European Commission

Business Innovation Observatory

Clean Technologies

Closed-loop waste management

Case study 29

Enterprise and Industry

Clean Technologies

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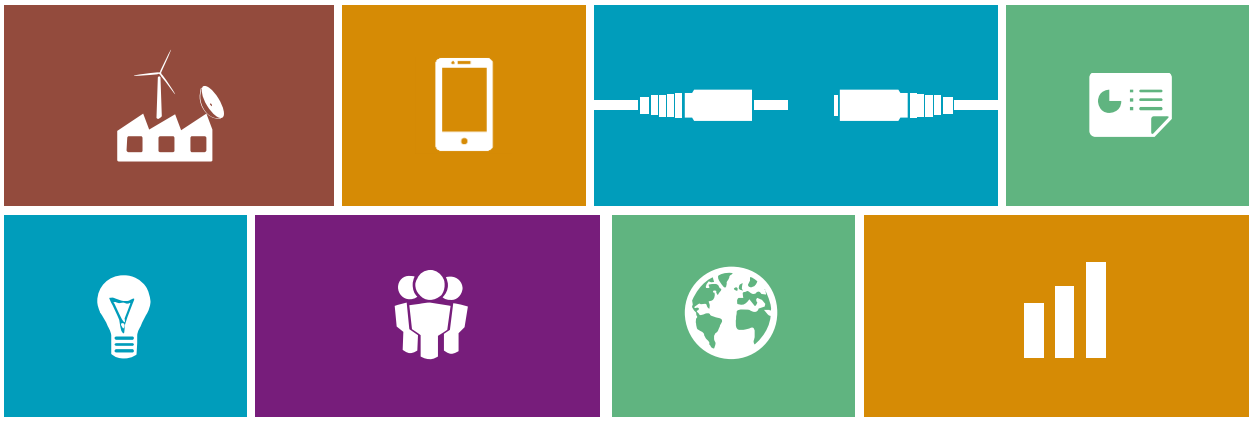


1. Executive summary

For years, the economy was based on a linear model, where growth was dependent on resources. This model needs cheap resources in large quantity. Currently, more resources are used than our planet can produce. Hence, two forces drive the emergence of a business innovation: the rise of the middle-class consumers, and the realisation that resources are in finite supply. This alternative, called "closed-loop model" or "circular economy", allows the infinite reuse of resources. Hence, "waste" could be replaced by "resource", and this trend called "closed-loop resource management". It proves that economic growth and preservation of the environment are two compatible challenges.

In 2010, 3 billion tonnes of waste were generated in the EU. Each of Europe's 500 million citizens is responsible for about 6 tonnes of waste per year. The waste stream for the EU28 countries in the same year was divided between construction (34%), mining and quarrying (27%), manufacturing (11%), households (9%), energy supply (3%) and other sources (16%)[1]. In 2013, the average of EU waste recycled reached around 40%, while the remainder ended up in landfills. Landfills have a high negative impact on the environment. Not only do they pollute the air, soil and water, but they also discharge carbon dioxide and methane, which are responsible for the greenhouse effect.

Pollution and greenhouse gas emissions discharged by landfills play a role in the current climate change. By increasing the amount of waste recycled, closed-loop waste management (CLWM) could limit the impact of the landfills on the environment. The principle of "use-recovery-reuse" also decreases the needs for raw materials. Thus, it represents another benefit offered by the CLWM. It lowers the dependency of companies and even countries on the suppliers of raw materials. Currently, more than 3 tonnes of materials per capita is imported to the EU each year[2].

Several main drivers explain the rise of closed-loop waste management. Firstly, directives introduced by the EU play a decisive role. The introduction of recycling targets has pulled the demand for CLWM solutions and the creation of new markets. Secondly, collaborations and networks facilitated by the EU have also had a positive impact. By fully integrating all three sides of the 'knowledge triangle' (higher education, research and business), innovation and knowledge exchange has been enhanced. More specifically, the role of the Knowledge and Innovation Communities (KIC) as opportunity enablers has been welcomed by companies.

However, some major barriers are still difficult to overcome. Finding suitable workers with the right skillset has proved to be tough for SMEs in the CLWM industry. A good mix between engineering and management is needed to work in these start-ups. Such a skillset is quite rare to find on the labour market and hard to attract in a financially strained SME. EU directives, which are identified as a driver, can also bring administrative headaches, especially for logistics and taxation. CLWM companies are located in a grey legislative area, where waste is transformed into resources. Finally, improvements are required for EU funding schemes, where timelines leading to the release of capital can be rather long.

