European Commission

Business Innovation Observatory

Clean Technologies

Circular supply chains

Case study 30

Enterprise and Industry

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Authors: Kristina Dervojeda, Diederik Verzijl & Elco Rouwmaat, PwC Netherlands, and Laurent Probst & Laurent Frideres, PwC Luxembourg.

Coordination: Directorate-General for Enterprise and Industry, Directorate B "Sustainable Growth and EU 2020", Unit B3 "Innovation Policy for Growth".

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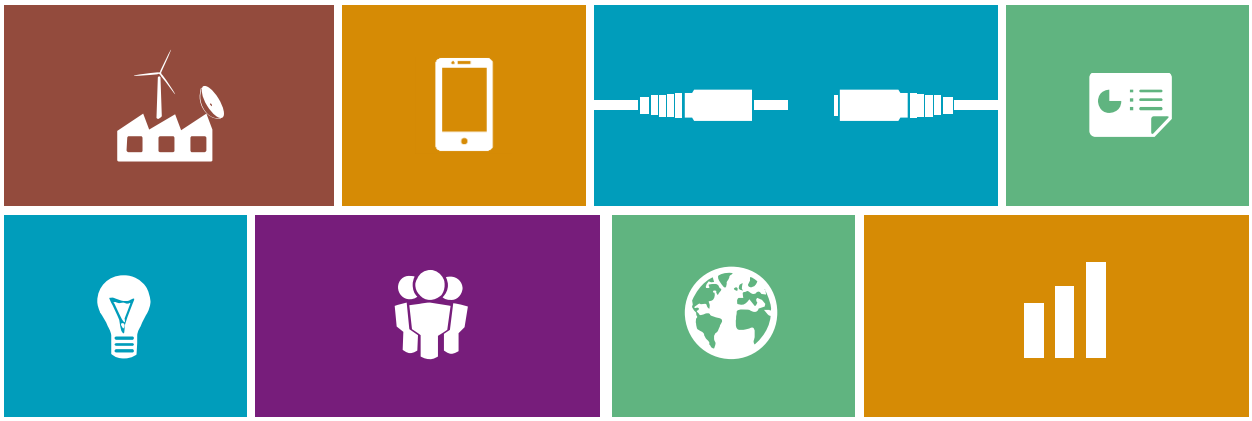


1. Executive summary

A circular supply chain refers to a production model that is restorative by nature. Ideally, this implies that resources which are used for production enter an infinite loop of reuse, remanufacturing and recycling. Resources that cannot be fully salvaged, like energy, must be based on renewable sources. The circular supply chain is the opposite of a linear production model. In this model, raw materials are extracted from the environment and are manufactured into products which, at the end-of-life stage, end up at landfills or incineration plants. This linear model is currently still dominant in most industries.

Up until now, the focus of circular supply chains in companies has been on zero-waste management through advanced recycling processes. This constitutes the outer loop in the circular model. However, the inner loop, consisting of reuse, repair, and remanufacturing activities is where the circular economy can add most value. These activities result in the highest resource-efficiency, defined as the ratio between product uses per resource spend. Specifically, this means that one should not repair what is not broken, not remanufacture what can be repaired, and not recycle what can be remanufactured.

Circularity provides economical, societal and environmental benefits. A company's financial performance can improve substantially as a result of resource savings. Potential materials savings as a result of circularity roughly amount to between EUR 280 billion and EUR 470 billion per year for Europe alone. In addition, implementation of circular supply chains reinforces the low-energy, high labour input part of the economy. This means that demand for labour increases, resulting in more jobs and potentially higher salaries. Finally, the environmental benefits of circularity opposed to linearity are evident. Reduced material and energy consumption results in lowered emissions and lowered damages compared to those currently associated with resource extraction.

Despite the obvious advantages, implementing a circular supply chain is also associated with several challenges to both companies and consumers. Companies face substantial upfront investments to implement a circular supply chain and are dependent on their suppliers and retailers to collaborate, as all value chain partners have to be involved. In addition, circularity extends the end-of-life phase for products resulting in decreased revenues at constant customer volumes. Consumers also face challenges in adoption of circular practices. Most product designs are still based on the linear model, meaning that they are not suitable for consumer repair or enhancement. In addition, many cultures across the world associate ownership of luxury goods with societal status. Consequently, a focus on repair and reuse can create tension for consumers.

Because of these challenges, it is crucial that policy makers implement measures which promote circularity. A relatively straightforward incentive for circularity could be to shift taxation from labour to natural resource usage. In addition, policy makers could implement a new economic indicator beyond GDP that steers towards circularity. Measurement of human wellbeing could be decoupled from product and goods manufacturing and consumption, as this indicator is based on the linear model and might prove to be difficult to sustain.

2. Circular supply chains

A circular supply chain refers to a production model that is restorative by nature. In essence, this means that when produced products or goods reach their end of life, they are taken back in by a manufacturer and fully re-used as input material for new production. Materials used during production, which do not end up in the product, also need to be collected and re-used. Resources that cannot be fully salvaged, because they are consumed during production or consumption, like energy or organic material, need to be based on renewable sources. Use of harmful materials like toxic chemicals and pollutants is ideally avoided, as these can almost never be revamped into useable inputs, and are likely to leave the supply circle and end up in the environment.[1]

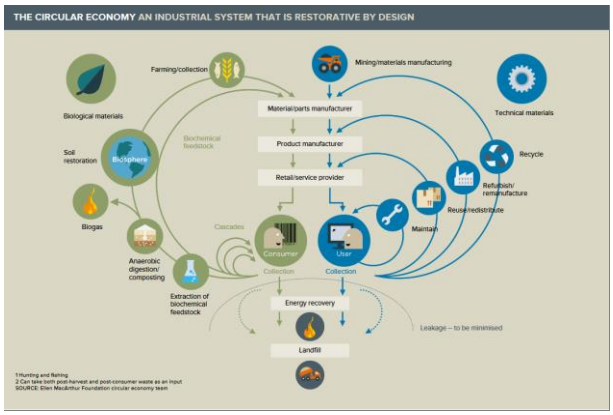
The opposite of a circular supply chain is the linear supply chain. The linear model is currently still dominant in most industries. In a truly linear 'take, make, dispose' model, natural resources are transformed into products which end up as landfill waste, through the processes of extraction, production and consumption.

