# Development of a Framework to Evaluate the Implementation Level of Circular Economy in a Company

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# Abstract

The circular economy has been gaining importance as a transition path towards a sustainable future, decoupling economic growth from resource consumption. It determines the environmental responsibility of enterprises, but measuring its performance and specifying its objectives is still unclear. Opposite to its linear predecessor, the premise is the prevention of excessive production. The word 'Circular' comes from the emphasis on reuse and recycle, to reduce the use of raw materials in manufacturing and return used goods to the production chain.

This thesis will propose a method consisting of indicators to allow the evaluation of the implementation level of an enterprise concerning the Circular Economy. The intention is to bring awareness to the current circular economy policies in businesses and to close the skill gaps that may exist among the workers.

To achieve the proposed objective a global review on Circular Economy will be done along with a comparison with the linear approach. The project will be centered on the life-cycle of the products and aspects regarding the internal procedures of the enterprises. All the factors that affect the transition to the circular economy will be presented and carefully considered. Research on current enterprise strategies will be done to find the ones that already include the Circular Economy and use their good practices as a model.

The result will consist of a series of indicators that position the current circular economy strategy of a corporation inside a framework. Furthermore, these indicators will demand transparency and explicit requisites to the enterprises, to avoid Greenwashing and justify the presence inside the framework. Nevertheless, an issue observed in recent studies determines that many indicators can mislead the aspect that we are measuring. Therefore categories inside the established framework will be unequivocal and objective with not more than the necessary information.



**Key Words:** Circular Economy; Product Manufacturing; Environment

# Resumen

La economía circular está ganando importancia como camino de transición hacia un futuro sostenible, desvinculando el crecimiento económico del consumo de recursos, y además puede servir para determinar la responsabilidad ambiental de las empresas, aunque aún no se ha desarrollado un método completamente claro sobre cómo medir su desempeño y especificar sus objetivos. Frente a su predecesor lineal, la premisa es la prevención de la producción excesiva, en consecuencia, la palabra "circular" apela a la reutilización y el reciclaje, implicando la reducción del uso de materias primas en la fabricación y vuelta de los bienes usados a la cadena de producción.

En la presente tesis se propondrá un método compuesto por unos indicadores que permitan evaluar el nivel de implementación de la Economía Circular en una empresa, con la intención de concienciar sobre las políticas actuales de economía circular y ayudar a acabar con la falta de habilidades que puedan existir entre los trabajadores.

Para lograr el objetivo propuesto se realizará una revisión global sobre el concepto de economía circular junto con una comparación con el enfoque lineal. El proyecto se centrará en el ciclo de vida de los productos y aspectos relacionados con los procedimientos internos de las empresas. Todos los factores que afecten a la transición hacia una economía circular serán presentados y considerados cuidadosamente y investigando, a su vez, las estrategias empresariales actuales para encontrar aquellas que ya incluyen la Economía Circular y utilizar sus buenas prácticas como ejemplo.

Así pues, el resultado consistirá en una serie de indicadores que posicionen la estrategia actual de economía circular de una corporación dentro de un marco, estos indicadores exigirán transparencia y ciertos requisitos explícitos a las empresas, para evitar caer en el Greenwashing y, así, justificar la presencia dentro del marco correspondiente. Sin embargo, estudios recientes determinan que demasiados indicadores pueden inducir a error respecto a lo que estamos midiendo, por tanto, las categorías dentro del marco establecido serán inequívocas y objetivas con no más de la información necesaria.

**Palabras Clave:** Economía Circular; Desarrollo de Producto; Medioambiente

# Resum

L'economia circular està guanyant importància com a camí de transició cap a un futur sostenible, desvinculant el creixement econòmic del consum de recursos, i a més, pot servir per a determinar la responsabilitat ambiental de les empreses, si bé encara no s'ha desenvolupat un mètode completament clar sobre com mesurar el seu acompliment i especificar els seus objectius. Enfront del seu predecessor lineal, la premissa és la prevenció de la producció excessiva, en conseqüència, la paraula "circular" apel·la a la reutilització i el reciclatge, implicant la reducció de l'ús de matèries primeres en la fabricació i volta dels béns usats a la cadena de producció.

En la present tesi es proposarà un mètode compost per uns indicadors que permeten avaluar el nivell d'implementació de l'Economia Circular en una empresa, amb la intenció de conscienciar sobre les polítiques actuals d'economia circular i ajudar a acabar amb la falta d'habilitats que puguen existir entre els treballadors.

Per a aconseguir l'objectiu proposat es realitzarà una revisió global sobre el concepte d'economia circular juntament amb una comparació amb l'enfocament lineal. El projecte se centrarà en el cicle de vida dels productes i aspectes relacionats amb els procediments interns de les empreses. Tots els factors que afecten la transició cap a una economia circular seran presentats i considerats acuradament i investigant, al seu torn, les estratègies empresarials actuals per a trobar aquelles que ja inclouen l'Economia Circular i utilitzar les seues bones pràctiques com a exemple.

Així doncs, el resultat consistirà en una sèrie d'indicadors que posicionen l'estratègia actual d'economia circular d'una corporació dins d'un marc, aquests indicadors exigiran transparència i uns certs requisits explícits a les empreses, per a evitar caure en el Greenwashing i, així, justificar la presència dins del marc corresponent. No obstant això, estudis recents determinen que massa indicadors poden induir a error respecte al que estem mesurant, per tant, les categories dins del marc establit seran inequívoques i objectives amb no més de la informació necessària.

**Paraules Clau:** Economia Circular; Desenvolupament del Producte; Medi ambient

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## MEMORY

# 1 Introduction

Lately it is becoming more common to hear about corporations becoming sustainable, announcing new lines of products that claim to be less polluting for the environment, performing changes in the packaging of their products or including numerous stickers or labels that inform about a good environmental behavior. This is due to the fact that the Earth is suffering drastic climate changes provoked by the overproduction and misuse of resources by the businesses, accompanied by an increasing of consumerism.

In consequence, a large number of scientific investigations and methodologies have appeared to mitigate the effects of pollution or even getting rid of them in an attempt to become more 'green' and guarantee a healthy planet for the generations to come. One of the concepts that has been growing importance is the Circular Economy (CE), which encourages the use of organic materials and reuse of resources as basis for an enterprise with the ultimate objective of minimizing waste.

Despite the simple description of CE given above, the concept complexity is much bigger. A Circular Economy model also includes the surroundings of a company, not only the production of the product. Therefore meaning that apart from the resources involved in the manufacturing of a certain good, the term includes the attitude towards the consumer, collaboration with partners, facilities owned etc.

Furthermore, consumers paper in the Circular Economy is almost as important as the enterprises one. They are responsible for the buying of the products or services offered and for the Circular Economy to really make its way into society it is crucial that these products are not over-consumed. The public has to learn to buy only the necessary. However, consumers are becoming more intelligent over the years, the education systems are better and more users know how to differentiate characteristics of products such as the country it was made, the materials used for it, origin of some components, techniques used to achieve certain finishes etc.

In consequence, during the present thesis this Circular Economy concept will be further explained in order to make it clear and relate it with different trends to finally develop a method that can categorize the level of implementation of Circular Economy in a certain business. The method intends to be as comprehensible as possible, as after reading some external literature the information provided can result too technical and obscure for everyone to understand. Likewise, the same method provided to the corporations to evaluate the grade of Circular Economy should be available for their consumers.

Accordingly, the enterprises to which this project addresses are micro and small-medium sized enterprises (SMEs). This size of businesses hasn't received the same importance as larger ones, as it is not possible to find as much bibliography. In addition, it is considered that they are a significant part for the change to Circular Economy, this is due to its closeness to the citizens acting as a link between them and larger firms. Additionally, this small companies have the opportunity to easily become transparent, which is one of the main factors for Circular Economy to work.

The mentioned transparency will be the key to implement the method presented at the end of the memory. This will provide the guarantee that the company truly has the performance they officially claim, and it will be for everyone to see and allow critical thinking among the customers. This will bring a new level of competitiveness, the customer will not only notice the price or the brand, but also which are the company values and how their services or products are prepared.

To be able to give this information to both enterprises and their clients it will be necessary to develop a series of indicators that display clearly all the relevant aspects. In this regard, it is necessary to mention that a vast research has already been made, ranging from works that propose a certain and specific methodology to others that classify different collections of indicators. Furthermore, the research has been conducted from all variety of sources, private corporations, scientific articles, university reports, books, government plans etc. This already provides a great quantity of information to work with, but still can create confusion due to the variety of perspectives.

In the current work a definition will be given to CE and then the concept will be broaden by adding new relevant factors that can serve a purpose in the evaluation for sustainability and modernism in an enterprise. Then, the study of the existing indicators will be taken into consideration, going from scientific articles with different focuses on the evaluation of Circular Economy to already established ones, such as the 'Eurostat Circular Economy Indicators'. Subsequently, an own list of indicators will be provided, as mentioned and accordingly to the purpose of the project, in the simplest and most comprehensible way for all to understand.

Finally, a plan of forthcoming actions will be recommended, as CE is an evolving term. An explanation of the importance of each of the indicators will be included, as well as strategies about how to improve in those aspects.

# 2 Context and Origin of Circular Economy

Ideas of reducing waste of resources and reuse of materials have been present for a long time in the industrial field. These techniques were used with the purpose of reducing costs and improving efficiency and they were not seen as a method of moving towards an environmentally conscious way of production [1]. But since the late 1970s the Circular Economy has been gaining popularity until, according to several authors, finally the concept was introduced by Pearce and Turner in 1989 [2].

This first vision of the concept described the influence of natural resources in economy, this was achieved by providing the inputs calculated during production and consumption in contrast with the outputs, represented by waste. Then, more features being introduced with the appearance of new studies and Stahel and Reday-Mulvey were the first ones to refer to the term of a 'closed-loop economy'.

Different contributions and perspectives for the concept were being introduced by Robèrt, K.-H. (1991) mentioning that environmental problems are based on the systemic error and linear processing of materials, Mathews and Tan (2011) manifesting the use of eco-initiatives to establish a CE, or Yang and Feng (2008) referring to the CE as a 'Resource Circulated Economy' [3].

At the moment, the most recent definition is given by the Ellen Mac Arthur Foundation (EMF) as *"A framework for an economy that is restorative and regenerative by design"* in the date of realising this work. The foundation is dedicated to develop the promotion and development of Circular Economy and offers a variety of tools to many different organism. This tools are assisted by professionals and are under demand with a main focus on big institutions.

Nevertheless, the number of authors interested in the topic has been increasing, and the number of comparisons and tools has augmented significantly. To support this argument, the next figure has been obtained searching *"Circular Economy"* on Google Scholar with the filter per each individual year since 2003.

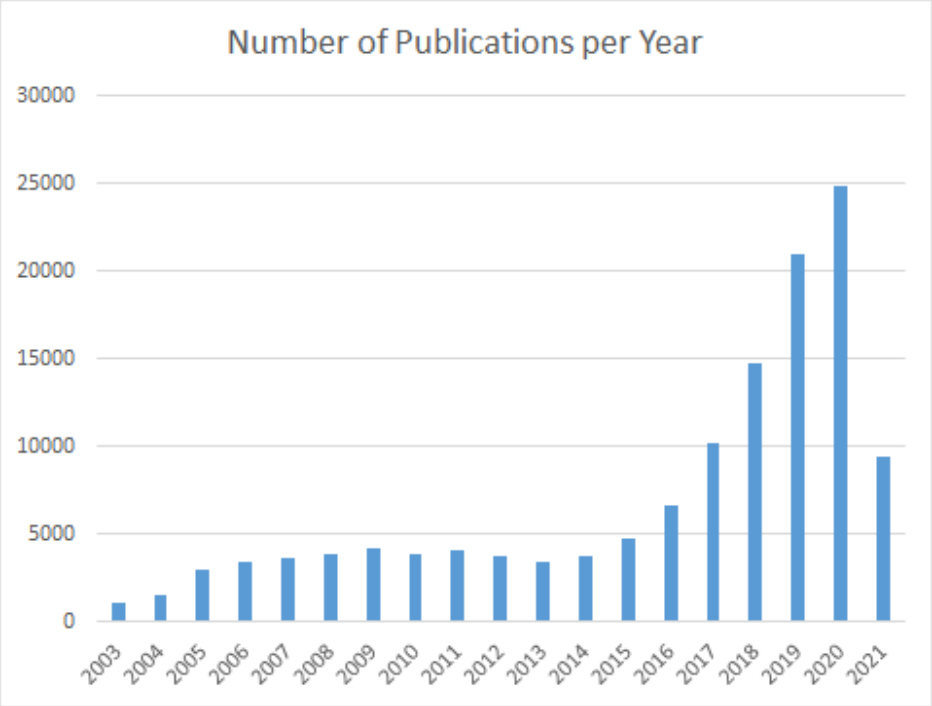


Figure 1: Publications per year on CE

This makes clear that the issue related with the transition to Circular Economy is highly relevant.

