Louvain School of Management

Structural analysis of six major Circular Economy currents and their implementation conditions

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Thank you,

“*All we have to decide is what to do with the time that is given us”*
Gandalf – J.R.R. Tolkien

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List of Abbreviations

ADEME	Agence De l'Environnement et de la Maitrise Énergétique
AFNOR	Association Française de Normalisation
CE	Circular Economy
CPP	Consumer Pays Principle
DFE	Design For Environment
EEA	European Environment Agency
EMF	Ellen MacArthur Foundation
EPA	Environment Protection Agency
GDP	Gross Domestic Product
GHG	Green House Gases
GPI	Genuine Progress Indicator
IE	Industrial Ecology
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
IRP	International Resource Panel
ISEW	Index of Sustainable Economic Welfare
ISIE	International Society for Industrial Ecology
MSW	Municipal Solid Waste
OECD	Organization for Economic Co-operation and Development
PAH	Polycyclic Aromatic Hydrocarbons
SDG	Sustainable Development Goals
UNEP	United Nations Environmental Plan
UNCTAD	United Nations Conference on Trade and Development
WFD	Waste Framework Directive
WHO	World Health Organization

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Introduction

Greenhouse gas emissions, floods, drought, melting ice, global warming, shortage of raw materials or, more broadly, climate disruption are all terms that can already be heard on a daily basis. Indeed, the climate issue is at the heart of the news and for good reason, the dramatic consequences that can result from global warming. Scientific results are unanimous, to avoid irreversible changes, by 2050, the global temperature increase of the planet should not exceed 1.5°C compared to the pre-industrial period.

The reasons for these changes can be linked to the advent of capitalism and the establishment of the linear system that follows from it. It is true that for nearly two centuries, human activity has disturbed the symbiotic balance of Nature, the main cause being a system based on "take-make-dispose". This system, which consists in extracting materials, processing them to make products, which are then used and then thrown away, has proven its limits, generating an overconsumption of rare and polluting materials, and pushing the planet to its limits. If things continue like this, the boundaries of the Earth will be crossed.

A proposed and popular solution to overcome this is the implementation of the Circular Economy. Contrasting with the linear system, and taking different forms, it aims to reduce the environmental impact by implementing a cyclicality of materials inspired by ecosystems. Moreover, the benefits of this model are not only environmental, since they also have a positive economic and social impact. However, the implementation of this system is subject to many barriers.

This work presents and analyzes six major Circular Economy currents, comparing them through six criteria in order to highlight their differences, similarities, and promises, but also to inform about the circular currents and their implementation conditions.

It will be divided into four chapters. The first chapter will attempt to give the reader an understanding of the current socio-economic context of the linear economy and what led to it. It will also describe the impacts that this system has on the environment and the socio-economic level. The second chapter will introduce the circular economy through its origins, followed by its many definitions and concepts, and ending with the opportunities it brings as well as the barriers it faces for its implementation. In the third chapter, six major circular economy trends will be described individually, summarizing their main ideas and characteristics. Finally, in the fourth chapter an analysis of the six previous currents will be made through six defined criteria, highlighting their similarities and differences. In the same chapter, a circular economy will be developed, taking into account each criterion.

Chapter 1: The Linear Economy

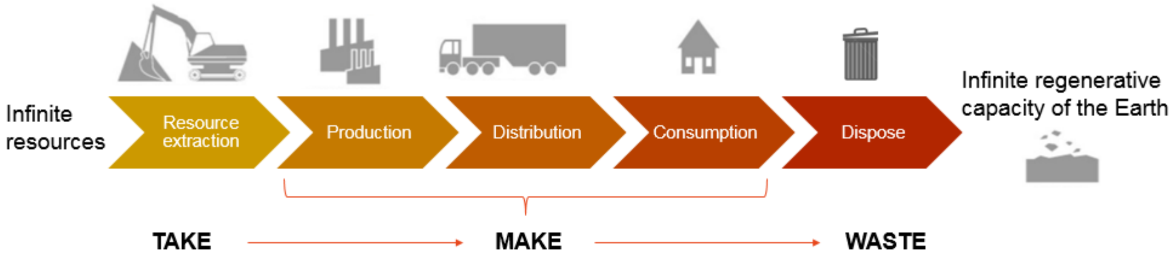
In this section, the current socio-economic context will be described, discussing its origins and analyzing its limits through environmental, social and economic scope.

1.1 Current context

Since the beginning of time, Nature has been the regulator of life on Earth. It provides the raw materials that living beings need for their survival, as well as for the propagation of their species. Living beings, for their part, agree to adapt their rhythm of life to that of the planet that shelters them. This is symbiosis. In this system, each element has a role to play, even the "waste". Indeed, in Nature, the waste of some is the energy contribution, the food or the material source of others (G. Pauli, 2019).

In this well-oiled chain, latecomers have appeared and are playing the troublemakers: Human beings, or at least Western ones. Although they had been playing the game for seven million years, some centuries ago they began to gut the goose that laid the golden eggs. No longer satisfied with the riches that Nature offered, they dug the earth in search of its treasure. Seeking to satisfy first the needs and then the growing desires of their species, during the Industrial Revolution, they put an end to a perennial cycle by moving from an originally circular system to a linear one where people Take, Make and Dispose/Waste (fig. 1) (Le Moigne, 2018; Wautelet, 2018). In that system, raw materials are processed in such a way that, once the products are consumed, the waste coming from them are no longer of any use to anyone and are just disposed. Moreover, it is based on the impression that the Earth's resources are unlimited and that the Earth has the capacity to absorb waste and regenerate itself infinitely, therefore suggested the idea of continuous growth. An idea that implies that people could extract raw materials, process them to make a consumer product, consume this product and once it has lost its usefulness, throw it away and buy another one that will follow the same process, and this forever. In that “take-make-dispose” system, value is created by maximizing production and selling of products (EMF, 2013). That last sentence immediately rings a bell. Indeed, aiming to produce and sell as many products as possible brings us back to the very principles of the capitalist system seeking the accumulation of capital and profit which is ruled by the law of supply and demand.

Figure 1: Linear Economy Schema



Source: Wautelet, Thibaut. (2018). p.18

But how did we get here?

Today the origin of capitalism is still unclear. Although the consensus establishes it around the 18th century, according to some authors such as André Gunder Frank and Gills (1993), this economic system dates back five millennia and is linked to the Neolithic revolution. The race to extract resources and the vision of power that they grant between the states of the Middle East would have been the precursor. Still according to these two authors, capitalism would imply several modes of accumulation that are the production reports, the modes of tributary productions and the merchants. Another version of the facts, established by the sociologist Immanuel Wallerstein in 1980, would be the appearance of this economic system due to a development of trade in Europe in the 16th century. Capitalism, formerly agricultural, would be possible thanks to trans-state merchant commerce and would therefore not depend on wage labour. The important point to note here is the fact that work does not have to be free, unlike the version that will be discussed now. Finally, the best-known version, which is related to Karl Marx's, is that of Robert Brenner (1977), which places the advent of capitalism at the end of the 18th century in England, following a social revolution (i.e., the end of serfdom). Capitalism, in this case, is characterized by proletarianization. In other words, by the possibility for rural labor power to seize market opportunities (Hugot, 2013).

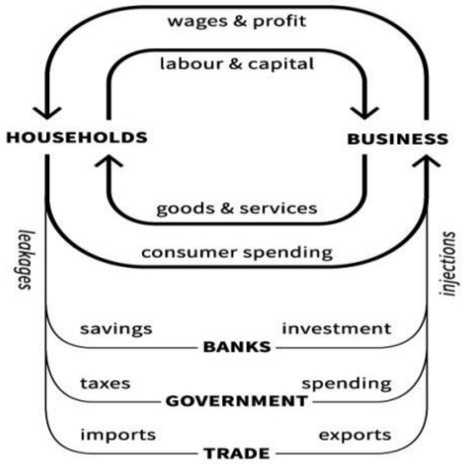
The different authors cited above also have divergent opinions concerning the Industrial Revolution. Indeed, in 1990, Gunder Frank explains it by the cost and scarcity of labor in Europe compared to China, which pushed Europeans to develop more efficient machines to reduce their costs in the face of Asian competition (Hugot, 2013). Wallerstein, on the other hand, argues that it is not coherent to speak of an Industrial Revolution when it took place over several centuries, and that it is the permanent search for capital accumulation that has induced a dynamic of innovation (Hugot, 2013). However, they all agree to place this revolution in England in the 18th century.

It seems important to note this connection to land, which occupies a prominent place in each of the three versions of the birth of capitalism. François Quesnay and his fellow physiocrats had already stressed this in the 18th century, evoking the importance of agricultural land in the understanding of economic values (Guyot, 1897). This thought was shared by two great liberal thinkers, Adam Smith and Ricardo, who, before delving into the secrets of productivity, mentioned, respectively, the importance of a nation's climate and soil for its development, and the influence of the scarcity of cultivable land and its productive power in economic value (Raworth, 2017). Land was thus indeed one of the three factors of production recognized by Smith and Ricardo alongside labor and capital.

It was not until the 20th century that the land was removed from the equation and only capital and labor remained. The currents that followed confirmed this perception. Indeed, in the middle of the 20th century Samuelson published his circular flow diagram (fig. 2), which was completed by the precursors of the neo-liberal movement, Friedrich Hayek and Milton Friedman. This scheme highlighted the contemporary way of thinking, neglecting many elements that are essential to economic life. Among the great forgotten elements was the Earth, which the neo-liberals completely ignored, under the pretext that it is inexhaustible and that, therefore, they could dispose of it as they pleased. This schema of Samuelson, embellished by his rivals, is a first explicit representation of the famous linear economy "take-make-dispose" under the pretext of innovation and the search for growth.

It is important to recognize that this system has had commendable virtues during the 20th century. The continuous relative growth has pushed the societies on social and economic perspectives, mostly western ones, towards a comfort of life never reached before, thanks to technological and scientific developments. However, something sounds wrong with this linear system. In reality, the planet with has a limited capacity of regeneration. By following a continuous growth with a linear system, Human are depleting raw materials and producing huge amounts of wastes beyond Earth’s bounds, causing harmful effects on humans, and especially on the planet and all its ecosystems (F. Martins & H. Castro, 2019). This is why this concept is today the subject of many criticisms, questioning its sustainability and pointing out its limits.

Figure 2: Samuelson's Circular Flux schema by Marcia Mihotich



Source: Raworth, K., & Audiobooks, R. H. (2017).

What path to follow?

The choice of what solution to adopt to counter this is today the center of many debates among political decision-makers. Indeed, it is difficult to choose unanimously the way that will lead to the re-establishment of symbiosis on Earth, while offering a comfortable life to its inhabitants. Although still very theoretical, two major currents exist and oppose each other in this quest; The Degrowth and the Green Growth (Lenaerts et al., 2021). The first movement, which was the subject of the book "The limits to growth" by Meadows in 1972, advocates, as its name indicates, degrowth. Those in favor of this movement emphasize the conceptual complexity of infinite growth in a finite biosphere. They seek to reduce the production and consumption of "rich countries" and achieve the principle of sufficiency (Parrique al., 2019).

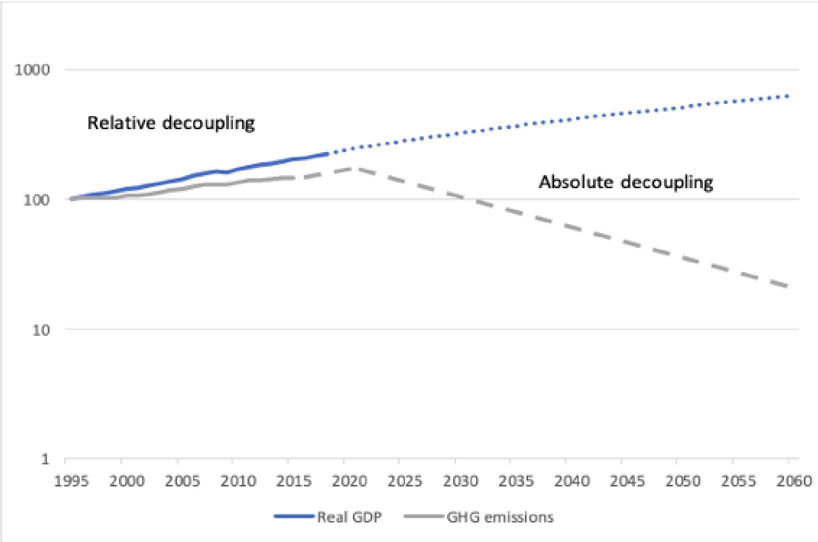
The objective is therefore to decrease the economy to get back into the limits of ecological sustainability, all without reducing welfare as defined by criteria that are not related to Gross Domestic Product (GDP) (Latouche, 2009; Kallis et al., 2018). Among these criteria, can be found the Index of Sustainable Economic Welfare (ISEW) (Daly and Cobb, 1994), and The Genuine Progress Indicator (GPI) (Cobb et al., 1995). However, this current is somewhat nuanced by its opponents, who point out the importance of economic growth and GDP in the development of welfare, but also for fundamental elements such as social security and pension management. Moreover, it is clear that emerging countries will not give up growth so easily and, therefore, may not align themselves with such policies (Lenaerts et al., 2021).

Born in 2011, the second movement differs from the degrowth in its vision of growth. Indeed, The Green Growth thinks the problem without excluding the latter. Therefore, the GDP is still part of the equation. Moreover, unlike the Degrowth, which aimed at sufficiency, the Green Growth is focused on efficiency (Parrique et al., 2019). The leitmotif of this movement is a principle adopted in 2001 by the Organization for Economic Co-operation and Development (OECD), i.e., decoupling (Parrique et al. 2019). This is based on the idea that Gross Domestic Product (GDP) and Green House Gases (GHG) growth are related and aims at separating them. More precisely, when the economic activity increases, the energy use and the consumption of natural resources increase as well (Lenaerts et al, 2021). Moreover, since the fossil fuels account for 80 percent of the global energy mix (IEA, 2020), energy consumption can be linked to GHG emissions. In addition, in 2021, in their paper “Can climate change be tackled without ditching economic growth?”, Lenaearts and his companions pointed out the fact that according to Kaya and Yokobori (1998), GHG emissions can be decomposed into a product of the global population, the GDP per capita, the energy intensity of GDP and the GHG emissions intensity of energy production. Therefore, they suggested that by considering the population as a given forecasted by the OECD and freezing the GDP per capita for the reasons mentioned above, the focus come on the two other elements that are the energy and emission intensity. Those two factors have to diminish without compromising the two others.

Therefore, the goal is to grow economically without increasing, or even while decreasing, the environmental impact (Vadén, 2020). In the first case it is referred as relative, or weak, decoupling, while in the second case is absolute, or strong, decoupling (see fig. 3) (Vadén et al, 2020; Lenaerts et al., 2021).

Finally, the Green Growth movement is followed by the European Commission in its Roadmap to a Resource-Efficient Europe, taken up by the United Nation Environment Programme and by the World Bank. In addition, since 2015 decoupling is a target for the United Nations' Sustainable Development Goals (SDGs) (Parrique et al, 2019). Therefore, it seems that this is the way chosen by the Western countries to tackle the global warming challenge that the World is facing.

Figure 3: Global real GDP (2010 prices, PPP) and total GHG emissions



Source: Lenaerts, K., S. Tagliapietra and G.B. Wolff (2021), p.4

1.2 Environmental and socio-economic impacts

It is clear that over the last few centuries, the linear system has had a considerable impact on the societal development of Western countries. Indeed, the advent of capitalism, liberalism and then neoliberalism, which are at the root of it, have been elements that have pushed individuals, whether from a private or entrepreneurial point of view, towards the quest for profit. Some, such as Laval in 2007, even evoke the creation of the homo-œconomicus, a being born of capitalism and focused solely on his interests and the maximization of his consumption. This anthropological phenomenon has pushed companies to develop their technologies and techniques in order to satisfy their desire for profit on the one hand, and to meet the ever-increasing demand on the other.

As mentioned before, this system has allowed developed countries to make technological advances that have considerably increased their standard of living, whether from a health, economic or social point of view.

However, these economic systems, and more precisely the linear economy to which more attention will be given here, does not have only virtues and the doubts concerning its sustainability are becoming more and more apparent. In the next section, some of the environmental and socio-economic impacts of the linear system will be showed. Of course, although divided into sub-sections, most of these impacts are interconnected.

1.1.2.1 Environmental impacts

Crossing Rockström et al' Planetary Boundaries.

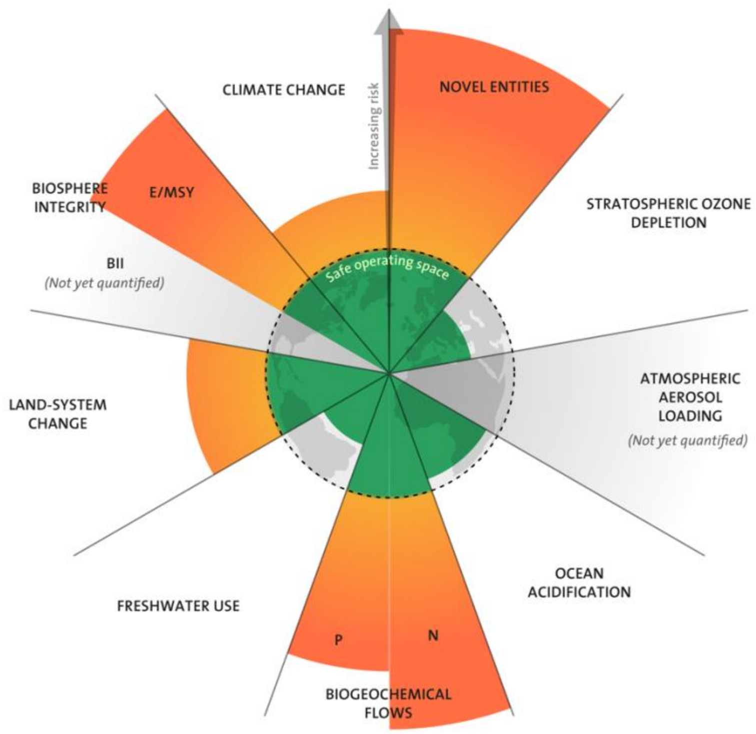
For some years or even decades now, alarm bells have been ringing concerning the Earth and its limits, or more precisely its borders, which is closer every day. Indeed, according to the Intergovernmental Panel on Climate Change (IPCC) report of 2014: "Climate Change 2014: Mitigation of Climate Change", the emissions of greenhouse gases are in perpetual increase and for cause the growth of the world economy and practices such as deforestation and consumption of fossil energy. As their name indicates, these greenhouse gases, whose main actor is CO_2, have the impact of warming the Earth, thus creating climate change. According to scientists, if by 2050 the general temperature increases by two degrees compared to the pre-industrial temperature, this could have irreversible consequences on the planet. The effects of these consequences can already be seen: summers are very hot, winters are mild, the melting of ice is accelerating, the level of the oceans is rising, natural disasters are taking place all over the planet and this list is obviously not exhaustive (Rockström et al., 2009). In July 2020, in Belgium, all this became very tangible with floods such as never seen before, leading to dramatic consequences.

Unfortunately, global warming is only one of nine boundaries defined in 2009 by Rockström et al. (Fig. 4). In this context it will be a crossing of the Earth's ecological boundaries, as explained by Pottier (2017). He assumes that the economic process is framed by its environment. Upstream are the "sources" of materials to be transformed, which are necessary for the creation of goods or services, and downstream are the "sinks" that must absorb the residues from production and consumption. The ecological limits related to the "*sources*", which will be the subject of the following sub-point concerning the exhaustion of natural resources, cannot be exceeded. These are illustrated as a maximum amount of usable material, even though it is possible to bypass them by using substitutes. Boundaries are related to "*sinks*" and are distinguished from limits by their crossable aspect but also by the fact that they are linked to the Earth's capacity to absorb wastes and may have negative effects that may not be visible in the short term. Pottier refers to them as soft boundaries that must be revealed by the work of scientists.

Human activity also has an impact on **Ocean acidification**. Indeed, the oceans absorb 25% of the CO_2 emissions caused by humans whose addition increases the acidity at the surface of the seawater. This increase has the effect of transforming underwater ecosystems that are highly sensitive to carbonate ions, e.g., converting coral reefs into algal-dominated systems. Among these boundaries, also stands the **Stratospheric ozone depletion** which is due to a too high concentration of O_3 which leads to a too high UV-B input causing radiation effects on human and ecosystem health. To this can be add the **Atmospheric aerosol loading** which affects monsoon, human health and which influences climate change and freshwater boundaries. But also, the **Biogeochemical flows**, and the **Global freshwater use** which can influence regional climate patterns such as monsoons and reduce biodiversity. Then, there are three last boundaries left which are the **Land-system change**, the **Rate of biodiversity loss** and **Chemical Pollution**. The first of these three elements concerns the overabundance of agricultural land that triggers a conversion of biomes to undesired states and reduces the regenerative capacity of the Earth. The second simply refers to the impact of species loss on biodiversity and the ethical problem this poses. Finally, the last frontier defined by Rockstöm et al., the Chemical Pollution, is derived from the concentration of emissions, plastic, endocrine disruptors, heavy metals, or nuclear waste, and has the impact of harming the health of humans and ecosystems while increasing the risks of crossing other planetary frontiers. In 2015, Steffen et al. redefined this last element as "Novel Entities", giving it a broader scope that includes new substances, new forms of existing substances, and life forms modified by anthropogenic actions (Persson et al., 2022).