The term circular supply chain fits within the broader trend of the 'circular economy'. The concept of the circular economy is grounded in the study of non-linearity, particularly observed in living systems. A major insight based on the study of living organisms or eco-systems is the notion to optimise systems rather than components. This involves careful management of material flows, which in the circular economy are distinguished as either biological or mechanical. Biological materials are designed to re-enter the biosphere safely and build natural capital (e.g. bacteria break down leftover food into compost, used for plant growth). Technical materials are designed to circulate at high quality within the circular supply chain. They are not meant to enter the biosphere.[2]

Consequently, circular supply chains draw a sharp distinction between owning a product or having access to it, and between using materials or consuming them. Circular supply chains often promote the use of a 'functional service' model in which manufacturers or retailers increasingly retain the ownership of their products and, where possible, act as service providers. In other words, they sell the use of products, not their one-way consumption or ownership. This is an opposite trend to the linear model, which turned services into products that could be sold (e.g. a shift from live-entertainment to DVDs and television sets). The functional service- or accessibility-based model makes it much easier for supply chain partners to develop an efficient and effective take-back system for products. In such a model, manufacturers are forced to use more easily recyclable materials, adopt design practices that facilitate disassembly and refurbishment of products and collaborate with all partners in the supply chain (value chain).

Up until now, the focus of the circular economy has been primarily on designing products for easier disassembly and recycling, the 'outer circle', which implies the creation of a closed loop of materials (zero-waste management). For electronics waste this for instance means the recovery of rare earth materials, something which is basically only feasible on a large scale with advanced technology or very cheap labour (Figure 1).

Figure 1: Schematic overview of the circular economy



Source: Ellen MacArthur Foundation[3]

The 'inner circle' consisting of reuse, repair, and remanufacturing has received much less attention in public discussions and from companies and policy makers. However, the inner circle is where the circular economy can add most value. Circular supply chain enthusiasts refer to an unwritten law which says that the smaller the loop, the more profitable and resource-efficient it is. Specifically, this means that one should not repair what is not broken, should not remanufacture what can be repaired, and should not recycle what can be remanufactured.[4] The company examples in this case study therefore focus on inner circle activities.

"One should not repair what is not broken, do not remanufacture what can be repaired, do not recycle what can be remanufactured" - ***Product-Life Institute Geneva***

It is argued that repairable objects are becoming unnecessary due to increased levels of recycling. Some involved in circular supply chains cast doubt on this argument, as most recycling processes result in new materials of a lower quality and with a limited range of application areas. In addition, recycling is often conducted on an international or global scale, with substantial

transportation costs (energy) and low-income labour involved. Therefore, even though recycling is preferable to landfilling, it should not become the dominant practice within a circular supply chain.

The most effective circular supply chain consists of a combination of various loops. It starts with 'small loops' like reuse, enhancement, and repair, which can be conducted by consumers themselves. Reuse activities increase the intensity with which each product is used before it reaches end-of-life. Repair and enhance activities extend a product's life-cycle. Repair simply restores a product's functionality, whereas enhancement improves a product's functionality, for instance after had has become technically obsolete. Reuse, repair, and enhancement all maximise a product's so called material cost per usage.

Companies can facilitate these loops by designing products to be easily dissembled and repaired. Design trends like modularity fit well with this purpose. An example is the modular cell phone which is currently being developed by companies like Google. If a component of the phone is broken or obsolete, the consumer does not have to dispose of the entire phone. He can simply remove the affected module (for instance the antenna) and replace this with a new component.

If a product is really at the end-of-life phase, it can be returned to the manufacturer for refurbishment or remanufacturing. The manufacturer upgrades the product using old components and materials that are still valuable. This fits with the trend of accessibility-based business models. In this model the consumer does not own the product but uses it for the time needed. After use, the product is returned to the manufacturer for reuse by other consumers or, if the product is worn down and technically obsolete, it can immediately re-enter the production process as a resource. This model stimulates companies to think carefully about product design and material usage, as they end-up with what they produce.

If a product cannot be repaired or remanufactured for some reason (e.g. the used materials are no longer safe or environmentally sound) it can be recycled. Recycling can be conducted in various ways. By upcycling the product, its quality or value is at least maintained but preferably improved. Down-cycling implies the opposite and is for instance applied by processing old car tires into rubber tiles for playgrounds. Recycling can also imply that a disposed product is completely disassembled and broken down into raw materials which can be used in manufacturing. It is easy to see that the smaller loops in the circular supply chain require less energy and natural resources than the larger ones. From an environmental perspective, it is therefore preferable that these are conducted first.

The environmental benefits of circular supply chains are evident. In addition, circular supply chains (as part of a nation-wide circular economy) increase the future resource security of companies and countries. This becomes increasingly important with rising world population numbers and scarcer natural resource supplies.

Companies and consumers can save substantial amounts of money by consuming fewer resources. This might be substantiated by heavier taxation of resource consumption.

Next to the financial opportunities, a circular economy has indirect benefits for business as well: supply chains are better managed, companies become less sensitive to price volatility of resources, and they build a longer and better relationship with their customers and other supply chain partners.[5]

3. Socio-economic relevance

The socio-economic relevance of circular supply chains is substantial, with potential cost-savings and job-creation being the most prominent benefits.