The EU can foster the emergence of the CLWM in multiple ways. The first step is to grasp the potential of the paradigm shift caused by the closed-loop model. Its scope requires pan-European collaboration led by business, with policy-makers and end-users. New models of measurements are needed to better assess the performance and effect of a company's activities. The whole impact of the value chain has to be taken into consideration, even the after-sale impact. Products that can be recycled and reused have to be considered more favourably compared to products that constantly drain resources. Finally, regulations need to be adapted to take into account the specific case of the CLWM companies.

2. Closed-loop waste management

Closed-loop waste management refers to the process by which waste from one product is used to make another product. The rise of this business innovation has been facilitated by clean tech, which has triggered a shift from a linear production model ("Take, Make, Dispose") to a closed-loop model ("Cradle to Cradle"). This case study lies at the intersect of the linear and closed-loop models, as it seeks to explore how companies are creating products and value by recycling disposed waste.

The circular economy would not be possible without clean technology. Clean technology, otherwise known as "clean tech", represents innovative products and services that: are superior in terms of their performance; reduce negative ecological impacts; and contribute to the more productive and responsible use of resources. In this case study, clean-tech is the enabler of the closed-loop model by transforming waste in something valuable.

The clean technologies applied in the closed-loop waste management use extremely different techniques. As closed-loop seeks to eliminate waste, the techniques must adapt to the type of waste. Dealing with metal is not the same as dealing with coffee. However, whatever the sector that they are used in, all these clean technologies share the same objective of leveraging on waste while not harming the environment. The products and services showcased as examples in this case study come from diverse sectors: the textile, the tyre, the new material and even the food industries.

These technologies are sparking a transition from the linear model of production and consumption that has shaped the global economy for the past 150 years or so. In the traditional model, the product life cycle has been characterised by manufactured goods being created, used and disposed of as waste. In the long term, it is unlikely that this "cradle to grave" approach for products will be sustainable, as resources become increasingly constrained and threaten today's linear model economy.

The differences between the linear model and the closed-loop model are based on two main principles. Firstly, the closed-loop aims to leverage on waste, as waste is considered as a resource. By default, products are designed and adjusted to ensure a continuous cycle, after their consumption and stock. Instead of relying on domestic extraction and imports, the model creates new materials from waste. Secondly, the consumables used in the closed-loop model have to be at least non-toxic, or have a positive influence on the biosphere. Eliminating the emissions, landfilling and incineration makes this model sustainable (Figure 1).

Figure 1: Closed-loop model of resources

Source: European Environment Agency[3]

The will to decouple growth from resource constraints has led to the emergence of innovative waste management activities, which have contributed to the EU's share of municipal waste that has been recycled or composted rising from 18% in 1995 to 42% in 2012[4]. Similarly, innovative waste management activities are providing market players with the opportunity to capitalise on EUR 750 billion of material savings[5].

Major companies are already integrating closed-loop waste management within their business models. For example, the Danish company Maersk Line - the largest container shipping company in the world[6] - has adopted a Cradle to Cradle passport for its new boats. The aim is to better trace the materials it uses and to reuse the same materials for new vessels[7].

Many SMEs are also active in closed-loop waste management, providing innovative solutions to different clients. The private sector remains their major target market, more specifically multinational companies. For example, Worn Again is working with major textile industry partners, while Cycle4Green is offering its recycling solution to all consumer packaged goods companies, large brand-owners as well as local national manufacturers.

3. Socio-Economic Relevance

3.1. The market potential of the trend

Overall market potential of the trend

In the EU, 3 billion tonnes of waste are produced every year. With 500 million citizens, it amounts to 6 tonnes for every man, woman and child[8]. The EU average for waste recycling is reaching 40% with some countries above the 50% (Austria, Germany, Belgium, Netherlands) and other below 5% (Bulgaria, Romania, Croatia). The rest of the waste ends up in landfills[9].

Landfills have a negative impact on the environment and contribute directly to climate change. They pollute the soil, water and aquifers, and also generate methane. Methane, a greenhouse gas, is more harmful to the environment than other gases such as carbon dioxide. A waste management system, which includes a closed-loop model, could thus drastically limit this impact.

In addition, recycling also lowers the depletion of natural resources and increases energy efficiency. Thus, the role played by recycling is vital in the shift towards sustainability. Currently, the turnover of the recycling industry is estimated at EUR 24 billion. With around 50% of world share of the waste and recycling industries, the EU is dominating the market and could reinforce its leadership with the uptake of the CLWM.

