. The manufacturing industry can affect the entire lifecycle of a product, it can introduce in the market green or circular products, made on sustainable raw materials, with high green technologies [18]. The circularity of the product can be addressed from the design phase, where the product can be designed for circularity integrating disassembly, repairability, modularity, adaptability and durability [19-20], thus they can close the loop, obtaining new resources from the transformation of waste in secondary raw materials.

Most studies that address the potential of waste use as secondary raw materials in manufacturing industry refer to construction sector [21-24]. These show the environmental benefits if the company take into account the value of waste as secondary raw material [25]. In addition to environmental benefits, the shift to CE can bring to companies' competitive advantage on the market and other economic gains, environmental benefits and social opportunities as jobs [26]. Another study in the field highlights the benefit of reducing dependence on imported raw materials and the importance in achieving the goals of the circular economy [27]. Another study underlines the importance of information system in the sense of collaboration between the parties in order to exchange secondary raw materials (wastes, by-products etc.), proposing a virtual marketplace for efficient exchange between parties, with associated CE benefits [28], and another propose for a better management of secondary raw materials is the industrial symbiosis [17]. Exploiting the potential of secondary raw materials is seen as an opportunity to close the loop, leading to environmental, social and economic gains, and ensure a secure supply to the industry [29]. In this regard are recommended measures to improve the European market for secondary raw materials, which is not very developed [30]. Another useful fact for improving the European market for secondary raw materials would be to intensify research on materials availability [31].

The manufacturing companies have the most important role in the CE transition, which can be successfully achieved if it acts in two directions: the first concerns internal evaluation and adaptation to the CE requirements, and the second is to be a driver factor towards the CE and to direct the collaborators to the CE [32]. Studies show that CE implementation in manufacturing companies cannot be done at the entity level, it implies the contribution and commitment of all stakeholders; they are an important part of a larger system [18]. As global pressures increase, cooperation between manufacturing companies and their upstream and downstream supply chain partners is needed in order to increase product quality in terms of eco-design and eco-efficiency and at the same time substantially reduce energy, resources, emissions and waste per unit of production [33].

2. Research methodology

The analysis aims to assess the progress towards a circular economy with a focus on secondary raw materials. The analysis was performed using the available statistics from Eurostat, European Union' statistical office. There are available a lot of statistical categories, we chose the category of indicators specific to the circular economy. The circular economy indicators are grouped in four sections as follows (Figure 1): Production and consumption, Waste management, Secondary raw materials and Competitiveness and innovation.

Figure 1. Circular economy indicators available on Eurostat

We analysed the third category of indicators, those related to the secondary raw materials. The databases were downloaded and the information were grouped to generate comparative graphs. Secondary raw materials indicators are organised also in two subsections: Subsection 1 - Contribution of recycled materials to raw materials demand, with two indicators End-of-life recycling input rates (EOL-RIR) (percentage) and Circular material use rate (percentage); the second subsection - Trade in recyclable raw materials, that consists in three indicators: Imports from non-EU countries, Exports to non-EU countries and Intra EU trade. The steps of the analysis can be seen in the Figure 2.

Figure 2. Steps of secondary raw materials indicators analysis

3. Results & discussion

The use of sections to divide the text of the paper is optional and left as a decision for the author. Where the author wishes to divide the paper into sections the formatting shown in table 2 should be used.

3.1. Contribution of recycled materials to raw materials demand

3.1.1. End-of-life recycling input rates (EOL-RIR) (percentage). This indicator refers to the amount of a type of raw material introduced into the production process and obtained from recycling of a material that has reached the end of its life, and his evolution in time can be seen in the following graph.