Today, four of these nine frontiers have already been crossed: Climate change, the Biosphere Integrity, the Land-System Change and the Biogeochemical Flows (Steffen et al., 2015). Persson et al. even argue a fifth crossing of the safe operating space, namely the Novel Entities. The overstepping of these boundaries, as well as the fact that fifteen of the twenty-four ecosystem services are being used in an unsustainable manner or are depleted (Ellen MacArthur Foundation, 2013), lead the group of researchers to believe that the stable and moderately evolving conditions that were unique to the Holocene have given way to the Anthropocene. This geological era is characterized by economic activity and social and demographic burdens due to humanity and causing radical changes. From then on, it is clear that the capacity of the Earth to support human activity is increasingly weak and characterized by the abuse of ecosystems (Sariatli, 2017).

Figure 4: Rockström et al.'s Planetary Boundaries reviewed by Steffen et al.



Source: Azote. (2022). *Planetary Boundaries* [Illustration]. Stockholm Resilience Centre. https://www.stockholmresilience.org/research/research-news/2022-01-18-safe-planetary-boundary-for-pollutants-including-plastics-exceeded-say-researchers.html

Natural resources depletion

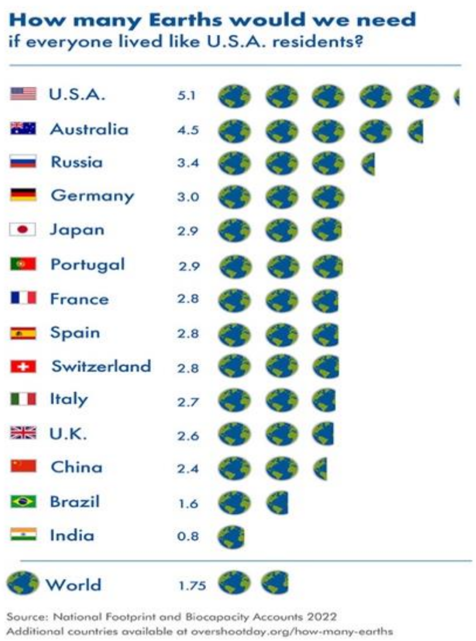
Among the environmental impacts of the linear system is the depletion of natural resources. Natural resources, or natural capital, can be broken down into two categories. On the one hand, renewable natural capital that can be naturally reconstituted and that, if the rate of extraction does not exceed that of renewal, can last indefinitely (e.g., water, forests, etc.). On the other hand, non-renewable natural capital, whose resources cannot regenerate at the same rate as its extraction and which, therefore, represents an ecological limit in Pottier's sense. This capital is mainly illustrated by fossil fuels and mineral deposits (OECD, 2009).

It is then intuitive to note the difficulty of compatibility of non-renewable capital with the linear system and Samuelson's macroeconomic explanations, which assume that the Earth's resources are inexhaustible and that the Earth is capable of absorbing waste and regenerating itself indefinitely. In reality, the world of today is a "full world" in which the economy exceeds the regenerative and absorbing capacities of the Earth, due to an ever-increasing demand leading to an overexploitation of natural resources (Daly, 1990). Moreover, forecasts estimate that by 2050 the population growth will reach nine billion people with purchasing power (Godfray et al., 2010), and therefore increasing the global demand that the economy will have to meet. This will require almost two times the current amount of resources (UNEP, 2017). And yet, today, according to The Global Footprint Network (2022), to meet the world's needs 1.8 planets are already required and forecasts estimate that two planets will be needed by 2030. Of course, the distribution of this consumption is not homogeneous (Fig. 5), with developed countries requiring far more resources (e.g., USA needs 5,1 planets to sustain its consumption).

To make this even more tangible, The Earth Overshoot Day was developed and calculated by the Global Footprint Network and aims to define the day when the annual human demand for ecological resources and services exceeds the Earth's regenerative capacity. This year (2022) for example, this day is estimated to be July 28. Human have not fallen short of the Earth's capacity since 1971.

Given that our current consumption of resources is already greater than the capacity of the Earth, if no solution is found and implemented, this risks creating shortages with disastrous consequences for humans and ecosystems. Unfortunately, according to the basic principles of supply and demand, what is scarce is expensive, and therefore the non-renewable resources whose generation is approaching the planetary limits take on a pecuniary and useful value, motivating their extraction even more, which leads these limits into a vicious circle from which homo œconomicus may have difficulty getting out (Pottier, 2017).

Figure 5: Number of Earths needed depending on the country



Source: National Footprint and Biocapacity Accounts 2022, retrieved from overshootday.org/how-many-earths

Waste management

As it has already been noticed, it is difficult to talk about the linear system without mentioning the waste it produces. Indeed, although they have always existed, their fate is quite different from the natural cycle, in which each element found its place and its utility, of the pre-industrial era. In the linear system, waste, whether it appears at the beginning or at the end of the chain, requires for the most part a special treatment. Depending on the country in which it is found, it will have different probabilities to end its life in a landfill, incinerated, recycled or backfilled.

Today waste exists in many forms and is closely linked to population growth, economic activity and of course consumption. Among these forms are the Municipal Solid Waste (MSW), the hazardous waste, the Industrial non-hazardous waste, agricultural and animal waste, production waste, medical waste, sewage sludge, ... Therefore, developed countries produce a lot of MSW and industrial wastes (EPA, 2022). In Europe, for example, the volume of waste amounted to 2.25 billion tons for the year 2020 (Eurostat, 2022).

While MSW (e.g., foodwastes, packaged goods, disposal goods, used electronics) (EPA, 2022), which can be linked to the mass waste of populations, is probably the first waste that comes to mind when a trash can is mentioned (Reno, 2015), it is far from having the same impact as commercial and industrial waste. Indeed, in Europe MSW accounts for only 10% of total waste, or 225 million tons per year (Eurostat, 2022). While looking a little closer (Fig. 6), it can be seen that a major part of the wastes is accountable to Manufacturing, mining and quarrying and constructions. In Europe, the waste treatment takes different forms as showed on figure 7. Only 38% of the waste is recycled in Europe, which means that the rest is either incinerated to recover energy and then enters another cycle, or does not return to the cycle and is destroyed or "stored" in landfills.

Waste management plays a particular role in the above-mentioned planetary boundaries, but also on the health of living beings. Indeed, it influences climate change, novel entities, freshwater use, land and system change, ocean acidification. And for cause, the majority of the waste contains carbon and its incineration is emitting CO_2 in great quantity, having the effects that known on the various borders.

In addition, according to Professor Wiedinmyer other elements such as mercury, fine particles or polycyclic aromatic hydrocarbons (PAHs) are emitted during waste incineration and can cause significant damage such as lung diseases, neurological diseases, but also cause heart attacks and cancers (Thompson, 2014).

Figure 6: Waste generation by economic activities and households, 2018, EU, 2018

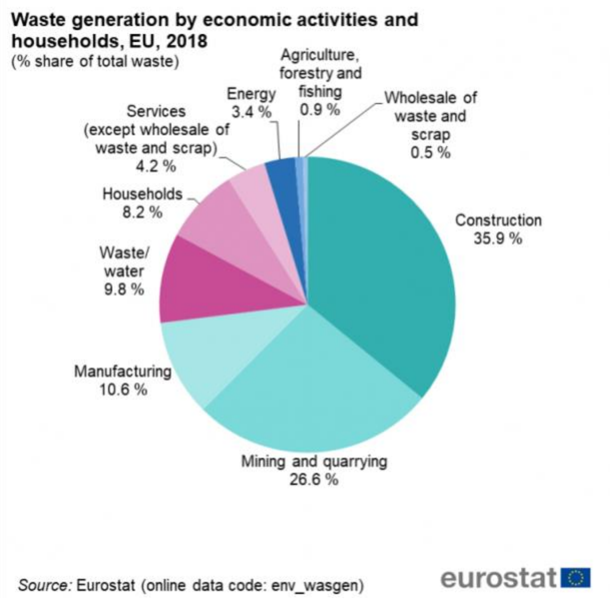
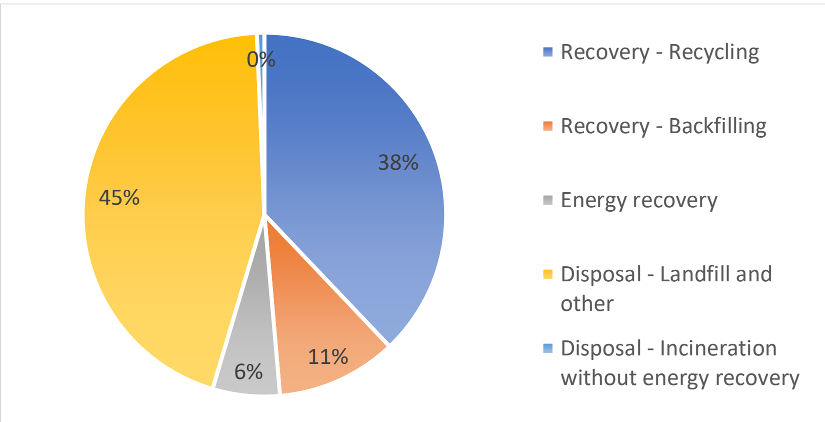


Figure 7: Waste treatment by type of recovery and disposal, EU, 2018



Source: Adapted by author from Eurostat

To this we can add the pollution of landfills whose degradation of the materials present emit methane, a greenhouse gas even more harmful than CO_2. If landfills are not built in an optimal way, they can contaminate soils and water, causing a cascade of health problems and deteriorating ecosystems (EEA, 2014). All of these problems, including health problems, can bring some social disparities because of the inequal waste management repartition on the globe (e.g., living close to a landfill increase risks) (WHO, 2015).

In order to deal with waste management, the EU has put in place legislation. The main one is the Waste Framework Directive (WFD) which defines a hierarchy of steps in waste management. Of course, the first step is prevention, then comes the preparation for reuse, the next step is recycling, recovery and finally disposal. Good waste management can lead to a significant reduction in CO_2 and methane emissions (EEA, 2014).

1.1.2.2 Socio-economic impacts

In the context of socio-economic impacts, the literature very often refers to the Ellen MacArthur Foundation (EMF) report, in collaboration with McKinsey, of 2013: "Towards the circular Economy: Economic and business rationale for an accelerated transiton", which identified a good part of them. In this report several impacts are mentioned such as Economic losses and structural waste, market risks, supply risks, ecosystem degradation or regulatory guidelines. Of course, this list is not exhaustive.

Economic losses and structural waste: In this section, the EMF points out the economic inefficiency of the linear system in terms of value creation. It highlights the fact that in Europe, only 5% of the initial value of raw materials is recovered through recycling and energy recovery. Structural waste concerns the lack of optimization in the use of certain elements that are considered to be optimized. The EMF takes as an example the immobilization of vehicles which, in Europe, are immobilized on average 92% of the time. Food waste is also put in the pillory because 31% of food is wasted along the value chain. There is therefore a real loss of profit in this linear structure.

Market risks: The volatility of raw material prices and supply disruptions are two elements that particularly worry companies. They feel trapped between rising and increasingly unpredictable prices in the resource markets, and stagnant demand in the various consumer markets. This can inhibit companies from investing, increase the costs of hedging resource risks, and thus have a negative impact on growth. This is illustrated by the fact that in the first decade of the 21st century, the volatility of the prices of certain products such as metals and agricultural products was already higher than in any decade of the 20th century.

Supply risks: In this section, the EMF discusses the unevenness of non-renewable raw material stocks across different regions of the world and the importance of imports in this context. The European Union, for example, imports six times more materials and raw materials than it exports. Some countries, such as Japan, have very few natural resources and are forced to import almost all of their liquid fuels. Therefore, there is a real dependency between countries that can lead to shortages in some nations when political or health situations are no longer stable (e.g., Covid Crisis and Ukrainian War).

Ecosystem degradation: As mentioned earlier, our current system is jeopardizing the various planetary boundaries defined by Rockström et al. among which are ecosystems. The degradation of ecosystems can have economic repercussions, notably through the depletion of reserves accessible at low cost, but also the deterioration of natural capital. For example, degraded soils can lose productivity and jeopardize the yield of agriculture.

Regulatory guidelines: Recently, authorities have been implementing more and more regulations to reduce and integrate negative externalities. Between 2009 and 2014, legislation has increased by 66%. Carbon is dealt with on the one hand via pollution rights, thus taking the form of carbon pricing consisting of an emissions trading scheme, and on the other hand via a carbon tax. The latter is proving to be very effective, since between 2009 and 2010, 2.1 billion euros were collected in 20 European countries.

The Ellen MacArthur Foundation therefore continues to process this data arguing the need to change the economic system and turn to alternatives such as the circular economy allowing to lay important foundations and to counteract the negative impact relative to the linear economy. Its elaboration is the subject of the next chapter.

Chapter 2: The circular economy

2.1 What is circular economy

In this section, the sustainable alternative to the linear economy that is the circular economy will be defined as mentioned in the literature, highlighting its main differences from the linear system. Then, its origins will be developed from its nominal appearance in 1980 to its place in the global context. Finally, its general characteristics will also be mentioned in order to highlight the interest of this system.

2.1.1 Origin

The circular economy is still difficult to define today, yet its concept is not new. Indeed, although the name circular economy first appeared in the literature in 1990 in "Economics of Natural Resources and the Environment" by Pearce and Turner, the concept is older. It can be rooted in two elements: the flow of materials through the economy and the economic conditions that drive these flows. This is related to the early environmental movements dating back to the 1960s (Ekins et al., 2019).

The first root can be associated with industrial ecology, which, in 1940, already included elements of the circular economy. Given that this current of economic geography was about finding the right place for industries to exploit resources in the most efficient way and to reduce waste. Then, Spilhaus (1970) mentioned the importance that in the next industrial revolution, there will be a loop back from the consumer to the firm that the industry will close. This being facilitated by a design that promotes return and remaking (Ekins et al., 2019).

Still on the subject of material flows in the economy, twenty years after Spilhaus, Frosch and Gallopoulos (1989) suggested the establishment of an industrial ecosystem consisting of an integrated model that optimizes the use of materials and energy, while reducing waste that will serve as raw material for another process. The industrial ecosystem would therefore be a copy of biological ecosystems. In addition, both authors will mention the importance of industrial ecology and system optimization concepts being learned and recognized by decision makers, industry leaders, and the media, and thus being adopted by governments and industry (Ekins, 2019).

Although it did not take off as they wanted, in 1997 the Journal for Industrial Ecology was born as a result of a growing interest of academics in research on the subject. Furthermore, in 2001 the International Society for Industrial Ecology (ISIE) was founded. However, it is interesting to mention that the term circular economy has never been mentioned in the research done around industrial ecology, despite the obvious similarities with the different definitions of this system (Ekins et al., 2019).

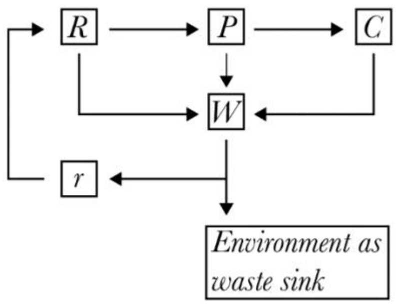
Regarding the economic conditions, the literature is aligned to declare Kenetth Boulding (1966) as a precursor (Ekins et al., 2019; Wautelet, 2018; Sariatli, 2017). Indeed, in "The Economics of the Coming Spaceship Earth", Boulding already laid the foundation for the circular economy by suggesting implementing an ecological cyclical system in place of a linear, resource-wasting system (Sariatli, 2017). He illustrated this by defining the "cowboy" economy and the "spaceship" economy. The former is related to so-called open societies in which people see the Earth's resources as unlimited and have exploitative, romantic, violent, and reckless behaviors. On the other hand, the spaceship is an analogy to the Earth whose reservoir is limited in terms of resource extraction and pollution. It is therefore imperative that humans find their place in a cyclical ecological system that allows for the continuous regeneration of materials, while knowing that they cannot escape the need for energy. He also mentioned the importance of considering the "stock maintenance" in a spaceship economy, in addition to the other elements that are GNP, production and consumption. Furthermore, he was already putting forward in 1966 that the problems associated with the spaceship were already contemporary (Ekins et al., 2019).

Boulding's work has inspired many researchers to dig deeper into the subject. For example, the Club of Rome suggested in 1973 in "The limits to Growth" (Meadows et al.) that, without change, cowboy economics might lead to catastrophe within a century.

Subsequently, Stahel and Reday (1981) mentioned that in Europe, substituting labor for materials and energy, extending the life span and repackaging products, as well as using recycled rather than virgin materials, can have benefits on costs as well as on unemployment. In 1982, Stahel followed up on this work by introducing the notion of spiral-loop, also known as closed loop (Sariatli, 2017), which could already serve as a definition of the circular economy, without actually bearing the name. The implementation of this system would allow for continued economic growth, while reducing the deterioration of materials, energy flows and the environment. This is broken down into four loops, the first of which is "reuse", the second is "repair", then comes "reconditioning" and finally "recycling" (Ekins et al., 2019). This concept, Stahel would develop almost 30 years later (2010) under the name "Performance Economy" (Sariatli, 2017).

In 1990, the name "circular economy" was first mentioned, and this by Pearce and Turner (Wautelet, 2018; Ekins et al., 2019) who developed the definition in economic terms. They contrasted the natural circular system with the economic linear system, arguing the importance of the difference between capital stock and their flows, all the while drawing on Boulding's theories (Wautelet, 2018) pointing to the importance of the laws of thermodynamics stipulating that each thing is the input of something else. Their initial explanatory diagram of the process was quite simple and may be the reason for the overemphasis on recycling in the circular system (fig. 8) (Ekins et al., 2019). However, they also highlighted the second law of thermodynamics which explains the impossibility of obtaining 100% recyclable materials and the impossibility of recycling energy.

Figure 8: Pearce and Turner's first circular economy diagram



Note: Key: R=resources, P=production, C=consumption, U=utility, W=wastes, r-recycling

Source: Pearce and Turner 1990: 38

Later, they added to their first diagram the notion of the planet's absorption capacity, allowing it to incorporate waste without suffering damage, but not exceeding a certain threshold, which may be linked to the planetary boundaries discussed above and the danger of exceeding them. To this scheme came to be grafted the notion of renewable and non-renewable resources, whose good use is essential in order to avoid their shortage.

Despite this, the success of the circular economy will have to wait a few more years before it really takes off in 2010 with the creation of the Ellen MacArthur Foundation which, in collaboration with the McKinsey Group, published several reports entitled "Towards the Circular Economy".

However, in the meantime this has led to the emergence of several concepts. As mentioned before, Stahel introduced the notion of closed-loop in 1982, from which the "Performance Economy" emerged in 2010. In this concept, the idea is that companies should sell performance. The original principle was first taken up in 2002 by Braungart and McDonought in their Cradle-to-Cradle, whose main idea is that every element included in industrial and commercial processes are nutrients that can be biological or technical. Benyus's Biomimicry was born in 1998, this trend having for principle to learn from nature and to imitate it in order to answer the challenges proposed by the industry and the trade. The Natural Capitalism appeared in 1999, whose objective is to be able to meet the needs of growth and those of the environment by the means already mentioned above such as the efficiency of the use of resources, the closed loop, to pass to a model of "service and flow". Another important concept is Gunter Pauli's Blue Economy from 2009, whose idea is also to be inspired by nature. This concept evokes the idea that the waste of an industry can be an input for different sectors. To this can be added Industrial ecology, which has already been mentioned earlier, and has a particular influence on the circular economy by aiming to creating closed-loops in order to regulate materials and energy in industry (Sariatli, 2017).

These different points will be developed in more detail in Chapter 3.

2.1.2 Definition

When analyzing the different definitions of the Circular Economy, it is clear that there is no single one that serves as a universal explanation of the concept. Indeed, each description of the CE is nuanced by each author of consultancy reports, scholars or decision makers, including some elements or omitting others. However, as Wautelet (2018) mentions, one of the reference institutions in the field of circular economy is the Ellen MacArthur Foundation (EMF) and the definition that the foundation proposed in its 2013 report has been endorsed by many professionals who use it in academic and non-academic discussion settings in Europe.

This definition is presented as follows:

> “The circular economy refers to an industrial economy that is restorative by intention; aims to rely on renewable energy; minimises, tracks, and eliminates the use of toxic chemicals; and eradicates waste through careful design.” (Ellen MacArthur Foundation, 2013).

Several elements can be drawn from this definition. First, it seems quite clear that the objective is to eliminate waste, or at least useless waste that no longer fits into any value chain and ends its life, at best in a landfill, if not in rivers or oceans. This goes perfectly in opposition to the linear model as described before. Furthermore, it mentions an industrial economy that is **restorative**. The definition therefore emphasizes an economy that would still be industrial, and whose intention would no longer be only to do less harm, but to do better by repairing the damage created (Wautelet, 2018). This being possible thanks to technological advances and designs that allow for a positive impact in the long run (Murray et al, 2017). A point supported by Le Moigne (2014), who mentions the importance of considering the sustainability and recycling of products or materials from their design to promote the efficiency of their use.