Market potential for each sub-sector

The showcased companies are active in various unrelated industries: food, textile, electronics (mobile phones and TV), packaging (release liners and carton packages for drinks). By looking at each specific sector, it becomes possible to define more clearly the size of the untapped market.

Pectcof's raw material is the pulp of coffee, which is the second most traded commodity in the world, with over 400 billion cups consumed each year. Around 40 coffee beans are required for a cup. World consumption of coffee has proven to increase steadily in the last decade, up to 138.5 million bags of coffee in 2010/11. If the same growth continues, the world market is expected to reach over 160 million bags by 2020[10]. At the moment, there is no solution for the coffee waste, which is leaching toxic compounds into rivers, lakes and the soil. Pectcof is the first company to enter this ever-growing untapped market.

Worn Again is active on the textile market, focusing on polyester. 27 million tonnes of polyester are estimated to be made for use in textiles from virgin resources every year worldwide. The total market worldwide was approaching EUR 80 billion by 2010 for new resources. Worn Again has the ambition to replace most of the new polyester with existing one. Textile recycling technologies make it possible to tap into this large market for new polyester.

SecondLifElectronics and Votechnik are focusing on mobile phones and LCD screens, which are both part of Waste Electrical and Electronic Equipment (WEEE). WEEE is currently believed to be one of the fastest growing waste streams in the EU, increasing at 3-5 % per year. By 2020, it is estimated that the volume of WEEE will increase to 12 million tons. For SecondLifElectronics, the market is reaching 100 million phones in Europe only[11]. An average user changes mobile devices every 18 months. The material loss from the discarded but uncollected devices is estimated at around EUR 350 million each year. For Votechnik, 25 million new LCD screens are sold each year.

Finally, Cycle4Green and Alucha Technologies are active in the packaging industry. For Cycle4Green, according to the European Label Association, less than 10% of silicone coated release liners are recycled. Between 600,000 and 700,000 tonnes are estimated to be used each year in Europe: 350,000 tonnes for the labels and 300,000 tonnes for the tapes and construction. For Alucha Technologies, the treatment of complex waste made of organic and inorganic waste is also substantial. Square cartons are typically used as packaging for juices, milk, soups or other liquids. 50 billion of these carton packages for drinks are used each year in Europe alone (Table 1 on page 4).

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

Company	Location	Business innovation	Signals of success
Pectcof	Netherlands	Unlocking the potential of the coffee pulp as a source of bio based materials	- Winner of the Dutch round of 2013 Venture Competition - 2 GreenTEC Awards nominations¨ - Finalist in the Venture Challenge - Spring 2013 - Presented at TEDxBinnenhof 2014 - Visited in March 2013 by the Dutch Minister of Economic Affairs (Henk Kamp)
Worn Again	United Kingdom	In development of a chemical textile recycling technology and closed loop resource model that will enable end of life clothes and textiles to be collected, processed and made back into new yarn, textiles and clothes again and again	- Featured by the Ellen MacArthur Foundation - Extensive press coverage - Worked with renowned clients (Eurostar, Virgin, McDonald's)
SecondLifElectronics	Bulgaria	Collect, refurbish and reuse mobile phones, portable electronics and their accessories from the European markets to other markets	- Starting partnership with one of the biggest Bulgarian electronics retailers - Currently expanding in Romania, Albania, Italy, Spain, Turkey and Greece
Cycle4Green	Finland	Developed an innovative method for processing silicone-coated waste papers.	- Featured in Packaging Magazine Europe, in Recycling Magazin - Major end-clients in the Consumer Packaged Goods (e.g. Beiersdorf, P&G) across Europe (UK, Germany, Austria)
Votechnik	Ireland	Developed a state of the art recycling technology which through a fully automated process removes the hazardous components from LCD flat screen panels and monitors.	- Young Entrepreneur of the Year 2010 - Frederick A Krehbiel II Innovation Medal 2010 - Outstanding Young Person of the Year 2011 for the CEO Dr. Lisa O'Donoghue - Best High Growth Company at InterTradeIreland 2011-2012 - LEAP (Limerick Enterprise Acceleration Platform) award (July 2012)
Alucha Technologies	Spain	Owns a unique technology that separates aluminium from plastic. It recovers clean aluminium that can be re-used in the aluminium industry. Further, plastic is also converted into fuels.	- Finalist in the BMW Innovations Award - Finalist in the Barcelona Entrepreneurs Awards - Most Innovative Initiative (Diputació de Barcelona) - Cover page & lead article in "Recycling International"

