

# 22 Circular Economy

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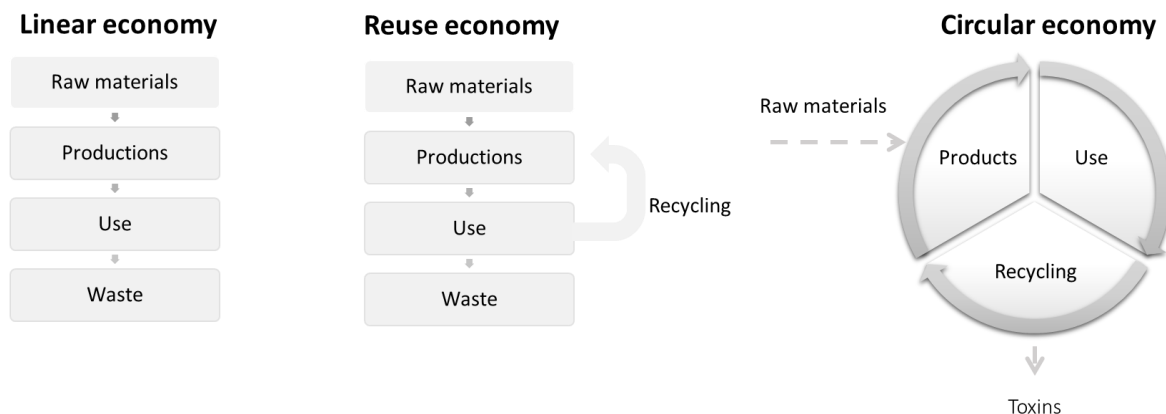
## 22.1 Abstract

Circular economy has been a hot topic in recent the years. The purpose of this paper is to address some of the challenges and opportunities regarding how to reach a circular economy. Circular economy is a concept where no waste will be produced. One way to summarize the solutions to achieve a circular economy is the phrase "No man is an Island", because it is a complex question with many stakeholders. A system perspective is needed as well as suitable legislation and standards with End of Waste criteria that make it easy in a safe way to turn waste in to products. Developing countries have a good opportunity to gain and take advantages of the transition to circular economy.

**Keywords:** Circular economy, Sustainability, Recycling, End of Waste

## 22.2 Introduction

The upbringing of the concept of circular economy is due to the understanding that the earth's resources are used to an extend that is not sustainable. For example, one person in Sweden today consumes resources as if there were 4 globes and gives rise to about 60 tons waste produced directly and indirectly per year [1, 2]. For a long time, "take, make and dispose" has been a normal way of handling products and resources, which symbolizes the linear economy, Figure 1. In the circular economy no waste will be produced, and very little virgin material will be used. Beside the fact that something needs to be done to have enough resources for the future, the idea is that a circular economy will have positive economic effects on the whole society [3].



**Figure 1:** Illustration of the different between linear, reuse and circular economy

Circular economy refers to a society in which resources are retained in the loops rather than waste. The main features of such loops are to reuse and recycle products and materials so that the economic value is maintained. The basis for financial growth should not be at the expense of virgin materials. The only thing that should be added to a circular economy is renewable parameters for instance solar and wind energy, things that humans cannot influence. The idea is that the materials and atoms that exist in the society today should be used infinitely many times. In order to achieve this, the idea is that products or materials should be reused as much as possible. If a broken product cannot be repaired, the parts must be able to be reused or be possible to reuse the atoms to form new products. No toxins should be present in the loops and there should be no waste that cannot be recycled into the cycle. In such a

society, waste is something that should be regarded as a resource that can be reversed in the value chain. One aspect that needs to be included in the calculation for circular economics is how materials that cannot be recycled today should be handled and how toxins should be handled in the future. [3, 4]

## 22.3 Background

The concept of "Circular economy" had a breakthrough after the Ellen MacArthur's Foundation's report in 2012. In 1966 an article was published concluding that the earth is a closed economic system where economics and the environment consist of circular conditions [5]. As a concept, "Circular economy" has been used by Pearce and Turner in the Economics of Natural Resources and the Environment 1990 [6]. The fact that the concept "Circular economy" received such an impact after 2012 is probably due to the concept was launched at an appropriate time in an easily accessible and educational way. There are also many other concepts on the same theme such as The R-ladder, Steady state economy, Green economy, Bioeconomy, Sustainable development / society, Cradle to Cradle which is a certification of products. Within the EU there are also strategies and policies for achieving circular economy through, for example, the "Manifesto for a Resource Efficient Europe" and "Moving towards a circular economy through industrial symbiosis" [3, 4, 7]