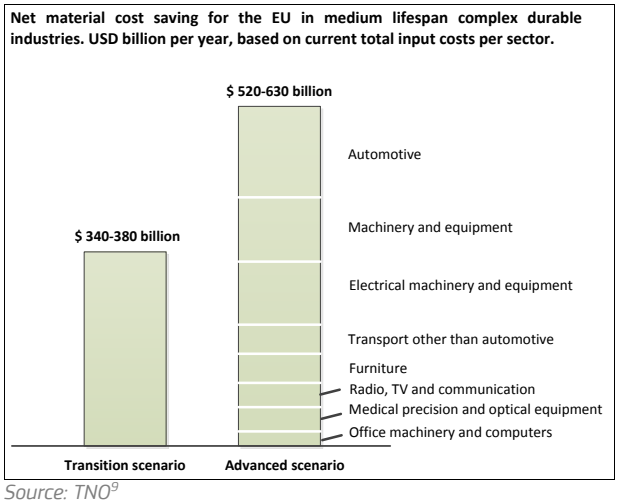
3.1. The market potential of the trend

The circular economy helps to prevent CO_2 and greenhouse gas emissions. Reuse, remarketing and service-life extension activities in circular economy preserve water, energy and corresponding emissions embodied in the existing goods. Besides the environmental gains, these water and energy savings and waste prevention can become profitable activities that positively impact corporation's financial performance.

Although the circular supply chains' primary benefit might appear to focus on environmental gains, it is also a matter of basic economics and profit maximisation. The Ellen MacArthur Foundation, in the announcement of its first report at Davos 2012 mentioned a business opportunity for the circular economy of EUR 280 billion up to EUR 470 billion per year for Europe alone.[6] This last number reflects a reduction in the current total manufacturing input costs of 19 to 23%. This concerns material cost saving opportunities within the medium-lived complex products industries. This savings potential is confirmed by the European Commission, which estimated annual net benefits of improving business efficiency in the range of EUR 245 billion to EUR 604 billion.[7]

When zooming in on the market potential of the circular economy for a specific Member State, we see numbers of similar magnitude (fitting within the mentioned range when extrapolating based GPD division between the EU as a whole and the Netherlands). The total forecasted growth potential for the expanding circular economy in the Netherlands amounts up to EUR 7.3 billion (Figure 2).[8]

Figure 2: Potential growth due to expansion of circular economy activities in the Netherlands in 2010 - EUR millions

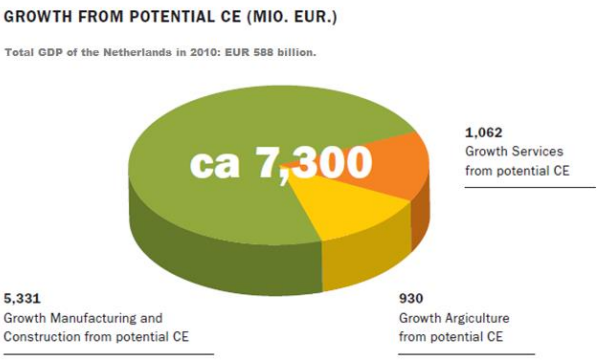


Source: TNO[9]

The benefits of the closed loop are highest when are realised locally, to mitigate transportation costs. Reuse and repair can for instance be easily realised on a local level, whereas recycling in many cases is a global business based on employing cheapest labour and sending waste to low-income countries. Moreover, the savings potential through implementation of circular supply chains is increasing drastically, particularly for resource-intensive industries, as a result of the rising resource and energy demand in emerging markets.

The cost saving potential related to circular supply chains is highest for the automotive sector, followed by machinery and equipment manufacturing (Figure 3).

Figure 3: The material savings potential in manufacturing ranges between EUR 280 billion and EUR 470 billion per year for Europe alone



Source: illustration based on World Economic Forum in collaboration with the Ellen MacArthur Foundation and McKinsey & Company[10].

Table 1: Overview of the company cases referred to in this case study

Company	Location	Business innovation	Signals of success
Sugru by FormFormForm	UK	FormFormForm developed a new material called Sugru, which allows customers to easily adapt, repair, or enhance their stuff property to make it work better. Sugru is a new self-setting rubber that can be formed by hand. It moulds like play-dough, bonds to almost anything and turns into a strong, flexible silicone rubber overnight.	Over 500,000 people in 153 countries are already using Sugru to make their stuff work better, representing total revenues of over EUR 1.2 million at the end of 2012. The inventor of Sugru, Jane Ni Dhulchaointigh acquired several prizes, including: FormFormForm was ranked number 22 on TIME Magazine's top 50 inventions in 2010; Jane received a £35.000 award from Nesta; finalist in the Ernst & Young Entrepreneur of the year; the 2010 Brit Insurance Designs of the Year award; and the Design Entrepreneur medal by London Design Festival.
StayGreenOil	USA	StayGreenOil hosts an online marketplace where users can list their used lubricants and cooking oil to sell to buyers instantly, without approvals or paperwork.	StayGreen Oil applied for and was accepted into the Abbeton Accelerator Fund, a Sarasota-based business investment pool.
Dutch aWEARness	NL	Dutch aWEARness is a young and innovative textile company guided by the principles of sustainable entrepreneurship. It has developed environmentally friendly polyester for clothing manufacturing and offers its clothing accessibility based.	Dutch aWEARness is part of the EcoProFabrics programme, which is a two-year pilot project within the European Commission's Eco Innovation programme. The European Commission has invested nearly EUR 2 million in the project, which is initially targeting the Netherlands, Belgium, France, Portugal, Germany and the UK. Mr Otto is working with a variety of other partners to introduce the scheme to at least nine new companies. To date, almost 20 Dutch companies have already expressed their interest, including a Dutch refrigerator company that wants aWEARness to supply its 4,000 staff with factory wear for five years. In fact, this company has been so inspired by what aWEARness is doing, that also want to apply circular thinking in their own supply chain.
The Restart Project	UK	The Restart Project is a London-based social enterprise that encourages and empowers people to use their electronics longer, by lteaching fundamental repair and maintenance skills. Through community and workplace events, it creates engaging opportunities for people to increase the lifespan of electronics and electrical equipment.	The Restart Project has received recognition from the Transition Network, Unltd and Lloyds Bank Social Entrepreneurs Programme. The social enterprise has currently run over 56 repair events and has inspired people in over 5 countries to come up with similar initiatives (USA, Italy, Tunisia, Canada etc.). Restart's business model projections show that in the near future, the social enterprise can become self-sustaining. A well-known social entrepreneur, the founder and former owner of the Body Shop, has provided Restart with funding for the first six months of its operation.
CIMV	FR	CIMV developed a revolutionary bio-refinery concept, which enables the recycling of vegetal plant wastes into renewable lignocellulosic plant resources including a phenolic polymer, cellulose and glucose, and sugar syrup.	In 2010, CIMV received the Pierre Potier Prize 2010 for innovation in Chemistry, for its vegetal refining process. The prize was awarded by the Fédération Française des Sciences pour la Chimie (FFC) in partnership with Union des Industries Chimiques (UIC). The awarding committee aims to promote Sustainable Development. CIMV is currently working closely with Technip on the engineering of its first lignocellulosic biorefinery plant. This industrial unit will be built close to biomass resources and will be operated in close collaboration with local feedstocks suppliers.