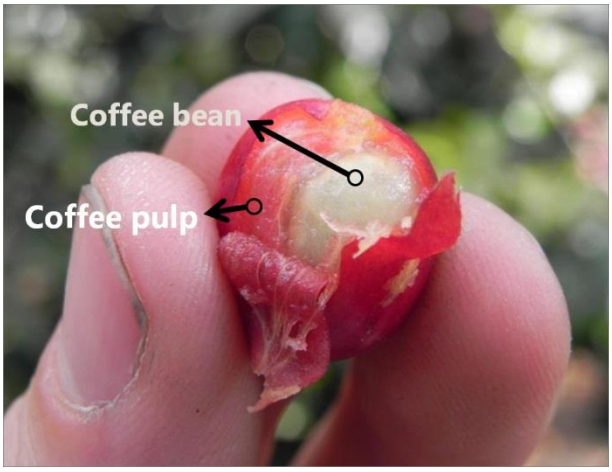
Problem 1 – The separation process used in coffee production results in major waste of coffee pulp surrounding the bean. Not used, this pulp waste is often being disposed of, and represents a danger to the environment.

Innovative solution 1 – Pectcof has developed a biorefinery solution which is based on green chemistry and biotechnology. The innovative process consists in collecting the pulp waste, shipping it to the Netherlands, extracting the product (pectin) from the waste and introducing it to its perspective markets.

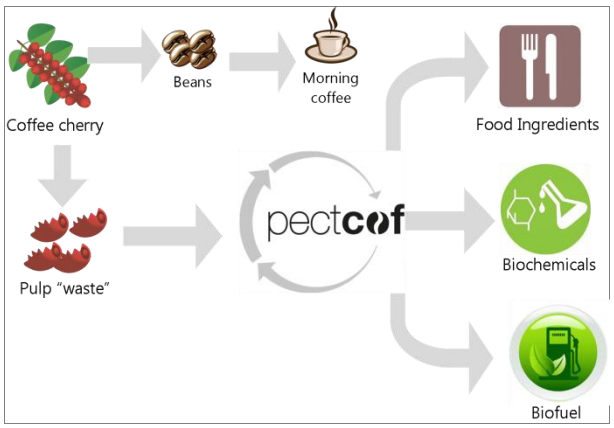
The biorefinery solution developed by Pectcof has several advantages. First, it enables coffee producers to detoxify their waste stream and therefore reduces their spending in waste management. It also prevents toxic leaching into rivers, lakes or soil that existed before the new process and therefore has a positive impact on the environment.

Up to now, Pectcof has managed to produce pectin from coffee pulp with applications in the food products and pharmaceuticals industries. They are currently working on biochemical and bio-fuels that could be produced from the new process.

Separation of coffee bean and pulp in the coffee cherry



The no-waste closed-loop approach of Pectcof



Source: Pectcof[12]

Problem 2 – End of life textile products and clothes are often thrown away. There is a need to leverage on this textile waste.

Innovative solution 2 – Worn Again has been developing a chemical textile recycling technology and closed loop resource model for the past 2 1/2 years. This technology separates and recaptures polyester and cellulose from the end of use textiles with the intention of turning it back into equivalent virgin resources at the same quality and price.

The solution that Worn Again is introducing aims to solve a current problem of the recycling industry. This includes the inability to separate blended fibre garments, dyes and other contaminants. The new Worn Again solution aims to recapture polyester and cellulose from cotton and eliminate this hurdle.

The company has received large press coverage when it was collaborating with household names such as Eurostar, Virgin and McDonald's. However, since then, their business model shifted from "upcycling", which means converting waste materials into new products, to closed loop recycling technology development. The company is currently partnering with major clothing retailers, while exploring routes to industrialisation.

Old staff uniforms turned into bags for Eurostar

Source: Worn Again[13]

Problem 3 – With the average user changing their mobile phone every 18 months, there is a large waste of electronic devices and accessories.

Innovative solution 3 – SecondLifElectronics has developed a recycling solution for portable electronic devices. The mission of the firm is to collect, refurbish, reuse mobile phones, portable electronics and their accessories. The solution developed by SecondLifElectronids is particularly beneficial for the end-users. They can now earn revenues from what they previously discarded, and thus renew their devices more often.