Other definitions, such as that of the European Parliament, seem to agree on elements included in the definition proposed by the Ellen MacArthur Foundation, i.e., the importance of good waste management and the positive impact in value creation that it can bring.

> “The circular economy is a model of production and consumption, which involves sharing, leasing, reusing, repairing, refurbishing and recycling existing materials and products as long as possible. In this way, the life cycle of products is extended. In practice, it implies reducing waste to a minimum. When a product reaches the end of its life, its materials are kept within the economy wherever possible. These can be productively used again and again, thereby creating further value.” (European Parliament, 2022).

The creation of value mentioned by the European Parliament is defined more precisely by the United Nations Conference on Trade and Development (UNCTAD) and the French Agency for the Environment and Energy Management (in French “Agence De l’Environnement et de la Maitrise Energétique” or ADEME), which mention the circular economy as a way of acting on the one hand on the economy, but also on the well-being of people and the environment on the other hand. This is joined by another definition of the EMF, that can be found on their website, which specifies that the CE "is a resilient system that is good for business, people and the environment". As well-being is often linked to GDP and its growth, the definition of the European Commission can also be interpreted in this way, as it mentions, like ADEME, the intention to continue to grow economically while reducing its consumption of resources, which is the definition of decoupling.

> “In our current economy, we take materials from the Earth, make products from them, and eventually throw them away as waste – the process is linear. In a circular economy, by contrast, we stop waste being produced in the first place. The circular economy is based on three principles, driven by design: Eliminate waste and pollution, Circulate products and materials (at their highest value), Regenerate nature. It is underpinned by a transition to renewable energy and materials. A circular economy decouples economic activity from the consumption of finite resources. It is a resilient system that is good for business, people and the environment.” (EMF, 2022).

“A circular economy entails markets that give incentives to reusing products, rather than scrapping them and then extracting new resources. In such an economy, all forms of waste, such as clothes, scrap metal and obsolete electronics, are returned to the economy or used more efficiently. This can provide a way to not only protect the environment, but use natural resources more wisely, develop new sectors, create jobs and develop new capabilities.” (UNCTAD, 2022)

“Circular economy represents a development strategy that entails economic growth without increasing consumption of resources, deeply transform production chains and consumption habits and redesign industrial systems at the system level.” (European Commission, 2014)

“An economic system of exchange and production that, at all stages of the life cycle of products (goods and services), aims to increase the efficiency of resource use and decrease the impact on the environment while developing the well-being of individuals” (ADEME, 2014).

“A system of production and exchange taking into account, from their conception, the sustainability and recycling of products or their components, so that they can become either reusable objects or new raw materials with the objective of improving the efficiency of the use of resources." (Le Moigne, 2014).

In addition, Kirchherr et al. (2017) identified 114 definitions of the circular economy in the literature and used them to produce theirs as a synthesis:

“Circular economy describes an economic system that is based on business models which replace the ‘end-of-life’ concept with reducing, alternatively reusing, recycling and recovering materials in production/distribution and consumption processes, thus operating at the micro level (products, companies, consumers), meso level (eco-industrial parks) and macro level (city, region, nation and beyond), with the aim to accomplish sustainable development, which implies creating environmental quality, economic prosperity and social equity, to the benefit of current and future generations.” (Kirchherr et al. 2017)

First, the authors mention the circular economy as an economic system, without focusing on the industrial side of it, so there is a broad connotation of the concept. This is endorsed by the mention of the different levels of action of the business model which can be micro, in the more common sense of the definition (i.e., products, companies, consumers), but also meso and macro. This principle of levels is supported by the definition of Geisendorf and Pietrulla (2017), which includes them in its characteristics allowing the classification of the different concepts of circular economies.

Moreover, in this definition by Kirchherr et al. there is mention of achieving sustainable development, which has not been cited in previous definitions although its characteristics appear in most of them. However, the notion of benefiting not only the current generation, but also future generations is a new element to further complete the understanding of EC. Furthermore, it is worth noting the absence of mention of public policies and states that can help implement the system in all these definitions (Ekins et., 2019). Yet, it is good to remember that the state plays a very important (second) role in economic systems, providing public goods, supporting the role of households, unleashing the dynamism of the commons, and framing the market via regulations that promote the commons (Raworth, 2017).

However, this last element is well taken into account by Alexandre Levillain and Dominique Bonet Fernandez (2014) who define the circular economy as follows:

“The circular economy (CE) is a global economic model that reconciles economy and preservation of the environment and local employment. As a new paradigm, it requires a regulatory framework addressing all actors of the society, public institutions in charge of initiating and controlling, companies that have to implement it as well as citizens.”

Putting forward the legislative framework necessary to allow the authorities to incorporate the circular economy model whose practices will be intended certainly for businesses, but also by citizens in a perspective of resource management beneficial for the economy, but also for the environment. This definition therefore mentions the principle of transversality of the CE which is perfectly put forward by Philippe Destatte (2014) who, sees the CE as an instrument of sustainable development and who gives the following definition:

“The Circular Economy is a major development axis that is articulated from the global to the local level and is the basis for systemic and transversal policies that are carried out at the European, national/federal, regional and territorial levels. These policies are intended to fit together, to be articulated, and to become more and more concrete as they get closer to the agents in the field, and therefore to companies.”

Destatte thus emphasizes the necessary intervention of different levels of power for the functioning of the EC. However, he differs from the previous definition by considering companies as the sole "actors" of the EC (Smaili, 2017).

Vincent Aurez and Laurent Georgeault (2016), for their part, point out that the various definitions may be too utopian and decide to balance them by recalling that the objective is to find a balance between resource use and economic development. They propose the following definition, which includes several important elements of the previous titles:

> “The circular economy is a principle of economic organization that aims to systematically reduce the quantity of raw materials and energy over the entire life cycle of a product or service, and at all levels of organization of a society, in order to ensure the protection of biodiversity and a development conducive to the well-being of individuals.”

Finally, Ekins et al. (2019), based on the work of Meril et al. (2018), but also Blomsma and Brennan (2017), and other authors (Ekins et al., 2019), will set out to explain the circular economy and its purpose in a narrative form rather than a definition per se. The circular economy thus aims to reduce the depletion of scarce natural resources, to cut the environmental damages caused by the extraction and processing of virgin materials. It also aims to decrease the pollution emitted during the processing, use and end of life of materials. There is therefore an action all along the value chain of the product.

Ekins then goes on to point out the different ways to achieve these goals. It is necessary to increase the efficiency and productivity of resource use, while reducing the amount of resources that are thrown away. In order to do this, new business models are needed, which are part of a whole system with a line of conduct regarding the use of resources and which would incorporate closed supply chains, regenerative design, reverse supply chain that will allow to keep the value of the product, as well as their derivatives, in order to minimize the creation of waste.

Of course, such a system must be financially manageable, which is no small task given the barriers that stand in its way. It will therefore be necessary to have changes in the political decision-making process to promote the adoption of CE, and thus minimize its obstacles, but also in the organizations of companies.

While analyzing all these definitions, several principles such as eco-design, waste reduction, reuse, emerge and will be the subject of an analysis in the following section.

2.1.3 Principles and actions of the circular economy

Once again, the Ellen MacArthur Foundation (2016) plays an important role in the literature, it establishes a model of characteristics related to the circular economy often taken up by other authors. They are presented as follows:

Design out waste: As the name implies, this principle intends to eliminate waste by manufacturing products with materials (biological or technical) designed so that they remain in technical or biological cycles. They can then be decomposed and refurbished. The biological materials will be composted, while the technical components can be used again, all this using as little energy as possible and keeping a high product quality. In this last clarification, the emphasis is on the difference with simple recycling which is often associated with a loss of quality as put forward by Braungart and McDonough in Cradle to Cradle about upcycling.

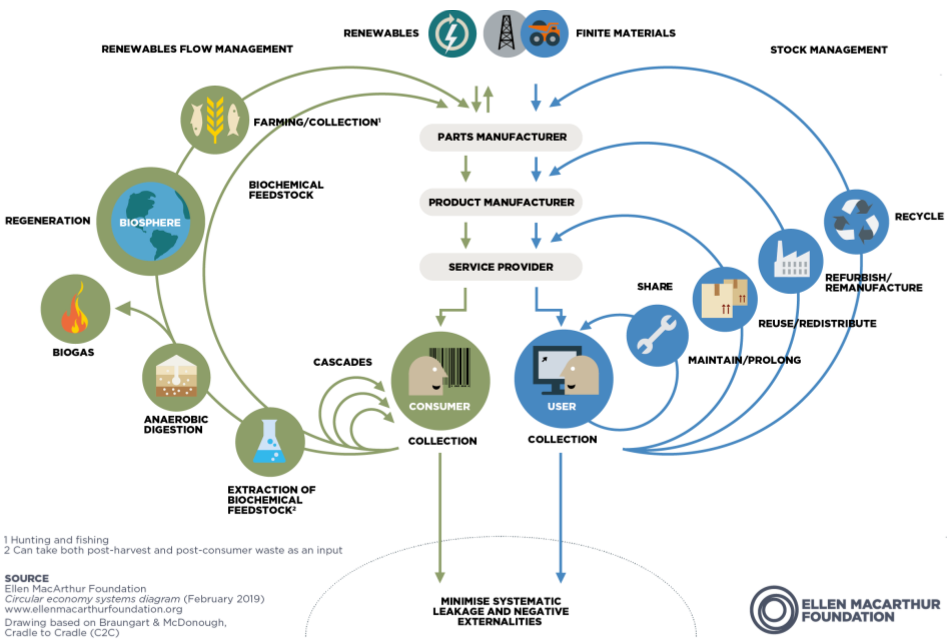
Build resilience through diversity: The world is in a state of perpetual evolution, what is acquired today will not necessarily be acquired tomorrow. The more diversified and interconnected a system is at several levels, the more resilient it will be to unexpected and sometimes difficult changes (e.g., Covid crisis and material shortage). It is therefore important not to simply focus on pure logistical efficiency, but to take into account potential risks and assimilate them in order to increase the ability to react. This adaptability is a key element of natural systems whose diversity, uniformity and complexity should inspire industrial processes to increase their resilience.

Rely on energy from renewable sources: As mentioned earlier, there are several sources of capital, renewable and non-renewable. This is also true for energy. Energy occupies a key place in our current system, and it seems obvious that to enter a cyclical system, it must be renewable. Stahel reminded us of the importance of labor in providing energy and argued that it should be put in the same category as energy. He therefore proposed to shift the taxation applied to labor to the consumption of energy and materials. According to him, this would ultimately lead to circularity and put pressure on a real societal concern which is the excessive consumption of resources.

Think in systems: It is important to think broadly and interconnectedly. Understanding how each stakeholder influences each other, in what context and for what reason is crucial. System thinking is often associated with a non-linear system, in which there is a combination of uncertain starting conditions and feedbacks that lead to surprising results that are not always proportional to the starting inputs. This puts the emphasis on flows and connections through time and incorporating regenerative conditions rather than a short term, single party view. It is therefore important to contextualize things when tackling a problem, as nature does, where nothing happens without context.

Waste is food: As previously stated, at the heart of the circular economy principle (again according to the EMF) is the intention to reintroduce products and materials into the biosphere via non-toxic and restorative loops for what is biological and to upcycle the technical components. This can be done through different steps as illustrated in the figure 9.

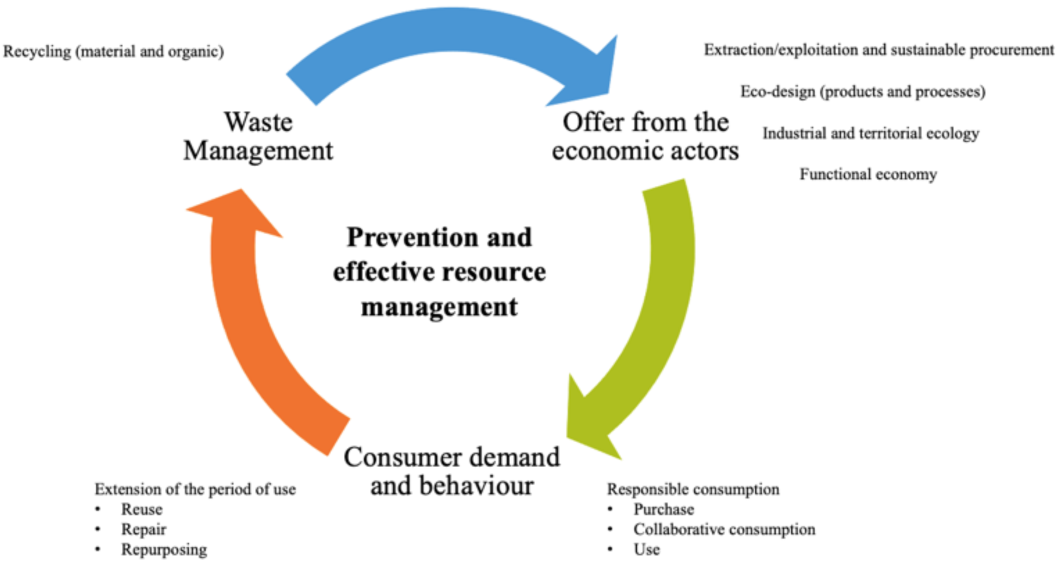
Figure 9: Circular economy butterfly diagram



Source: Ellen MacArthur Foundation (2019)

Another vision of the existing principles is that of ADEME, which evokes seven major pillars of the Circular Economy divided into three areas (fig. 10):

Figure 10: ADEME' pillars of circular economy



Source: Adapted by author from *Expertises, Économie circulaire* –. (2017). Agence de la transition écologique. https://expertises.ademe.fr/expertises/economie-circulaire

The offer of the economic actors:

This area targets the leverage of economic actors in the circular economy and this through the offers they present on the market and the way they supply. It is therefore segmented as follows:

- **Sustainable supply** is an essential pillar in the world of supply and industry, since it encourages an extraction and exploitation of resources that is efficient and therefore avoids as much waste as possible in these processes. In addition, it encourages the minimization of environmental impact in the exploitation of energy, mineral, forestry and agricultural materials, regardless of whether the capital is renewable or not. Moreover, this principle applies to both the public and private sectors.

- **Eco-design** consists of "the systematic integration of environmental aspects from the design and development of products with the objective of reducing negative environmental impacts throughout their life cycle. This approach, from the beginning of a design process, aims to find the best balance between environmental, social, technical and economic requirements in the design and development of a product" according to the Association Française de Normalisation (AFNOR) (Papadopoulos, 2019). This can be likened to the EMF's "design out waste" highlighting the importance of manufacturing one's good so that it stays in the cycle and can be reused, repaired, remanufactured or recycled. To this can be added the economically favorable component for companies that, by reintroducing their products into the cycle, can enjoy a reduction in costs related to the extraction of raw materials and thus increase their competitiveness (Papadopoulos, 2019).

- **Industrial and Territorial Ecology**: Industrial ecology is a concept of the circular economy brought in 1989 by Frosch and Gallopoulos in "Strategy For Manufacturing". It owes its name "industrial" to the fact that it focuses on product design and manufacturing processes. It sees companies as "agents" of environmental improvement because they have the technological expertise to create environmentally friendly product and manufacturing designs. Furthermore, it focuses on industry given its considerable impact in terms of providing goods and services (Lifset and Graedel, 2002).

  It is also called industrial symbiosis because it is based on industrial metabolism. It consists of a tool for evaluating the material and energy flows included in an industrial system, analyzing the various interactions and transformations taking place there and producing a manufactured good or waste (Erkman, 2004; Le Moigne, 2014, Smaili, 2017). In addition, it constitutes a mode of organization between companies, which are generally independent, by exchanging flows or pooling needs via collaboration and possible synergies thanks to geographical proximity (ADEME, 2014; Le Moigne, 2014).

  Territorial Ecology differs from Industrial Ecology by its application to entire territories and not just to industries.

- **The economy of functionality** whose foundations are brought by Stahel and Giarini in 1986 under the name of "New service economy". The name will evolve as the work progresses to become "Utilization Focused Service Economy" in 1994, "Functional Economy" in 1997, which will evolve into "Functional Service Economy" in 2006 and finally Stahel's work will punctuate into "Performance Economy" in 2010 (Le Moigne, 2014; Sariatli, 2017, Smaili, 2017).

  Its definition is given by the ADEME as follows: “The economy of functionality consists in providing companies, individuals or territories with integrated solutions of services and goods based on the sale of a performance of use or a use, and not on the simple sale of goods. These solutions must allow for less consumption of natural resources, in a circular economy perspective, an increase in people's well-being and economic development" (ADEME, 2017).

The principle of this pillar is that the consumer buys the service provided by the product but not the product itself. In other words, the consumer is never the owner of the product in question, but is a sort of tenant of it, the product always belonging to the firm. The company that has made the good available recovers it when the consumer no longer finds a use for it. Of course, through such a process, the firm has every interest in designing the product in the most optimal way possible, via ecodesign, so that it has a long enough life and retains as much value as possible while minimizing the energy and raw material requirements to keep it in being (Le Moigne, 2014; Smaili, 2017).

Consumer demand and behavior:

- **Responsible consumption** "must lead the buyer, whether an economic actor (private or public) or a citizen-consumer, to make his choice by taking into account the environmental impacts at all stages of the product's life cycle (goods or services). This principle is broken down into three categories: the method of purchase, the mode of use and collaborative consumption" (ADEME, 2017)

- **The extension of the duration of use**

Reuse, as its name indicates, reuse consists in reusing a product in order to counteract the overconsumption present in our current system. It can be defined as the resale or donation of a product by its owner, who no longer has any use for it, to a third party who will use it. This allows the product's life to be extended, postponing its potential end. This is also a principle known to the general public as Second Hand (Destatte, 2014; Papadopoulos, 2019).

Repair, this principle always takes place in this context of overconsumption, but also of programmed obsolescence doing a lot of damage. Indeed, today it is even easier than before to replace a used product by a new one when the first one could still work. The definition of the repair is not sophisticated since it consists simply in the restoration of a product to its original state of use in order to give it a second life. By doing so, the product stays in the cycle and this prevents waste (Destatte, 2014).

Repurpose, for the same reasons as stated above, it finds its usefulness by repairing a product that is in a state of waste in order to restore its value and reintroduce it into the cycle. When the product is not repairable, it is broken down into spare parts to be used in the composition of another product (Destatte, 2014; Smaili, 2017; Papadopoulos, 2019). Destatte (2014) defines reuse as “an intervention on waste to introduce it, whole or in spare parts, in another circuit or economic channel, with a qualitative choice and a will of sustainability”.

Waste management:

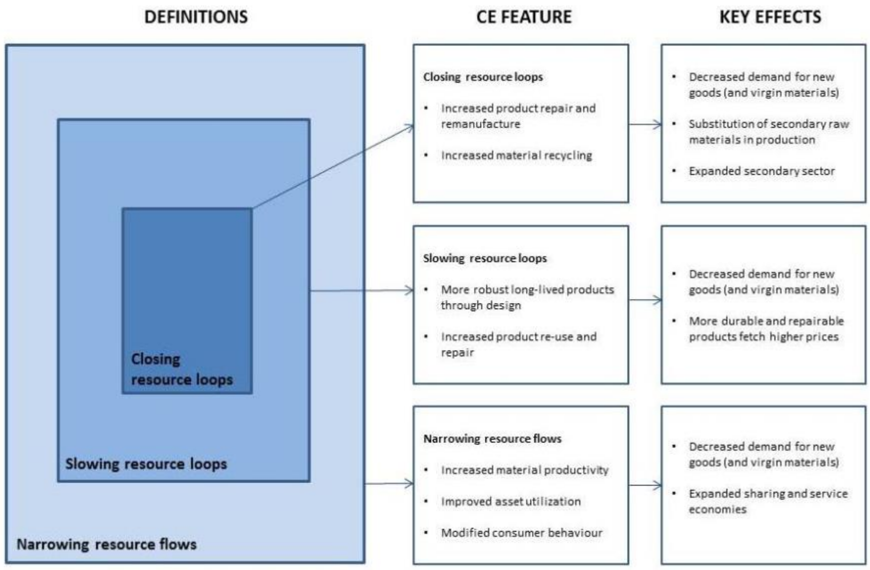
Recycling is defined since 2008 by an EU directive (Directive 98/2008/EC Article 3(17)) as “any recovery operation by which waste materials are reprocessed into products, materials or substances whether for the original or other purposes. It includes the reprocessing of organic material but does not include energy recovery and the reprocessing into materials that are to be used as fuels or for backfilling operations.” (Bartl, 2014). It is also explained by Remy Le Moigne (2014) as the “treatment in a production process of the materials contained in the waste, for the same or other purposes as originally, but excluding energy recovery”.

Therefore, there is a duality in the process of recycling and treatment of waste. Indeed, on the one hand, it can be done in a closed loop, the raw materials of the waste are then reused in order to produce similar goods, the use remaining the same. On the other hand, the raw materials can be used in an open loop i.e., the raw materials from the waste are exploited again in order to produce goods different from the original ones, thus addressing another industry (Destatte, 2014; ADEME, 2019; Papadopoulos, 2019).