3.2. Companies active within the inner loop of the circular supply chain

Problem 1 – While studying for a master in Product Design, Sugru's inventor Jane Ni Dhulchaointigh came up with a design challenge for a very practically problem. She wanted to develop a solution for "hacking" the stuff she already owned to repair it or make it work better. She simply did not want to buy new products all the time.[11]

Innovative solution 1 – Jane started experimenting with all sorts of materials at the beginning of 2003. The first version of Sugru was a mixture of silicone caulk and waste wood dust from the wood workshop. This version did indeed provide some product enhancing capabilities, but it was still not very useable, for instance due to the horrible smell. She fine-tuned the prototype material with pigments and finer powders to give it a better look and feel and presented it during her study's final exhibition. Most spectators were very interested in the material and were interested in buying a sample. This is when Jane realised she had to turn her idea into an actual product. At the end of 2004, Jane gathered a team of specialists to help her to bring the material to the market. The team included two retired silicon scientists, a patent lawyer and a business partner. With a EUR 44,000 grant from Nesta, the company FormFormForm was founded. Initial tests at a contract lab proved costly and Sugru's inventor decided to set up her own small-scale laboratory with the help of the two silicon specialists. After two years of test work, a successful chemical formulation was developed, with which the company applied for patents.

"I don't want to buy new stuff all the time. I want to hack the stuff I already have so it works better for me" - ***Sugru***

The final version of Sugru is a new self-setting rubber that can be formed by hand. It moulds like play-dough, bonds to almost anything, and through air exposure turns into a strong, flexible silicone rubber overnight. Sugru's patented technology is unique in its combination of hand-formability, self-adhesion, and flexibility when cured. Once cured, its durable properties mean it is comfortable in extreme environments, from the dishwasher or oven to the ocean in Antarctica.

As it cures, Sugru becomes flexible rather than rigid, meaning that it can potentially be used to repair things like textiles, shoes, or cables that need to move, as well as for more static objects.[12]

Examples of how FormFormForm's customers have used Sugru to repair or enhance their things

Source: Sugru[13]

Problem 2 – Oil is a precious commodity across the globe, but despite this there is still a significant proportion of this valuable resource that goes to waste in industrial processes. Oil products like lubricants and cooking oil can easily be reused in biofuels.

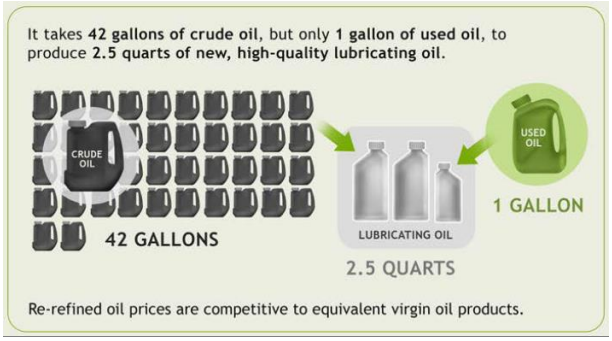
Innovative solution 2 – The founders of the StayGreen Oil, Brian Davis and Michael Griffiths, were both working in the fuel industry and were constantly being asked by companies where they could source reasonably priced used oils. As a result of this clear demand the couple decided to develop a platform that connects people in need of used oils with people who want to sell their used oil.

"We were constantly being approached by used oil collectors asking for access to our client base. At the same time we were being asked by our customers if we could assist them in getting a better price for their used lubricants." - ***StayGreen Oil***

StayGreen Oil is an online marketplace through which businesses, which regularly use oil and produce oil waste products, are encouraged to sign up as members and trade their unwanted leftovers with other platform members, reuse companies, which are seeking oil waste products. The platform facilitates the transaction between the vendor and buyer by offering them a one-stop-shop for reporting, contracts, and communications.

These reuse companies can transform used motor oil into lubricants and fuel and cooking oil into soap, animal feed and cosmetics. Effectively, StayGreen Oil's platform is helping to close the reuse loop for oil products.[14]

The illustration highlights that it is much more efficient to produce lubricating oil from used oil, than from crude oil



Source: StayGreen Oil[15]

Problem 3 – The global textile and apparel industry is one of the most resource-intensive industries on the planet. It relies on complex, linear-model supplier relationships. The lack of transparency across the value chain can result in massive toxic pollution, unethical labour practices and increases waste production. The rise of 'fast fashion' and heavy season-dependency means that products in this industry are quickly reaching their end of life. For instance, in the USA, the majority of this type of textile waste ends up in landfills.