The company is aiming at two types of clients for the collected devices. Firstly, the end of life stock is recycled by melting to leverage on the parts with high value. Secondly, the devices, which can still be used, are sold to emerging markets, where the demand for such products is high.

SecondLifElectronics gathers old phones from retailers and buys back from end-users.

Source: SecondLifElectronics[14]

Problem 4 – Release liners are used for one particular task, carry labels on consumers and industrial goods, and are wasted as soon as they fulfilled this role.

Innovative solution 4 – Cycle4Green developed an innovative solution .in order to collect and transform used silicone coated release papers e.g. in self-adhesive labels into recycled label papers. This process is based on a new technology which separates the silicone from the fibre and therefore enables to reuse the fibre material in the production of recycled paper.

The solution proposed by Cycle4Green offers multiple advantages. First, it leads to a global paper waste reduction by giving release liners a second life. Currently, only 10% of this waste is recycled, according to the European Label Association. Second, the on-site collection program allows customers to lower their waste management costs. For one tonne of self-adhesive label, 50-60% waste is generated in manufacturing and label applications.

The solution provided by Cycle4Green has reached the products of large Consumer Packaged Goods companies such as Beiersdorf, Unilever and Procter & Gamble. Indeed, the customers from Cycle4Green are manufacturing and packaging companies, which are working directly with the aforementioned CPG firms.

Previously discarded paper can now be recycled

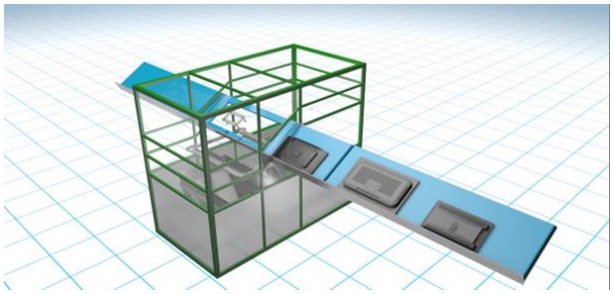
Source: Cycle4Green[15]

Problem 5 – As there is currently no universally recognised legislation compliant technology to process old LCD screens, the wasted screens were stockpiled indefinitely.

Innovative solution 5 – Votechnik developed an automated recycling technology for LCD flat screens, called Trumaster-ALR™. The hazardous material containing components in the LCD screens include the CCFL tubes and the liquid crystal panel. This technology removes these hazardous components through a fully automated process. It allows the rest of the LCD to be further recycled using standard in house recycling infrastructure.

This new technology presents many advantages for the client. The automated technology offers efficient processing to customers at the rate of 80 screens per hours. It enables low labour costs and flexible volumes as well as being easily scalable. It therefore maximizes the release of value content from the LCD waste system.

Conceptual view of Votechnik technology



Trumaster-ALR Machine by Votechnik

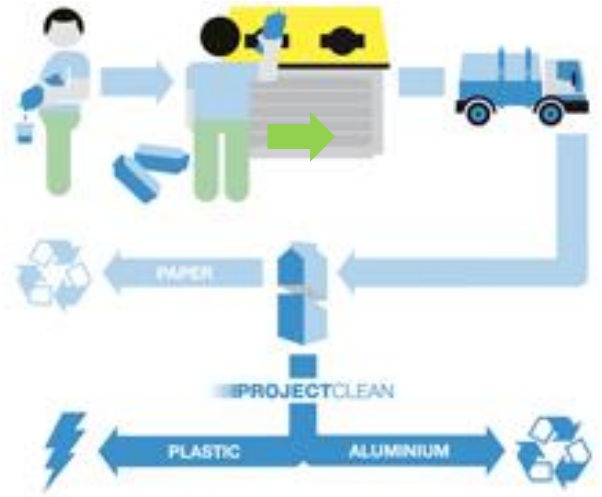
Source: Votechnik[16]

Problem 6 – Carton packages for drinks are composed of paper and thin plastic-aluminium layers (called laminates). Up to now, only the paper is recycled.

Innovative solution 5 – Alucha Technologies has developed a technology, which separates aluminium from plastic in the laminates collected from paper factories. Aluminium is then recovered and can be reused by the industry. The plastic is also converted into fuels which can be used for example by paper factories.

Paper factories are the main beneficiaries from the CLEAN technology. The solution prevents dumping or incineration of laminates and therefore enables them to save money. They can also sell the recovered aluminium or use the fuels produced by Alucha and therefore increase their revenues and/or reduce their expenses. The CLEAN process also leads to an important reduction in CO_2 emissions.