It is not only that the number of studies are increasing, but also a very large number of companies show proudly their initiatives towards a more sustainable production. For this reason, on the next section of the thesis the necessity for the implementation of Circular Economy will be explained. Further, in section 4, an more deeply insight in the definition on Circular Economy will be commented.

# 3 Necessity of Circular Economy Transition

## 3.1 Evolution from a Linear Model

The first thought that can come into our minds is why the evolution from the linear economy model into Circular Economy is necessary. The answer can be reduced to two issues: environment and limit of resources.

Following its name, the linear economy model, is based on five consecutive steps: Extract, produce, distribute, use and dispose. In the phase of extraction, raw materials are obtained from the Earth. The materials will then be manufactured and applied in the production process. The product will be distributed to the user for being utilized. And finally the product will be used until it is substituted by a new one or it reaches its obsolesce.

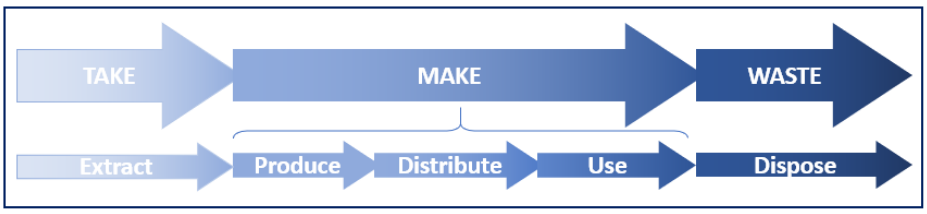


Figure 2: Linear Economy scheme

Closely analyzing this simple description of the linear model, the two issues commented in the beginning of this section can be found. The exploiting of raw materials is clearly related with the finite resources that are at our disposal on Earth, while the environmental impact is related with the phases of manufacturing, distribution and waste of the items.

All the elements in the Earth are thought for being replenished, the planet's ecosystems and nature recreates all the materials that have been used to manufacture our creations. Unfortunately the nature has its own pace, and when the speed of consumption is faster than the speed of regeneration is when the problems appear. The mindset years ago did not conceive this aspect, as the world was finding its way to the capitalization and mass production, where the industrial revolution and fast advances in technology lead to the rapid development of the market with sales growing constantly. But as the experience of the latest years tells this trend cannot last for ever. It is a fact that the level of the seas are rising, temperature all over the world is getting higher and unpredictable and biodiversity is fading away.

To stop this for becoming a bigger problem, it is necessary to create knowledge and favor sustainable means of production and less aggressive markets which don't depend only on the use of raw materials. In order to do

this, the linear model has to be investigated and transformed into a different one. Coming over the phases of the linear model once again it is worth noting that phase of using the product does not raise any harming issues. When a product is being used it is not wasted for a new one and no raw materials need to be extracted again. This is when Circular Economy makes its appearance, with its focus positioned in the reuse.

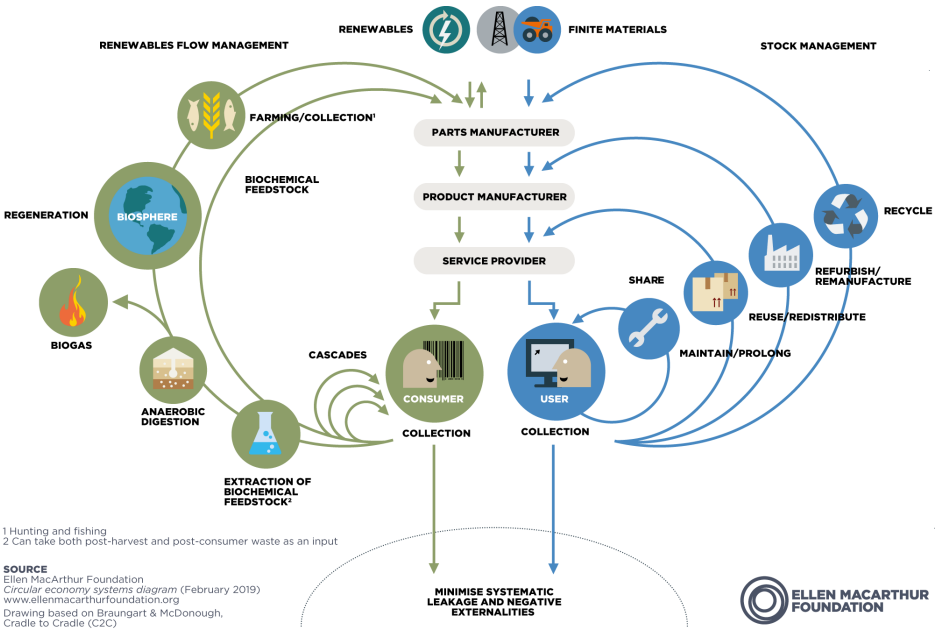


Figure 3: Circular Economy According to the Ellen Mac Arthur Foundation

With a closer look into the 'Figure 3' it is possible to see the two main factors that the CE will affect in order to achieve a sustainable development. This time the image is provided by the Ellen Mac Arthur Foundation, one of the main institutions promoting the transition to CE and it shows a simple and quick look from above of what CE is and how it is possible to achieve it.

## 3.2 Sustainable Development Goals and Material Criticality

It is clear now that the topic in this thesis is in urge and can be crucial to ensure the living quality of the forthcoming years. Governmental institutions, such as United Nations, have shown interest in supporting the fair rights of the workers and sustainable production. This is expressed through the Sustainable Development Goals (SGDs) which supports a transition to a

environmentally friendly growth pattern. The transition requires a quick appearance of emerging technologies that are highly dependent on a stable, adequate and economic supply of materials [4].


Figure 4: United Nations Goals for Sustainable Development

The concept of material criticality appears in this context to identify those materials with great "imbalances between supply and demand"[5]. Nowadays, almost every single person possesses one or even more than one smartphone, not counting on other pieces of technology, this supposes around 50 or more raw materials inside such a small piece of technology. This reveals that a quantification and monitoring of the materials is necessary, as the strategic positioning and economic development of the countries are dependent of it. In consequence, the European Commission (EC) has built the 'Critical Raw Materials List' with the aim of maintaining a strong and reliable industry.

The last list published by the EC was during 2020 and it tells the ambition of decreasing external dependencies and environmental pressures, specifically addressing *"the underlying problem of rapidly increasing global resources demand needs to be addressed by reducing and reusing materials before recycling them"*.

In this context, in the 'Communication COM (2020) 98 final' it is possible to read that the 'enormous appetite' for resources (including energy and food apart from raw materials) is the cause of the environmental issues, responsible for half of the greenhouse gas emissions and over the 90% of biodiversity loss and water stress. Furthermore, it claims to be 'vital' to reach climate

neutrality by 2050.

The 2020 CRMs list contains 30 materials (out of 83 screened in total), three more than the previous 2017 version, and though the aim and research for the making of this list was centered in the European Union member states it can also be used as an example for other members, as well as an outer image for the people and businesses that do not know about it. The mentioned list is now provided, as well as a graphic indicating the countries from where this materials come:

| 2020 Critical Raw Materials (new as compared to 2017 in bold) | | |
|---|---|---|
| Antimony | Hafnium | Phosphorus |
| Baryte | Heavy Rare Earth Elements | Scandium |
| Beryllium | Light Rare Earth Elements | Silicon metal |
| Bismuth | Indium | Tantalum |
| Borate | Magnesium | Tungsten |
| Cobalt | Natural Graphite | Vanadium |
| Coking Coal | Natural Rubber | **Bauxite** |
| Fluorspar | Niobium | **Lithium** |
| Gallium | Platinum Group Metals | **Titanium** |
| Germanium | Phosphate rock | **Strontium** |

Figure 5: List of Critical Raw Materials (CRMs) last iteration in 2020

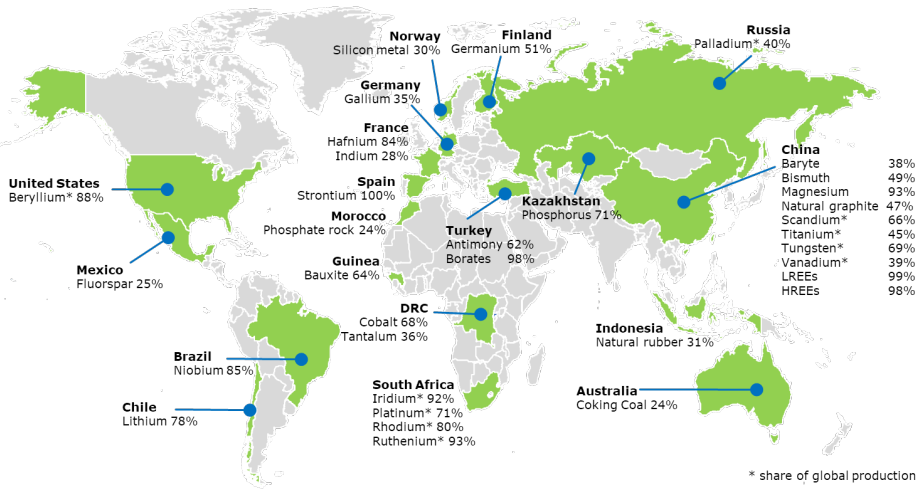


Figure 6: Countries accounting for largest share of EU supply of CRMs

As it is expected the document containing this list not only provides the names of them, but also more details provided in the Annexes.

To highlight even more the necessity for the adoption of a Circular Economy the Organization for the Economic Co-operation and Development (OECD)

forecasts an increase in the demand of metals from 8 to 20 billion tones by 2060, meaning a 150% increase [6].

## 3.3 Waste Management in Micro and Small Enterprises

According to the OECD, an enterprise is defined as *"the smallest combination of legal units that is an organizational unit producing goods or services, which benefits from a certain degree of autonomy"* and in the last entry of its book "Entrepreneurship at a Glance" published in 2017 between the 70% and 95% of all firms are micro-enterprises, leaving the second larger percentage the small sized businesses, as it is possible to see in the next graphic [7]:

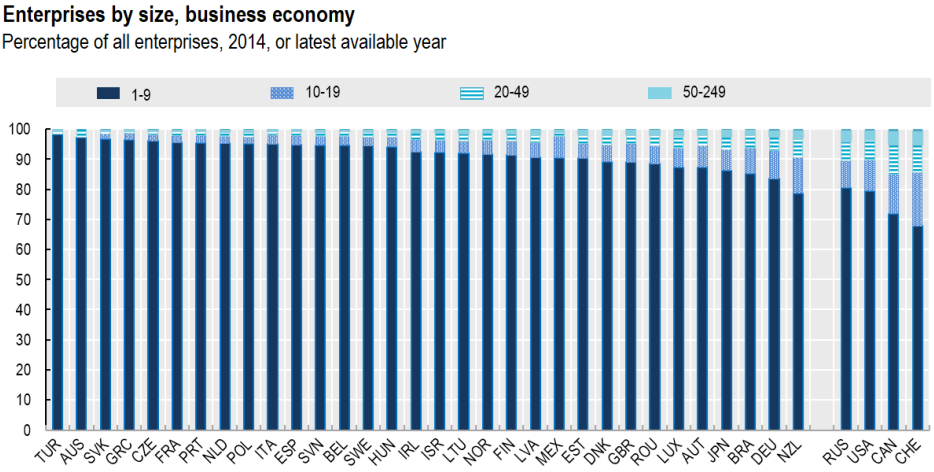


Figure 7: Percentage of enterprises by size

To comprehend the numbers above the actual graphic it is necessary to know how enterprises are organized by size categories [8]:

- Micro enterprises: up to 9 employees
- Small enterprises: between 10 and 49 persons employed
- Medium-sized enterprises: from 50 to 249 persons employed
- Large enterprises: more than 250 employees

Apart from the numbers given above, micro enterprises can be understood as businesses financed by a small loan or microcredit. Usually, they are created in order to improve the welfare of developing countries and add value to local economy. On the other hand, small enterprises are the ones that

operate under a certain threshold of assets and revenue and help creating innovation.