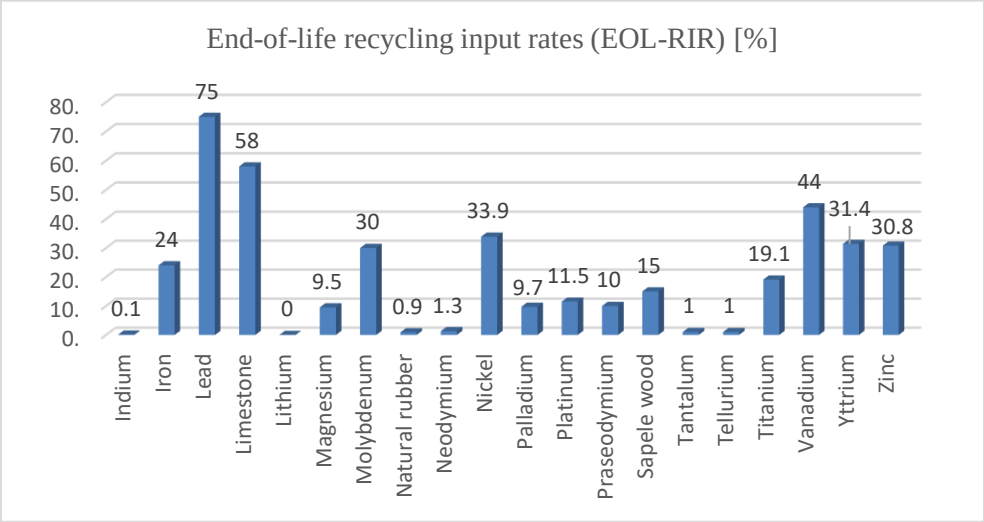

Figure 3. End-of-life recycling input rates [%] in 2016

The above figure shows that the material with the high rate of reintroducing in production process at the end of its lifespan, at the European level is Lead, with 75%. In other words, 75% of the lead's input into the production comes from recycling. The next material with a high rate of a provenience from recycling process is limestone with a rate of 58%, followed by Vanadium (44%). The lowest rate we can see for the Natural rubber (0.9%), Indium (0.1%) and Lithium (0). Unfortunately, the most recent data available are for the year 2016.

Relevance of the indicator for CE: due to the ascending demand on raw materials, the secondary raw materials are a solution for avoiding new virgin materials dislocation. The development of a secondary raw materials can help the EU in raw materials supply and contribute to a sustainable and circular economy in national and European terms. This indicator also shows the recycling's contribution of the type of material to materials demand.

3.1.2. Circular material use rate (percentage). This indicator shows the percentage of material recovered and reintroduced into the economy and the contribution to overall materials demand with the recycled materials - thus closing the loop in the product life cycle and avoiding the dislocation of new virgin raw materials.

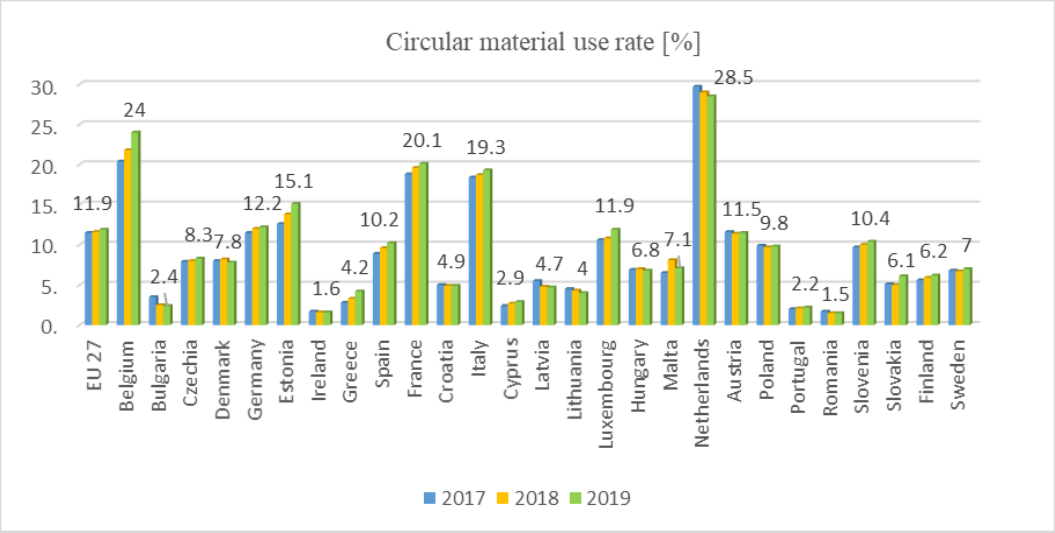

Figure 4. Circular material use rate [%]

In the figure 3 we can see the trend of the circular material use rate at the Europe level, for the three consecutive years – 2017, 2018 and 2019. We put the labels with rates' value correspond to the year 2019, to make it easier to compare. The graph shows the EU 27 mean of 11.9% in 2019 having an a slightly upward trend, the highest values for 2019 are recorded in Netherlands that is on a descendent trend, followed by Belgium but with an ascendent trend and France, also with an ascendent trend. The lowest values of the indicator we can see in Portugal, Ireland and Romania, that are well below the European average value.

Relevance of the indicator for CE: in a circular economy, waste is considered as a resource, so that can be traduced in a big material recovering and feed back into the economy from the end-of-life products, avoiding virgin resources extraction. A high value of the indicator shows a decrease in the need for new virgin material and a low level of waste.

3.2. Trade in recyclable raw materials

The indicators from this category taken into account the following five groups of materials: plastic; paper and cardboard; precious metal; iron and steel; copper, aluminium and nickel and they refer to the imported / exported quantities.

Relevance of the indicator for CE: the transformation of waste into resources and reintroducing it into European economy is an important aspect at the EU level as well as the imports / exports of certain categories of waste and by-products from non-EU countries, that can improve the supply with raw material, reduce the waste and preserve the natural capital.