Recycling schema of the carton packaging using the solution of Alucha Technologies



Source: Alucha Technologies[17]

3.2. The creation of new markets and jobs

According to the EU Environment Council, waste management and recycling industries are estimated to provide between 1.2 and 1.5 million jobs in the EU. The size of the industries could reach nearly EUR 95 billion. This estimate of the number of employees includes the public sector, multinationals, and other smaller contractors. According to Eurostat, employment by multinationals and in the public sector is approximately 200,000 in the two industries. Hence, the other private companies, mainly subcontractors, employ over 600,000 persons.

Currently only 39% of EU waste recycled. The report "More jobs – less waste" provides an estimation of potential new jobs, if the objectives set by the EU of 70% for recycling of key materials were reached. Within the EU27, more than 320,000 direct jobs would be created by increasing the recycling of glass, paper, plastic, ferrous and non-ferrous metals, wood, textiles and biowaste. In addition, indirect and induced jobs are also expected and estimated to reach respectively 160,000 and 80,000 new positions. In total, it represents more than half a million new jobs that could be created[18].

Yet, it must be underlined that these opportunities can only be secured in Europe if the growth in recycling is achieved by shifting toward the closed-loop model and not through the rise of exporting recyclate.

3.3. Client perspectives and challenges related to the uptake of the trend

On the one hand, all clients are potentially interested in a closed-loop solution but only if it does not bring additional costs to them. Providing such a solution is the main challenge for CLWM companies. This means that the solution must be affordable, scalable with quality remaining identical. However, another challenge related to the uptake of the trend is a lack of understanding of the closed-loop waste management concept. The public may recognise the words "closed-loop" as familiar but is generally not able to define what the model entails. Yet, when the concept is understood, the trend is largely supported, on the condition that neither costs increase nor quality decreases. For example, in the textile industry, matching cost and quality of the linear model is an extremely difficult task, as the linear model benefits from years of experience to optimise its learning curve and economies of scale.

On the other hand, firms which embrace the CLWM model can leverage on multiple positive perspectives. First, exploiting what was previously considered as waste creates new revenue sources for companies. Transforming liabilities into assets is something all companies can find an interest in. Moreover, reusing raw materials indefinitely allows companies to lower their dependency on raw materials. For example, screens for LCD and mobile displays need europium, yttrium, and terbium, which are classified as Rare Earths Element (REE). The recycling of the REE limits price rises and provides better control over their procurement. Finally, an increasing number of companies are developing zero-waste policies. What was previously considered as improving the brand image will soon become a must.

4. Drivers and obstacles

The drivers pulling the success of the CLWM include: the networking support offered by the Knowledge and Innovation Communities; and the role played by directives to foster the industry. However, major obstacles are hindering the growth of SMEs including the difficulty to find the right workforce; delays in the disbursement of funds of public funding schemes; and a number of regulations with grey areas. These obstacles, along with the aforementioned drivers, are further detailed in this section.

*"Because of the legislation, Europe is very attractive for us" – **Votechnik***

4.1. Directives as a catalyst for the CLWM companies

Throughout the discussions with the companies in the CLWM industry, EU directives have been repeatedly identified as a driver for the industry. Companies such as Votechnik or SecondLifElectronics are responding to directives such as the Waste Electrical and Electronic Equipment (WEEE) Directive or the Restriction of Hazardous Substances (RoHS) Directive, the Packaging and Packaging Waste (PaPW) Directive. The WEEE Directive defines objectives for all types of electrical goods to be collected, recycled and recovered. The directive has been updated in 2012 to reflect the rise of e-waste. The RoHS limits the exploitation of hazardous substances in electrical and electronic equipment. The PaPW wants to reduce the impact of packaging and packaging waste on the environment.

The requirements imposed by these directives created a demand and a new market. The collection targets of the latest WEEE directive aim at an ambitious 85% of WEEE produced. Up to now, LCD screens, which contain highly toxic mercury in them, were stockpiled due to the lack of recycling solution. Votechnik is thus providing a solution on a new market craving to solve an identified problem. Potential clients are already eagerly anticipating solutions to liberate the value of the LCD stocks.

Similarly, other showcased companies benefited from the directives. SecondLifElectronics is also leveraging on the WEEE directive, through the collection of e-waste. Meanwhile, additional opportunities have emerged from the PaPW directive. For example, Alucha Technologies recycles the plastic-aluminium waste, and Cycle4Green focuses on release liner.