Innovative solution 3 – Dutch aWEARness' founder Rien Otto has worked in the fashion industry for nearly two decades. He is therefore well aware of the environmental and social challenges associated with production. In order to tackle these challenges, he embraced fair trade, organic cotton, and life cycle analysis, and began researching alternative materials. In 2010, he met cradle-to-cradle pioneer Michael Braungart and, inspired by their discussion, set about investigating how the cradle-to-cradle (C2C) concept could be applied to the textile supply chain. Rien Otto was aware of an Austrian company called Backhausen, which was using recyclable polyester to make C2C-certified furniture. Based on this application, he developed a method to use the same material for clothing manufacturing.

Dutch aWEARness creates clothes from 100 percent recyclable polyester, called Returnity. The company does not sell the individual clothes to its customers, but sells the performance of the clothes like a service. Dutch aWEARness maintains ownership of the clothes and once the product reaches end-of-life they are returned by the customer and remanufactured into new clothing without loss of quality. In addition, the company's manufacturing process uses 95% less water, 64% less energy and produces 73% fewer carbon emissions per garment compared to conventional cotton.[16]

Dutch aWEARness' supply chain for its recyclable polyester called Returnity. After the garments have been worn out, they are collected, shredded into fibres, which are turned into new yarns, which are woven into new fabric. The process can be repeated without quality loss

Source: Dutch aWEARness[17]

Problem 4 – The founders of Restart Project were annoyed by how many useful products and particularly electronic items were being thrown away on an annual basis. This linear waste model is fuelled by the increasing complexity of electronic equipment and its design, which does not allow for consumer repair or replacement of broken parts.

Innovative solution 4 – Janet Gunter and Ugo Vallauri, the founders of Restart Project, both have a background in international development, and have worked in developing countries where they experienced vibrant local repair economies. They wanted to bring these repair economies to the UK, by organising their own repair events in London.

The Restart Project is a London-based social enterprise that encourages and empowers people to use their electronics longer, by learning fundamental repair and maintenance skills. In London, each month it hosts two "Restart Parties" – free community repair events –during which people can get free repair help from the Restart community of repairers. Restart also offers similar workplace events for companies, schools, business parks, and city councils. It aims to bring the spirit of repair, resilience, team troubleshooting, and fun, to workplaces and educational environments. These paid services are innovative, represent value for money, and support the organisation of free community events.

To build its repair community, Restart began with rallying grassroots groups within the founders' own network. These people were already interested in some aspect of sustainability. What Restart did was to make them aware that their considerations towards for instance biological

products are more or less similar to their need for reduction of electronics waste.

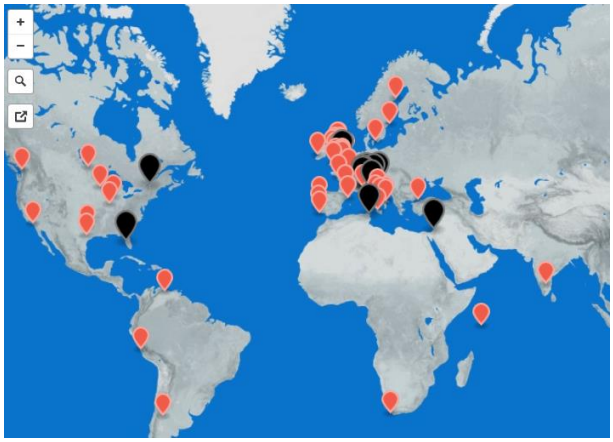
Restart started working in specific communities of early adopters for this initiative. There is a substantial group of consumers who are frustrated with the lack of manufacturer support for many products and devices. This was not limited to just printers, computers and smartphones. There was a lot of interest in other electronics products, including hair dryers, electrical razors, and earphones.

Restart started promoting its services to the commercial sector as well, by contacting Corporate Social Responsibility (CSR) departments and Human Resources (HR) departments, as well as colleague engagement programmes. As a result of this, The Restart Project also gained a lot of press interest from for instance the BBC and Daily Telegraph.

There was a breakthrough when a journalist from the BBC visited a repair event, where an assembler managed to repair an iPad screen in 8 hours of work. The journalist wrote an article about this bizarre amount of time needed to replace the screen. The article was read by 2 million people.

According to Restart, community repair is the first level of communication in bringing consumers back in connection with their possessions. Restart wants to create a future of repair and wants to help shape future design to become more repairable. It contributes to shaping a circular economy, in a sense that it does not want stimulate recycling, but rather encourage consumers to repair or enhance their owned products once they are at the end-of-life stage. According to Restart's founders, repair and enhancement are the best ways of creating the value out of an energy and material investment in a product.

Map displaying repair initiatives around the world that have been inspired by the Restart Project. Black dots indicate hosted events, red dots people that have shown interest in organising a repair event



Source: The Restart Project[18]

Problem 5 – The natural reserves of our conventional energy sources like oil and gas are rapidly reducing. Society therefore has to look at alternative sources of energy, preferably renewable sources.

One of those sources could be the production of energy from biomass waste, for instance from agricultural production. This sector produces nearly 4 to 5 billion tons of vegetal plant waste (straws, leaves and stalks of crops, sugar cane pulp residue, etc.) on an annual basis, as a result of food production. This waste represents a renewable source of energy - neutral in terms of carbon emissions - but most of it is currently barely or poorly recycled and promoted.

Innovative solution 5 – As a pioneer in its sector, the technology developed by CIMV represents a major industrial breakthrough. It is currently the only technology in the world that can separate the three components of plant biomass (the non-food part of the plant), being lignin (part of plant cell wall), cellulose (plant sugar) and hemicelluloses (plant carbohydrates), without the use of environmentally unfriendly chemicals. These intermediate products can be used by the chemical and biofuel industries: cellulose pulp can be used for biofuel, paper and bio plastics; (bio) lignin can be processed into glues, adhesives and carbon fibres; and sugar syrup can act as a resource for animal feed additives or biofuels.