The layout that defines these whole organizations is not as complex as its bigger counterparts and the relation treatment with their customers is closer. Nevertheless, the smaller size or this ventures offers difficulties to acquire expensive and modern equipment and the knowledge inside the organizations is not as wide as in, for example, a large enterprise, as the shorter number of individuals does not easily allow to bring much variety in terms of specialization and points of view [9] [10].

In relation with this and according with some journals, micro and small or medium enterprises can have difficulties optimizing their processes and difficulties evaluating their grade of sustainability. For example, in the manufacturing of fabric, traditional methods tend to waste a great quantity of materials which can represent up to a 60% to 70% of the total costs [11].

Furthermore, as these small businesses are specially common in developing industries, other papers report that the recycling methods used may be harmful towards the environment. Proof of this can be seen in the case of furniture micro enterprises in Turkey, where 96.9% of the exceeding composite waste was burned as heat fuel for home in incomplete combustion conditions [12].

Other studies point out that small enterprises do not appear to put much impetus in the implementation for waste minimisation, as it is the case in the Finnish scenario. In the study performed by Mika Ilomäki and Matti Melanen, 41 Finnish SMEs of different sectors were analyzed, and the result was an augment of waste due to an increase of production. With little cost savings foreseen and and minor environmental motivation the upcoming decisions in the corporation should focus on the image of the company. Therefore the investigations of the company were centered in which were the key aspects for coping with their environmental challenges.

In the conclusion of the article the authors stated that the reason that motivates enterprises to apply environmental management systems is due to the demand by their stakeholders, rather that market opportunities or environmental risks [13].

In summary, after reading the cases presented, it is visible that SMEs and micro enterprises environmental attitude still can be improved. Ecological knowledge must be shared among the employees and enterprises need to face the reality that they function in a world with finite resources and an a fragile ecosystem that needs to be respected. Some of the members inside these institutions are not aware of the current problems or lack the motivation to plan strategies for environmental change.

This is why a free tool consisting in a set of indicators might help the

enterprises raise awareness related with this topic and a clear and simple framework can motivate the decision making process in the right direction. Furthermore, to narrow the focus of the project the indicators will prioritize the mentioned micro and small enterprises, which still have a lot of room for improvement, and contrarily to bigger enterprises do not receive the same attention by other institutions.

# 4 Exploration on the Circular Economy Meaning

The Circular Economy has been defined by many different authors since it first appeared, what lead to the finding of up to 114 definitions by the end of 2017 [14]. These definitions were not always created ad hoc, as the term was usually described inside reports with a certain focus, or developed following the models of different kinds of enterprises. As a result, a wide variety of terms are utilized for each time the CE is defined.

Due to this, many authors have stated that consensus over a final meaning of the term is unreachable ([14];[15];[16]). Yet, after looking through many bibliography and counting on the history of the concept it is possible to see that the Circular Economy is an umbrella concept that keeps evolving as the time goes by. A Circular Economy per se and without considering the context is a simple concept that auto-defines itself thanks to the word 'circular'. Circularity means to 'close the loop', to stop using 'new' and motivate the reuse. But it is when we look at the surroundings of applying for a Circular Economy transition that we realize closing the loop has many variables that will affect it. Efficiency is hard to obtain and the reality is that materials don't have an infinite life so the research on closing this loop has to be permanent to keep it updated, and this means including new perspectives.

The conclusion after this is that Circular Economy is a vast term, that even if it could be defined in the least amount of words possible, its implications would still affect many other aspects of the environment and life. It is when a set of indicators have to be made that the Circular Economy is really being defined, as the objective is to comprehend every aspect it covers in order to evaluate and achieve it. Some aspects relevant for the creation of these indicators will be presented along this chapter.

## 4.1 Circular Economy and the 'R' Framework

The well-known R framework refers to the different circular strategies during the production chain, called like that because the name of all of the starts with the letter R. During the years this framework has been expanding, as it started with the 3R rule consisted only of the group 'Recycle, Reuse and Reduce', and today it is possible to find up to 9 Rs.

The reason for this change is the same as the one commented soon before with CE, as the topic was gaining more fame and getting more investigated, deeper studies remarked the necessity of a major definition of the item. In consequence, Recover was added to the group, the fourth R referred to the

recovery of those materials that reach the end of their life and are used for producing energy by burning them. Then other authors started adding new circular activities to the group, but out of all, Potting presented the 9R perspective, visible in the following figure, extracted from bibliography [17].

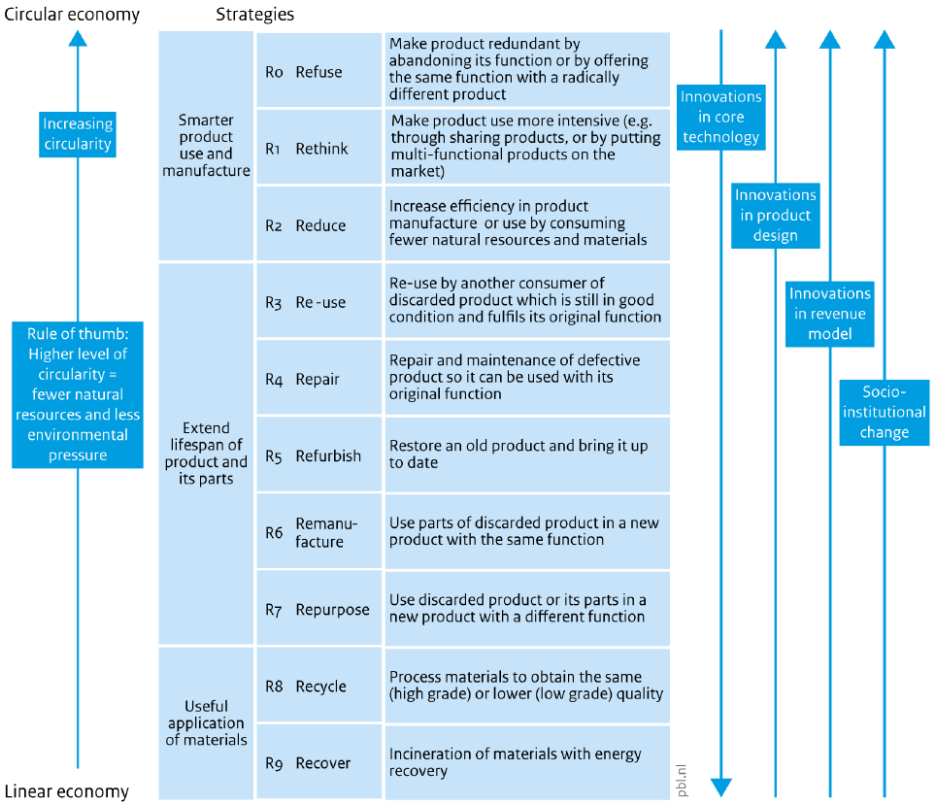


Figure 8: 9R framework in Circular Economy [17]

Potting differentiates the categories and dissects them to make the public understand where the main improvements have to be made to reach the better grade in a certain R category. In the same work it is also claimed that along with innovation, CE requires socio-cultural change in order to be implemented. Further in the section the meaning of both of them will be related with CE.

## 4.2 Circular Economy relation with Environmental Quality and Sustainability

In the work published by Martin Geissdoerfer [2] it is stated that, even both sustainability and Circular Economy are two strategies after which companies

and policymakers are studying, their relation has been understudied. Other papers that have studied the definition of Circular Economy advise that its link to sustainable development is weak, like in the case of Kirchherr [14]. However, this second study states this due to the few times that both terms appeared defined and linked together in the same document. This lead to the conclusion that there is still room to create new projects linking both concepts.

In this regard, and after reading all the bibliography presented for this thesis, notwithstanding Circular Economy and sustainability may not have been explicitly linked or related they always appear together in the same document. Attending to this fact it is clear that a relation exists. Following the work of Geissdoerfer, focused completely on the relation of both topics, even a list of similarities is given. The list is presented now, as it shows many different aspects of the Circular Economy that can be useful to understand the indicators presented beyond this section [2]:

- Intra and intergenerational commitments
- More agency for the multiple and coexisting pathways of development
- Global models
- Integrating non-economic aspects into development
- System change/design and innovation at the core
- Multi-/interdisciplinary research field
- Potential cost, risk, diversification, value co-creation opportunities
- Cooperation of different stakeholders necessary
- Regulation and incentives as core implementation tools
- Central role of private business, due to resources and capabilities
- Business model innovation as a key for industry transformation
- Technological solutions are important but often pose implementation problems

Environmental quality is dependent on Circular Economy, the reuse and recycling processes and self-renewal of the ecosystems are the only way to achieve it, leaving economic growth as a secondary tool as it cannot improve or maintain environmental quality by itself [18].

## 4.3 Circular Economy and Economic Prosperity

The Circular Economy can be also understood as a tool capable of bringing economic growth to those corporations that implement it right. Because of this numerous articles make a reference on how it can result in an economic benefit for enterprises while developing their environmental performance. Furthermore, other sources like the Ellen Mac Arthur Foundation [19] or the United Nations Environment Programme, consider the Circular Economy a necessity to maintain the economic output.

From the perspective of the world reaching the resource limitations and environmental problems, since the supply chain of the enterprises will be harder to maintain if there is a lack of goods and the prices will grow. Competitiveness will be achieved by bringing the most circular methods to the processes of the enterprise, if the priorities are aligned with this perspective. In the future, the economic status of an enterprise shall stay improved or unaffected, due to the early implementation of Circular Economy.

## 4.4 Social Factor in a Circular Economy

It is common to find in literature references how Circular Economy affects the social environment. The innovations and mission it brings to the corporations sends a message of awareness about how the supply of materials can suffer drastic changes and to explain why this is happening. It is mandatory to reference the actual situation, this means highlighting the environmental issues and blaming them on jeopardizing trends like the fast fashion, which promote the overconsumption and quick design to satisfy a growing and increasingly demanding market. This awareness not only raises the concern about the environment but also about social aspects, that now have being taken into consideration.

The classical tools and metric on circular environment had been focused on achieving economic goals and environmental efficiency leaving social gains aside. Although to achieve the full Circular Economy the mindset of the people requires a change, and when the objective to accomplish consists in paying respect to such a considerable problem, it is worth mentioning those characteristics favorable to a good cause, such as social equity and welfare state.

In the 2020 work of Padilla a framework is proposed for those areas that define the social dimension affected by CE:

| Thematic Areas * | Labor Practices and Decent Work | Human Rights | Society | Product Responsibility |
|---|---|---|---|---|
| Social Aspects | 1. Employment<br>2. Labor/Management Relations<br>3. Occupational Health and Safety<br>4. Training and Education<br>5. Diversity and Equal Opportunity<br>6. Fair distribution of income<br>7. Quality and Well-being | 8. Investment<br>9. Non-discrimination<br>10. Freedom of Association and Collection Bargaining<br>11. Child Labor<br>12. Forced or Compulsory Labor<br>13. Security Practices<br>14. Human Rights Mechanisms | 15. Social inclusion (equity)<br>16. Social networks<br>17. Social cohesion<br>18. Participation and Local Democracy<br>19. Anti-corruption<br>20. Public Policy<br>21. Compliance<br>22. Supplier Assessment for Impacts on Society<br>23. Cultural Traditions<br>24. Tourism and Recreation<br>25. Local Communities (Sense of community and belonging) | 26. Customer Health and Safety<br>27. Product and Service Labelling<br>28. Marketing Communications<br>29. Costumer Privacy<br>30. Compliance<br>31. Anti-competitive behavior |

Figure 9: Areas of the Social Dimension Areas affected by a Circular Economy [20]

From this areas the ones more frequently referred on academic papers are: Employment, Quality and Well-Being, Social Equity; Social Networks, Local Communities, Social Cohesion and Participation and Local Democracy [20].