Of course, recycling is facilitated by eco-design which is necessary to obtain a quality product (upcycling) rather than a product of lesser value when the original product is not intended for recycling (downcycling).

Many of the features previously included in the ADEME list are also considered by the OECD. Indeed, the following features were identified by McCarthy et al. (2018): increased product repair and remanufacturing, increased material recycling, more robust products with long lifetimes due to their design, increased product reuse and repair, increased material productivity, improved asset utilization, changed consumer behavior. This having the following objectives: decreased demand for new (and virgin) goods, substitution of secondary raw materials in production, expanded secondary sector, more durable and repairable products, and expanded sharing and service economies (fig. 11).

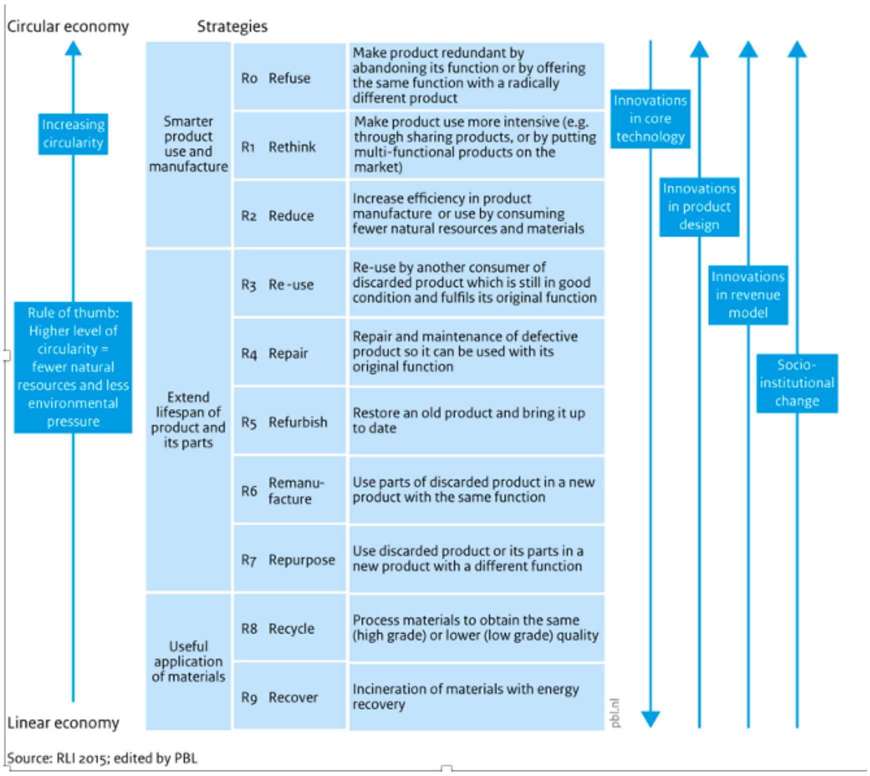
Figure 11: Differing definition of the circular economy



Source: McCarthy, A., R. Dellink and R. Bibas (2018), "The Macroeconomics of the Circular Economy Transition: A Critical Review of Modelling Approaches", OECD Environment Working Papers, No. 130, OECD Publishing, Paris. http://dx.doi.org/10.1787/af983f9a-en.

Finally, Potting et al. (2017) defined nine Rs (fig. 12) as characteristics regarding circularity strategies to be adopted in production chains. Despite some discrepancies in terms of definitions of the terms, it is easy to see that many Rs are indeed present in the analyses done above. Moreover, it is interesting to note that two of the EMF Rs (i.e., restorative and regenerative) are not included in this list (Ekins et al., 2019).

Figure 12: Circularity strategies within the production chain, in order of priority



Source : Potting et al. (2017), Figure 1 : 5

2.2 Opportunities

In this section, some opportunities will be pointed out in an economic, social and environmental perspective.

Economic opportunities

Economic growth

One of the principles of the circular economy as defined above is decoupling, allowing, among other things, to dissociate economic growth from the exploitation of raw materials. Therefore, the use of circular economy policies allows the economy to be less dependent on these resources and to be able to grow despite potential shortages (EMF, 2015; McCarthy et al., 2018; Elisha, 2020).

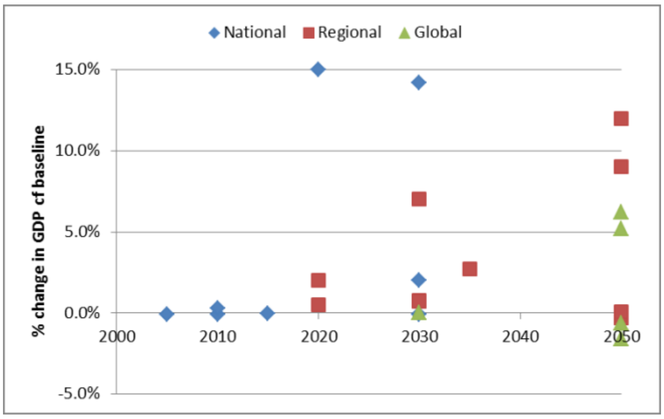
In addition, emerging circular activities as well as manufacturing cost reductions resulting from the effective use of raw materials in industry can have an impact on the market, in terms of supply, demand and prices (EMF, 2015). Indeed, according to The United Nations Environmental Plan (UNEP) by 2050 the more efficient use of raw materials could offer a benefit of $2 trillion per year (UNEP, 2017). While according to Dobbs et al (2011) this figure would amount to US$ 2.9 trillion per year for private investors by 2030 and offering, in 70% of cases, a rate of return higher than 10%. This has a cascading effect that can impact all sectors of the economy and thus have a positive influence on GDP. It can also increase household incomes leading to a better remuneration of labor which can be explained by the increase in spending and savings.

Furthermore, the new circular industries will require a specialized workforce, which will increase the demand for these jobs and reduce the demand for less specialized jobs related to the extraction and processing of raw materials. The latter will raise the value of labor (WE Forum, 2014; Elisha, 2020). European GDP could therefore jump by 11% between 2015 and 2030 and by 27% by 2050, which is to be seen in the context of a linear economy projecting 4% and 15% (EMF, 2015).

This is corroborated by the UN Envionrment's International Resources Panel which states in 2019 that “implementing an integrated package of resource efficiency, sustainability, and climate policy actions results in net economic benefits globally from 2030 onwards, with global GDP 8 per cent above Historical Trends in 2060, as projected economic gains from resource efficiency outweigh[ing] the near-term economic costs of achieving ambitious reductions in net greenhouse gas emissions.” (Ekins et al., 2019).

Although the numbers are not as telling, this is supported by McCarthy et al. (2018) highlighting the convergence of the literature with respect to GDP growth due to the implementation of circular economy principles, pointing to only two studies that announce a possible depression of GDP compared to the baseline (i.e., Schandl et al. (2016) and Hu et al. (2016)). Indeed, as shown in Figure 13, among the remaining studies, the majority of studies show a GDP increase of less than 5%. While seven of them are above 5% and 3 even above 10% (Ekins et al., 2019).

Figure 13: Headline modelling results in the studies considered in this review: GDP with respect to baseline



Note: Geographic coverage – national, regional, global – refers to the area that results were reported for. Some models have global coverage but only report results for a particular region.

Source: McCarthy et al., 2018

However, these results need to be balanced because on the one hand, they are assertions that depend on the type of economic model used, the treatment of investment, the rate of non-utilization of resources in the economy (the focus is on labor), the rate of skills needed for the new circular activities and their availability, but also the policies put in place to increase resource efficiency (McCarthy et al., 2018; Ekins et al., 2019). On the other hand, also suggest that the current model is very clearly inefficient in terms of resource extraction.

Finally, the result may be positive globally, but negative locally in some countries. Indeed, the transition to circular industries risks creating segregation, with some countries or sectors doing better than others. Countries whose economies are more dependent on upstream extraction activities (e.g., mining, oil and gas, fishing, ...) and material processing may see a decline in these. For example, according to the report by Meyer et al. (2016), countries such as Russia, Brazil and Canada are likely to see their GDP fall by 27.7%, 16.5% and 7% respectively by 2050 (McCarthy et al., 2018).

Significant reduction in net material costs

Another consistent benefit of the circular economy is its impact on the net cost of materials. While raw material extraction, costs and prices are still growing, this seems to be a welcome development. According to the EMF (2015), in Europe a reduction of 630 billion dollars in net costs related to complex products with a medium lifespan is possible in an advanced circularity context. For goods with shorter life cycles, the EMF indicated a higher possibility of $700 billion on a global scale. However, according to the Circle Economy, only 9% of raw materials were fully recycled in 2019 (Circle Economy, 2019). So, there is still a long way to go.

Job creation potential

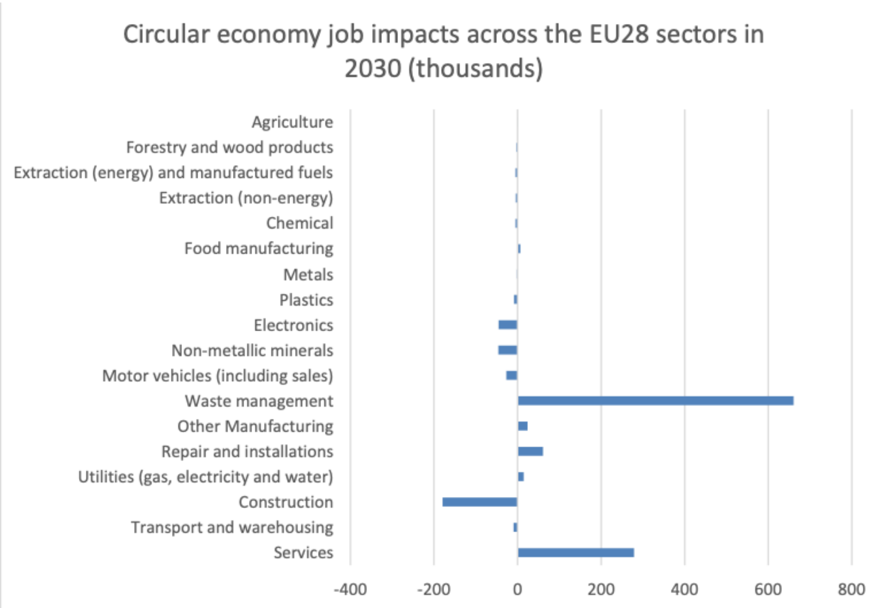
One of the concepts of the circular economy brought by Stahel (1982) is the importance of labor which is considered a renewable resource. Such a statement can only have a positive impact on employment. This is supported by a comparative study, including 65 papers, led by the EMF, McKinsey and SUN (2015), arguing that the literature converges on an estimate of increased employment in case of a transition to circular. This is explained by higher spending in anticipation of price reductions across sectors as well as labor intensity in high quality recycling activities. This workforce will be specialized in refabrication and remanufacturing. This study also highlights the rich and varied breadth of impact of the circular economy in terms of employment, the creation of which will affect all industry sectors. This is caused by locally implemented reverse logistics in small and medium-sized enterprises, but also by an increase in innovation and entrepreneurship. To this can be added a new service-based business model (Elisha, 2020).

In addition, as part of the study conducted by the three organizations, an analysis carried out in Denmark showed that ten circular business opportunities could lead to the creation of 7,300 to 13,300 jobs by 2035 in the country compared to the scenario based on the linear economy. These figures represent 0.4% to 0.6% of the Danish workforce (EMF, 2015).

These predictions are supported by Wijkman and Skanberg (undated) who write about the subject on a European scale: “unemployment rates, compared to today, could be cut by a third in Sweden and the Netherlands, and possibly more, maybe even cutting unemployment in half provided that some of the likely trade surplus gains would be used for investments domestically. In Spain the unemployment rate is likely to be reduced from the current over 20% to somewhere close to 15%, in Finland unemployment would be cut by a third, and in France by almost a third, provided that some of the likely trade surplus gains would be used for investments domestically.” (Ekins et al., 2019). Finally, according to Dobbs et al (2011) who argued that the implementation of resource efficient technologies could save private investors $2.9 trillion, also pointed out that this implementation would require $900 billion which in turn would allow the creation of 9 million to 25 million jobs over the long term at the global level (Ekins et al., 2019).

Nevertheless, all these figures (at least regarding Europe) are moderated by a European Commission report conducted by Cambridge Econometrics (2018) which states that circular policies can have an impact on the labor force of 0.3%, or 700,000 jobs by 2030. This detailed report on the impact of circular economy policies on the labor market also provides a view of the possible evolution of employment according to different sectors by 2030 (fig. 14) (Cambridge Econometrics, 2018; Ekins et al., 2019).

Figure 14: Job impacts of Circular Economy across the EU28 in sectors



Source: Cambridge Econometrics, 2018

Innovations

The revolution of the linear economic system will require many changes at the systemic, technological and sociological levels. This will require a shift in thinking to address the challenge, and therefore drives innovation. The investments aimed at increasing the efficiency of resource technologies can also have a positive impact and create a new wave of innovation in the long term (Dobbs et al., 2011).

Moreover, an innovative economy is a lever for technological progress, but also for increased material performance, it also boosts the profitability of the workforce while offering better energy efficiency which leads to many profit opportunities for companies (EMF, 2015).

Finally, the search for optimization linked to the innovation challenge related to the implementation of the circular economy, can lead to an interdisciplinary cooperation between designers, producers and recyclers, thus offering new insights and new thoughts (Kirchherr et al., 2017; Elisha, 2020).

Environmental opportunities

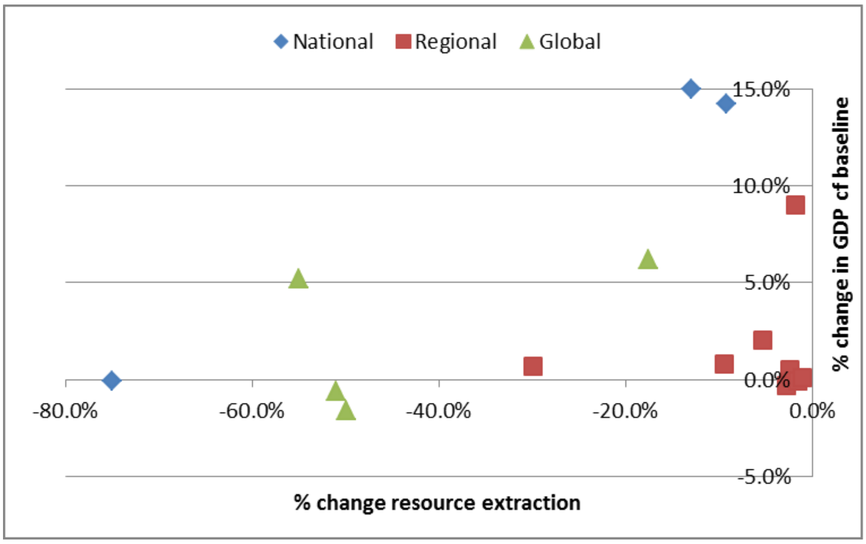
Consumption of natural resources

It has already been mentioned several times, the circular economy is considered as a necessary tool for decoupling and is part of the green growth. It goes without saying that among the opportunities present is the reduction of the consumption of natural resources, which is one of the main objectives of this change in the economic system. Indeed, it has been shown before that the inadequate and excessive extraction and disposal of non-renewable natural resources is a danger to the sustainability of the planet, which is gradually reaching the limit of its reserves.

According to the EMF (2015), circular development could lead to a reduction in primary resource consumption of 32% between 2015 and 2030 and 53% by 2050. These figures can even go up to 80% compared to business as usual according to some studies.

However, this is nuanced by the existence of trade-offs between higher growth and lower resource extraction (Fig. 15). Some studies show that circular economy policies have the effect of stimulating economic growth, but without a reduction in terms of resource extraction. This can be explained by the fact that productivity improvements are a must for long-term economic growth, but it also leads to a rebound effect due to increased household income. Conversely, many studies show that circular economy policies can have a positive impact on reducing resource extraction, but without increasing economic growth. This is explained this time by the additional costs related to taxes on the use of materials in the study cases presented (McCarthy et al., 2018).

Figure 15: GDP and resources extraction



Source: McCarthy et al., 2018

CO_2 emissions

Greenhouse gas emissions and more specifically CO_2 emissions are, along with the extraction of non-renewable resources, at the center of the concerns of the 21st century leading to the reflection of the necessity of changing the economic system. It is therefore more than expected that the implementation of circular economy systems will have an impact on these, allowing their reduction.

Contribution (UDC) of current environmental policies, by 2100, the global temperature is expected to increase by 3.2 degrees compared to pre-industrial times. CO_2 emissions are expected to decrease by 7%. This is far from being sufficient, and this is due to the inadequacy of current measures, which if left unchanged, will only lead to a reduction of 11 to 13 billion tons of CO_2 equivalent. Whereas by implementing circular development strategies, a much larger reduction is expected, in the order of 50% to 70%, or 28.8 billion CO_2 equivalent (EMF, 2016; Circle Economy, 2021).

Land productivity and soil health

As discussed earlier, the current system puts soils and lands at risk, decreasing their fertility, reducing the biodiversity that is normally present and degrading unique landscapes. Degradation can also have monetary consequences, as it is estimated to cost $40 billion per year worldwide, not including the elements mentioned above. The circular economy by increasing land productivity, reducing waste in the food value chain and allowing nutrients to be returned to the soil leads to a revaluation of land and soil assets. Some processes such as using organic waste as fertilizer can lead to soil regeneration and even substitute chemical fertilizers 2.7 times. Finally, by adopting a circular system for food in Europe, from 2015 to 2050 the consumption of chemical fertilizers can be drastically reduced by 80%. This is one of EMF's main concerns, since it is about the regeneration of the soil and the use of fertilizers (EMF, 2016).

Externalities reduction

The negative externalities to the environment due to the linear system are extremely numerous. They can be associated for example with material flows, and therefore the use of circular economy allowing a reduction of material consumption can have a positive effect and reduce these externalities (Sariatli, 2017). In addition, it can reduce the dependence on these materials. Among the changes caused by the circular transition are the exclusion of the intensive use of energy and water during the different manufacturing processes, but also moving towards less toxic materials. These elements will reduce GHG emissions, water use, but also alleviate the pressure and damage on biodiversity (EMF, 2016).

Opportunities for Business

Potential benefits

Among the opportunities that companies can achieve with the advent of the circular economy is the reduction of the costs of different inputs (e.g., material). They can also create new sources of profit by developing new markets. In today's linear system, the extraction of raw materials is subject to uncertainties along the supply chain and is therefore a source of high costs (EMF, 2016; Vermunt et al., 2019).

CE, by offering lower costs due to longer material life cycles, as well as increased safety and cooperation along the supply chain strengthening the latter, can be a source of profit for companies. Additionally, it can also increase brand image by showing sustainability actions to customers. (Vermunt et al., 2019).

Reduced volatility and improved security of supply

As discussed in the limitations of the linear economy, the volatility of raw material prices and their security of supply are two dangers inherent to the current system that can play tricks on companies.

These can be greatly reduced by implementing the circular economy, which, by using so-called virgin materials and making use of recycling, maximizes the value of these materials over their entire life cycle and increases the cost of labor. The cost of materials will therefore be lower than the cost of labor, resulting in greater stability and availability of their costs, reducing the exposure of companies to volatility risks. This reliability allows companies to engage in more favorable long-term investments, and also to be more resilient to threats such as natural disasters and geopolitical issues and imbalances influencing supply chains. Firms will therefore be more independent (Preston, 2012; EMF, 2016; Sariatli, 2017; Vermunt et al., 2019).

New demand for activities and services

The implementation of the circular economy will require a lot of changes in terms of organization and will therefore lead to the creation of many new activities and more specifically service activities. So many activities that will be new opportunities for entrepreneurs. The Ellen MacArthur Foundation (2016) lists them as follows:

- Companies whose specialty is reverse logistics, i.e., to reintroduce products at the end of their life into the economic circuit and thus increase their value
- Still in the perspective of extending the life of products, there will be a need to remarket products whose life is extended, which can also be facilitated by the creation of platforms
- The remanufacturing of products from spare parts and components is an area that will require specialized companies, which can also focus on the renovation of products

In many cases, these services are being offered on a large scale by subsidiaries of existing manufacturing companies that need to take advantage of opportunities to change their business model so that they can collect, disassemble, refurbish and re-integrate products, and capture as much value as possible (EMF, 2016).

Improved customer relations and loyalty

Once again, the (business model) innovation required to implement the circular economy promises to lead to the creation of many opportunities with regard to customer retention. Indeed, the transition to rentals, leasing and services can lead to longer-term business relationships on the one hand via increased contact between the company and the customer throughout the extended product life cycle (EMF, 2016; Vermunt et al., 2019). And on the other hand, the fact that the supplier remains responsible for the product even when it is delivered, but also for interim service and maintenance requires good communication. This gives the possibility to retrieve many insights allowing a personalization and customization of the delivered "performance". This will result in customer satisfaction, but also in an increase of customer loyalty. (EMF, 2016; Elisha, 2020).

Opportunities for citizens

This section is developed mainly on the basis of the Ellen MacArthur Foundation (2016) report "Vers une économie circulaire: Arguments économiques pour une transition accélérée".