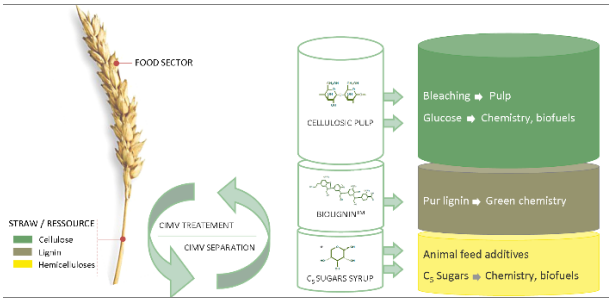
It took the company ten years of laboratory work and the construction of a pilot plant to optimise this process. As part of this process, sixty series of test runs were conducted, to test production capacity for industrial purposes and to optimise construction parameters of the industrial production facility.

The industrial pilot plant was built in 2006, in the region of Pomacle (France). This was the final step prior to successful industrialization of the technology. During the lengthy period of testing and experimenting, CIMV has acquired several international patents protecting its technology.

The truly novel aspect of the CIMV technology is that it extracts and promotes a non-deteriorated lignin, (biopolymer similar to a phenolic polymer), discovery of which can be considered a substantial scientific advancement.

Currently, CIMV is positioned as a credible alternative to oil, because it enables the production of biomass-based energy and intermediate products for the chemical and biofuel industries, with an equivalent quality to oil.[19]

CIMV's biorefinery process separates the three principal components of dry plant biomass into three useful intermediary products for the biotechnology and chemistry sector



CIMV Website[20]

3.3. The creation of new markets and jobs

Circular supply chains, and particularly the inner or smaller loops of repair and remanufacturing, reinforce (local) job creation at all levels. The CEOs interviewed for this case study report that, on average, 75% of the energy required to generate a product is required for raw materials production, whereas only 25% is used for actual manufacturing. Meanwhile, they argue that the reverse is true for labour requirements, where 25% is needed for raw materials production and 75% for manufacturing. Remanufacturing or repairing products in a circular supply chain, much like labour intensive manufacturing, reinforce the low-energy, high labour input part of the economy. Subsequently, remanufacturing and repair are often even more labour-intensive than manufacturing from raw materials. Compared to the linear model in which raw materials are produced and processed in manufacturing, circular supply chain practices constitute a shift from energy to manpower. This is supported by labour market numbers on circular economy activities in specific Member States. It is estimated for instance that the expansion of the circular supply economy in the Netherlands is associated with the creation of 54,000 jobs.[21] When extrapolating this number to the whole EU based on the GDP comparison between the Netherlands and EU (roughly EUR 600 billion versus EUR 13,000 billion) we end up with a job potential of well over 1 million.

More specifically, a key benefit of for instance the repair loop is that it is particularly labour intensive (Figure 4: Job creation as a result of various electronics (waste) processing activities). The less labour intensive recycling sector is still responsible for substantial job creation. In the EU, the recycling sector alone is responsible for creating 500,000 jobs.[22] Figure 4 Job creation as a result of various electronics (waste) processing activities) below illustrates the job potential of repairing electronics (inner loop activity) compared to landfilling and recycling them. It shows that repairing or enhancing broken/obsolete equipment generates more jobs than landfilling or recycling those items.

Figure 4: Job creation as a result of various electronics (waste) processing activities

Source: IFIXIT[23]

Another benefit of inner loop activities is that few businesses continue to grow in a down economy, but repair and remanufacturing do. This means that these jobs are created anti-cyclical to conventional ones.

For instance, in the USA, thousands of locally owned and operated smartphone repair shops have popped up in the last several years. The electronics and computer repair industry in the United States generates income for some 60,000 small businesses that employ approximately 175,000 people, for a total of EUR 15.7 billion in annual revenue.[24]

3.4. Customer perspectives and challenges related to the uptake of the trend

There are several challenges for the uptake of circularity amongst consumers. As a consequence of product design based on the linear 'take, make, dispose' model, consumers are confronted with unrepairable or not (easily) recyclable products. Many products are not designed to be disassembled and repaired by consumers. This is for instance the case for most electronic equipment, which is often glued together. Repair of such goods is often more expensive than buying a new version. Consumers owning such products are forced to dispose their malfunctioning products.

Another key barrier to uptake of the circular supply chain trend amongst consumers has to do with the status that is derived from owning certain products. Particularly the small loops of circularity, reuse, and repair are affected by this. In many cultures around the world, public interpretation of a person's success is derived from the goods he or she owns. It might not be so appealing to a hardworking self-made man to reuse and repair his property to the end of days. Such an individual might want to show that he or she is successful by owning the latest gadgets and luxury goods. Widespread acceptance of circularity might therefore take substantial time.

4. Drivers and obstacles

A shift towards circular supply chains and a circular economy can be argued to be inevitable if one considers the rising population numbers in developing countries, combined with the expected depletion of natural resource reserves. According to such reasoning, a shift towards circularity therefore appears to follow logically. However, linearity is strongly ingrained in our economic, societal, and political DNA. Combined with the major upfront investments required for implementing a circular supply chain, this creates significant obstacles for circular supply chain pioneers to overcome.

4.1. Major upfront investments needed and limited access to funding

The shift from the linear production model to a circular one will take many years. Major investments are needed from a company's perspective, without knowing whether the expected returns will be realised in time. To successfully establish a circular supply chain, companies need to constantly monitor and optimise their product's lifecycle, in order to maintain value and performance of resources within the loop. As the product loop has no beginning and no end, it requires constant attention from all parties in the value chain, including customers. It takes substantial time and money to get all parties aligned and committed.

This is where companies that want to shift to a circular supply chain face difficulty. Financiers, including banks, are positive concerning the circular economy, yet the uncertainty regarding the financial return on circular business models and the risks associated with operating such models, has banks apparently maintain a safe distance from them. When the companies within a certain supply chain are depending on different funding entities for their financial resources, the situation becomes even more challenging.