4.2. Networking support from the KIC

EU institutions provide different types of support to SMEs, the most appreciated was clearly the networking support. Pectcof, the Dutch company aiming to valorise the coffee pulp biomass, is an example of a great success story. Leveraging on the visionary idea of its founders, the EU supported the company from its early days. For example, the company has been involved in BioBaseEurope, the first open innovation and education centre for the bio based economy in Europe; as well as in the Knowledge and Innovation Communities (KICs), a public private partnership which brings together education, research, and innovation. Taking part to these initiatives led the CEO of Pectcof to conclude that the bio based economy in Europe is heading in the right direction. Similarly, he praised the Climate-KIC for the networking possibilities that it offered. For two young entrepreneurs finishing university, the networking opportunities represented a real added-value for business expansion.

*"The major asset of the KICs is the networking opportunities" – **Pectcof***

Likewise, Votechnik is currently not a member of a KIC, but is convinced of their potential. The firm via its University of Limerick founder is involved in the creation of a new KIC called "Raw materials: sustainable exploration, extraction, processing, recycling and substitution". This new KIC is expected to be established by the end of in 2015. Votechnik is also involved in an EIP WEEE2020 Raw Materials Commitment bringing together stakeholders across the entire WEEE value chain.

4.3. Difficulty in finding the right workforce

For many SMEs, finding suitable employees is a real challenge. This is even more the case for the waste management sector, where companies need employees that understand the process behind their solution. Thus, they are required to have a good mixed background in business processes or management and engineering, as SME employees are asked to take part to diverse tasks.

Engineers tend to not anticipate the commercialisation part of a new product, while business workers often overlook the challenge related to production. People with backgrounds that are suitable to understanding both do exist, but it can be hard to attract them in a start-up, especially when their experience justifies higher wages. Attracting them requires being able to offer acceptable and attractive packages.

4.4. Improvements needed for EU funding schemes

The main point of improvement for EU funding relies in the speed of delivery of capital. Votechnik and Alucha Technologies both identified it as a severe bottleneck. The Spanish company explained it took them nearly a year to obtain the funding through the Climate-KIC call for ideas. The deadline for the call ended in August 2013, the results were released in December 2013, followed by 3 more months to get the official green light. Two additional months of due diligence will lead the company to receive its promised money in late June or July 2014.

The exact same problem was also flagged by Votechnik, who applied for eco-innovation project funding under the Competitiveness and Innovation Framework Programme. Their experience was very similar than the one from Alucha Technology. They applied for funding over 9 months ago when they were interviewed and the process is still ongoing. This long time frame can prove particularly problematic for a company, which has to shift their strategy. This has not been the case for the interviewed company, yet it was one of their fears. Having to wait such a long time endangers the relevancy of the application, as the company may be required to adapt its strategy.

*"In an SME you need a good mix between business and engineering, and that is hard to find" – **Votechnik***

Additional observations focused on the lack of transparency and the limited focus of the funds. First, the myriad of rules and regulations makes it complicated for companies to understand where and how to apply. Secondly, it appears that structural funds have a rather limited focus in some countries. According to SecondLifElectronics, the JEREMIE funds in Bulgaria were considered to put too much emphasis on high-tech projects. This is why SecondLifElectronics applied for funding from "INNOVATION NORWAY".

4.5. Regulations as a hindering factor

Regulations have proven their positive impact and their role as a catalyst as described earlier. However, they can also have a negative impact. The transformation from waste to resources is not clearly understandable by customs and tax administrations among others, which lead Second-LifElectronics to run into hardships. The firm had troubles particularly on tax and logistics issues. The products that they are handling do not fit the definition of waste, but still have to follow waste regulations.

The new WEEE Directive gave EU Member States more authority to monitor the illegal export of waste. Such shipments of WEEE are concealed as legal shipments of used equipment, in order to avoid EU waste treatment rules. With the tightening of this regulation, even legitimate exports are becoming more burdensome for companies, such as SecondLifElectronics. The transport of waste across EU countries adds another layer of bureaucracy complexity. As waste collectors, companies like SecondLifElectronics or Cycle4Green have to follow the Waste Framework Directive regulating the documentation that has to be provided. The lack of harmonisation across Europe creates a jungle of regulations, hard to read for SMEs. For example, EU Regulation 1013/2006 sets clear rules and guidelines to all EU countries but the life of SMEs as complicated by different national regulations and exemptions.