This considered the most relevant social characteristics, as they are the ones that appear the most in papers can be useful towards understanding how Circular Economy works, how it affects society and therefore useful on how to build indicators that are agreed and understood by everyone.

In this regard and as a conclusion for this part of the chapter is worth mentioning the concept for Corporate Social Responsibility (CSR), defined by Esken [21] as:

*"[...] a concept embedded in the idea of sustainable development which embraces all those actions, operations and initiatives by businesses that contribute to an improvement of social and environmental issues by voluntarily going beyond the corporations' legal obligations. Such undertakings have to be in line with the businesses' legal, ethical and philanthropic responsibilities, besides the given economic ones. Thereby, they have to reflect the needs and interests of all their relevant stakeholders, including customers, employees, investors, the general community and the environment."*

In this context, the adoption of CE by the enterprises and participation in social welfare activities is partially justified by CSR. The stakeholder perspective does not approach anymore just from the strategic point of view, but now it can be interpreted a shareholder value perspective, strongly focusing on the environment and social welfare. [22]

## 4.5 Industrial Ecosystem in a Circular Economy

According to the Oxford Languages dictionary: *"an ecosystem is a biological community of interacting organisms and their physical environment"*, and translated to the case that occupies in this project, the name refers to all how

a company works internally as well as how each different company interacts with each other. It is obvious that companies affect each other, either because they work together or because they are competitors. In any case, for Circular Economy to properly function all participants in the ecosystem need to adapt to it.

Two development areas are found to be open for change in order to achieve a circular ecosystem. The first area is the need for enterprises to convince old and new partners to adopt a circular business model. Meanwhile the second refers to the adoption of the circular business model an enterprise itself.

When a company wants to promote the change in this regard one of the first realizations is that they need to operate with the maximum efficiency possible, this means having a good relation ship with all the allied corporations that support their production. As a consequence, if the objective is to pursue a more sustainable chain of production, those corporations that participate on it will require to adopt the same attitude and align their objectives. Therefore, there is the responsibility by the business to entice close organizations to embrace the transition towards Circular Economy.

When a business part of the environment is changing their business model and motivating its associates to do the same it may cause other enterprises to think about similar strategies. In case this happens then all the environment will start changing, spreading the circular business models over the older linear one.

When it comes to adapt the current organizational model into circularity the main factor is to completely understand what this transition means. One of the proposed solutions for installing the right model is to offer a service-based business model [23]. In this setting it is the manufacturer who still owns the product, making the customer pay according to the time of use. The main advantage of a service is that the own manufacturing company is in charge of the lifespan of the product and can ensure its use until the end of its life, or in case the customer releases it do the proper reparations or refurbishment.

In summary, to achieve the desired industrial ecosystem it is necessary to adopt certain mechanisms, being the basis of all of them the transparency. Enterprises need to comprehend the model that they want to acquire and transmit it to close corporations. The development of standards, use of software for knowledge sharing and negotiation mechanisms must to continue improving and provide the right tools to communicate, detect innovative technological trends and markets and have openness in cooperation.

## 4.6 Innovation in a Circular Economy

As it has been said before, Circular Economy is a concept that keeps evolving as time goes by and new technological advances appear. For this reason, and because efficiency in processes is crucial during a Circular Economy, it will be highly important to keep up with the latest advances in the market and never stop working on research and continuous improvement.

### 4.6.1 Industry 4.0

Industry 4.0 is name that refers to the fourth industrial revolution, consisting of the combination of classical production with information analysis to make it more efficient using techniques like big data, machine learning and smart technology. Because the intention of the Industry 4.0 is to make more efficient the supply chain and optimize manufacturing it is compatible with the perspective of Circular Economy. For this reason it is considered in this paper, to understand better the relation between both terms and study industry 4.0 in case it might be useful to develop Circular Economy indicators.

Joining Industry 4.0 techniques and Circular Economy can result in an improved model of recycling waste and new product delivering. According to [24], it is possible to use 3D printing techniques to process waste and states that implementation of industry 4.0 along with CE in local business networks can help generating local jobs.

In accordance with other articles, scientific community should find new opportunities inside the Industry 4.0 which may contribute to identify new sustainable paths. Mathematical tools and computer optimization models can support the decision making process and achieve industrial symbiosis. Big data can also facilitate the communication between enterprises and favor trust, culture and corporate behavior [25]. Industry 4.0 will permit the monitoring of performance and energy and waste recovery. It will as well allow predictive maintenance and improved reliability and flexibility, modularity and problem solving. [26]

### 4.6.2 Lean Manufacturing

Lean manufacturing defines waste as something with no aggregated value for the customer. As a result, lean strategies tend to plan sustainable supply chains, including eco-innovation and eco-design to minimize the waste [27].

Due to this, lean manufacturing is considered to contribute effectively to the Circular Economy and the information in its regard can be useful as an insight to develop Circular Economy bibliometric analysis with more specific and detailed.

## 4.7 Conclusion and Final Thoughts

After the research of CE external definitions and gathering of knowledge of topics related with it the conclusion is that Circular Economy is defined many times, sometimes according to the purpose of each project, sometimes following the inherent meaning of both words "circular" and "economy" put together.

The most complete definition is the one given in the work of Prieto-Sandoval, in which after the analysis of 114 definitions and related topics, it proposes: *"Circular Economy as an economic system that represents a change of paradigm in the way that human society is interrelated with nature and aims to prevent the depletion of resources, close energy and materials loops, and facilitate sustainable development through its implementation at the micro (enterprises and consumers), meso (economic agents integrated in symbiosis) and macro (city, regions and governments) levels. Attaining this circular model requires cyclical and regenerative environmental innovations in the way society legislates, produces and consumes"* [15]. On the other hand, the shorter definition and the one most commonly found on literature comes by the hand of the EMF and reads as follows: *"A framework for an economy that is restorative and regenerative by design"* [19].

Not only enterprises like the Ellen MacArthur Foundation or scholars are the ones writing definitions for the CE, but also governmental institutions. The European Union defines the Circular Economy as *"The Circular Economy is one in which waste materials and products are reused and recycled within the production and consumption system. It is the better use of waste for new materials."*[28] inside the Raw Materials Information System (RMIS) section of the EU Science Hub portal.

Practically all the definitions are correct, ones being more complete and complex while the others shorter and easier to understand. Nevertheless, as complete as the previous definition was it can only work to give an idea of what CE is, but it doesn't reflect all the parts that exist inside the topic. According to Oxford Languages, a definition is *"an exact statement or description of the nature, scope, or meaning of something"* and due to CE being a growing umbrella concept discussing about what definition is better leads nowhere. This statement is supported by multitude of papers in which at the beginning of those advert of the lack of consensus among the academics and professionals that define term, some of the calling it a *"conceptual deadlock"* [14] or others alleging that *"now we have developed so many indicators that we are having to ask ourselves, what exactly are we measuring"* [29].

In conclusion, for this thesis the intention is not to bring a definitive solution to the concept but rather providing a description of all the topics seen

before, and that can help establishing a framework with indicators capable of designating the progress made in its regard. As a result, the list of topics can be modified, and as new trends or innovative technologies appear, or the current ones are improved, it will be easy to modify or add any of the given items. This is thought to be the best strategic approach, as the ramifications of concepts may grow and the industry advances at great speed, forcing the enterprises to be dynamic, do not anchor themselves in a specific working manner, and bet for the renewal and innovation.

# 5 Research on Existing Circular Economy indicators

Due to the expansion of literature involving Circular Economy, many works now analyze the indicators that exist up to date. These analysis consist of a categorisation of the indicators, a taxonomy that shows the different aspects to measure and what tools are used for this purpose. For this reason, and to give some background to the proposal that will be done in the next chapter, along this section the mentioned indicators are presented as well as the framework inside they can be classified and techniques used for them to indicate or measure.

## 5.1 Framework and Useful Characteristics to Identify Indicators

This first part will consist in a description of different properties to help identify CE indicators. It will consist on a set of characteristics that define CE aspects and also cover other tendencies that can be related with CE. The intention is to aid in the understand of existing CE indicators while helping to identify new ones in the future.

### 5.1.1 United Nations Sustainable Development Goals

Some may argue that Circular Economy does not intrinsically comprehend social factors such as the working conditions, gender equality, etc. But as it has been stated before, during the development of this thesis it is not the purpose to narrow the focus of the concept, but contrarily, widen it. Circular Economy made its appearance due to the necessity for the environmental change, the resources of the planet are depleting and the constant grow of the population and highly exigency of the customers are the causes that impulsed the movement towards a cleaner and circular production. Noticing what has just been said it is possible to identify that the people is the reason that humanity is where it is right now. favoring a good cause can only be achieved by implementing a good behavior in the worldwide population, this meaning not only the consumers in developed countries, but also those living in the developing ones. Acquisition may not be that easy for everyone, and this is due to the different laws of every country, that affect directly on the working conditions of the employees.

Prosecuting equality and human rights is, without a doubt, a common objective. In consequence, the United Nations published the Sustainable De-

velopment Goals which *"are the world's shared plan to end extreme poverty, reduce inequality, and protect the planet by 2030"* [30]. All the goals were depicted in the 'Figure 4', and even though they do not make any explicit action or goal referring the use of raw materials it can directly affect all of them. In the previously mentioned EU Science Hub it is possible to find the following image:

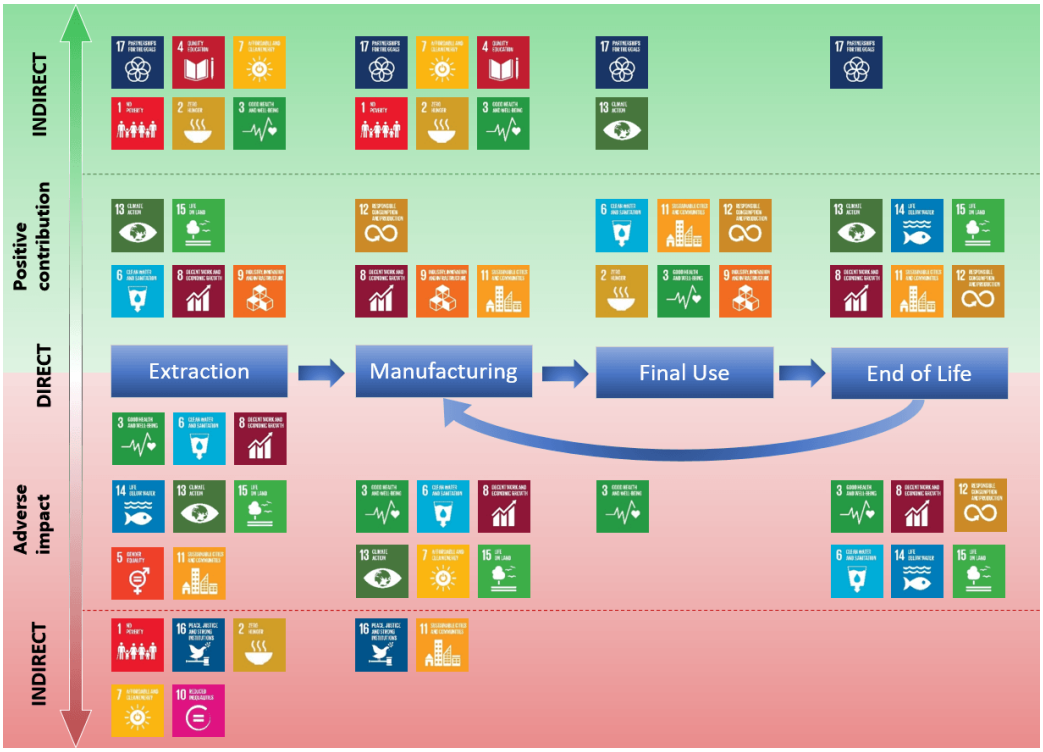


Figure 10: Supply Chain of Raw Materials with SDGs per Phase [28]

The 'Figure 10' tells those goals inside the European sustainable development framework that affect the supply chain of raw materials. It points out how each phase can have either positive or adverse impact on the different goals set by the United Nations. Nevertheless, the interest of the figure remains on the appearance of circular economy by the arrow that goes back from the 'End of Life' to the 'Manufacturing' phase, and in consequence indicating the Sustainable Development Goals that have more relation with those stages. These goals can be taken into account when developing or studying a set of indicators to evaluate circular economy.