Currently, funding is often limited to several pilot projects, which banks use to gain experience with circularity. If the number of loans for circular business models increases, banks might be able to combine loans and offer them to institutional investors. However, due to the lack of international standards and definitions for circularity, it is hard for these investors to compare and invest in circular business models.[25]

4.2. Legal uncertainty associated with possible collusion

In the circular economy, competition is no long driven by individual companies but by complete supply chains. Herein lays the challenge that all parties in the supply chain have to be willing to collaborate. If there are forms of competition within the supply chain, for instance due to vertical integration threats by a much stronger manufacturer (downstream or upstream), collaboration amongst smaller suppliers or retailers might be hampered.

In addition, high levels of collaboration between supply chain partners might be considered as collusion in the eyes of authorities. Currently, EU legislators are tolerating increased levels of cooperation, to monitor the possible outcomes of circular supply chains, but there is a possible legal risk for the involved companies.[26]

4.3. Dropping revenues on the short-term

Apart from this, designing products to be easily repaired or reused means that consumers can use the same product for a much longer period of time. This may not benefit a company's short-term sales performance, and considering that many shareholders are interested in short-term gains, it may be expected that supporting repair or reuse initiatives is not a primary driver within most companies.

*"Considering that many shareholders are interested in short-term gains, this is not a very interesting option for managers of for instance publically owned companies". - **The Restart Project***

This is a hurdle that for instance the Restart Project is also facing. The social enterprise is currently aiming to organise events for electronics manufacturers, to help their employees to understand what circularity is about. However, there have been no major breakthroughs yet, and companies are not used to discuss this topic. CEOs interviewed for this case study report that company spokespersons do not always have a fitting response to concepts and topics such as eco-design and repairable products. Restart is therefore primarily targeting consumers and encouraging them to demand manufacturers to make their products more repairable. Restart did already manage to partner with companies that make spare parts and components for repair hobbyists.

Dropping revenues on the short-term can also result in financial obstacles. Companies that provide access to their products rather than selling them, such as Dutch aWEARness, are likely to receive their revenues spread out over a longer period of time. However, because the vendor first has to fabricate or procure its products prior to selling them to customers, this results in an increased demand for working capital. Acquiring this funding at a financier might

prove difficult, as future revenue streams are subject to the risk of customers who are not able to make their payments (opposed to upfront payments by customers in the linear model). In addition, this forces companies to critically assess the creditworthiness of their customers. [27]

4.4. The rising population number and dropping natural resource reserves

During the last century, industrial and technological development in combination with global trade has resulted in an enormous economic growth, which has driven human welfare. In developed countries, living standards are already extremely high and associated with high levels of consumption. Developing countries, such China, Brazil, India, and Indonesia, are quickly catching up and the consumption levels of their populations are increasing rapidly. Three billion middle-class consumers are expected to enter the market by 2030. This trajectory will result in exponentially increasing demand for resource. By 2050, global resource use is expected to have tripled, while exploration and extraction costs are constantly rising.[28]

Apart from the environmental perspective, reduced resource consumption also poses financial drivers for companies to implement a circular supply chain. A company like Dutch aWEARness saves procurement costs by reusing their old products as input material. Without making concessions to product quality and customer satisfaction, the company is able to improve its financial performance.

4.5. Societal developments are driving the spread of circular supply chains

There are several societal developments which are driving the adoption of circular supply chains.

From a socio-demographical point of view, increasing urbanisation is reducing the logistical costs associated with operating a circular supply chain. If most parties within a supply chain are located in close proximity of each other, e.g. in a city, it becomes easier to control, monitor, and operate a circular supply chain. Proximity reduces the transaction costs for reuse, repair, and recycling oriented companies, as taking in products from consumers is less expensive. For example, in a dense urban area it is much easier for companies like the Restart Project to organise community repair events than it would be in a rural area, since more people with repairing skills would live in close proximity to people in need of these skills.

Apart from socio-demographics, changing consumer attitude is also driving adoption of circular supply chains. Particularly younger consumers in western societies are more open to accessibility-based business models, illustrated by the rise of the 'sharing economy' success stories like Airbnb. This group of consumers values 'access over ownership'. This coincides with circular supply chain activities like reuse, remanufacturing and recycling. If a company can maintain ownership over a product it becomes much easier to monitor and steer the material flow within its supply chain. Combined with information and processing technologies, it enables them to orchestrate circularity.

4.6. Linear technologies are still deeply rooted in our economy

Although it might be evident that society needs to change its linear model, change may not come so easily. Because linearity is so deeply rooted in our economy, many technological and institutional aspects are still tailored to this dominant model.

From a technological perspective, there has been limited attention for the end-of-life phase in current product designs. This means that not all products can easily be recycled. It also means that most products are not suitable for repair or enhancement, simply because a products is assembled using glue, or because spare parts are not offered for sale. Other technological obstacles include the limited availability and quality of recycled material for manufacturing, the challenge for companies of separating the bio cycle from the techno cycle, and the limited capacity of reverse logistics, i.e. consumers returning a product to a vendor, which limits exchange of materials. These aspects are major obstacles for companies focused on repair, remanufacturing, and recycling of products.

From an institutional point of view, current legislation in most countries is oriented towards facilitation of linear business practices. Because, a product's total financial and long term environmental cost do not have to be reflected in its sales price, it is generally considered cheaper to manufacture products using a linear production model. Moreover, circularity is not yet effectively integrated in innovation policies. It needs adjustment in order to stimulate circular research, development, and innovation. Innovation policy may unintentionally protect the position of established companies by providing incentives for incremental innovation within the existing linear model, while leaving little room for disruptive innovation that might constitute a shift towards circularity. Finally, anti-collusion and competition law may prevent the intensive collaboration needed between value chain partners, in order for circularity to be established.

4.7. Lack of sufficient differentiation between recycling and reuse at an institutional level

An obstacle for companies active in the reuse, repair, and remanufacturing sectors of the circular economy is the lack of sufficient differentiation between recycling and these so called inner loop activities at an institutional level. This directly concerns policy makers at the European level. There is a strong European focus on recycling and not so much on policies that stimulate the adoption of repair and reuse activities.