According to Ellen MacArthur Foundation, should Europe's manufacturing industry be able to save \$ 630 billion annually by 2025 by turning it into a circular economy. The global potential is for consumer goods are \$ 700 billion. The EU is estimated to be able to save about € 600 billion annually for waste reduction and increased recycling, while at the same time providing about 2 billion more jobs and reduced greenhouse gas emissions. [3] Globally, carbon dioxide emissions would decrease by about 3.6 Gt carbon dioxide by 2050. [8]

## 22.4 Business Models

In the context of a circular economy, it is often mentioned that a circular economy will need and lead to new business models. Initially, a great deal of innovation and design of products is needed, as well as changing in the consumer behavior and collaboration between different policy areas. Business models usually refer to how different businesses can benefit from each other such as the use of residual products and energy (industrial symbiosis). Other examples are that the business models contain renewable raw materials or that the product is provided for a function or that the material/product is to be rent out instead of to be sold. The ownership of the material and parts of it will be in hands of the traditional seller/producer and the consumer will rent or lease the product. Products should be Eco-designed that can be repaired or changed so that it can be resold. Shared ownership is something that is usually mentioned in the circular business models. [3, 6, 9, 10]

Compared to earlier, many materials are used today in a way that reduces the need to produce new ones. One example of such a material is metal that can be remelted to be used for new products over and over again without the need for any major change or energy input compared to new iron to reuse the material. Another example is the secondary market for clothes, mobile phones or cars, these products are also possible to rent. But more and more materials need in the future to be reused and recycled. [3, 7]

Sharing economics is a concept that often is raised when it comes to circular finances. The prerequisites for a sharing economy have been improved through simpler electronic payment solutions and electronic platforms. The environmental awareness, convenience and financial motives are common reasons for to participate in the sharing economics. Problems with this are often that laws and rules are not really adapted for this and that people and companies need to be honest and want to do the right things. [3, 10]

The car is often mentioned when talking about circular economy. The reason for that can be

that they have a low utilization and accounts for a large part of the emissions from steel, plastic and aluminum. If the car is not private owned it may be possible with car with fewer seats that use less material and fuel. Enkvist and Klevnäs report that the circular car model with shared cars reduces the cost and carbon dioxide emissions by more than 70% compared to today. [8]

## 22.5 Challenges and Opportunities

The challenges to achieve a circular economy today is a lack of the system perspective, procurement, legislation, standards, end of waste criteria and thermodynamics. There are also many other problems to reach circular economy for example because it is difficult to judge the best alternative, low demand for recycled materials and products, that the price to use virgin material is often too low. It is also the case that political strategies, innovations, investments, knowledge and infrastructure for recycling, etc. are needed to reach a circular economy. New business models can be both a challenge and an opportunity. [3, 4, 7, 8, 10]

Circular economy is complex and includes many actors, behaviors and materials so that policy efforts are needed. Policy efforts need to have a holistic perspective and need to be coordinated for efficiency. This applies not at least to regulations and implementations that are very important. The regulatory system affects most things in terms of accounting, deposit, increased requirements for life expectancy, prohibition of environmentally harmful technologies, packaging, guarantees etc. Rules and investments in the waste area are in demand in areas of landfill, End of waste criteria and free mobility. Public investment as a complement to private investment is needed in the form of structural funds and investment in research, meeting platforms, tax incentives (for example, lower tax on repair and higher on the use of virgin natural resources) and campaigns to influence the attitude and stimulate collaboration. To increase the demand for circular business models in public procurement, which gives companies clearer rules how to act and what is expected of them. [3, 4, 7, 8]

Previously, the Lansink's ladder (waste hierarchy) was used to illustrate how waste should be handled. This applies to a great extent even today, but a further focus is needed on that materials and products being recycled. Both to create products where the individual components/materials can be recycled but also in order to create a waste treatment for the products that cannot directly enter in to a new loop. In several areas, work is underway to develop better technologies and new solutions in order to return more material into the material loops. One example of this is that how the incineration residues from energy recovery have been improved where previously non-magnetic metals that were less than 10 mm were not recycled. Today non-magnetic metal residues of about 1 mm are usually recycled today and there is technology for recycle even more [11]. To use recycled aluminum consumes about 5 % of the energy and reduce carbon dioxide emissions by about 98% compared to new aluminum production [8]. However, an improved technology is still required to separate the various metal alloys so that they can be used at a higher level in the waste hierarchy and enter an eternally loop in the circular economy. Techniques for separating metals exist today. In the future better technologies is expected to be used to separate different alloys or use another approach to be able to produce purer metals. Much of the recycled aluminum today is used as cast aluminum. Today there are few attempts produce a higher degree of separation from recycled metals so it can be used in finer aluminum products. The low difference in price between primary and secondary aluminum can be another reason that makes it difficult for secondary aluminum to compete with new aluminum. High security requirements are often imposed on new products that are delivered, and because of that the use of recycled materials can reduce the alternatives. [8]