3.2.1. Imports from non-EU countries. As the name suggests, the indicator is about the quantities of certain categories of waste and by-products imported by EU Member States from non-EU countries.

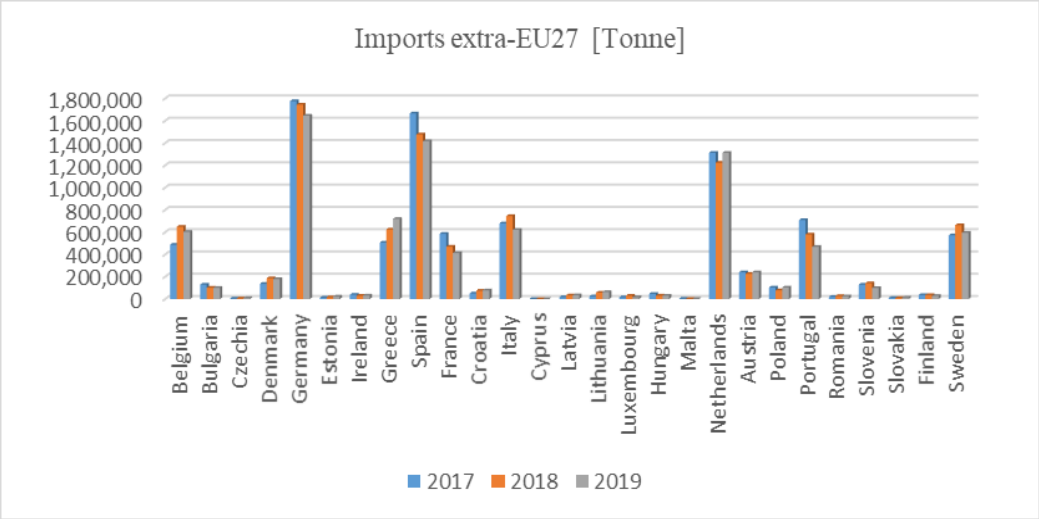

Figure 5. Imports extra-EU27 [Tonne]

The figure shows that the imports of the recyclable materials from the non-EU countries are almost non-existent or very low in many states, including Romania. It can be remarked in some countries like Germany, in a descendent trend in last three years available data, Spain with a descendent trend, also Netherlands, Italy, Sweden, Portugal, Greece, France and Belgium.

3.2.2. Exports to non-EU countries. Like the above indicator, this is about the quantities of certain categories of waste and by-products but exported by EU Member States to non-EU countries.

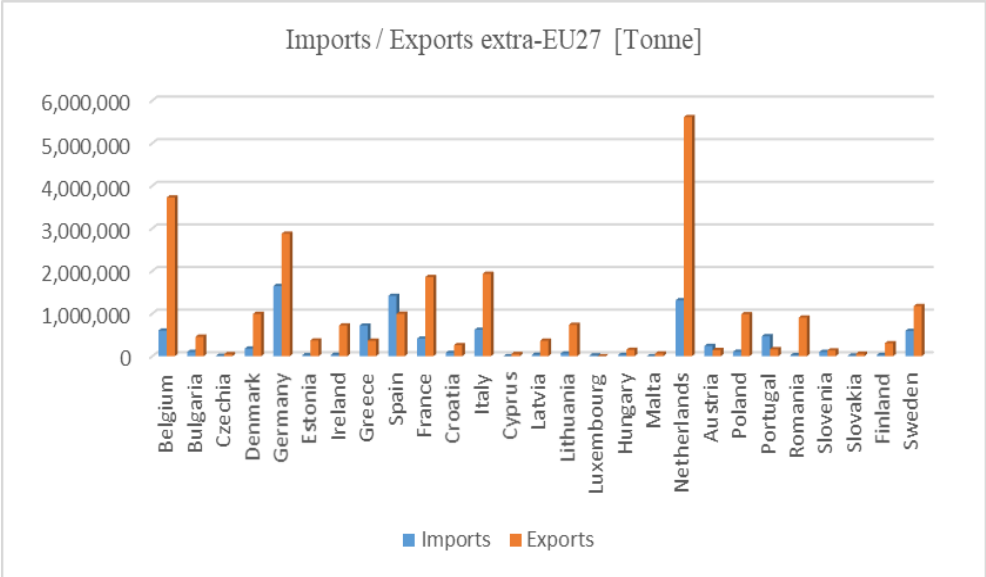

Figure 6. Imports / Exports extra-EU27 in 2019 [Tonne]

In the above graph (Figure 5) we can observe a comparison between the imports and exports of secondary raw materials in 2019. The level of the exports is bigger than the imports for most of the states, excepting Greece, Spain, Portugal and Austria. The biggest levels of exports are recorded by Netherlands, Belgium, Germany, Italy and France. In the other states, exports are almost 1000 tons or less, as in the case of Romania.