### 5.1.2 9Rs and Diagnostic Questions to Measure CE

As seen previously during this thesis in the work of Potting, Hekkel, Worrel and Hanemaaijer [17], there is the description of nine 'Rs' referring to the different stages that are possible to find during the life cycle of a material. According to the introduction of their work *'the study focuses in on identifying what needs to be measured'* and intends to build a framework on CE, then granting a mention in this part of the present thesis. The work made by this group has been highly resounding, appearing numerous citations among other bibliography studied on the subject, and it is that a exceptionally useful classification is made. The 9 stages offer a logical and wide variety of phases that can be easier analyzed in comparison with the 3Rs and allow the classification or deduction of new or existing indicators in such categories. These 9Rs were shown previously in the 'Figure 8' and in the next picture they are put in the context of a manufacturing process from the point of view of the author:

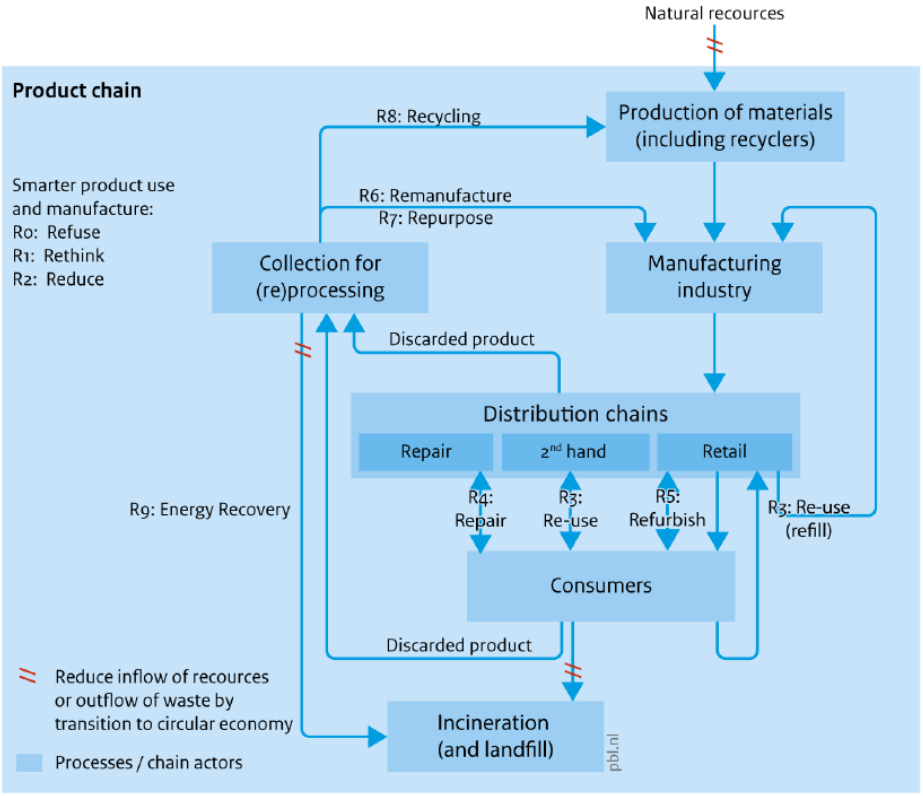


Figure 11: 'Circularity strategies and the role of actor within the production chain' [17]

This last image can aid fulfilling the purpose of framing the indicators for measuring circular economy implementations and their effects on the different phases inside the product Life Cycle.

Further ahead in their work it is possible to find a set of diagnostic question divided in 4 different groups that were planned to measure the progress in the transition to the Circular Economy:

**Means:**

- Mobilisation of means
- Knowledge development

**Activities:**

- Knowledge exchange
- Experimenting by entrepreneurs
- Giving direction to search
- Opening markets
- Overcoming resistance

**Achievements:**

- CE design
- Production
- Consumption
- Waste

**Effects:**

- Circularity
- Environment
- Economy

This questions can support the elaboration of a preliminary questionnaire that can give a quick image of how a corporation is dealing with the transition to circular economy. It potentially can provide useful and direct information that everyone could understand as well as dissecting in categories the different strategies used to achieve circularity, which can lead to a simpler identification of different perspectives on how to act.

### 5.1.3 Similarities between Sustainability and Circular Economy

Undoubtedly Circular Economy and Sustainability are aspects intimately close. In consequence, it is worth studying both together, in case some aspects of the sustainability evaluation can support the assessment on Circular Economy as well.

In the paper by M. Geissdoerfer [2] a relation between the two terms is presented and a list highlighting their similarities is shared:

- Intra and intergenerational commitments
- More agency for the multiple and coexisting pathways of development
- Global models
- Integrating non-economic aspects into development
- System change/design and innovation at the core
- Multi-/interdisciplinary research field
- Potential cost, risk, diversification, value co-creation opportunities
- Cooperation of different stakeholders necessary
- Regulation and incentives as core implementation tools
- Central role of private business, due to resources and capabilities
- Business model innovation as a key for industry transformation
- Technological solutions are important but often pose implementation problem

It is important to say that even though Geissdoerfer counts with an analysis of the risks, during the present study they will not be taken into account due to being out of the purpose of assessing the grade of CE implementation.

### 5.1.4 Connection between Industry 4.0 and Circular Economy

The industry 4.0 has come a long way until the current times and it shares a main characteristic with the CE, which is that both are still being developed. Furthermore, they are also linked, as it was possible to observe in the previous or other sections, due to the necessity for Circular Economy to bring the latest technologies and innovation in order to achieve always the best results and maintain a constant improvement.

Another list of related terms are extracted from literature to support the study of the indicators that will be done later. This time from the work of Shubhangini Rajput[26], a number of factors connecting Industry 4.0 and the Circular Economy is offered:

- Reliability: ability to work together with different technologies and still work.
- Scalability: ability to improve or update the the system.
- Modularity.
- Quality of Service.
- Integration and interoperability: robustness of the system.
- Self-organization and adaption: allowance and ease to monitor.
- Predictive Maintenance and Recovery: ability to detect errors and address them for reparation.
- Flexibility: adaptability of the response in front of different situations.
- Consumer Internet of Things (CIoT): Applications that drive consumer Responsibility.
- Block chain: maintenance of immutable information of a product throughout the whole supply chain.
- Laws and Policies.
- Infrastructures of the Corporation.
- Product Service System: ability to reduce environmental impact.
- Functional Service Economy: optimisation of the resource management.
- Energy Internet of Things: ability to monitor variables in real time information systems
- Energy Recovery.
- Waste Recovery.
- Cloud Manufacturing: high demand usage of manufacturing resources.

- Big Data: Capacity to store, manage and analyse great quantities of data and enhance supply chain.
- Cyber-Physiscal Production System (CPPS): communication link between machines and products
- Collaborative Robotics: interaction between humans. and robots during production in order to achieve accuracy and higher quality.

All of these items provide a segmented view of some innovative aspects, fe. Cloud Manufacturing, CIoT etc. Counting on what previous statements assumed, the use of innovation is really necessary to achieve the best result possible of the CE in a corporation. It is become clearer that the use of internet in the industry can provide great benefits, delivering real time monitoring of processes, quick analysis of vast quantities of data and better communication and possibilities to delegate part of a manufacturing process to other more efficient businesses. Using internet as a tool allows improving efficiency, having less work or giving more time to concentrate better in other specialized tasks and saving money.

## 5.2 Current Circular Economy Indicators

The previous characteristics assist the understanding of Circular Economy and other aspects related with the topic. Eventually, it is possible to create an image of what are the aspects that compose CE and can be evaluated.

An indicator is a well defined attribute or quality of a bigger concept that allows the evaluation of that certain characteristic by using a measuring tool that concludes with an precise and useful result. With a set of indicators it is possible to fully quantify the progress in the development of a complex concept. In order to guarantee the efficacy of the method the indicators must be diverse, unique and kindred. This means that each one of them has to evaluate an individual aspect so when they join there is no conflict or confusion due to overlap of study subjects, and additionally have to be compelling and comprehend the totality of the concept.

Creating indicators is not simple, fist of all they require knowledge about the topic they will evaluate, then some indicators might be created for specific environments or industries and it is important to know the tools used to measure. This process can be understood as iterative, as new indicators may appear every time a new study is developed.

In this chapter, the revision of external bibliography will continue with the intention to gather and display existing Circular Economy indicators. As it has been stated before CE is growing, new studies are published, and

therefore an overload of information can lead to confusion. Consequently, this section features the circular indicators that are being used currently and intends to understand how they measure CE so in the next chapter they can be analyzed and bring improvements or new indicators in case of being necessary.

### 5.2.1 Governmental Institutions Indicators

The Circular Economy has reached the interest of the many governments. Main producers and manufacturer countries have realized that not adapting measures against the depleting of materials and deterioration of the environment can affect heavily the market and jeopardize their supply chain. This pushed countries inside the OECD and China to take measures to build an ecological civilisation [31] and, in consequence, creating new policies and methods to measure and allow the evaluation of sustainability and pollution for the economic participants.

Regarding the measurement of Circular Economy, the European Union developed a monitoring framework that comprehends a variety of indicators classified inside four areas. These indicators have public access and can be easily reached in the Eurostat section of the European Commission web page and besides the mentioned indicators it is possible to encounter additional information about them as well as the trends and performances of some of them. However, a summary table regarding the indicators is given in order to show what they are based on:

| Group | Nº | Indicator |
|---|---|---|
| **Production and Consumption** | 1 | EU self-sufficiency for raw materials (percentage) |
| | 2 | Green Public Procurement |
| | 3 | Generation of municipal waste per capita Kg per capita) |
| | 4 | Generation of waste excluding major mineral wastes per GDP unit (Kg per thousand euro, chain linked volumes (2010)) |

| | | |
|---|---|---|
| | 5 | Generation of waste excluding major mineral wastes per domestic material consumption (percentage) |
| | 6 | Food waste (million tonne) |
| **Waste Management** | 7 | Recycling rate of municipal waste (percentage) |
| | 8 | Recycling rate of all waste excluding major mineral waste (percentage) |
| | 9 | Recycling rate of overall packaging (percentage) |
| | 10 | Recycling rate of overall packaging (percentage) |
| | 11 | Recycling rate of plastic packaging (percentage) |
| | 12 | Recycling rate of wooden packaging (percentage) |
| | 13 | Recycling rate of e-waste (percentage) |
| | 14 | Recycling of biowaste (kg per capita) |
| | 15 | Recovery rate of construction and demolition waste (percentage) |
| **Secondary Raw Materials** | 16 | End-of-life recycling input rates (EOL-RIR) (percentage) |
| | 17 | Circular material use rate (percentage) |

| | | |
|---|---|---|
| | 18 | Imports from non-EU countries |
| | 19 | Exports to non-EU countries |
| | 20 | Intra EU trade |
| **Competitiveness and Innovation** | 21 | Gross investment in tangible goods (percentage of gross domestic product (GDP) at current prices) |
| | 22 | Persons employed (percentage of total employment) |
| | 23 | Value added at factor cost (percentage of gross domestic product (GDP) at current prices) |
| | 24 | Number of patents related to recycling and secondary raw materials |

So far, the indicators provided result of great help as they are supported by complementary information in the Eurostat web page. This supplementary data contains instructions on how the measurement of each certain characteristic is realized in addition with the current standards of the parameter according to the different countries of the European Union.

The utility of this information is clear, as it can provide specific numbers that a micro or small business can easily understand and take as a figure to maintain or improve, as well as the tool instructions and tool to implement in order to evaluate each parameter.