Policy makers invest significant financial sums as well as effort in incineration and recycling, but do not appear to invest in reuse and repair initiatives. An initiative like the Restart project is completely subject to the pressures of the open market, whereas recycling has always been able to attract policy support. More policy attention for reuse and repair could be desirable, considering the earlier mentioned benefits of inner loop activities above outer loop activities.

"Equal billing for reuse and repair initiatives , compaired to recycling would be desirable" - ***The Restart Project***

5. Policy recommendations

Policy recommendations towards circular supply chains focus on macro level measures like a change in economic indicators, a shift towards integrated reporting by companies, and taxation breaks for labour, which enable circularity to prevail over linearity. However, policy makers should not blindly embrace all circular economy aspects, as some activities are more desirable than others.

5.1. Create a tax shift from labour towards natural resource usage

For sustainable politics to be effective one needs simple and convincing solutions. A clear example of this could be sustainable taxation. Sustainable taxation implies that governments should not tax what is desirable or sustainable.

As mentioned afore, circular supply chain activities contribute to the low-energy, high labour input part of the economy. It is therefore argued that lower taxes on labour compared to resource and energy consumption will stimulate companies to move towards more circular supply chains. This will boost job creation, employment, and occupation in all forms and in all labour intensive sectors. It also increases the competitiveness of labour intensive economic sectors of the circular economy, compared to conventional manufacturing sectors.[29]

Other supportive taxation measures could be implemented through VAT breaks. Less VAT could be charged on reuse and repair activities. For these parts of the circular supply chain to flourish, other ways need to be found to reduce the costs of repair activities and spare parts.

In addition, companies are not compelled to make information available to product owners on how to repair products and how to find spare parts. This could be stimulated by policy makers by providing tax breaks to companies that do.

5.2. Give repair and reuse priority in the waste hierarchy

Reuse and repair businesses like the Restart Project or FormFormForm are not the most commercially attractive initiatives. Therefore they face more serious scaling up challenges than for example internet start-ups. They do not simply flourish in isolation, without any public funding or fundraising.

Policy makers could step in by giving repair and reuse activities a higher priority in the waste hierarchy, and by providing consumers and companies with incentives to first try to repair, reuse or remanufacture products, before they are disposed.

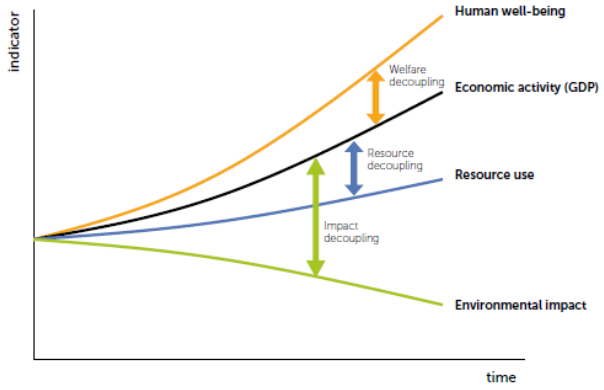
The United Kingdom for instance is currently focusing entirely on diverting waste electronic and electrical equipment (WEEE) from landfill and getting consumers to recycle end-of-life products. Local authorities are allocating community space to recycling centres, but reuse initiatives hardly get any attention.

Community repair workshops and the collection of spare parts require space to flourish. Forward-thinking policy makers could provide repair and reuse initiatives with a physical presence in recycling centres, to allow them to divert functioning or economically repairable products from waste. In addition, municipal collection points for disposal of for instance electronics waste should display information on local opportunities for electronics reuse. This could trigger consumers to first think of reuse or repair before disposal.[30]

5.3. Implement a new economic indicator beyond GDP that steers towards circularity

Policy makers should re-evaluate what is meant by economic success. In other words, they should think about a reorientation from production of goods defined in terms of GDP, towards other measures of well-being. Reduced production of goods and consequently GDP is currently associated with dropping welfare. Figure 5 below describes this phenomenon referred to as 'welfare decoupling'.

Figure 5: Graph illustrating the types of decoupling: human well-being and economic activity decoupled from resource usage and environmental impact



Source: IMSA Amsterdam for Circle Economy[31]

The above graph illustrates the different types of decoupling. In this example, human well-being grows faster than economic activity measured in terms of GDP with relatively fewer resources used, which might be the case in a circular economy. The environmental impact of economic activities is absolutely decoupled. Human well-being and economic activity are increasing while environmental impact is dropping. The trajectories of the four indicators are not based on any actual numbers, but are only meant for illustrative purposes.[32]

5.4. Have companies report True Value and enable further collaboration

Another administrative measure policy makers could implement could be a shift towards integrated reporting. By replacing traditional financial reporting with mandatory and accountable integrated reporting, corporate culture could move towards the concept of True Value. Integrated reporting is a method to disclose a company's true value and shows the practical outcome of an organisation's integrated thinking. This way, companies are forced to not only publish their financial performance but also their impact on the environment and human well-being.

Mainstream companies which do not differentiate on sustainability will need incentives or penalties to shift towards a circular mind-set.

Finally, to create a truly circular supply chain, companies across the value chain have to work together closely. In some cases, enabling this might require adjustments in anti-trust and collusion legislation.

6. Appendix

6.1. Contacts

Company	Interviewee	Position
FormFormForm	Jane Ni Dhulchaointigh	Founder and CEO
StayGreen Oil	Brian Davis	Co-founder and CEO
The Restart Project	Janet Gunter & Ugo Vallauri	Founder and CEO
Dutch aWEARness	Rien Otto	Founder and CEO
CIMV	Michel Delmas	Founder

6.2. Websites

Sugru by FormFormForm	http://sugru.com/
StayGreen Oil	http://www.staygreenoil.com/
The Restart Project	http://therestartproject.org/
Dutch aWEARness	http://dutchawearness.com/
CIMV	http://www.cimv.fr/

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