Increase in disposable income

By analyzing three sectors, mobility, food systems and the built environment, the EMF was able to point to the effectiveness of the circular system in increasing the disposable income of an average European household. This is due to the reduction of costs and services, and the minimization of unproductive and unused periods of products (e.g., reduction of traffic jams and thus time wasted in transportation). According to the EMF, the average income of European households could increase by 3000€ between 2015 and 2030, which is an 11% increase compared to the current linear system. (EMF, 2016).

Better functionality

Complementing one of the previous points about improving customer loyalty, increasing product functionality or perceived customer benefits through greater choice or higher quality is one of the levers of the circular economy. The eclecticism emanating from market opportunities allows for product customization that has the ability to better meet customer needs (EMF, 2016).

Reduction of obsolescence

One of the concepts of the circular economy is the quality of manufacturing to increase the life cycle of materials and thus retain maximum value. Therefore, products will be designed to last or to be reused, which is an economic advantage for customers. Indeed, this will drastically reduce the cost of ownership and avoid costs related to repairs and returns (EMF, 2016).

2.3 Barriers

When talking about barriers, some distinctions are interesting to highlight. Indeed, barriers can be divided into two main categories. They can be internal to companies or to individual practices and therefore be related to the strategies and decisions that are made within the firm or by the individual, so there is a form of control. On the other hand, external barriers are related to the context of activity, and therefore imply an absence of control by the aforementioned actors, and will require intervention at the political level (Ekins et al., 2019; Vermunt et al., 2019). These numerous barriers were partly identified by Vermunt et al. (2019) in the report "Exploring barriers to implementing different circular business models" in which they analyzed 41 business cases that will serve as the basis for what follows.

Lack of knowledge and technology

One of the great characteristics of the implementation of the circular economy, which is a change in terms of business model, is the fact that it is very recent. Therefore, companies, like individuals, cannot rely on past experiences to implement the new practices (Sariatli, 2017). During their survey of companies, Vermunt et al (2019) were able to highlight the difficulty encountered by firms regarding the technologies and practices to be implemented in order to recover resources and more specifically regarding waste recycling, but also at the level of the supply chain and procurement since products must be designed differently in order to correspond to ecodesign. Indeed, companies sometimes have to adapt their machines so that they can be used in accordance with circular practices (e.g., one firm had to rebuild its entire machine so that it could separate the components of a product and recycle them). This could also apply to someone who wants to grow mushrooms on the grounds of their morning coffee and does not know how to do it.

Organizational barriers

Depending on the circular strategies implemented, firms interviewed in the survey conducted by Vermunt et al. (2019) also mentioned organizational difficulties. In fact, many firms said they struggle with legal, administrative, and financial transitions, especially in the "product as a service" model requiring continuous product ownership. For example, setting up contracts and demarcating them for the consumer is difficult on the legal component. On the administrative side, lease contracts requiring monthly invoices are the obstacle. Finally, it is also difficult to implement from a logistical point of view, given the increased storage of components inherent in repairing them. Therefore, companies must be able to send, receive, and store all of these components (Vermunt et al., 2019).

Financial barriers

This is another one of the great arguments of the circular economy, it should allow in the long run to increase GDP, and therefore also be a source of income for companies and individuals. It has also been mentioned that it will reduce dependence on resource prices whose volatility can sometimes be detrimental to the global economy (Preston, 2012). However, in the short term, it requires numerous investments (Sariatli, 2017) to procure the infrastructure, equipment, and labor reskilling necessary for the transition as far as companies are concerned (Preston, 2012). This can also lead to insufficient rates of return on investment and unprofitability (Ekins et al., 2019). This is particularly the case for companies that have implemented the "product as a service" business model and have to make upfront payments when they only have small amounts coming in each month (Vermunt et al., 2019). This innovation at the business model level therefore includes a notion of risk regarding financial commitments, dependency between companies due to supply, but also existing synergies between sectors of activity (Smaili, 2017).

This barrier, although internal, can be seen as an external one as it is also influenced by the market and supply chain and could be subject to long-term political support allowing for low-cost financing, reducing commercial financing costs and therefore encouraging investment, while providing a financial benchmark to cover the risks inherent in the implementation of CE (Preston, 2012; Smaili, 2017; Ekins et al., 2019)

Behavioral barrier

Human behavior can represent a major barrier. Indeed, the individual has been educated and accustomed to a linear system of production and consumption, becoming little by little, according to some such as Pottier (2017), homo œconomicus. As a reminder, homo oeconomicus is attracted by gain and profit maximization, which are capable of overshadowing his interest in environmental issues. He is not strictly speaking against so-called preventive measures such as CE, but given the costs that these can represent, he prefers to wait for the appearance of a technology that can "save the planet" without reducing his personal interests. A 2014 study conducted in relation to lean manufacturing is a rather revealing example as it mentioned that 96% of Europeans were in favor of a European transition towards a more efficient use of resources, while only 21% have used leasing or renting a product rather than buying it, and only 27% have used sharing schemes (EMF, 2015). This will be discussed in the "Market barrier" sub-section, since this individual's preferences may also have an impact on the ability of companies to take action.

There is therefore a need for cultural change on the part of the individual, but also on the part of the producer, to promote the transition to circularity. One of the levers could be an increased communication between producers and consumers, thus increasing the information available to the latter (Smaili, 2017). To do so, it may be interesting to take into account the psychology and economics as in behavioral economics, mentioning deviations over time in individuals' preferences, beliefs and decisions. This could lead to better prediction of economic behavior, and thus to better policies (Ekins et al., 2019).

External barriers

Supply chain barriers

In terms of supply chain, one of the difficulties encountered by the business world is that circular supply business models are not yet sufficiently developed, which results in a reduced capacity to supply biodegradable and recyclable materials. For example, some firms producing bio-based products can only rely on one supplier, not being able to increase their production because of the risk of creating an unhealthy dependency for each business (Vermunt et al., 2019).

Then, the question of the quality of the material used leads to some reticence at the business level. Indeed, the use of waste as a resource makes the quality of materials more uncertain compared to the so-called traditional use. Factors such as the way consumers sort their waste and process their products can have a significant influence on the value generation of products made from them, impacting the overall life of the product, but also the recovery process. Messy sorting can increase the difficulty both technologically and financially and can lead to an uncomfortable dependency of these companies on their suppliers (Vermunt et al., 2019). However, it is interesting to point out the external nature of this barrier at the level of manufacturing companies, but internal to the behavior and organization of the consumer as well as the suppliers. The latter sometimes focus too much on the "discard" side and omit the fact of reuse, and then provide materials that are too damaged and whose value has dropped (Vermunt et al., 2019).

Furthermore, the dependency on the supplier is not limited to this, as the timing and volume of waste can also act as a disruptive factor. There are uncertainties regarding these factors, causing complicated situations in terms of inventory management which becomes highly variable. This requires a collaborative organizational change in the supply chain, promoting better transparency and two-way information exchange in order to optimize the implementation of circularity (Preston, 2012; Vermunt et al., 2019).

Market barriers

Another barrier related to the market this time is the lack of consumer acceptance. The reasons for this may be different depending on the type of implementation. Customers may be reluctant to buy products made from waste. They may also not perceive the added value of such products. The reluctance can also come, in cases of increased product life, from a lower and less fashionable perception of value of the product by the consumer. In addition, the customer is attracted to "made to order" design, whereas uniform design is more interesting for product life extension. Finally, one of the models related to the circular economy is the "product as a service", where consumers have a brake mainly on the loss of ownership and then offer to buy the products. This is mostly due to a lack of understanding of the concept and a lack of marketing campaigns on the topic (Sariatli, 2017; Vermunt et al., 2019), but also to internal factors as mentioned above.

Yet, as Felix Preston already stated in 2012, the development of circular products can only benefit companies if citizens have enough information about the products on offer and their importance. Thus, to reach the mass market, he advocates for companies setting up labels and certifications to inform customers about the benefits of their products.

Still in this market context, the transition to circular concepts can lead to difficulties in materials recovery. On the one hand, competitors may try to taint the new circular activities by claiming a lower quality of the products resulting from these processes. On the other hand, when companies implementing a recovery and recycling business model were not initially manufacturers of the products they use, after implementation, their competitors also become their suppliers. This can lead to abuses, with original manufacturers demanding exorbitant prices for specific components to protect their product (Vermunt et al., 2019).

Institutional barrier

A criterion that comes up in most barriers is the legislative framework surrounding the implementation of the circular economy. Although there is no legal regulation yet regarding the circular economy and its applications (Circular Academy, 2017; Sariatli, 2017), some already existing norms put obstacles in the way of CE pioneers. This is particularly the case with waste management laws preventing firms from using waste as a resource. Indeed, companies wishing to experiment with the use of waste in their production chain must obtain permits that they will not have because these resources are considered as waste from another industry. They must then turn only to waste from their own industry, which limits the possible inputs (Vermunt et al., 2019). Moreover, as waste is considered an environmental threat, waste managers prefer to dispose of it safely rather than to exploit it in a way that gives it new value (EMF, 2015). Therefore, some environmental regulations aimed at health and safety sometimes have the effect of hindering the reuse of raw materials to make new products (Smaili, 2017).

Another barrier that has already been addressed from an institutional point of view is the financial aspect. Indeed, business model changes are expensive, and to make a transition or to launch a new business model, it is necessary to go hunting for investors. This is not an easy task, especially for certain business models such as product as a service for which banks do not seem inclined to invest (Vermunt et al., 2019). Particularly since the standards currently in place, whether internal or governmental, are still focused on the development of the linear economy, favoring intensive resource extraction via subsidies (Preston, 2012). In Europe, for example, in 2015 fossil fuel subsidies amounted to €300 billion, while environmental taxes amounted to the same amount per year. In addition, labor is taxed at 51% (EMF, 2015), while according to Stahel, labor is the primary source of renewable energy. Yet, the transition to the circular economy will imperatively require support from the authorities in place and this via financing frameworks, incentives for the training needed for the transition or even a favorable taxation for it (Smaili, 2017).

Moreover, Preston already mentioned in 2012 the need to incorporate the cost of externalities into the prices of energy and their greenhouse gas emissions, thus taking into account the social and environmental impact, the costs of which are much higher than the current price. It is also pointed out that many European cities do not take into account the price of congestion, even though it has a clear impact on workers' productivity, on air pollution, and on the need for investment and infrastructure (EMF, 2015).

A final barrier is the lack of institutions that award for standardization of methodologies across countries, also highlighting the costs of resource consumption for individual firms, but also allowing for certification of resource efficiency and circular economy practices (Preston, 2012).

However, as Kemp et al. (2014) point out, barriers should not be isolated, but rather considered in their entirety as a "web of constraints" because many synergies can exist between internal and external barriers, or between the business and individual levels. An internal barrier can be influenced by an external fact. For example, technology can be developed by firms internally as part of their innovation process, but it can also be part of a government R&D program. Technology can also be influenced by policies encouraging their development (Ekins et al., 2019).

Therefore, even though the Circular Economy presents a lot of opportunities and positive impacts, it is not yet widely implemented because of numerous barriers. However, it doesn't mean that it is not feasible.

Chapter 3: Presentation of six main currents of Circular Economy

In this chapter, six currents of the Circular Economy will be summarized in order to better understand the holistic aspect of the Circular Economy and what it promises, before being analyzed in the following chapter. Some examples of the application of those currents can be found in the appendix.

3.1 The Performance Economy of Walter Stahel

3.1.1 Summary

The performance economy has already been mentioned many times in this work. It originated in a report entitled "The Potential for substituting Manpower for Energy" commissioned by the European Commission in 1976 and co-authored by Walter Stahel, an architect and industrial analyst, and Genevieve Reday. In this book, which develops the principle of trading energy for manpower in the context of car manufacturing and building construction at the macro-economic level, the importance of increasing product life in order to achieve this objective is discussed (Wautelet, 2018b). Following this, in 1981, both authors developed a vision of a loops economy, being a first mention of the circular economy (EMF, 2017), with potential in terms of job creation, economic competitiveness, resources saving and waste prevention and this by promoting the reuse, repair and remanufacture of goods (EMF, 2015; Wautelet, 2018b).

It was in 2010 that Stahel would give life to the "Performance Economy," presenting it as a way to counteract the harmful effects of the current system such as the overconsumption of resources, the large and ever-growing mass of waste, the unemployment rate, the public debt, and the faltering economic growth (Stahel, 2010; Wautelet, 2018b). The focus then shifts from "doing things right" to "doing the right things". In the first case, the actions taken are " just " addressing the observed problems, or harms, and reducing the environmental impact, and this via processes such as eco-design, but without considering their source. Stahel (2010) and his Performance Economy believe that we need to do the right things, by implementing systemic solutions, instead of manufacturing business models, and promote resource sufficiency over resource efficiency, which could be a source of social wealth and job creation (Wautelet, 2018b).

The Performance Economy is thus built around three objectives presented by Stahel as follows (Stahel, 2010, pp.2-3):

1. The exploitation of science and knowledge to develop smart materials, products and solutions, which are important levers for decoupling income and wealth creation from resource exploitation.

2. Increasing wealth and welfare, through the application of Functional Service Economy business models via increased responsibility performance of economic actors throughout the product life cycle.

3. Create jobs locally by shifting from a focus on resource optimization to asset management, and this in insourcing jobs rather than out-sourcing work.

It is interesting to note that the Performance Economy is applicable in both developed and developing countries, since it also consists of the implementation of the Functional Service Economy which involves the development of business models integrating products and services to create jobs and wealth while reducing resource consumption and proposing to internalize the costs of risks and waste (Stahel, 2010).

This transition will, however, require changes in roles.

Consumers, through initiatives such as the Consumer Pays Principle (CPP), will be taxed on their consumption of common goods, which are usually taken into account by all taxpayers and whose amounts are independent of the intensity of their uses.

Nations and States will have to abandon "command and control" policies, given their inefficiency in terms of seizing opportunities and transforming them into innovations that could be transferred to the market. To do the right things, governments should encourage innovation, education, research and entrepreneurial risk-taking. In addition, they can shift taxes on labor to taxes on resource extraction, thereby promoting local job creation. They also have the opportunity to encourage and reward entrepreneurs who want to build a performance economy by creating operating frameworks and providing incentives but keeping in mind that they cannot be risk-taking entrepreneurs themselves.

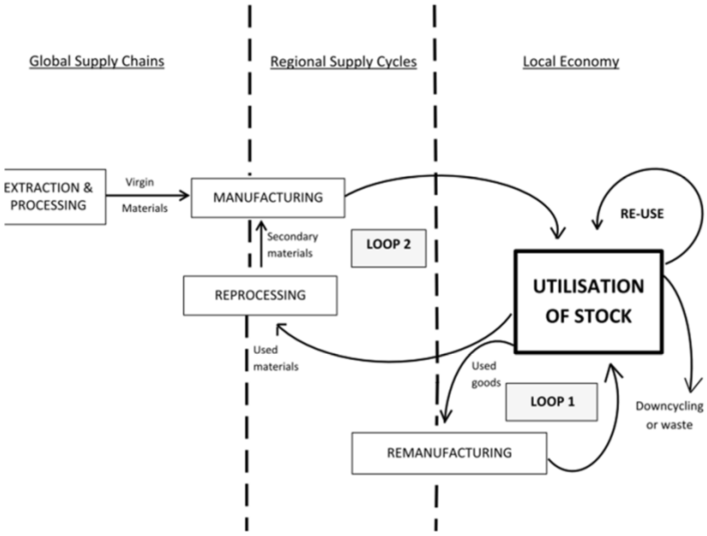
Finally, a last role change is that of resources because "the goods of today are the resources of tomorrow, at yesterday's price." (Stahel, 2010).

3.1.2 Main concepts

The Performance Economy diverges from the current industrial economic system, in part due to its shift from flow management to inventory management, but also because of the shift from value added to value preservation and maintenance. A change in principle that has an impact on three loops defined by Stahel and Clift (2016, p.140) and having impacts at the geographical level (Wautelet, 2018b). These three loops are as follows:

- Reuse Loop: Which predominantly takes up the second-hand market, but also private and commercial uses. In the first case it is for example online resale such as Vinted, or flea markets. For the next two items two examples would be the refill of glass bottles or clothes. All of this is usually done locally.
- Loop 1 - Remanufacturing: This consists of repairing, remanufacturing and upgrading materials in local or regional centers in order to extend their life.
- Loop 2 - Recycling: Consists of the recovery of secondary materials that will be reused to make new products at a regional level or as part of a global supply system.

Figure 16: The different loops of Performance Economy



Source: Stahel and Clift (2016, p.141)

Interestingly, there is a loop exit, leading to downcycling or waste (Wautelet, 2018b).

Via these loops, the Performance Economy is characterized by five principles established by Stahel (2013):

1. **The smaller the loop (activity-wise and geographically) the more profitable and resource efficient it is**

Regarding “activity wise”, this means acting logically by not remanufacturing what can be repaired and not recycling what can be remanufactured, this refers to the loop1. The geographically refers to the fact that small loops are more effective when they are made locally or regionally (i.e., less packaging and transports, via ownership maintained less transition costs). This therefore relates more to resource sufficiency, whereas loop 2 focuses on resource efficiency through the recycling of materials embedded in products (Wautelet, 2018b). The two loops are thus in contrast, with the second one being more based on global business and larger-scale industrial production. This includes the classic activities of the industrial system that can sometimes lead to abuses such as sending used electronic goods to Africa to be put back on the market, yet they will end up in highly polluting recycling and incineration processes (Stahel, 2013).

2. **Loops have no beginning and no end**

As discussed, the Performance Economy is also about shifting from a flow management to an inventory management and value-added concept, and maintaining the value, quality and performance of goods (Stahel, 2013, p.5). In the Performance Economy, the business seeks to maintain the value of goods throughout their life cycle, by keeping possession of them. Therefore, the value added associated with the sale, which then leads to depreciation, is no longer relevant (Wautelet, 2018b).

3. **The speed of the circular flows is crucial: the efficiency of managing stocks increases with a decreasing flow speed**

The most obvious example in terms of recycling is that of beverages, which are considered as short-lived. As a result, they are subject to rapid cyclical flows leading to a quick loss of material stocks. Indeed, only 50% of the base materials are recycled in the first cycle, 25% in the second cycle, 12.5% afterwards, etc. There is therefore a total loss of the original material very quickly, highlighting the importance of reuse (Stahel, 2013; Wautelet, 2018b).

4. **Continued ownership is cost-efficient: reuse, repair and remanufacture without a change of ownership save double transaction costs**

A concrete example is tires. While tires usually belong to the owners and users of the corresponding vehicle, in the Performance Economy they remain the property of the manufacturers, allowing them to internalize retreading and maintenance, which results in an increase in service-life and a positive impact on profit. This is the case of Michelin, which offers a pay-per-kilometer system to truck fleets (Stahel, 2013; Wautelet, 2018b).

5. **A Performance Economy needs functioning markets**

Like the industrial economy, the performance economy requires a market where supply and demand can meet. For example, the market for used consumer goods has been expanding, partly through advertising, but mostly through the advent of electronic marketplaces (Stahel, 2013).

3.2 The Cradle-to-Cradle design philosophy of William McDonough and Michael Braungart

3.2.1 Summary

Stahel and Braungart first mentioned the term "cradle-to-cradle" (C2C) in 1981 (McDonough Braungart Design Chemistry, 2012) in opposition to "cradle-to-grave" manufacturing processes and simplified waste management, i.e., waste recovery that is then deposited in landfills or in the sea (Stahel, 2010). However, it was in 2002 that this concept gained a broader and recognized dimension with the publication of the book "Cradle to Cradle: Rethinking the Way

We Make Things" written by chemist Braungart and architect McDonough (Braungart and McDonough, 2008).

Through their books, the two authors want to highlight the need to change the processes of production, distribution, waste management, but also to offer socially responsible products and thus reduce environmental impacts (Visser, 2010; Geisendorf and Pietrulla, 2017).

To do so, they put forward the need to draw inspiration from the processes of nature's biological metabolism and thus to develop a technical metabolism, allowing for a better knowledge and understanding of the molecular compositions of materials, which leads to a better reuse and more adapted recycling of materials and avoids downcycling in favor of upcycling (McDonough and Braungart, 2008; EMF, 2015; Wautelet, 2018b). All of this is in keeping with the cradle-to-cradle philosophy establishing the fact that "less bad is no good." It is in this same mindset that the concept points to the importance of moving from eco-efficiency to eco-effectiveness. Indeed, although McDonough and Braungart recognize the usefulness of eco-efficiency, particularly in terms of reducing the ecological impact of business, they mention the fact that this process is not sustainable, arguing that on the one hand it is "getting more from less" and on the other hand that it focuses on the treatment of the problem and not the source of it (McDonough and Braungart, 2002). Eco-effectiveness, on the other hand, means "working on the right things" and not "making the wrong things less bad". In other words, the main difference is that it focuses on improving quality in order to have a positive impact, rather than reducing the quantity of negative impacts. This approach has a broad spectrum of action, as it applies to the world of manufacturing industry (micro level), as well as to areas such as building, construction, urban environment, even taking into account social criteria. All these elements are included in their certification proposed by c2ccertified.org to promote implementation (Geisendorf and Pietrulla, 2017).