Together with the last statement and returning to the link between the OECD countries and China in the collaboration for sustainable development an organization was created to work together for achieving the common goal. The project receives the name of *'Sino-European Circular Economy and Resource Efficiency' (SINCERE)* and following the information given in their home web page it aims to *'develop new economic tool to understand the resource use patterns of China and the EU'* by addressing metrics, indicators and historical patterns.

The contents of the web do not match the organization of the ones given by the Eurostat, not offering a list of indicators to follow. However, it still can be useful, as it contains some collaborative publications between European

and Chinese researchers that publish numbers referring different parameters related with consumption of raw materials and can make reference or additions to existing or faulting indicators.

After all,it has been possible to identify indicators given by the EU that already provide a framework useful to evaluate Circular Economy. Nevertheless, as it was described before CE is an umbrella concept, with a variety of aspects that affect it and many new indicators and metrics can be proposed for its analysis. In this regard, the following part of the project will explore more indicators found in external bibliography.

### 5.2.2 Collection of Article Indicators

Many different indicators have been created for specific projects and, in consequence, some papers are dedicated to collect these indicators from the different sources and join them in different conglomerates of a framework.

This is mostly visible in the work by Michael Saidani, Bernard Yannou, Yann Leroy, François Cluz and Alissa Kendall titled *"A taxonomy of Circular Economy Indicators"*, which after the analysis of 327 articles proposes a classification of 55 sets of Circular Economy indicators [32]. The items of the list are proposed in the following table:

| **Nº** | **Name of CE indicator and Abreviation** | **Nº** | **Name of CE indicator and Abreviation** |
|---|---|---|---|
| 1 | Assessing Circular Trade-offs (ACT) | 29 | Evaluation of Regional Circular Economy (ERCE) |
| 2 | Building Circularity Indicators (BCI) | 30 | Eco-efficient Value Ratio (EVR) |
| 3 | Material Reutilization Part (C2C) | 31 | Economy-Wide Material Flow Analysis (EWMFA) |
| 4 | Circle Assessment (CA) | 32 | Five Category Index Method (FCIM) |
| 5 | Circularity Assessment Tool (CAT) | 33 | Hybrid LCA Model (HLCAM) |
| 6 | Circular Benefits Tool (CBT) | 34 | Indicators for Consumption for CE in Europe (ICCEE) |

| | | | |
|---|---|---|---|
| 7 | Circularity Calculator (CC) | 35 | Circularity Indicator Project (ICT) |
| 8 | Circular Economy Company Assessment Criteria (CECAC) | 36 | Indicators for Eco-design for CE in Europe (IECEE) |
| 9 | Circular Economy Index (CEI) | 37 | Indicators of Economic Circularity in France (IECF) |
| 10 | Circular Economy Indicators for India (CEII) | 38 | Integrative Evaluation on the Development of CE (IEDCE) |
| 11 | Circular Economy Indicator Prototype (CEIP) | 39 | Input-Output Balance Sheet (IOBS) |
| 12 | Circular Economy Monitoring Framework (CEMF) | 40 | Indicators for Production for CE in Europe (IPCEE) |
| 13 | Circular Economy Performance Indicator (CEPI) | 41 | Industrial Park Circular Economy Indicator System (IPCEIS) |
| 14 | Circular Economy Toolkit (CET) | 42 | Material Circularity Indicator (MCI) |
| 15 | Circular Economy Toolbox US (CETUS) | 43 | Measuring Regional CEeEco-Innovation (MRCEEI) |
| 16 | Circular Economic Value (CEV) | 44 | National Circular Economy Indicator System (NCEIS) |
| 17 | Circularity Index (CI) | 45 | Product-Level Circularity Metric (PCM) |
| 18 | Circular Impacts Project EU (CIPEU) | 46 | Regional Circular Economy Development Index (RCEDI) |
| 19 | Circularity Material Cycles (CIRC) | 47 | Resource Duration Indicator (RDI) |
| 20 | Closed Loop Calculator (CLC) | 48 | EU Resource Efficiency Scoreboard (RES) |
| 21 | Circular Pathfinder (CP) | 49 | Recycling Indices (RIs) |
| 22 | Circularity Potential Indicator (CPI) | 50 | Resource Productivity (RP) |

| | | | |
|---|---|---|---|
| 23 | Data Envelopment Analysis Model (DEA) | 51 | RPI Reuse Potential Indicator (RPI) |
| 24 | Evaluation of CE Development in Cities (ECEDC) | 52 | Recycling Rates (RRs) |
| 25 | Evaluation Indicator System of Circular Economy (EISCE) | 53 | Sustainable Circular Index (SCI) |
| 26 | Indicators for Material input for CE in Europe (IMCEE) | 54 | Value-based Resource Efficiency (VRE) |
| 27 | End-of-Life Recycling Rates (EoL-RRs) | 55 | Zero Waste Index (ZWI) |
| 28 | Environmental Protection Indicators (EPICE) | | |

Notice how indicators attend diverse qualities and, as a result, may utilize different measure parameters than the rest. For instance, the CEI is proposed as a single indicator to estimate the circularity of a product [33] meanwhile the ZWI measures how the use of virgin materials can compensated by the use of waste management systems [34].

It is a must to know the existence of these indicators in order to properly evaluate the processes inside a business, distinguishing which are the ones that can provide the most accurate measure of all the processes performed.

In the same line as the last article commented, the article *"Circular economy indicators: What do they measure?"* provides a collection of Circular Economy indicators for the micro-scale, aspect that in Saidani's work was stated lacked some research. The following table shows the CE indicators that have not been featured in the previous work [35] :

| Nº | Name of CE indicator and Abreviation |
|---|---|
| 1 | ease of Dissassembly Metric (eDIM) |
| 2 | old scrap Collection Rate (CR) |
| 3 | Recycling Input Rate (RIR) |
| 4 | Old Scrap Ratio (OSR) |
| 5 | Longevity |
| 6 | Total Restored Products (TRP) |
| 7 | Lifetime of Materials on Anthroposphere (LMA) |
| 8 | Displacement |
| 9 | Global Resource Indicator (GRI) |

With all the indicators given it is possible to create an idea of some of the aspects that are measured using them. Nonetheless, the task of knowing exactly in which context it is correct to use any of the indicators seen is complex. Due to this both of the mentioned articles make a classification of the indicators shown, to recognize up to which extent (depending on the micro, meso or macro-scale) they allow to be used and inside which groups they can be categorized, in order to provide the righteous results according to the processes that they analyzed (ie. Environmental impact, raw materials consumption, energy or water management etc.).

In further chapters of the work the indicators will be applied for the case of micro and small businesses, but before it will be necessary to explain the different techniques that allow the indicators to *'indicate'*, namely, the tools that allow the measurement and guarantee their objectiveness.

## 5.3 Measuring Techniques and Assessment Tools

To better understand the indicators featured in the previous section it is necessary to know which are the possible tools that exist to measure them. This part of the chapter will facilitate the information necessary of the methods or tools that currently are used in the evaluation of the CE indicators.

### 5.3.1 Material Flow Analysis (MFA)

Among all the bibliography revised the MFA is mentioned in all of the papers as it is the main method to assess environmental sustainability. The method comprises every characteristic involved in the supply chain of a business, taking into account the inputs and outputs of materials, use of energy and management of stocks.

The method is not created exclusively for the CE assessment. All enterprises need to know the amount of materials needed in order to adapt

their production to the demands, therefore the MFA is an accounting tool that provides all the information required in this regard. Particularly, the quantification of resources used that offers the MFA is exceptionally apt for the CE evaluation regarding the consumption of raw materials, as well as information about the origin of other materials used, destination of waste generated and recycled materials.

In summary the MFA deals with the uncertainty in resources used and gives a clear image of the use of resources in business. This result, as it was possible to observe in the point 5.2.1, is usable as indicator for the Circular Economy. Metrics of energy and materials given in the corresponding normalized and usual units allow the easy analysis and comparison of an enterprise with industry standards and, in consequence, favoring the CE bringing measures to relevant aspects.

The measure performed by the Material Flow Analysis can result exceptionally complex when it comes to big enterprises and software can be found to ease this task. To be able to run the analysis a deep understanding of the systems is necessary. Despite the software being interactive the first phases can be designed in a paper sheet, afterwards the information introduced will be processed using mathematical formulas and other tools of the program.

It is worth mentioning that it is possible to find a freeware tool that allows the performance of the MFA method called STAN. Information around how the STAN software works can be found, as well as screenshots of its aspect. The following image will contain a screenshot of the program:

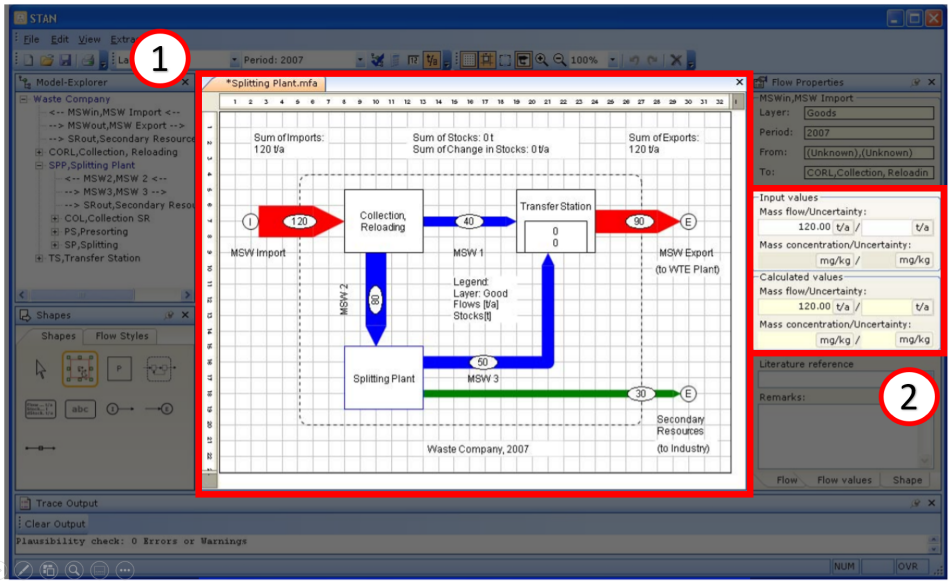


Figure 12: Screenshot from STAN software for MFA [36]

The numbers in the figure represent the 2 main important parts of the program. The first one is the scheme for the MFA, for its construction it will be mandatory to include all the information regarding the every process in the enterprise. The second will be the input values for the process. A disclaimer have to be made that no further insight has been made into the program, and the figure above is only presented with illustrative purposes to represent how the MFA looks and which information can be retrieved from it.

### 5.3.2 Life-Cycle Assessment (LCA)

Along with the MFA it is common to see references to Life Cycle Assessment to aid the evaluation of CE. The LCA provides assessment of all environmental impacts during the complete life-cycle of a product, since the use of raw materials and design for its creation to its use and disposal. Environmental impact of the resource use, land use and emissions are considered, in principle, through the life pf the product [37].

By the hand of Michael Z. Hauschild an introduction the LCA methodology is presented [38]. The first notice of the process is that LCA commits to an iterative approach, starting from an overview that eventually leads into details of all the different phases and elements. The article references to the ISO 14040:2006 [39] in which it is inspired. In this norm the LCA studies are said to be composed by four phases, represented in the following figure:

Following the 'Figure 13' the enterprises must frame their processes in the same manner. The norm provides practical an example on how could this be made and establishes the framework for the methodology to be applied [39]:

Th first step is to establish the objectives, and for that it will be necessary to know:

- The action that will be performed.
- The reason for the realization of the study.
- People responsible for the study and to whom it will be directed.
- Prevision of the results that will be given to the general public.

This is followed by the scope of the analysis, with information regarding: the system subject of study in the shape of its limitations, functional units and requirements and the methodology for impact evaluation, with initial quality and data requirements, assumptions and categories for the classification of the impact.