Another directive created difficulties for one of the showcased companies. Alucha Technologies have to comply with the waste management directive, which considers thermal treatment processes such as pyrolysis to be in the same category as incineration. The permitting procedures to install an incineration plant are extremely long, often taking up to a year or two, with multiple points of contacts. As the company uses the pyrolysis technique, it represents a real slowing factor to their development.

5. Policy recommendations

5.1. Closed-loop: a new approach

The old model of linear economy based on "Take-Make-Dispose" is gradually being replaced by the closed-loop approach. This change of model represents a major paradigm shift that requires systemic change. There is a need to break also from the old organisational model, which tends to be too restrictive. For example, the metrics currently used to assess a company are still based on the old model, and solely focus on the economics.

*"Change what we measure will force the companies to change" – **Worn Again***

To support the closed-loop model and the circular economy, new measurement models need to be developed to assess the actual impact of a firm's activity (even the after sale impact). The economics of the company are one of the dimensions, along with solid measurements for natural, social and environmental impact. This new model should measure the actual impact of the activity along the whole supply chain.

5.2. Forward thinking and awareness

To develop this new model of measurement and to support the reaching of critical mass, there is a need to better understand the circular economy and the closed-loop model. Currently, there is a lot of talk, but insufficient awareness. It is a concept that people have heard of but cannot really define. This can be achieved by two means. First, awareness should be raised among businesses and policy-makers. Secondly, engaging forward thinkers with innovative ideas to drive systemic change is also a possible approach. Bringing in new thinkers with a new vision is the best way to break from the old train of thoughts.

5.3. Support to reach critical mass

Reaching critical mass is vital for the uptake of CLWM. Raising awareness is of course a good first step to reach critical mass. Nonetheless, some additional support could be provided at the supra-national level. For example, the introduction of a universal charger for EU mobile phones is an interesting practice that could be expanded to other areas. Votechnik was explaining that they had to face a steep learning curve when the firm was entering new European countries. The wiring systems in the LCD screens differ in most countries forcing the company to tailor their solutions to each market. Harmonising such standards would facilitate the creation of a common European market in waste management.

Reaching critical mass requires a sizeable market. Companies can also achieve this by adopting a Pan-European approach. The need for a big enough market forced companies to internationalise early and they are all thinking at the European level. SecondLifElectronics has branches in Bulgaria, Albania, Romania and Italy. Alucha Technologies has offices in Spain and the Netherlands. Votechnik is opening a plant in Denmark. However, non-harmonised legislations across European countries remain as barriers for this internationalisation.

5.4. Adapt regulations to CLWM

Regulations are not always suited to the CLWM industry and can even act as a barrier. Yet, regulations such as WEEE, RoHS or PaPW are aiming to have a positive impact on the environment, sharing an overall objective with CLWM. Their relevancy is thus unquestionable and they are compatible with the CLWM. However, several improvements can be done. The transformation of waste to resources is hard to define and creates a grey area. This makes the life of the companies particularly difficult due to heavy bureaucracy. It could be simplified with a catalogue of answers and support to interpret the myriad of directives and legislation on the matter. New CLWM innovations should be acknowledged faster in EU regulations as often financial benefits for waste generators are minor or even some development costs are involved.

Another area of improvement could lie in updating the existing regulations with relevant objectives. For example, the WEEE directive states that collection targets are set for 85% of WEEE generated from 2019 onwards. But, valuable materials are in low quantity in the electronic waste. In order to increase the uptake of the trend, it is important to incentivise a good return on investment for recycling e-waste. Hence, an interesting recommendation would be to focus not only on volume but to also set recycling targets in terms of value.

6. Appendix

6.1. Interviews

Company	Interviewee	Position
Pectcof	Rudi Dieleman	Founder & Director
Worn Again	Cyndi Rhoades	Founder & Closed-Loop Executive Officer
SecondLifElectronics	Todor Blajev	Founder & CEO
Cycle4Green	Petri Tani	Founder & CEO
Votechnik	Dr. Lisa O' Donoghue	Founder & CEO
Alucha Technologies	Gijs Jansen	Co-Founder & CEO

6.2. Websites

Pectcof	www.pectcof.com
Worn Again	www.wornagain.co.uk
SecondLifElectronics	www.secondlifelectronics.com
Cycle4Green	www.c4g.fi
Votechnik	www.votechnik.com
Alucha Technologies	www.alucha.com

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