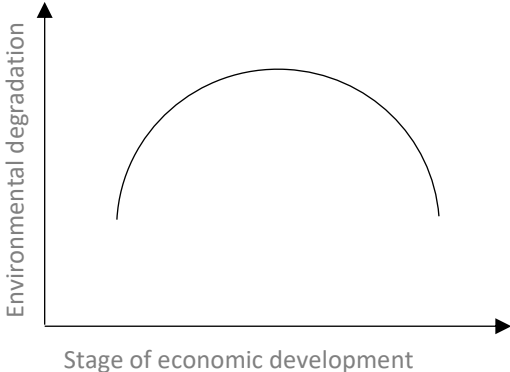
Another example is that work is in progress on extracting materials is the separation of the salts from flue gas treatment residues. Potassium chloride, sodium chloride and calcium chloride can be extracted and separated from the flue gas treatment residues from when waste is incinerated. [12]

Techniques such as computers and smartphones are products that usually today need for to

be produced example rare-earth metals and that create mining waste. Artificial intelligence is one of the tools that today often need to use these rare-earth metals. The technology makes it possible to speed up development and design, compile and analyze data in order to understand new areas of use. There is a need to create efficient logistics for material flows in order to, for example, achieve circular solutions. Although even if not everything needs to be based on artificial intelligence, it is a fact that digitalization has led to a great opportunity for circular economy by being able to perform calculations and optimizations faster that are more efficient than people can do. The computer capacity makes it possible to maintain, for example, service intervals in order to increase the service life or, in a structured manner, see which parts that is limited, and because of that often breaks down. This follow-up makes it possible to better monitor costs. Manufacturing can also take place with robots, which requires less movement of people. [8, 13]

## 22.6 Circular Economy in Developing Countries

The circular economy will probably create new goods, products and services. With this, there are both threats and opportunities for developed and less developed countries. The circular economy is basically based on resource management, something that has not been as much focus on in the linear economy. With this, different countries can use their different advantages. [8, 14]. Several ways have been used to describe how financial growth and environmental interest are related. A common illustration of this relationship is an upside down Kuznet curve or also called the environmental Kuznet curve, Figure 2.



**Figure 2:** Environmental Kuznet curve.

Facts that have been used in order to obtain the model indicate that at a certain point of economic growth, the focus is more on emissions and environmental issues. The model has received criticism because it does not match or does not include all relevant parameters. However, the model has had a great impact and is often referred to. On the same theme as the model, there are also perceptions that free trade often leads to a better environment [15, 16].

In developing countries, the circular economy has generally not received the focus that would have been needed. One of the problems is the view that circular economy is a way of managing waste while circular economy is more about system thinking and closing the loops. Generally, in developing countries, the change in society is needed and the society is usually not organized as the public and private sectors are in industrialized countries. Developed countries often have a greater diversity/fragmentation, especially in the private sector. There is often a shortage of technology in developing countries and, which makes it more difficult to convert to circular economy [14].

Developing countries often have a large informal sector that already today acts circular through, for example, telephone repairs. What is most often required is investments, among other things, in infrastructure and technology so that these countries also efficiently can handle and repair

products from other countries. These developing countries have a tremendous opportunity because they are not tied to old thoughts and ideas, which often seems to be the case in industrialized countries. What is not to be done, however, is that these countries become dump sites and that there are poor working conditions [14].

Many of the investments that are made in developing countries are based on raw material extraction, which probably is because it is easier to calculate income and expenses in that sector than in new, more untested technologies and business models that are considered higher risk [14]. The circular economy has been formulated in the EU and in the industrialized countries, which has meant that there has not been as much focus on agricultural issues. Agriculture is, for example, an important area that in developing countries in achieve a circular economy [8] [14]. Today, a large part of production is in developing countries, but a large part of consumption takes place in the industrialized countries. In the long run, developing countries will increase their consumption and then they are even more important that there are circular solutions for the earth's resources to suffice [14].

Undeveloped countries have the opportunity not to make the mistakes that developed countries have made in order to create a sustainable host. Much capital is tied up in the developed countries in the linear value chains. Undeveloped countries have the opportunity to see which things have not worked and skip that step and thus that create a strong competitiveness [8].