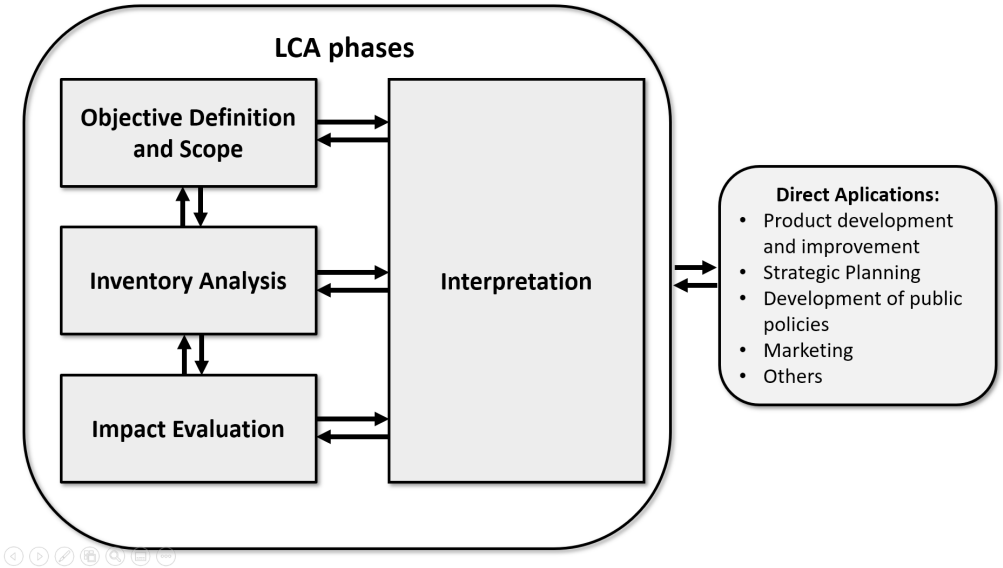


Figure 13: Phases of the LCA and their Relation according to the ISO 14040 [39]

The second step relates the Inventory Life-cycle Analysis, core of the LCA, contains the information of how the parameters have been quantified and how the data has been collected.

The data collected can be classified in:

- Inputs of energy and materials, ancillary inputs and other physical entrances.
- Products, co-products and residues.
- Air, water and soil emissions.
- Other environmental aspects.

Then it is processed by calculations including:

- Validation of the introduced information.
- Relation with processes.
- Relation with the flux of information coming from the functional units.

The third category corresponds to the evaluation of the life-cycle impact, and the main objective of this part is to utilize the results obtained in the last step to assess the significance of the environmental impact. In the ISO 14040 a figure represents this phase:

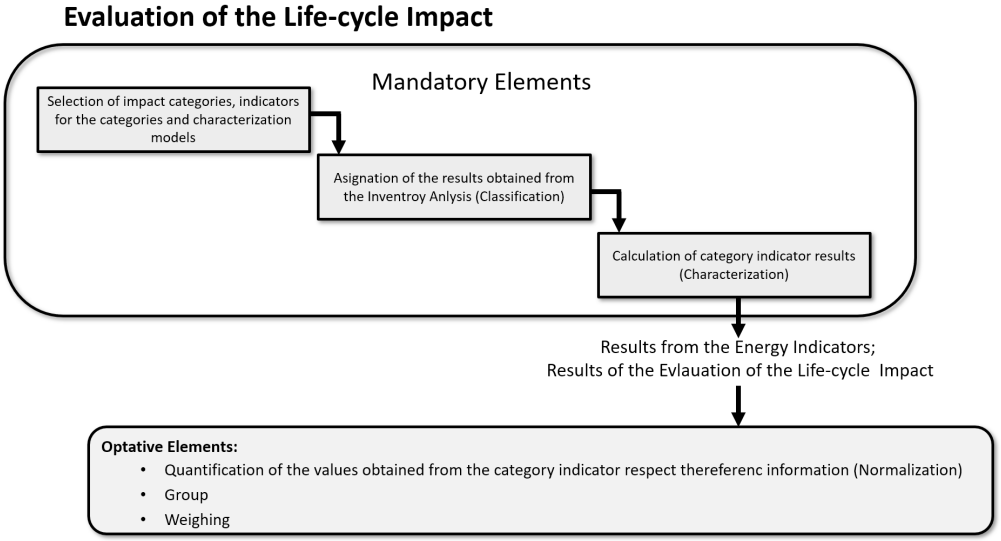


Figure 14: Evaluation of the Life-cycle Impact [39]

Finally the fourth and last part is the interpretation of the life-cycle and iteration of the process. The results obtained from the other sections might bring new perspectives that are worth analyzing and, due to the complex nature of the LCA, some details might have escaped in the first models created. The bright side is that the work done is not lost, and new information is added to it. Eventually, the method will provide a complete description of the systems and life-cycle of the product that conveniently explains the origin of the environmental impacts and results practical for the evaluation of the Circular Economy.

### 5.3.3 Evaluation and Monitoring of the Indicators

Following the description of the LAC and MFA a parenthesis has to be made to explain how the measure inside them is realized. The most common method is to perform the research for the different parameters that can describe each part of a system. Taking for example the manufacturing of the body of aluminum cans, the aluminum comes from a coil that will unroll and provides the machines of the system with the material necessary to obtain the final shape. In the same process all the machines will need an input of aluminum and will provide an output that can range from its cutting and shaping to its cleaning and painting. Every phase, in consequence, will have the involvement of a material entering the operation as well as the output and a residue.

The quantification of the materials will be present in all systems and the CE will use those numbers providing from methods like the MFA and LCA to assess its grade of implementation. As it can be deducted, the methods despite having or not a focus on the environmental responsibility, can suppose the improvement of processes inside the enterprise and higher efficiency of resources as well as less energy consumption. This goes in pair with the main cause of the circular economy, namely the decoupling of economic growth and resource consumption.

The point of this section is to advice of how to measure the parameters. The different number of businesses make impossible to give certain units or standards that every company can follow. Nevertheless, there is plenty of information of all kinds of processes and metrics in specialized articles, and it depends on the enterprises to take the wisest decision in how to measure and show a variable.

In an article written by Yong Geng [40] it is possible to find the intention of China of creating a single national Circular Economy Indicator System, but inquiring deeper in the article it is found that numerous problems have appeared regarding the still needed need for determination whether the system has had any results and a lack of indicators for particular points.

Even thought the article did not offer a definitive conclusion that would make everything simple and standarized, it is still valid for decision-makers to obtain valid metrics and indicators and clarify their ideas and desired outcomes.

Finally, a reflexion can be made, which is that *"the implementation of the Circular Economy depends on the intentions and culture of an organizations"*. The multitude of possibilities of indicators and metrics used to measure them combined with the variety of businesses leaves the corporations as the ultimate responsible for they righteous implementation. In their hands is the task of choosing the proper indicators, evaluate all inputs and outputs with the correct units and make the right decisions. Therefore, the work of the articles, books and this thesis can only provide assistance in those decision and supply collection of indicators, explanations of methods and compilations of other titles where more specific information can be found.

### 5.3.4 Ancillary Approaches

Departing from the anterior approach based on the objectivity and use of reliable metrics, it is also worthy considering an alternative approach. Until now, the thesis has mostly focused in the precision of the methods and clear evaluations of the characteristics. Nonetheless it has also been clarified that for the Circular Economy to function, not only a change in the measuring

and implementation is required, but as well, a shift in the culture of the enterprises and mindset of the people has to happen.

This part of the chapter pretends to encourage the take of not so necessarily objective approaches based of scientific data. Tests that reveal the company culture and organizations and the profile of its workers are key in the transition towards circular economy. An environmentally motivated employee working in a company with a clan culture can prove exceptionally useful. A company with a clan culture is characterized by openness and sincere communications, offering less trouble for even a low ranked worker to communicate a great idea vertically to a higher command and even maybe motivating other peers.

realization of culture tests and gathering the feedback of the employees can provide a useful tool. A corporation that knows its workers can educate them to stay in line with the vision of the enterprise and match the objectives. HHRR departments can lea the procurement of such information as the MFA method did with the supply chain data, and adapt it to improve the implementation of Circular Economy.

Furthermore, beyond it own employees, organizations have to take care of their customers and influence them in the correct path, making them consume the necessary and best products. In this regard, collection of information on social networks, statistical results, etc. that are related to the social dimension are important.

Again, it is clear that Circular Economy is influenced by many factors, all of them need to be measured in one way or another and can be more or less objective and efficiently measures, but the most important factor is the raise for awareness. Therefore, ancillary approaches can be used to evaluate those particular Circular Economy characteristics that are more difficult to measure.

# 6 Method of Circular Economy Evaluation

The conclusions obtained during the last section create the path for how the method developed by the thesis is shaped. All the actions inside an enterprise count, and inside an organization only what is measured can be improved, therefore the following table of indicators contains all the variables that have been deduced from all the information captured during the research. Furthermore, the social impact of Circular Economy still has to grow as the term is not known by the consumers and, ultimately, they are the main factor in control of the success of Circular Economy. The indicators shown will be represented with all the simplicity possible so they are not only directed towards the enterprise bu towards the common public.

Lately the growing research and importance on CE hasn't only provoked the elaboration of more papers around the issue, but the awakening of many CE consultants. The assessment on the topic is nowadays a niche in the market and, in consequence, a large number of different private organizations are dedicated to aid enterprises on this transition. As it can be acknowledged, those processes are kept from the public and may not be available for every business. However, the present thesis is dedicated for the general public and designed to be available for whoever is interested.

In summary, the present thesis will be at the disposition of whoever it might result of interest and will compile, as smoothly and simply as possible, the information extracted from literature. Nevertheless, the topic between hands and the current situation force the announcement of a disclaimer:

***Disclaimer:*** *Circular Economy is in arise, and as many works and entities are participating in this, the most relevant concept to have in mind is that any method is necessarily better than others. The many interpretations and types of businesses, as well as platforms dedicated to their evaluation, offer changing perspectives that may shape better depending on the situation. The case that occupies this document is a simplification and critic of contents and may not be taken as a definitive solution. Circular Economy units inside the enterprises are necessary in order to update the database, create improvements and adapt to the new situations.*

Finally, before the introduction of the method, a last reflexion is made: with regard to the enterprises the most relevant characteristic to allow the implementation of Circular Economy in the general market is the transparency. A market is free when the competition is allowed, and CE can be a new parameter in the competition, like when a customer buying a new laptop compares the characteristics of two models in a spreadsheet, the same could be

applied to circular economy. Similar evaluations with the maximum amount of transparency possible on how circular is the product or service can make the client have a new preference in its decision. And in case customers developed the necessary mindset on the environment, and enough knowledge on CE is created, it may lead them to decide the 'greenest' option and, in consequence, enterprises will compete not only to provide the best technology, but also the most sustainable one.

## 6.1 Steps for the Method

The method described below will consist of three steps which are only descriptive and contain an explanation telling why it is important to perform each one of them. Nevertheless, each enterprise knows better how they function, and the adaption of an unique method for all of them cannot be guaranteed. Therefore, the steps proposed are not mandatory nor rigid and can be adapted freely to fit as best as possible any business model.

In any case, the procedure starts by posing a set of questions to define how of CE affects the enterprise and how is it understood by the employees, followed by the establishment of a framework. Then, a set of indicators are proposed to formally evaluate the most relevant aspects in the normal working routine of the enterprise. Finally, the third and last step consists in the redaction of a conclusion, to plan how the analysis of the information obtained from the indicators and plan future measures to improve the circularity.

### 6.1.1 STEP 1: Establishment of Framework and Objectives

Enterprises operate in many different fields and with diverse organizational structures. For this reason, the first step is to perform a test of the current organization. The test shall provide information regarding the image that the employees have over the enterprise, as well as represent the current knowledge about circularity at the working place.

A view of the current circular economy is necessary to correctly plan the strategies that will aid its implementation or future improvements, therefore the next questions are proposed:

1. Are the employees aware of the circular economy concept?
2. Does the company have a CE Management Team?
3. Does the company count with laws and policies CE related?
4. Is there a reward system to encourage circular economy?

5. Are Industry 4.0 or other techniques to monitor CE implemented?
6. Does the enterprise count with EIoT to control real time variables?
7. Does the enterprise count with CIoT to study consumers responsibility?
8. Are the systems inside the enterprise modular?
9. Are the systems inside the enterprise scalable?