3.2.3. Intra EU trade. The indicator is about the quantities of certain categories of waste and by-products imported between Member States of European Union.

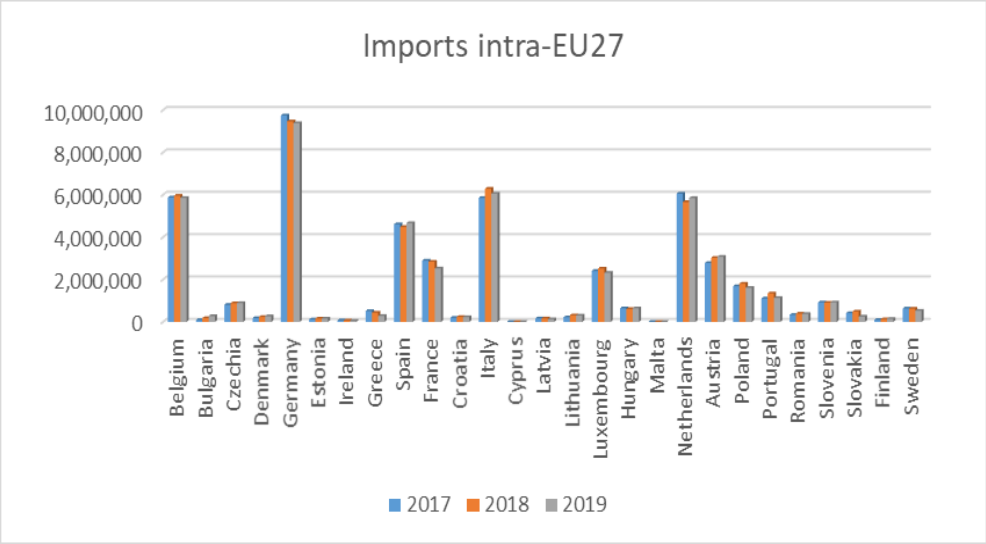

Figure 7. Imports intra-EU27 between 2017 - 2019 [Tonne]

The figure 7 reveals the statistics on intra-EU imports on last 3 years available on Eurostat – 2017, 2018 and 2019. We can see that Germany is the country more implicated in intra-EU imports with waste and by-products, registering a decreased trend, followed by Italy, Belgium and Netherlands. Romania has a lower level of this type of import, but the lower imports were in Ireland, Malta and Cyprus.

4. Further directions for the development of the raw materials indicator system

The EU monitoring framework is based on indicators that refer to the preserving of raw materials and materials, through recycling and waste production. Thus, the main focus of European transition policies is represented by material resources and waste [34]. Therefore, we consider that the monitoring framework indicators should address the three pillars of sustainability, environment and society harmonized with economic processes.

In order to boost the transition, we can see a need of improving the data collection system for indicators. Between the collection / processing of information and the elaboration of decisions for their change / application there must be an optimal correlation, to address the specific measures to improve the indicators within a reasonable time, or we can see that the recent data for End-of-life recycling input rates indicator are from 2016.

For an accurate image of the state of secondary raw material of each country, would be good if the statistics will be available for a certain type of material and by-products.

We must underline the fact that the circular economy is not just about the preservation of materials, we say that because most of the indicators are related to materials and recycling, the fact that is concluded also in many studies of CE issues [16]. Monitoring framework must cover and address the entire potential of the CE through specific indicators, and we suggest the expanding of indicators system is needed in order to have comprehensive measures and strategies for the circularization.

5. Conclusions

The highest EOL-RIR of materials in Europe are corresponding to materials like Lead, Limestone and Vanadium. Regarding the circular material use rate at European level, the average of EU 27 is on ascendent trend but to a low level (11.9%). The highest rate of this indicator is recorded by Netherlands, while the lowest is in Romania.

In terms of trade of recyclable materials in 2019, the exports and imports are a low level in Europe. The biggest quantities of recyclable materials from non-EU states are imported by Germany, Spain, Netherlands. Just a few countries practice this type of import, and in Romania it is almost non-

existent. The level of the recyclable materials exported is bigger than the imports for most of the states, and the highest level can be seen in Netherlands. The imports between Member States are remarkable at a high level in Germany, Italy, Netherlands and Belgium.

The analysed indicators highlight a need of improving the data collection system, in order to boost the transition in a reasonable time horizon, and the implementation of decisions should not be made too late.

Due to the presented facts above, we consider that the manufacturing industry can have a significant apport to the transition to the circular economy through the phases of design and production in which they can impregnate sustainability of the product, and the second raw materials can be seen as one of the necessary instruments needed to meet the CE scope. Regarding the fostering the transition to a circular economy, an important condition for success is the collaboration with stakeholders.

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