## 22.7 Discussion and Conclusions

As can be seen from the content and the reasoning of the concept of circular economy, "No man is an Island" is a good way to summarize the concept. The environmental issue cannot be solved in a separate way. System solutions are needed, the new solutions will probably influence others and it will lead to new ways of thinking and improved activities.

Much needs to be done and there will probably be lots of creative ideas on how materials can be utilized and how to get existing atoms and materials in closed loops. It is important that companies and legislators are at the forefront of the development. Otherwise it is a risk to becoming as did for the Eastman Kodak company the analog filmmaker who did not realize in time the effect of digitization.

A lot of the legislation that exists is good but does not always contribute to the fastest changes. One example is the End of Waste criteria which can be perceived as unclear and obstructing the recycling of materials. There are some troubles with material that could be used as raw material, but it is difficult due to it is classified as waste. Material need to be able to be transported in an environmentally friendly way to one who is suitable to handle the material and bringing it back to society.

One business model that is relatively new and that does not claim to be circular is Airbnb, where housing can be used for temporary housing. The advantages of this are, for example, that land and resources are not used for hotel buildings. Disadvantages are whether this leads to reduced tax revenues and tax evasion because it is easier to control hotel operations than the private person although it should be possible for the company that conveys the lease to submit information to the tax authority. Other parts of this are that it creates uncertainty among neighbors and does not really follow the regulations that tenant-owner associations advocates.

Another new phenomenon are electric scooters. An interpretation of the business model is that it follows many of the parts symbolizes circular economy. The system is based on that you pay for the time it is used and that the scooter can be repaired and upgraded. The question is whether it is renewable raw materials that can be charged with solar energy, or batteries with rare earth metals that maybe not going into the loop or harmful substances. If these can satisfy the entire circular idea, depends much on how the owner takes care of these batteries for charging, how they are collected, if they will have a long life, if they are designed for repair and replacement, if there is a management for how materials can be taken care of, if new, more

efficient batteries are developed or if the components can be used in other applications. It can be questioned whether electric scooters have replaced any other transport need or if it is just an unnecessary supplement that takes more resources than it creates. In the best of worlds, these vehicles have replaced cars that require more material and energy for movement and currently contribute to emissions, the products are repaired, and the raw materials are recycled, and the time savings leading to higher production.

The business model proposed for cars is often some form of rental system where the user rents a car when he needs it. It is relatively common today that transport companies use this model by purchasing transport services to carry out transports they have undertaken to carry out. Price models work as such that the price can be different at what time of the day the material is to be transported in order for the transport company to have as high occupancy on their cars as possible for maximum profitability, in the same way as it currently works in the airline industry. For passenger car transport, these models could work, but it is doubtful what effect they would have. Today cars are used relatively simultaneously, just watch the rush hour and the parking spaces at the shopping center. It is not certain that sharing cars will drastically reduce the number of them. Greater effect would probably have if working hours were distributed more irregularly so that there is no rush traffic or weekends, but the question is whether it is accepted in society. Leasing is a model that to some extent can be considered circular because it can still be the manufacturer who owns the car and thus has ensured that the car can be used for raw material in future production.

The circular economy will probably not be completely circular so that only the substances we already have in circulation are used. As the example of artificial intelligence and earth metals, the development can benefit from the introduction of new materials in the existing flows as it can create benefits. This, of course, should be made aware of which pros and cons it creates. Presumably, the use of the possibilities of artificial intelligence will be able to produce methods for using the materials as much as possible in order to prevent waste or to make existing materials that are reused in the circular economy.

From the literature it can be concluded that developing countries have big potential when it comes to circular economy. Arranging society and the infrastructure to be for a circular economy is likely to be beneficial in the long term. The historical interpretation of which may indicate that high economic wealth gives less environmental impact through more awareness of the environment and that products, materials and atoms need to be recycled. New environmental thinking and activities can be what drives economic growth in the future.

Regardless of what concept is used to describe a sustainable future, the future will continually be in change. As many have said, we cannot continue as we have done. Like the fashion for clothes, the attitude to what is a luxury living and quality of life will vary, owing and use petrol-powered cars or use an electric powered small vehicle. The wise man (Homo Sapiens) will change his life if he has knowledge of what is happening, but he will always benefit his own gains. The fact that the environmental issue has become more actual in recent years (even though these years can be considered many), so has nevertheless the knowledge increased of what threatens humanity, which makes it possible to make decisions.

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