These questions are simple to answer and can show if the enterprise has any strategy going on in line with the CE while bringing awareness on the internal knowledge of circular economy. According to the answers some of the elements listed above could be implemented. Ultimately, the objective is to expand the knowledge on CE to the whole enterprise and provide the necessary tools to measure the indicators that will be given in the next section.

Before getting into the next step, a comment has to be made regarding the culture of a company. The culture will define how the knowledge is created and how the information flows in the enterprise as well as characterizing the relation among the employees and what are the main aspects that are evaluated for the success of the company. To know what is the culture of a company, a variety of test can be used, such as the OCAI tool. The test relies on the answers of the employees, and will tell the current culture and additionally, the preferred culture. If both preferred and current culture are the same, it will mean that the company will be able to focus in the improving of current systems. In the opposite case scenario, the changes should be done towards offering the employees the desired culture in the enterprise.

This last comment is important due to the fact that CE relies on the attitude of the employees and knowledge sharing inside the enterprise. All employees should know the term of CE and be able to make suggestion for its improvement, and if the systems and software are not prepared for that the results may not be successful.

Finally, when the situation of the enterprise is fully specified it is possible to go to the next step.

### 6.1.2 STEP 2: Table of Available Indicators

This part of the work refers to the provision of a table with Indicators to measure aspects regarding the Circular Economy. Note that not all of them are necessary as businesses can be very different. For this reason, it is important the the framework and objectives from the previous step had been clearly defined and the decision of the indicators to use is correct and meaningful.

The table with the indicators is proposed in the following pages:

| Nº | Indicator | Formula | Units | Objenctive | Useful Tools |
|---|---|---|---|---|---|
| **A** | **Waste Management** | | | | |
| 1 | Liquid Waste | Liquids Input / Liquids Output | % | Reduce | - |
| 2 | Recyclable Paper Waste | Paper Input / Paper Output | % | Reduce | - |
| 3 | Recyclable Plastic Waste | Liquids Input / Liquids Output | % | Reduce | - |
| 4 | Organic Waste | Organic Material Input / Organic Material Output | % | Reduce | - |
| 5 | Solid Waste | Solids Input / Solids Output | % | Reduce | - |
| 6 | Hazardous Waste | Hazardous Material Input / Hazardous Material Output | % | Reduce | - |
| **B** | **Circularity in the Design Process** | | | | |
| 7 | Volume of Plastic Packaging | Volume mathematical formula ; Direct Measure | m3 ; mm3 | Reduce | - |
| 8 | Volume of Paper Packaging | Volume mathematical formula ; Direct Measure | m3 ; mm3 | Reduce | - |
| 9 | Reused Components | Adquired Reused Components / Total Components of the Product | % | Increase | - |
| 10 | Recycled Materials | Recyclable Materials in Finished Product / Total Number of Materials | % | Increase | Material Databases ( ie. GRANTA EduPack ) |
| 11 | Design for Manufacturing Assembly (DfMA) | E = N*ta / tma | % | Increase | [41] |
| 12 | Use of Critical Raw Materials | m = sigma * Volume | kg ; g | Reduce | [42] |
| 13 | Use of Banned Chemicals ( V4.0 of the C2C ) | ppm = mass solute (mg) / volume solution (L) | ppm | Reduce | [43] |

| Nº | Indicator | Formula | Units | Objenctive | Useful Tools |
|---|---|---|---|---|---|
| **C** | **Supply Chain Sustainability** | | | | |
| 14 | Water Usage in Manufacturing | Direct Measure | Litres | Reduce | - |
| 15 | Recovered Materials from Manufacturing | (Mass of recovered materials + Mass used in products) / Total mass of materials acquired | % | Improve | - |
| 16 | Greenhouse Gasses Emissions | Total CO2 Equivalent = E[Mass of Emited Gas * GWP value) | CO2 Equivalent | Reduce | [44] |
| 17 | Energy Consumption in Production | Direct Measure | Joules | Reduce | - |
| 18 | Renewable Energy in Production | Direct Measure | Joules | Improve | - |
| 19 | Percentage of Renewable Energy | Renewable Energy / Energy Consumption | % | Improve | - |
| 20 | Use of Fossil Fuel in Transport | Direct Measure | Litres | Reduce | - |
| **D** | **Return of Materials and Products to the Loop** | | | | |
| 21 | Energy Consumption Invested in Recycling Materials | Direct Measure | Joules | Reduce | - |
| 22 | Energy Consumption Invested in Gathering Recycled Materials | Direct Measure | Joules | Reduce | - |
| 23 | Repared and Remanufactured Products (R&RP) | R&RP / Total Number of Products sent to Market | % | Improve | - |
| 24 | Refurbishing of Old Products | Refurbished Products / Total Number of Products sent to Market | % | Improve | - |
| 25 | Repurposed Products | Repurposed Products / Total Number of Products sent to Market | % | Improve | - |

| Nº | Indicator | Formula | Units | Objenctive | Useful Tools |
|---|---|---|---|---|---|
| 26 | Recover of Own Products | Recovery of Own-Branded Products / Total Number of Products sent to Market | % | Improve | - |
| **E** | **Circular Infraestructure** | | | | |
| 27 | Shared Spaces | Area designed for sharing in planning | m2 | Improve | - |
| 28 | Reuse of Building Materials | Mass of Reused and Recycled Materials in Building / Mass of All Materials Used | % | Improve | - |
| 29 | Deconstruction | Area allowed for deconstruction in planning | m2 | Improve | - |
| **F** | **Social Environment** | | | | |
| 30 | Circular Development and Investigation | Circular Economy related Papers published / All published Papers | % | Improve | - |
| 31 | Circular Economy in Social Networks | Circular Economy posts in Social Networks / All posts | % | Improve | - |
| 32 | Circular Economy Partners | Associated Enterprises with Implemented CE Strategy / All associates | % | Improve | - |

The indicators given are the conclusion of all the examined literature in the previous sections along with some general information and common knowledge obtained in the engineering degree. The formulas and units given in the table have been represented in the simplest way possible, as the purpose of the thesis is the proportion of a method that anyone can apply and understand. This is specially useful for those entrepreneurs that are starting new businesses or micro and small enterprises and are looking forward to implement a circular economy model.

Those organizations interested in the method and elections of the indicators above need to have clear in which market are they positioned as well as the aspects in which they want to get better. Furthermore, and reinforcing the point of view given previously, corporations can differ in many characteristics and rely on different parameters, so it will be their job to make the right decision of which indicators to use and, if considered necessary, add any other indicators supporting Circular Economy that are useful for them.

After all indicators have been chosen it is possible to move to the last step.

### 6.1.3 STEP 3: Processing of the Information

After the indicators have been chosen and properly evaluated the next step is compare them with the standards of other businesses or those other given by governmental institution. The objective is to use this comparison to really know if the numbers obtained are in line with he current trends and create a plan on how to improve them.

This step can be adopted as an iteration that in case of unexpected or unsuccessful result can redirect back to the previous or first step. Nonetheless, even if the results coincide with the desired ones it doesn't mean all the work is done. It is important to remember that industry advances at rapid rates and new technologies and techniques are brought constantly, this affects CE, which concept can result expanded or new methods, tools and indicator systems may appear to improve it.

The result is a continuous process that requires to be scheduled for its repetition at a frequent rate to ensure that the data is updated and the measuring is up to date with the latest advances.

The representation of the results is also an aspect to take into consideration. The public towards the result is directed can vary between stakeholders, members of the enterprise, the circular economy management team members, consumers, usual clients of the brand or other allied companies, etc. This means that the information given shall represent always the most relevant aspects for each case and companies have to be careful and show the proper

results to the corresponding units. For example, in the case of common consumers the information needs to be kept as simple as possible, so it results easy to process and can be understood; meanwhile with stakeholders, partner companies or internal employees the information delivered has to guarantee its precision and usefulness.

Moreover, if implemented correctly, the tool can provide a solution to the 'Greenwashing'. Greenwashing refers to those companies that make fake claims of pursuing environmental wellness and performing sustainable processes. Commonly, such announcements are done by only giving the final part of the information, namely giving a series of objectives or achievements that are not supported by any objective number or external studies. For this reason, the outcome of using the indicators of the second steps can serve as proof of the real advances made in a corporation. And in case of disbelief in the data above, the enterprise shall provide enough transparency to let external studies or individuals prove them by themselves.

Finally, the process will provide to all parts related with the enterprise an true image representing the implementation of the Circular Economy and will allow its understanding, criticism and improvements.

# 7 Future Development of the Method

Before getting to the conclusion, a reflexion of future strategies and development of the method can be done.

The study performed has shown how the evolution of the concept of Circular Economy has lead to the appearance of a multitude of papers. These documents can be seen as a double-edged weapon, as they provide many useful information and tools but the differences between them can cause confusion. Furthermore, the common public is not aware of the Circular Economy concept and thus, they need to be educated in this regard, to make them understand that their decision on what to buy can have consequences.

The method developed in this thesis has been developed with this last statement in mind. It is necessary to remember that the CE is an umbrella concept, and looking for a specific characteristic during the research for this work leads to other many new variables. This is why it is necessary to build a simple standarized method to evaluate the most crucial characteristic of CE inside the enterprises. A method that allows its own expansion and updating when new categories appear and need to be added.

In consequence, the future developments of this method shall consists in the addition of other simple parameters that can help the same cause. There are many other characteristics that affect the sustainability in an organization but have rather difficult processes to measure them, or to be able to understand the results obtained it is necessary to have studied the concept. The future work will consist in the expansion of indicators to enlarge the past standards with more useful characteristics that are simple and understandable for the maximum amount of people possible, inside or outside the enterprise.

Finally, the iterations over the method can lead to a complete, free for everyone and simple data-sheet that offers support to those companies, specially micro and small enterprises with less complex procedures and less resources, to implement and measure circular economy. Even so, the data-sheet will trust the transparency in companies, and will serve as a new comparison tool or element between products or services sent to the market to be valued by the consumers.

# 8 Conclusion

As Circular Economy gains relevance in the industrial field many tools for its evaluation are coming out from different sources. Among many others, the Ellen MacArthur Foundation with 'Circulytics 2.0' or the 'CTI tool' by Circular IQ are two accessible professional assessment tools for circular economy. Nevertheless, these tools are expensive and not easy to use for those enterprises that may have less resources or are not aware of the whole image that CE portrays.

The summary of the circular economy situation is that, even though the term strictly refers to the re-circulation of materials back to the production process, it affects and is affected by many other aspects of the environment. Enterprises and consumers need to be brought together for the circular economy model to be successful.

The literature has shown that the concept is very extensive and complex and can lead to misunderstanding and disagreement. However, instead of positioning all the focus in the concept it can be useful to have a look at its environment. All kinds of products are massively produced, and trends like fast fashion or the race for providing new pieces of technology as fast as possible are the cause of this. Consumers are increasingly demanding and looking forward to buy new products without minding the old ones that they may have, but they are also becoming more intelligent and thoughtful, which means that a product nowadays can be seen for more than how it looks, what are its specs or what is it for.

The door for a new competitive category is opened and sustainability can become a new parameter in the market. At any rate, consumers do not have to be the ones to make the effort and discover circular economy by themselves, therefore it is in the hand of the manufacturing or services companies to provide them with advise and information.

Simpler methods that do not provoke doubt have to be developed. This is why the current thesis provides yet another circular economy tool. Micro and small enterprises are the ones closer to their clients and have less resources to dedicate to the investigation and implementation of a circular business model. Nonetheless, they are not as complex as their bigger counterparts and consecutively can adapt faster to new situations and have more ease at measure the variables given above.

The mentioned big brands applying for the circular economy strategy usually claim their activity about it in their website or social media. There are two possible ways this is usually done: the first one is by providing the consumer with the objectives for the future or statements supporting sustain-

able procedures carried in the enterprise, and the second is by providing the the objectives for the future while also claiming what is the progress made so far. It is easy to guess that, in order to believe the claim of an enterprise, it is necessary to support it with numbers rather than just providing the argument. For this reason, companies have to work on their transparency and educate customers to not fall in 'Greenwashing' techniques.

Finally, the last reflexion of the thesis is given: *"Do what you can, manifest what you do, make the organization and customers understand and let them decide."*

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