Finally, through its various principles, C2C seeks not to limit economic and technological growth, but to use them to catalyze innovations useful to the transition.
McDonough and Braungart have developed three main characteristics of cradle-to-cradle: waste equals food, use current solar income and celebrate diversity.

3.2.2 Main concepts

Waste equals food

It is a reality in nature that there is no waste, since the waste of one is the nutrient of another. This is the essence of the analogy of biological metabolism exposed previously suggesting to transpose this in the industry and consequently eliminate waste. The idea is therefore to design products and services that keep materials in one of the two cycles (i.e., biological or technical). It is important to note that these designs will depend on whether the products are consumer products or services.

In the case of the first, it is about products that must be able to return to the natural system at the end of their use, without degrading it and in the spirit of "doing good" serve as a nutrient for living systems and therefore enter the flows of biological metabolism and this thanks to biodegradable materials (Wautelet, 2018b). The second concerns products that have required transformations at the level of materials and are therefore technical. It is necessary to keep them in the technical metabolism via a closed loop. One of the levers of this method is to sell performance or service products allowing companies to remain owners of the materials and facilitating their return to the cycle, but also inciting them to propose quality materials that can be upcycled later.

Products can also be a mix of both principles in the sense that their use emits particles (e.g., tires) and that it is therefore necessary to design them based on biodegradable materials, but that they can also enter a technological closed loop by remaining the property of the manufacturers.

In order to be cost effective, it is also necessary for the products of services to collaborate between companies at the supply chain level. As already mentioned before, it is necessary to know the composition of the materials used in order to be able to reuse them correctly. To do this, it is necessary to develop an information transfer via what McDonough and Braungart call an intelligent materials pooling which is a materials bank that leases components to companies which will process them into products and sell performance to consumers.

Use current solar income

The sun is the source of life on Earth, it is also the source of many renewable energies. These renewable energies are a highlight of C2C, which considers that they are numerous enough and available to supply industries and households. This is yet another example of the contrast between eco-efficiency, which advocates reducing energy use, while eco-effectiveness emphasizes energy quality via renewable energy (McDonough and Braungart, 2008; Wautelet, 2018b).

Celebrate diversity

Ecosystems are very resilient because of their diversity, which has allowed them to find a balance and evolve over time despite various stresses and shocks. C2C understands this because it places diversity among its important characteristics at the level of biodiversity as well as at the social and cultural levels. Therefore, they propose solutions adapted to local socio-cultural habits, and using locally available materials (Wautelet, 2018b).

3.3 Biomimicry as articulated by Janine Benyus

3.3.1 Summary

Biomimicry is probably one of the simplest concepts to present and to illustrate in this work. Indeed, the idea of biomimicry is rather simple and can be sum up, citing its creator, Janine Benyus (1997), in one sentence: "(Biomimicry is a) new science that studies nature's models and then imitates or takes inspiration from these designs and processes to solve human problems". Behind these words is the key idea that the human species is quite young and that most of the challenges that we are facing today have already been solved by the living organisms around us. Still citing Benyus, "life creates conducive conditions to live" and it has been doing so for several billions of years. Considering also that nature always try to find the most efficient way to use and converts energy by using a minimum of energy and resources, it is probably the best example anyone can use.

Biomimicry might be confused with biomimetism (El-Zeiny, 2012), but only the former has its place in this work. Indeed, if both terms refer to the idea of using nature and all living organism to tackle technical problem, only biomimicry includes this idea of "sustainability" in the solution. Biomimetism only tackles the technological problem and does not care of the environment in which the solution must take place. On the other hand, biomimicry tries to include this life-inspired solution in an ecological fashion, using the most efficient materials, producing the minimum amount of trash and respecting the needs and rights of the human species (Wautelet, 2018b). To clarify the idea biomimetism is not always biomimicry while biomimicry is an advanced version of biomimetism.

Practical examples of biomimetism are relatively easy to find. It is more complex to find comprehensive examples of biomimicry as it is often implemented to a certain level but not on the full scale of the process used to face a given challenge. It is in this way that biomimicry can be seen as a circular economy (or the other way around).

3.3.2 Main concepts

Biomimicry is articulated on three simple principles (Wautelet, 2018b):

1) Nature as a model: Before trying to tackle a new challenge from scratch, one should have a look at how nature solved a similar problem. The imitation should also take into account the place that this solution takes in the ecosystem: how is it made, with what, and in which context? From this knowledge, innovative solution can be created.
2) Nature as a measure: It is almost impossible to do as well as nature in terms of efficiency, but it can still be used as a mean of comparison. When designing a life-inspired solution, one should try to get as close as possible to what can be found in nature. In other words, the sustainability of a project should be evaluated using ecological standards.
3) Nature as a mentor: Nature should not be seen as a mean or a resource but as a teacher. We should try to learn from nature rather than learn about nature.

3.4 The industrial ecology of Reid Lifset and Thomas Graedel

3.4.1 Summary

This has been discussed before, Industrial Ecology (IE) is one of the founding currents of the circular economy (Preston, 2012; Ekins et al., 2019). Indeed, in the 1970s Spilhaus spoke of the need that in the next industrial revolution products should be designed so that they can be taken back to the factory and remade. Thus, creating a loop back from the customers to the firms that would close the loop. Adding to this the fact that firms are the main agents of this principle because they possess the creative technological capabilities that will be paramount in developing environmentally oriented process and product designs, the term "industrial" takes on its meaning (Lifset & Graedel, 2002).

The ecological side refers on the one hand to the willingness to take inspiration from non-human natural ecosystems and their practices (Frosch & Gallopoulos, 1989), such as the fact that many ecosystems are intractable in terms of resource recycling, and apply them in industry, which is also called the biological analogy (Wernick and Ausubel, 1997).

On the other hand, it refers to placing the industry and the economic system in a broader context. More precisely, it is about considering technological and economic activities with the ecosystems that surround them and that allow them to exist, i.e., sources of resources used, capacity of absorption of Earth. This comes from the realization that human economic activity can be the source of adverse environmental change and how and to what extent this is the case (Erkman, 1997; Lifset & Graedel, 2002).

Robert White (1994) defines Industrial Ecology as: "the study of the flows of materials and energy in industrial and consumer activities, of the effects of these flows on the environment, and of the influences of economic, political, regulatory, and social factors on the flow, use, and transformation of resources”. This approach will then allow for the optimization of industrial processes and material regulation by drawing inspiration from natural processes or by completely transposing them to industry (Iung & Levrat, 2014; Wautelet, 2018b).

In addition, the notion of ecology can refer to the concepts of community and diversity, which play a very important role in the resilience of systems and are characteristic of ecosystems (Lifset & Graedel, 2002). It is in this spirit that IE seeks to promote collaboration between different firms, allowing for better resource management (O'Rourke et al., 1996). It is therefore a matter of considering the industrial system as a whole forming a loop (Erkman, 1997). The analogy sometimes even goes to the side of metabolism, highlighting the importance of information flows and interactions between the different parties in the system, namely government, society and industry, and then referring to the social aspect of ecology (Lifset and Graedel, 2002; Jonker and Harmsen, 2012).

3.4.2 Main concepts

Biological analogy

This characteristic is one of the basic principles of Industrial Ecology, since it emphasizes the importance of loop closing and the importance of achieving a "near-closed material cycles" such as those that can be found in the nature (O'Rourke et al., 1996). With this in mind, waste should be used as a source of energy and materials (Frosch, 1992; Ghisellini et al., 2016). To this end, Erkman mentions the possibility of eco-industrial networks in which the residues of one company can become the inputs of another, or of another process (Wautelet, 2018b). Among these networks is industrial symbiosis, which has already been discussed in the "Origin" section, taking into account the industrial ecosystem of Frosch and Gallopoulos (1989).

Use of systems perspectives

This characteristic relates primarily to the fact that Industrial Ecology stresses the importance of thinking broadly, taking into account the whole picture and possible consequences when a decision is made (Lifset & Graedel, 2002; O'Rourke et al., 1996).

To do this, several methods are possible:

- The life cycle perspective, which consists of taking into account the entire environmental impact inherent in the production of products and services, from the extraction of materials to consumption, but also waste management, which is one of the priorities of IE (Frosch, 1992; Ghisellini et al., 2016; Geisendorf, 2017). Among the tools enabling this are the Life cycle Assessment (LCA). Furthermore, this perspective is also reflected in the cradle-to-grave principle that is applied in policy making and research (Lifset & Graedel, 2002)
- The analysis of materials and energy flows at different levels, or analysis of societal and industrial metabolism seeking to understand the flows and ensure a neutral balance in the inputs and outputs of these and sometimes to understand how human activities have impacted the natural cycles
- The systems modeling which analyzes the human-environment interaction in order to improve the understanding of environmental analyses, but also the existing connections between the behavioral factors of the different systems studied

  Multidisciplinary and interdisciplinary research and analysis emphasizing the importance of using cross-disciplinary techniques and insights (Lifset & Graedel, 2002), although they are difficult to implement.

Role of technological change

This has been discussed before, technology is seen by some as playing a life-saving role in the transition to a more environmentally friendly economy and industry, although this is balanced by some (Lifset & Graedel, 2002). This approach takes the now familiar form of ecodesign or

Design For Environment (DFE), which reduces the environmental and health damage of products and services (Erkman 1997; Wautelet, 2018b) via design that relies on systems approaches such as those mentioned above to assess potential impacts (Lifset & Graedel 2002). There is also a macro impact to this technological change as it fits into the IPAT equation (Impact=Population X Affluence X Technology) assessing the extent to which, relative to population and consumption, technology influences environmental quality (Lifset & Graedel, 2002).

Role of companies

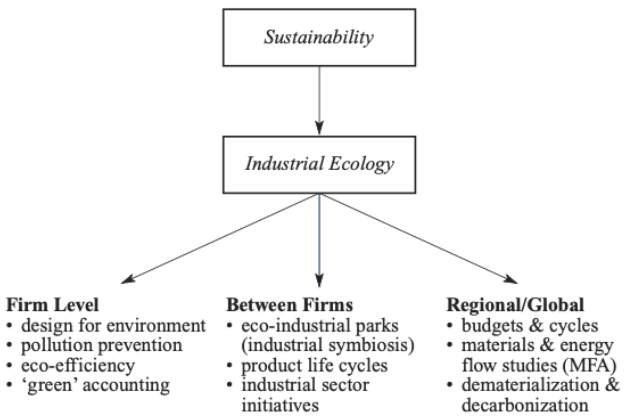
As mentioned earlier in the summary, given that change for environmental improvements is primarily based on technological innovation, companies play a key role in this transition. Furthermore, they can influence the exit from the "command and control" system, which is considered inefficient and counterproductive (Lifset and Graedel, 2002), mainly due to the asymmetry and lack of information from political authorities (Wiesmeth, 2021). The idea is therefore to turn the business world into a "policy maker" and no longer a "policy taker" (Socolow, 1994). However, in 2021, according to Wiesmeth, companies still do not seem to have taken on the role of policy maker, allowing them to be guides in technological development.

Dematerialization and eco-efficiency

In order to achieve the goal of advanced circularity and thus reduce resource consumption and environmental impact, closing the loop is compounded by the need to apply several concepts such as dematerialization (Ehrenfeld, 1997), which by reducing the amount of materials needed to perform tasks contributes to decoupling, but also other ones such as the intensity of material use, or decarbonization and eco-efficiency (Lifset & Graedel, 2002). This can be done, for example, by moving towards a service society, in which the use of products is promoted rather than selling them (Erkman, 1997; Wautelet, 2018b).

When everything is combined, it is clear that Industrial Ecology is present at the micro, meso and macro levels. Indeed, as shown in the figure, at the micro level the focus is on individual firms and unit processes. At the macro level, which focuses on the regional and global levels, the study of flows, dematerialization and decarbonization are emphasized. Finally, at the meso scale, which focuses on inter-firm relations, is the central point of industrial ecology and its system of industrial symbiosis, with the archetypal eco-industrial parks, an example of which will be given below (Lifset and Graedel, 2002).

Figure 17: The different levels of Industrial Ecology



Source: Lifset and Graedel, 2002

3.5 The natural capitalism by Amory and Hunter Lovins and Paul Hawken

3.5.1 Summary

Natural Capitalism is an idea that emerged in 1994 and finally took shape in 1999 from a fusion of Hawken's ideas published in "The Ecology of Commerce" and Amory and Hunter Lovins' "Factor Four: Doubling Wealth, Halving Resource Use. As the authors analyzed business cases, they realized that the economic, environmental and social components should not be favored one over the other but should be considered as a whole and integrated in the design of technical devices, production systems, companies, economic sectors, cities and societies.

It is made clear that this book is not to be considered as complete, nor completely clear, it proposes solutions, but it is not about "fixes"; it is not a manual, but a collection of opportunities that, if seized, can change the course of things and lead to the next industrial revolution. The name of this concept refers to what capitalism could become if the natural capital of ecosystems were valued correctly; it establishes a set-up that can protect the biosphere, while increasing profits and business competitiveness, through changes in the way businesses are run, improving resource productivity and bringing benefits to current and future generations. Natural Capitalism is therefore oriented towards integration and restoration, and is a systems view of our society and its relationship with the environment (Hawken et al., 2000, p.xiii).

In addition, Natural Capitalism and its economic development seek to link the industry, the local government and the local people, creating a web of business relationships which will result in jobs creation, more income, and even savings. Moreover, it leads to positive environmental impacts such as cleaner air and water. It also distributes the fruits of local labor more equitably. Therefore, it has for effect to optimizing the local wealth of the community (Kinsley, 2002).

3.5.2 Main concepts

Natural Capitalism is built around four main guiding principles:

Dramatically increase the productivity of natural resources

By reducing waste of energy, water, materials and other resources, many opportunities are available to companies, especially from a financial point of view. To do this, it is necessary to implement a whole system design, allowing managers to take a step back and look at the bigger picture, helping them to make changes that may be small but have a big impact on the rest of the production. This also includes the adoption of innovative and environment friendly technologies, sometimes inspired by nature (e.g., biomimicry), which will complement the implementation of the whole system. Eco-responsible products with increased efficiency are already available on the market, but their success is hampered by cultural barriers.

Shift to a biologically inspired production models

Natural Capitalism is also inspired by nature and its closed-loop system to completely eliminate waste, especially toxic waste, which must be isolated to prevent it from harming natural systems, thus generating high costs and risks. Each product is designed in such a way that the outputs are returned to nature and its ecosystems as nutrients without negative effects or remain in the cycle as input for another product. Such a process allows for increased production efficiency, which in the long run can lead to a 90% reduction in material requirements in most sectors (Lovins et al., 2007).

Move to a solutions-based business model

The business model proposed by Natural Capitalism is that of offering value through a flow of services. This principle is a paradigm shift, since it implies moving from a model where affluence is measured by acquisition, to a model based on the continuous satisfaction of consumers due to the possibility of changing expectations in terms of quality, utility and performance of products. This creates a long-term relationship between customers and producers, aligning their interests. On the one hand, this reduces customers' need for capital and, on the other hand, it maximizes and extends the value of suppliers' assets, leading to a decrease in the volatility of asset turnovers within companies and ultimately the volatility of the global economy.

Reinvest in Natural Capital

Finally, Natural Capitalism through business wants to have a positive impact by restoring, making more sustainable and expanding natural ecosystems. Thanks to this, they will be able to produce more abundantly their different services and respond to the growing needs of humans and decrease the costs related to their deterioration. To do this, companies that have implemented the above principles to create value must reinvest in natural capital. Failure to do so can have a negative impact on the indirect profits of companies, notably through a tarnished image with customers.

Finally, the three authors highlight the fact that if companies still do not implement these elements, it is because they do not allocate their capital in the right way, not taking the total cost of ownership of the elements they buy. In addition, they point to the inadequacy of the policies and taxes in place. Moreover, they point out that the behavior of companies goes against the current trend. They act as they did during the industrial revolution, when labor was scarcer and resources more abundant. However, this trend has been reversed, now with the demographic boom, labor is abundant, but nature's capacities are no longer. Since nature cannot be replaced by money or technology, Natural Capitalism proposes a new economy and a new production system because it is necessary and profitable (Lovins et al., 2007).

3.6 The Blue Economy by Gunter Pauli

3.6.1 Summary

The blue economy is a concept that has been germinating for almost 20 years in the mind of Gunter Pauli, a former entrepreneur and member of the Club of Rome, whose professional experience was striking and opened his eyes to certain realities of the so-called green economy. His biggest breakthrough came when he was CEO of Ecover, a biodegradable cleaning products company whose primary source was palm oil. As the success of these products grew, many farmers sacrificed large tracts of rainforest, and their inhabitants, to replace them with palm trees to meet the demand. While he thought he was doing good, Pauli realized that "recycling" and "biodegradable" did not necessarily go hand in hand with "sustainable development". Numerous publications on the subject followed. In 1991, in a South Korean economic magazine, he urged entrepreneurs to take inspiration from natural ecosystems and the fact that there is zero waste and zero emissions, arguing that sustainable development can only be achieved by fully integrating energy and nutrients and combining them. This would allow to reach the natural balance. Subsequently, it was the rector of the Tokyo-based United Nations University who commissioned an economic model free of GHG emissions and waste, and with a positive impact on employment and social cohesion, all without being more expensive. Three years later, in collaboration with the United Nations Development Programme (UNDP), Pauli created the ZERI (Zeros Emissions Research and Initiatives) Foundation to demonstrate the economic viability and technical feasibility of such a system through the implementation of pilot projects (Pauli, 2019, pp.9-10).

It was in 2009 that Pauli first published his book on the Blue Economy, highlighting the numerous opportunities arising from the social, economic and ecological difficulties of the current system and the need to draw inspiration from ecosystems and their logic. This economy is blue because the Earth is composed of 72% water and is surrounded by 95% blue sky. It is also blue because of its differentiation with, on the one hand, the current red economy that only thinks about the economy and is harmful to the environment, and on the other hand, the green economy that, although it is oriented towards the environment and sustainability in a broad sense, is too expensive requiring investments from companies and consumers for products of identical quality (Agus, p.158; Pauli, 2019, p.12). The blue economy thus proposes a shift in perspective from doing less harm, to doing good. It is no longer about preservation and conservation, but regeneration. This means ensuring that everyone can benefit from the eternal flows of Nature that exist thanks to the creativity, adaptability and abundance of ecosystems that have the capacity to "always evolve to higher levels of efficiency, to cascade nutrients and energy, to leave nothing to waste, to utilize the abilities of all contributors, and to respond to the basic needs of all" (Pauli, 2010, xxviii). Pauli also emphasizes the leverage that the Blue Economy has on the possibility of "changing the rules of the game," allowing for a shift from a monopolistic society in which decision making is done by a few people to global decision making done by all stakeholders (Pauli, 2019, p.13).

Through his book, Pauli promotes the Blue Economy and its ability to create more income, more jobs and remain competitive, taking many concrete examples. By 2019, 200 projects had been completed, 3 million jobs created and 5 billion euros invested (Pauli, 2019).

3.6.2 Main concepts

The Blue Economy is established on 19 major principles divided into three sections that are "Drawing inspiration from Nature," "Changing the rules of the game," and "Living on your land" (Pauli, 2019, pp.392-474).

Drawing inspiration from Nature

This was established in the summary, the Blue Economy finds much of its inspiration in natural ecosystems and their capacity for resilience (Resist through diversity), being able to move from scarcity to abundance and using all the resources that are available to them locally (Optimize and co-evaluate). Despite his wonderment of natural systems, Pauli (2019, p.395) still emphasizes that it is not about returning to the wild, but about learning. Learning from the fact that there is no waste, no emissions, from the fact that what is not necessary for one can be food, energy, or material for another (Knowing how to stop being linear). Nothing is ever lost in this system and all actors have a role to contribute to society. Therefore, there is no unemployment in nature. It is a system that uses materials efficiently, creating continuous flows. It uses widely available and renewable energy sources such as the sun and gravity, knowing how to store them (Focus on physics).

Changing the rules of the game (of business)

In today's society, change is associated with risk, preventing any radical innovation that could be lifesaving. For the Blue Economy, changing the rules of the game means thinking about the integration of several simultaneous, networked innovations, including the technology of production, the type of revenue, and the interactions with the communities involved, which creates new business models. The risks inherent in innovations diminish only for those who accept the change of written and unwritten rules. In addition, Pauli mentions that networked innovations can lead to free commodities becoming the new commons. Changing the rules of the game is thus "a new choice to identify opportunities, start and exploit production, delivery and consumption to increase efficiency and improve the ability to meet basic needs for all." (Pauli, 2019, p.427).

Living on the land

In order to meet basic needs, to have a resilient community ready for the cyclicality of life, we will have to do much better and see economic opportunities in a different way. Monitoring their performance and managing their development. This means moving away from a system where economy of scale is the main point of action, despite the fact that labor and raw materials are only worth 10% of the value of a product. To do this, the blue economy proposes to *Focus on the economy of perspective*, which consists in diversifying to save on a large scale, creating niches of activities, increasing the share of work and therefore optimizing everything that can be done locally with local resources. This creates a cycle of raw materials and energy that changes the social, economic and environmental components at the local level into a well-oiled and functional process. It also proposes to *Generate multiple outlets from one initiative*, each of which systematically generates financial and non-financial benefits and fulfills the primary objective of generating value by supplementing basic needs. This increases local economic returns and reduces risk for entrepreneurs. *Vertical integration* (primary and secondary sectors) is also a process to be implemented, consisting of local economic development of the territory and local resources, to meet the needs of local markets first. This leads to a reduction in packaging and transportation and strengthens the network of local companies, eliminating unnecessary costs, increasing the value added by design through increased labor, and circulating money in the territory. Thus, there is a multiplier effect ensuring "feedback loops of social, ecological, and local community strengthening capital." (Pauli, 2019, p.462). The next sub-principle is *Manage without a business plan* through the teams of a project that ensure that initiatives are a catalyst for action and self-learning of the so-called multi-disciplinary teams that allow to transform an idea into a business. So, there is no planning, but a dynamic and participatory system like the one in Nature, with the help of mathematical modeling. Then you have to *Decide on the basis of the financial statements* and confirm the initiatives via the income statement and the balance sheets. Just because priority is given to dynamic and non-linear models does not mean that annual progress should not be established, and the health of the company evaluated. Finally, the Blue Economy advocates *Putting ethics at the center* by doing good and not just less bad. This is why all the models proposed by the Blue Economy are open source, allowing everyone to access and contribute to them. Putting forward that it is not the technologies that will be saving, but the models designed by the new system allowing to adapt everywhere and at any time.

Chapter 4: Similitudes and differences between the different circular economies

4.1 Categorization of the circular economies

Based on the different readings accumulated along this work it has been possible to develop some criteria considered as important for the circular economy application. This section is dedicated to the explanation of those criteria and then the segregation of the six currents related to them. It is important to note that some of the criteria are not clearly stated in the currents, therefore there was some need for interpretation.

4.1.1 Criteria for analysis

System preference: Every nation has an economic system. This system represents the mode of organization of its economic activity and is often extended to the social organization. It is a very important element for nations since it can influence the standard of living of their inhabitants, the inequalities, the international relations, but also the economic power. Among the main currents we find capitalism and socialism. As mentioned in the socio-economic context, the linear economy is mainly the result of the development of capitalism in Western countries. The system preference criterion therefore raises the question of what kind of system is necessary for the implementation of each circular economy. Is this circular economy conceivable in a system aiming at private property and advocating growth? Can we envisage a growth of capital, or should we move towards degrowth? Another option is the emergence of a different economic system. Indeed, as we have seen, economic systems can appear via revolutions (e.g., the end of serfdom for capitalism, the Bolsheviks for Communism, ...), when he is up against the wall, human manages to react and reinvent himself. The idea here is to observe the necessity of such a revolution for the currents of circular economy.

Country development: In this criterion, we are interested in the development stage of the country in which the circular economy is applicable. Is the country developed or developing? The idea of this criterion is based on the fact that developed countries do not have the same distribution of economic activity as other countries. Indeed, the latter are often more focused on the tertiary sector while the others are mainly based on primary and secondary sectors. Depending on this, countries will have a different impact on the natural resources used and the environmental impact which are not necessarily linked (at least from an economic activity point of view) (Vadén, 2020). Therefore, we can estimate whether the different concepts of circular economy are focusing more on the extraction of materials (primary sector), on the manufacture (secondary sector) or on a service-based method (tertiary sector).

Geographical scope: This element is linked to the previous one. Indeed, when we talk about circular economy to implement, it is important not to put them all in the same basket. As Vaden pointed out with decoupling, it is important to compare comparable things. Therefore, one criterion that seems natural is the scale at which the type of circular economy can be applied. Are the concepts applied on a local scale or on a global one?

Activity scope: This section analyzes the activity scope targeted by the circular economy. As mentioned in the definition of Kirchherr et al. (2017) (cfr. Definition), the circular economy can act at three different levels: the micro, focused on products, companies and consumers at the individual level and their preferences notably on the means to increase their circularity, the meso focused on symbiotic associations between the different actors with a notion of geographical proximity (eco-park) (Guzzo et al, 2021) and the macro centered on the industry in general, the global and the nations (Kirchherr et al., 2017; Guzzo et al., 2021).

Efficiency, effectiveness or sufficiency: Our current societies are strongly based on the principles of efficiency. That is to say, to reach an objective with the least amount of resources possible. This is partly what has been and is being allowed by technological development. However, it has been shown that efficiency can have a perverse side leading to rebound effects. Indeed, a fairly typical example is the electric car, which is less polluting than the conventional car. With this in mind, electric car users will have the impression that they can drive more kilometers with a clear conscience, until the extra kilometers compensate for the advantage of the electric motor over the internal combustion engine, thus causing a higher climate impact than the initial one. Or simply the money saved on gasoline, can be spent on more polluting things such as travel abroad by plane etc. Eco-effectiveness is a longer-term view and can be defined as "doing the right things" while eco-efficiency is more "doing things right". These two terms are defined as follows by Jakobsen in 1999:

1. Eco-effectiveness is improving the total impact on environment when the consumers needs or demand is satisfied by alternative fulfilment of the function in question. One way of fulfilling a function is said to be more *eco-effective* than by fulfilling it in a

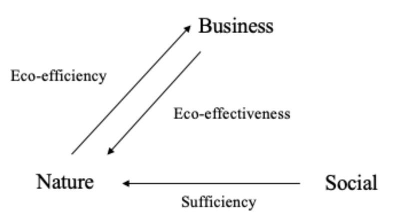
different way, if it gives a larger contribution to sustainability of the eco-system in question than the second way of fulfilling the function.

2. Eco-efficiency is the improved environmental performance of a product through the selection of low-impact material, reduction of material usage, reduced energy consumption, reduced waste and pollution per functional unit of a product during its life cycle. One unit of a given product system is said to be more *eco-efficient* than one unit of a competing system performing the same function, when the environmental burden of producing, using and ending the life of the first product is less than for the second product."

Another consumer-related term to consider is Eco-sufficiency, defined by Figge et al. (2014) as a concept related to reducing consumption in order to live well with less, thus limiting what is produced and consumed in a general way.

Dyllick and Hockerts (2002) illustrent ces relations de la sorte (fig. 18) :

Figure 18: Eco-efficiency, Sufficiency and Eco-effectiveness relations



Source: Dyllick and Hockerts (2002), adapted by author

States' role: As we have said, in the neo-liberal model proposed by Samuelson and supported by Friedman, which is very close to the linear system, the State is not part of the equation. However, as Raworth points out in the "Doughnout theory", the state has a crucial role in the development of the economy. It does so by providing public goods such as education, by supporting households that are the backbone of the economy, by revaluing the commons, by framing the market and promoting the common good, and by financing technological advances. It is therefore necessary to accelerate public and private investments, as well as those of the commons and households, in order to achieve the objectives of sustainability. In addition, we saw how important the role of the State in the making of legislations is, enabling actions to tackle big problems such as the waste management.

Therefore, it is interesting to look at the role of the state in the implementation of the different circular economies, to see if it is part of the model, a spectator or plays an important role.

4.1.2 Analysis

System preference

After analysis, the results concerning this criterion are quite unanimous. Indeed, each circular current seems to remain in line with the principles of capital accumulation, profit and ownership of the means of production linked to capitalism. Although some mention sufficiency and effectiveness in the Degrowth, such as the Performance Economy and Cradle-to-Cradle, decoupling GHG emissions and natural resource extraction from income and wealth remains a priority. The circular currents do not advocate degrowth in various economic sectors, but are always in search of profit and capital accumulation combined with a reduction of resource consumption. This is achieved through technical and metabolic closed loop processes, inspired by nature, as well as the implementation, for four of them, of service and performance products. In fact, apart from the Blue Economy and Biomimicry, each stream mentions changing the business model to that of the Functional Service Economy. This represents a new paradigm for consumers, who will have to give up owning products in favor of a long-term "rental", but also for businesses, which will have to adapt by changing the limits of their responsibilities. So, there is no need for systemic change as such, but a transition in terms of mentality for customers and in terms of operation for companies.

These six major circular currents therefore remain within the capitalist mentality of profit-seeking and capital accumulation, although with the nuance that the latter is valued differently. Indeed, the emphasis is placed on the performance and quality of capital rather than on its possession. In addition, the notion of capital is refocused on the valuation of natural capital, which was so lacking in the linear vision. It is therefore an industrial and cultural revolution, but not a systemic one.

The six major currents therefore seem to be applicable to the capitalist system, although they require a revision from a behavioral point of view. Indeed, in order to implement these paradigms, a cultural revolution will have to take place, leading to the end of homo-economics. Moreover, it is all about returning to an original capitalism as proposed by Adam Smith and Ricardo. As a reminder, in this capitalism the land and its agriculture were included in the notions of economy before disappearing from the equation and giving way to capital and labor in the 20th century. This is what Natural Capitalism proposes by revaluing natural capital.

Country development

Only the Performance Economy and Natural Capitalism are explicit about this criterion. Natural Capitalism refers to the development of mutually supportive actions of developed and developing countries (Hawken et al., 2000, p.14). Stahel clearly states that his model is applicable in both developed and undeveloped countries, and because of this his system named the Functional Service Economy which involves the development of business models integrating products and services to create jobs and wealth while reducing resource consumption. However, as can be seen from the diagram on the page, the Performance Economy does not act on the primary sector and focuses mainly on the three loops described.

Cradle-to-Cradle, Industrial Ecology and Natural Capitalism also focus on the use of products rather than their sale and therefore sell the performance and product service that allows them to retain ownership. In addition, they emphasize the development of smart technologies to increase productivity and achieve eco-efficiency. This has an impact on all three sectors of activity, giving a holistic aspect to this method. It is interesting to note that the primary sector, although concerned, will see its activity decrease given the objective of limiting resource use. However, while this element seems to be a brake for the implementation of the currents in developing countries, where most of the income and employment comes from this sector, the establishment of new business models in these countries could be an opportunity in terms of job creation and wealth, moving the workforce to the secondary and tertiary sectors.

Biomimicry is also incorporated in developed and undeveloped countries, with the difference that it focuses on the secondary sector and manufacturing and the primary sector in terms of materials extraction, but on the tertiary sector. Indeed, its more technical and less systemic side is limited to proposing circular and nature-inspired manufacturing techniques, as well as reviewing the selection of materials extraction banning rare or difficult to extract materials.

As far as the Blue Economy is concerned, it is equally applicable in developed and developing countries and across all three sectors of activity. Indeed, it encourages companies to use resources that are close and locally available, impacting all three sectors and bringing them back to short circuits.

The currents are therefore globally applicable in both developing and developed countries. Apart from Biomimicry, which only applies to the primary and secondary sectors, and Performance, which has no effect at the primary sector level, the currents have an implication for all three sectors of activity. This analysis is almost entirely supported by the work of Geisendorf and Pietrulla (2017), with the only discrepancy being the scope of application of Industrial Ecology, which they claim does not extend to the tertiary sector. This difference in results may come from the broad literature of this current. Indeed, as O'Rourke et al. (1996) mention, the absence of the principle of switching from porduct service to produtc ownership is a weakness of Industrial Ecology. However, this shortcoming is remedied by Erkman in 1997, who mentions product service as a lever towards dematerialization. This leads to a notion of change in the service sector. Geisendorf and Pietrulla considered Biomimicry to be only focused on the secondary sector. This can be explained by the fact that Biomimicry's action on the primary sector is not necessarily tangible, since it is about avoiding scarce and hard-to-reach resources, not about improving ease of extraction.

Geographical scope

For Gunter Pauli's Blue Economy, ideas such as the rehabilitation of the forest of Las Gaviotas, restoring an entire ecosystem that allows an entire village to have fresh water, increase work opportunities and reduce disease. In this case, the method seems more favorable to the local. It is a matter of doing with the local resources that we have at our disposal. In fact, Pauli clearly mentions the importance of optimizing everything that can be done locally with local resources and to reconstituting local communities creating a virtuous cycle. The same is true for Natural Capitalism, whose economic development is partly based on relationships between local governments and people and industry, having the same virtues of wealth creation in the community as the Blue Economy.

This notion of local exploitation is shared by the Cradle-to-Cradle approach, which proposes tailor-made solutions adapted to local socio-cultural habits as well as the use of locally available resources in order to create diversity such as that present in ecosystems and which is their source of resilience. The notion of local also applies to the Performance Economy, which emphasizes the importance of a short first loop to be more efficient and to promote the principle of sufficiency. Indeed, this reduces transportation and therefore packaging needs, and also allows for better circulation in the second-hand market. In the Performance Economy, remanufacturing is also done on a local or regional scale. In addition, Stahel promotes local job creation through the implementation of asset optimization. Furthermore, Performance Economy is applicable on

a more global level with regard to manufacturing and its second loop regarding recycling which are linked to the larger-scale production.
Industrial Ecology can also fit in both. Indeed, eco-parks like the one in Kalundborg have a very local application since they are inspired by ecosystems, allowing to reduce transport and packaging costs. In addition, like the loops described by Stahel, the extraction of materials and recycling are done on a more global scale.

As far as Biomimicry is concerned, its scope can be both local and global. Indeed, being mainly a technical means for manufactures, this system will adapt to the current by which it is used.

There is therefore a convergence of currents to move towards shorter circuits and to exploit local resources in order to optimize the use of materials, as well as to circulate wealth in communities and encourage local job creation. Although the extraction of materials is not unanimously local.

Activity scope

In terms of scope of activity, Industrial Ecology plays on all three levels. Indeed, although its main scope is the meso, notably via the implementation of eco-parks, this current is also present from a micro point of view putting forward technology and the development of eco-design, and based on eco-efficiency. At the macro level, it is its study of flows and its search for dematerialization and decarbonization that can be represented as changes at the global level.

The Performance Economy provokes a change at the macro level since it proposes a complete paradigm shift modifying the whole industrial economic system through a proposal of performance, but also a modification of ownership in the long term. In addition, the Performance Economy proposes the Consumer Pays Principle taxing consumers as a consequence of their use of the commons. Stahel also proposes changing taxes by placing them on non-renewable energy rather than on labor. Global change at the macro level is an element shared by the Blue Economy and Natural Capitalism which, through their innovative business models, propose a total revolution of the economic system.

Biomimicry focuses on the micro by having a clear impact on material change.

Cradle-to-cradle proposes solutions tailored to each company, thus having a micro impact on the manufacturing of products as well as on the functioning of companies. It also establishes change at the meso level by advocating collaboration between firms along the supply chain so that everyone is aware of the composition of materials and can therefore reuse them properly.

Three of the major streams provide a macro-level perspective that applies to the global industry. This is a total paradigm shift, requiring reforms in the business plans of companies. Industrial Ecology is clearly defined in the report by Lifset and Graedel (2002) as having implications at all three levels. Indeed, eco-design at the firm level, eco industrial parks at the meso level and flow studies at the global level. This element diverges with the vision of Geisendorf and Pietrulla already mentioned above. Both authors do not attribute the macro/global impact, despite the study of flows mentioned in the literature. This distinction may, once again, result from the numerous existing sources on the subject of Industrial Ecology. On the other hand, the results converge for Cradle-to-Cradle, Biomimicry and the other three streams.

Eco-efficiency is present in each of the models. Indeed, being an important lever for decoupling and therefore the possibility to increase profit by reducing resource use and GHG emissions, this element seems to be essential to implement.
However, for the Blue Economy, the Cradle-to-Cradle and the Performance Economy this is not enough. Indeed, the Blue Economy appears to check all three boxes as Pauli clearly mentions the need to use what is locally available in order to meet basic needs, which is his primary objective. In addition, he mentions the importance of using renewable energies that are abundant (i.e., gravity and sun), so this notion relates to eco-effectiveness as explained earlier. Finally, he mentions several times the importance of increasing the eco-efficiency of materials by drawing inspiration from ecosystems, in order to meet the various needs while remaining competitive.

Cradle-to-Cradle recognizes the usefulness of eco-efficiency in reducing environmental impact, but emphasizes that it is not a sustainable way because it only treats the problem and does not address the source of it. It is about doing more with less. McDonough and Braungart therefore categorize this as doing less harm. In order to do the right thing, and address the source, they establish the importance of moving to eco-effectiveness, which is about "working on the right things", thereby improving quality and enabling positive impact.

The Performance Economy also stands out for its duality. As mentioned, this trend is based on sufficiency in its first loop, in order to make it last as long as possible and maximize its utility and minimize the environmental impact. Indeed, the "activity wise" principle mentions the importance of keeping products as long as possible, by not remanufacturing what can be repaired and not recycling what can be remanufactured. Efficiency on the other hand is found in the second loop and in manufacturing, allowing an increase in material productivity and thus a decrease in the use of materials during recycling.

Finally, Biomimicry through its processes encourages designers to free themselves from technologies whose manufacture requires scarce or difficult to reach resources. Consequently, in addition to its search for eco-efficient products, Biomimicry encourages eco-effectiveness.

Eco-efficiency is therefore a key element in the development of circular economies. However, it is clear that several currents prefer to associate it with eco-effectiveness, looking for what is abundant in terms of materials and less impacting on the environment, but also by applying sufficiency at the level of consumers to extend the life of materials.

States' role

One of the characteristics that emerges in the different currents is the inefficiency of the policies and procedures put in place by governments and authorities. They are considered to be a real brake on seizing opportunities and turning them into innovations. The Performance Economy and Industrial Ecology mention the counterproductive side of "command and control" policies that allow policy makers to regulate, at the level of process and quantity, the actions of companies related to maintaining environmental quality (Britannica). The two currents each have a way of dealing with this subject. Indeed, Industrial Ecology believes that the business world must move to the role of "policy maker" and not just a "policy taker". By taking the state out of the equation, business can take on a leadership role in technology development.

Instead, the Performance Economy simply suggests that nations and states change their tune and agree to do the right things by investing in innovation and encouraging entrepreneurs to take risks, but also by developing education. Added to this is the idea of changing taxes on labor and shifting them to resource extraction, thus allowing for the creation of jobs at the local level. This idea is joined by Natural Capitalism and the Blue Economy.

However, the role of the state in the Blue Economy should be minimized over time. Indeed, while initially the state will play the role of an investor and will have to reform the educational system, according to Pauli, the development of the perspective economy can lead to numerous financial and natural benefits for the commons and create a healthy community therefore reducing the responsibility of the State. Of course, this is utopian and does not take into account the behavioral barriers of humans.

With respect to Cradle-to-Cradle, there is no particular specification of the role of the State. However, it is important to note that this system is taken as a model in some countries to promote the circular economy. This is the case in particular in the Netherlands, whose public procurement department has embarked on the Cradle-to-Cradle procedure in order to show the way to Dutch companies. To this can be added the assumption that there is also a need to revise the model of policies implemented by decision-makers as mentioned above.

Finally, as Biomimicry is more a tool than a paradigm as such, the question of the role of the State does not seem relevant. Although it can be mentioned that the state needs to be encouraged to push companies to use such a process.

The state therefore always plays a role at least in the implementation of each stream, encouraging it to review its incentive and taxation strategies. However, there is no mention of a key role as described by Raworth, although in these models the state intervenes as a financial aid via investments, it is not a market regulator.

4.2 Summary of the criteria

Table 1: Summary of the criteria regarding six currents of Circular Economy

Criteria	Characteristics	Blue Economy	Natural Capitalism	Biomimicry	Cradle to Cradle	Industrial Ecology	Performance Economy
Systems preference	Capitalism	X	X	X	X	X	X
	Other						
Country Development	Primary sector	X	X	X	X	X	
	Secondary sector	X	X	X	X	X	X
	Tertiary sector	X	X		X	X	X
Geographical scope	Local	X	X	X	X	X	X
	Global		X	X	X	X	X
Activity scope	Micro			X	X	X	
	Meso				X	X	
	Macro	X	X			X	X
Efficiency/Effectiveness/Sufficiency	Eco-efficiency	X	X	X	X	X	X
	Eco-effectiveness	X		X	X		
	Sufficiency	X					X
States' role		X	X	X	X		X

Source: author

While analyzing the table above, four characteristics stand out in each of the currents of circular economies observed. The first is the system preference that converges towards the possibility of continuing in the capitalist system, with the nuance, however, that it is necessary to return to its initial precepts taking into account natural capital in the equation. Moreover, for four of the currents, it will require a change of mentality at the individual level to renounce the possession of products, which will not be an easy thing to do, as has been mentioned in the barriers. This also means that these circular economy streams are moving in the direction of Green Growth (not to be confused with Green Economy). This trend is confirmed by another unanimous criterion in each stream, that of eco-efficiency, which is one of the main tools advocated by Green Growth to achieve decoupling allowing to continue to grow while reducing resource extraction and GHG emissions. The third criterion, which is found in every stream, is the scope of activity of the secondary sector. Indeed, it is not a surprise since it is closely related to the two previous criteria, eco-efficiency includes the increase of the productivity of material use and also insinuates the eco-design, which is done at the manufacturing level. Finally, the last element common to every circular economy is the local aspect. This can take many forms. For some it refers to local extraction of materials, for others it is the use and appearance of product services that must be local. It can also refer to the creation of communities that allow for a local circulation of flows and have beneficial effects on job creation.

As for the other characteristics, they are often convergent but not unanimous.

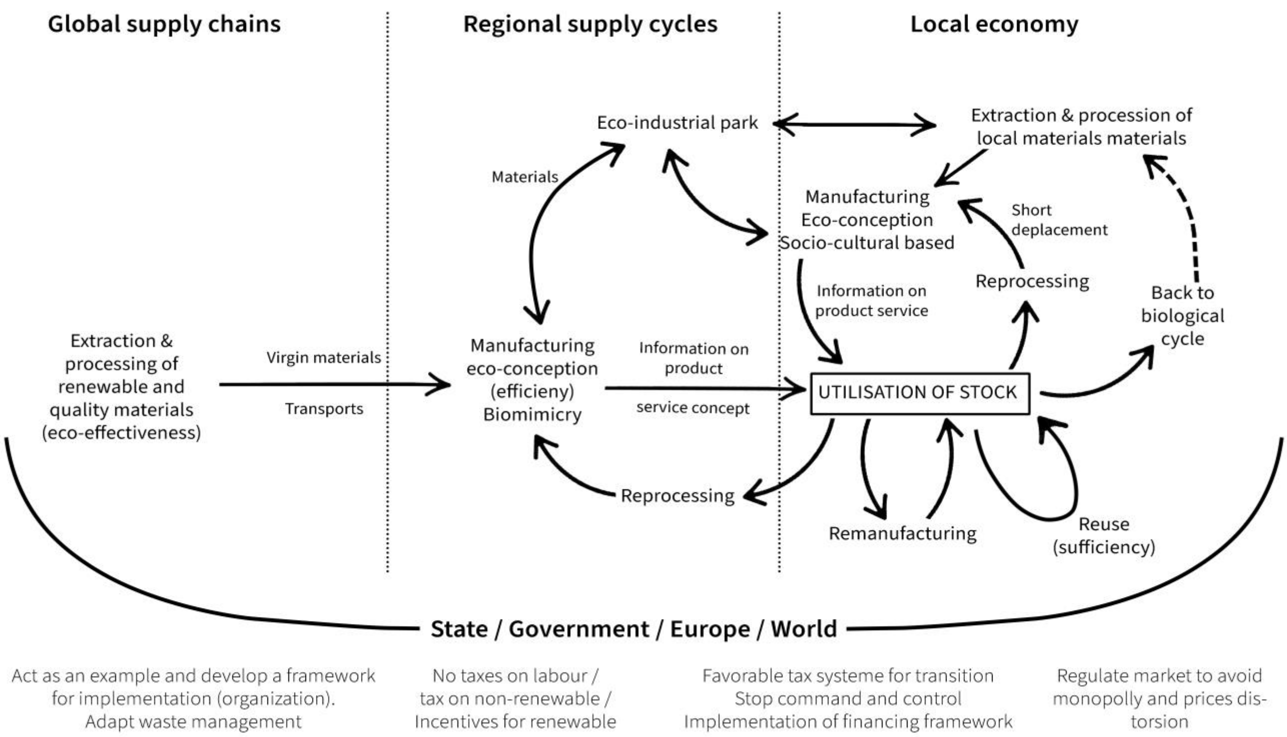
4.3 Sketch for a new paradigm

On the basis of the previous information, in this section a sketch of a circular economy trend using all criteria will be done (fig. 19).

It would be applicable in the capitalist system of Smith and Ricardo in which natural capital was then part of the economic equation. This current would allow for further economic and demographic growth while decreasing the impact of GHG and resource extraction, thus achieving absolute decoupling. It will not be a matter of doing less bad, but of doing better and doing the right things to regenerate the Earth and its resources by drawing inspiration from natural ecosystems.

To do this, three levers will be applied. Firstly, eco-efficiency will allow the evolution of technology towards designed materials and products in order to always be part of the biological or technical cycle, allowing also the reduction of resources utilization. This element being subject to the rebound effect, it must be accompanied by eco-effectiveness and sufficiency. Through the first one, businesses will try to use only renewable and high quality materials and energies, and when possible replace them with nothing. Sufficiency concerns consumers who will have to be satisfied with fulfilling their needs, and thus live well with less. In addition, the trend will suggest moving to a product service model, applying these three levers. Through this model, manufacturers will remain the owners of the materials used to manufacture their products, except for the manufacturing waste that will be used as raw materials by a local company, thus entering an eco-industrial park. These eco-industrial parks will be based on collaboration and transparency without any information asymmetry.

Figure 19: Sketch of a new paradigm



Source: Author adapted from Stahel and Clift (2016, p.141)

This paradigm will therefore have an impact on the primary sector of activity, since it will reduce the extraction of resources, banishing even those that are not renewable in favor of abundant and mostly local resources. Even though there is a risk of job losses in that sector, this will be offset by the creation of new opportunities in the secondary sector. Indeed, the implementation of eco-design concepts as well as remanufacturing and reprocessing concepts will have a significant impact on the creation of jobs that will be upgraded through increased specialization. Finally, the tertiary sector will also be affected by this change, notably via the transition to products as a service, but also in terms of the information, marketing or not, necessary for the understanding and acceptance of the new concepts by consumers. Consequently, it will be applicable in both developed and developing countries, offering the latter the opportunity to continue to grow while reducing environmental impact.

In order to be as effective as possible, the use of materials must be as long and as local as possible. This means avoiding remanufacturing what can be repaired and not recycling what can be manufactured. As already mentioned, the majority of materials will be sourced from what is available locally, and products will be adapted to local socio-cultural habits as well. This can be supported by relationships between local governments, residents and industries, and can create local communities and increase their wealth and resilience. Of course, the extraction of certain materials will always be done on a global scale, but globalization is not totally excluded as it brings diversity and innovation.

This trend will have an impact at the micro level in the sense defined above, since it will act at the level of firms with tailor-made solutions by reforming their way of doing business, encouraging them to go green. It will also be micro at the level of product design, leading them towards an eco-design resulting in better productivity and staying in one of the two cycles. As mentioned before, it will also set up eco-parks, giving it a meso impact. It will act at the macro level through its implementation of a business model revisiting the general way of operating at the industry level.

Finally, this system will, at least in the beginning, give a first role not to the State, but to the States. Indeed, it is at a global level that change must take place. The role will consist first of all of putting an end to the "command and control" system, which is considered ineffective. Then, in order to promote the transition, it will be responsible for breaking down barriers.

Therefore, the first point of action will be to change its approach to taxes and incentives. Indeed, the States will have to get out of their still linear vision and redirect their subsidies towards the circular. In the same vein, the State will have to revalue natural capital, notably by incorporating the costs of negative externalities (social and environmental) into the price of resources and energy.

In addition, it will be necessary to shift taxes from labor to non-renewable and less abundant resources, creating a tax system that is favorable to the transition. Moreover, by allowing low-cost financing, reducing commercial financing costs which encourages investment, and allowing financial benchmarking, the state will reduce the risk of implementation.

It will also be responsible for legislating a framework for implementation, but also for adapting certain laws that hinder it, such as the waste management law that prevents some companies from reusing another company's waste.

Then, by setting an example in implementing responsible practices (cradle-to-cradle) at the public level and creating implementation frameworks, it will reduce the barrier of technological implementation difficulties in processes related to eco-design, but also in waste recovery. The same will be true for the development of organizational frameworks, facilitating the transition to product as a service and the management of responsibilities and contracts related to leasing.

Finally, the States will have to act as market regulators in order to avoid abuses such as the establishment of monopolies owning all the goods and imposing inappropriate prices.

This is how the Circular Economy would be built, ticking off each of the criteria mentioned above. It should be noted that some elements have been left aside because they are more difficult to elaborate in a more schematic context. This is particularly the case for the educational reform proposed by Gunter Pauli, which requires more attention.

Conclusion

In order to meet the challenge we are facing, the scientific literature and the major organizations are unanimous: we need to move away from the linear system currently in place. However, this must not be at the expense of economic growth and development, nor of global well-being. It is therefore necessary to find a way to continue to grow in these areas, while reducing the use of resources and greenhouse gas emissions, or in other words, to achieve "decoupling".

A difficult challenge that may be met by a model that has been gaining momentum for some years now: the Circular Economy. From this model, many economic, social and environmental opportunities can arise. Indeed, the implementation of this system can lead to an increase in the economy via reductions in material costs, an increase in specialized jobs, it can also reduce the volatility of material prices, and increase innovation. At the environmental level it is the regeneration of soils, the reduction of GHG emissions and negative externalities that are positively impacted. It is also a boon for business and citizens, creating new profit opportunities and bringing better functionality through quality products.

However, these opportunities are also accompanied by barriers to implementation. These can slow down the establishment of a system by a lack of knowledge and technology, some organizational difficulties, an important need of investments, behavioral and cultural barriers, dependency on suppliers and institutional barriers.

Based on six main currents of the Circular Economy, which are The Performance Economy, The Cradle-to-Cradle, The Biomimicry, The Industrial Ecology, The Natural Capitalism and The Blue Economy, this work was able to show, on the basis of fourteen characteristics, certain similarities and divergences existing in each reform plan. The fourteen characteristics were grouped into six criteria as follows (table 2):

Table 2: Criteria and characteristics for implementation

Criteria	System Preference		Country Development			Geographical Scope		Activity Scope			Efficiency/Effectiveness/Sufficiency			State's role	
Characteristics	Capitalism	Other	Primary sector	Secondary sector	Tertiary sector	Local	Global	Micro	Meso	Macro	Eco-efficiency	Eco-effectiveness	Sufficiency	Yes	No

Source: Author

It was found that four characteristics were unanimously shared by the six currents analyzed. Among these characteristics is the fact that it is applicable to capitalism, with the nuance that it is the original capitalism of Smith and Ricardo in which natural capital is part of the economic equation. The other three characteristics are eco-efficiency, the application of change on the secondary sector and the local scope. The first two are quite complementary and are each a lever towards decoupling. The local scope, on the other hand, takes the form of the extraction of materials on a local scale, as well as the development of communities in which the materials circulate as long as possible. As for the other characteristics, most are convergent, but none of them is unanimous.

Of course, these results are subject to certain limitations inherent to the work. Indeed, it was not possible to take into account criteria such as education or financial and social impacts in the report due to the lack of time and space dedicated to this thesis. The desire to localize the economic system in space could also not be addressed in depth. A possible extension of this thesis could be to analyze the impact and ease of implementation of circular economies by considering these different aspects (local variations in resources and labor, education and social impacts). In addition, the approach used for the analyses is very theoretical, on the one hand for the same reason as mentioned above, and on the other hand because the circular economy is still a very recent topic with not many applications yet. On top of that, some currents propose very broad implementations (defined as macro), of which examples are rare.

In this context, through an attempt to elaborate an "ideal" system taking into account each characteristic, it was shown how difficult it is to apply such a model without the intervention of the authorities in place to facilitate the removal of barriers to implementation. Indeed, the decision-makers will have to act as a catalyst, starting by stopping command and control, which is considered inefficient. It will also be necessary to refocus taxes on non-renewable resources and favor the use of renewable resources (e.g., labor). Then, natural capital will have to be revalued, via the incorporation of costs linked to negative externalities in the price of materials and energy. In order to limit the risks of entrepreneurs embarking on the transition of systems and to attract investors, it could be interesting to promote low-cost financing, to reduce the costs of commercial financing and to allow a financial benchmark. In addition, it will be useful to set up a legislative framework that facilitates the implementation of systems and to revise certain laws that hinder implementation. Another role will be to set an example for public services by implementing circular practices, as is already the case in the Netherlands where public procurement is done on a Cradle-to-Cradle model. Furthermore, an implementation framework can be developed that can lead the way on a technological and organizational level (e.g., leasing contracts). Finally, governments will have to act as market regulators in order to avoid abuses such as the establishment of monopolies owning all goods and imposing inappropriate prices.

There are therefore many currents of ideas and concepts that are more than interesting in order to continue to grow while reducing the environmental impact. However, the implementation of these ideas is still subject to many barriers. Of the different trends analyzed, Biomimicry is a philosophy that seems to be more easily applicable and could become a basic precept for all manufacturing. From a broad economic point of view, with the exception of Biomimicry whose scale of application is smaller, Cradle-to-Cradle seems to be more easily implemented than the other trends. Nevertheless, the paradigm that can bring the most social, economic and environmental benefits is the Performance Economy. Using it as a basis and adding all the best elements of other circular economies could lead to very interesting goods.

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Appendix

Appendix 1: Example of Performance Economy

Michelin offers its truck customers a tire rental formula, thus shifting its production activity to service. This measure is advantageous in many respects:

- For the customer: easier management, cost savings
- For the supplier: better customer loyalty, improved products, increased profits
- For the environment: increase in the performance of the material, which has become more durable and resistant, with a reduction in negative impacts (waste).

Read more:
https://www.capital.fr/entreprises-marches/pourquoi-michelin-mise-sur-la-location-de-pneus-365980

Appendix 2: Example of Cradle-to-Cradle (and Natural Capitalism)

RIVER ROUGE, FORD MOTOR COMPANY's industrial estate in Dearborn, Michigan, was an icon of the industrial era of the last century. Established in 1917 by Henry Ford, it became the largest automotive manufacturing estate in the world, implementing vertically integrated production processes and fast-paced production lines.

This past splendor generated unforeseen environmental problems, of which we are all aware today.

In 1999, in the age of outsourcing, Bill Ford, great grandson of Henry Ford, chose to declare the Ford Motor Company "Native" to Dearborn and revitalize its industry; breaking with the traditions of industrial architecture, he installed isothermal green roofs on all buildings to collect and filter rainwater, as well as porous soil parking lots that collect and channel water to underground retention ponds. The entire industrial landscape is embellished with natural trenches to filter and recover wastewater. These eco-innovations, while improving functional efficiency, have saved Ford Motor Company millions of dollars.

This is a shift in industrial design: manufacturing processes are also being redesigned toward a sustainable manufacturing strategy, enabling many companies to produce goods and services that are environmentally friendly and generate social well-being as well as economic growth.

Read more https://mcdonough.com/writings/new-era-manufacturing/

Appendix 3: Example of Biomimicry application

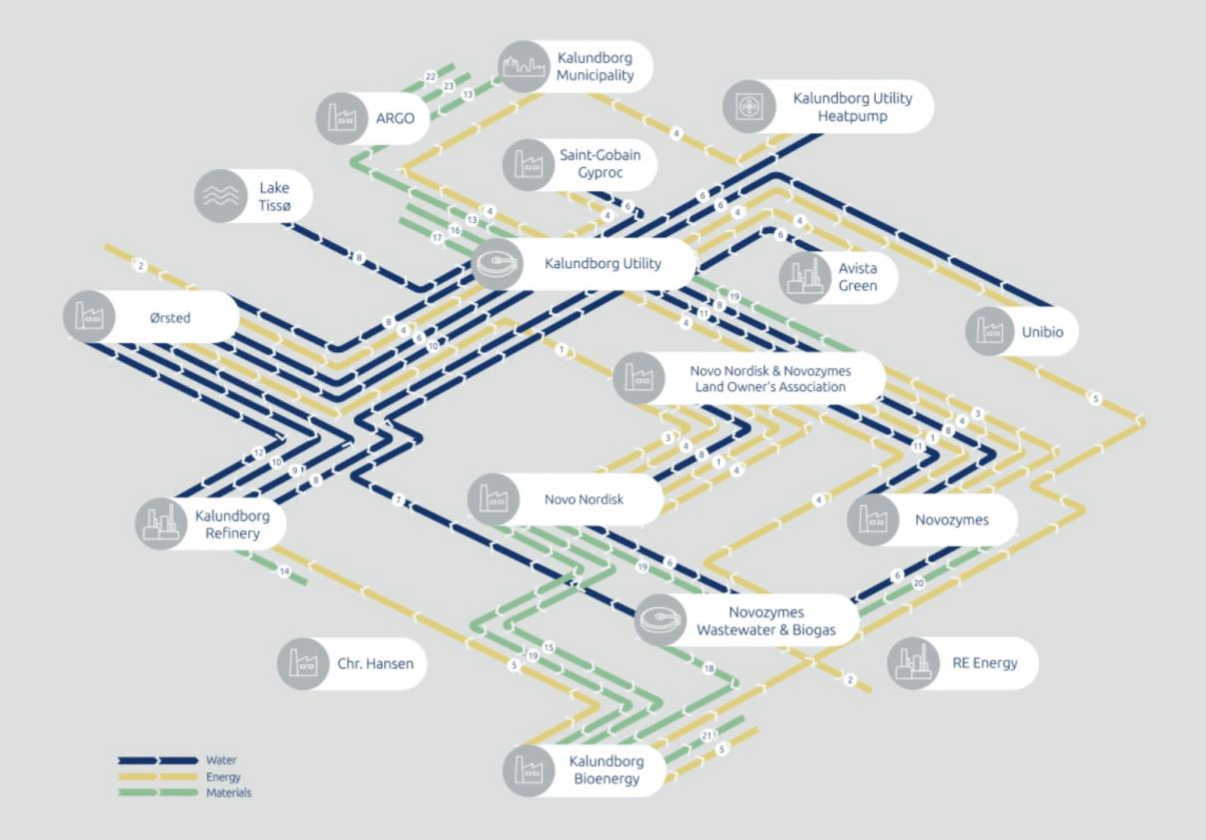
The conformation of humpback whale fins has inspired WhalePower designers to improve the aerodynamic performance of wind turbine blades by increasing their resistance to stall by 40% compared to conventional blades. Read more:
https://www.futura-sciences.com/planete/photos/nature-biomimetisme-nature-inspire-innovations-2134/baleine-eoliennes-imaginees-partir-nageoires-baleines-15870/

Appendix 4: Example of Industrial Ecology

One of the earliest examples of industrial ecology or industrial symbiosis is the Kalundborg eco-industrial park in Denmark (Ehrenfeld and Gertler, 1997). Created in 1972, it is the very first eco-park, implementing circularity and cooperation between companies. The principle is simple, since the waste of one company become the resources and raw materials of another. Excess energy, water and materials are shared, and waste is reduced.

This example is particularly well known because it demonstrates that this approach is possible and can bring economic and environmental benefits. Creating financial resilience, but also opening up opportunities for trust and innovation within the park. By 2020, this eco-park had 14 collaborators working with businesses and local authorities across a range of sectors, employing 4500 people, and creating just over 20 streams of excess resources flowing between firms. This led to a saving of 4 million m^3 of ground water use replaced by surface water, 586.000 tons of CO_2 and led to 62.000 tons of residual materials recycled (Kalundborg Symbiosis, 2022).

Figure 20: Kalundborg's Industrial Symbiosis flows



Source : http://www.symbiosis.dk/wp-content/uploads/2022/01/Streams_WEB_EN_V01.gif

Appendix 5: Example of Blue Economy

Paolo Lugari has succeeded in putting an end to 450 years of intensive agriculture and recreating a tropical forest of 8000 hectares in Las Gaviotas, Colombia. And this thanks to the symbiosis between the Caribbean pine and a mycorrhizal fungus present in the plantation lands. These pines create shade on the ground protecting its roots from ultraviolet rays and preventing it from dying in case of too much heat. The needles falling on the ground will maintain the soil temperature and thus allow a good penetration by water. This has for main advantage to keep the carbon rate which the micro-organisms need, in the ground. The forest will therefore develop and increase the abundance and freshness of rainfall. This forest in addition to increasing the capture of CO_2 and the emission of oxygen has increased the food and drinking water, harvestable in the region, by 3000. The JP Morgan bank has decided to invest in this project and there is now talk of 100,000 hectares of the same process. They estimate that they will be able to create 100,000 jobs in ten years, based on an investment of $300 million (Pauli, 2019, p.45). A lot of other examples are available in Pauli's book and on his website: https://www.theblueeconomy.org/the-blue-economy/

Master Thesis Tom Dormans:

Structural analysis of six major Circular Economy currents and their implementation conditions

As global warming and its impacts on the planet are becoming more and more present in our daily lives, it is time to look for solutions and changes. Among these proposed solutions is the Circular Economy (CE), which is the opposite of the current linear system. This very broad principle presents many advantages and opportunities at the environmental level, but also at the socio-economic one. However, it is subject to many barriers that can be cultural, related to the need for possession, organizational and technological, or institutional. This work focuses on six major currents of the CE: The functional service economy (Performance Economy)" by Walter Stahel, reviewing the Industrial Economy in an integrated way. "The Cradle-to-Cradle design philosophy" of William McDonough and Michael Braungart, which advocates the upcycle, in other words, recycling that maintains the quality of raw materials throughout the recycling cycles. "Biomimicry" as articulated by Janine Benyus, the design and production of materials, structures, and systems that are modelled on biological entities and processes. "The industrial ecology" of Reid Lifset and Thomas Graedel, viewing firms as environment improvement agents since they have technology to successfully make environmentally designed product. "The natural capitalism" by Amory and Hunter Lovins and Paul Hawken, create opportunities and avoid scarcity of the natural capital. "The Blue Economy" by Gunter Pauli, inspired by natural ecosystems. Thanks to six criteria, certain characteristics necessary for the implementation of these currents are put forward, revealing their adequacy with capitalism, a scope of application aiming at the use of the local as well as the global, the impact on all sectors of activity, from the primary to the tertiary, changes applying as well to the level of firms as to the decision-makers and mentalities, the necessity of a combination of eco-efficiency, eco-effectiveness and sufficiency. Finally, it highlights the importance of the role of the state in the transition.

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