European Commission

Business Innovation Observatory

Sustainable supply of raw materials

Optimal recycling

Case study 60

Internal Market, Industry, Entrepreneurship and SMEs

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Business Innovation Observatory
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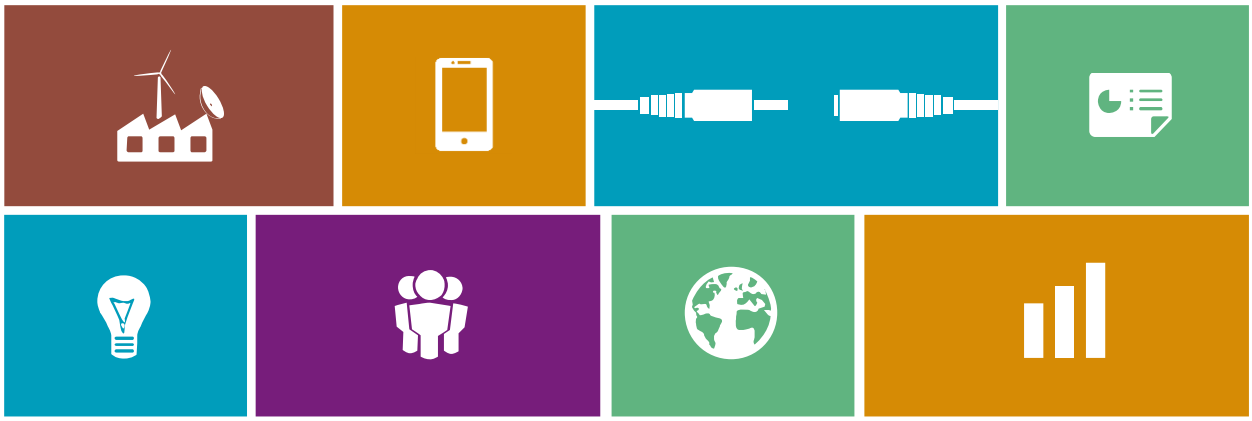


1. Executive summary

Recycling rates in Europe are rising and the reuse and recycling of discarded products and materials will become a necessity as there is an increasingly pressing scarcity of raw materials. **Today, new technological solutions are being brought to market that will increase both the amount and the quality of recovered raw materials and allow for recovery also from novel sources,** such as the recycling of metals from complex end-of-life products.

The European Union is working towards transforming its economy towards a more **circular one**. Adopted in 2015, the Circular Economy package aims at changing the way we consume products and generate waste through influencing the whole chain, from the extraction of raw materials, the design and production of products, consuming patterns, re-use and recycling to the use of old components and secondary raw materials in new products. The EU and many other international bodies and governments **promote the principle of a waste hierarchy**, shifting from "disposal" to "recycling" and "prevention by design" e.g. by using less material in design and manufacturing, and by promoting durability and reparability. The aim to move up the waste hierarchy is also a **response to the often great technological recycling challenges posed by certain difficult-to-separate waste types**. Technology developers are moving more upstream in the waste cycle to produce products and materials that are easier to separate, re-use and recycle.

Adopting optimal recycling solutions will have a positive **impact on the environment** in several ways. It will lead to a decrease in disposal of waste in landfills and a reduction in energy consumption and greenhouse gas emissions. There will also be a decrease in demand of new ("primary") raw materials as recycled material available on the market is often a cheaper source for manufacturers and producers. However, to increase the demand for recycled material, its quality must be at least on par with primary material, which is still an issue with certain products such as plastic and textiles.

Moving towards a more circular economy and thereby increase recycling rates will create **more economic value by facilitating secure and stable access to raw materials**. Increased recycling will also have a direct impact on employment in the waste management sector as well as an indirect impact in fields such as construction, maintenance and administrations of the recycling facilities. If fully implemented, better eco-design, waste prevention and reuse can bring net savings for EU businesses of up to EUR 600 billion.[1]

Sustainability is becoming a business imperative with pressure from consumers and investors for companies to adopt more corporate socially responsible practices. In turn, **price volatility and resource scarcity concerns** will continue to drive demand for high quality recycled materials, as well as **stricter regulation** and fiscal policy which impose costs on disposal and financial and non-financial incentives for recycling efforts. However, **existing legislation may not necessarily promote increased efficiency and innovation in recycling**. **Existing waste collection systems may also not be optimal** in providing wider access to recyclable products.

Accordingly, policies should aim to **reward the use of efficient and economical processes to extract high quality recyclable material**. This can be done by **financial incentives for quality** as well as quantity, providing appropriate data support, **encouraging local or regional governments** to closely collaborate with innovative recycling companies e.g. in the context of public procurement, and **optimising the separate collection and sorting of waste**. **Encouraging an even playing field**

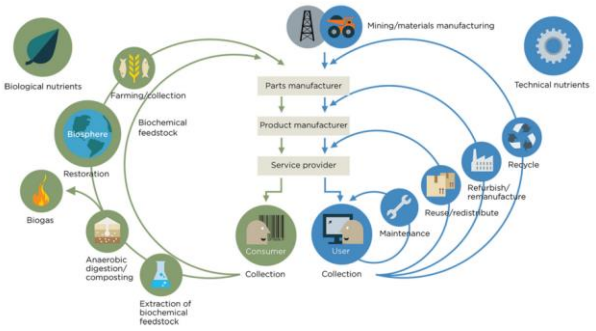
between private and public sector service providers for waste and recycling would also allow for increased private sector investment, and hence innovation, in the waste and recycling industry.

2. Optimal recycling

2.1. Trend presentation

A large part of the raw materials used today are increasingly becoming scarce, thus driving the need for greater amounts of recycling. While it is unlikely that recycling will meet the total demand for raw material in Europe in the foreseeable future, it can still serve to improve affordability and stability of access to resources. To reach and optimal level of recycling for all products, **there is a need for new technological solutions that will improve both the amount and the quality of recovered raw materials from novel sources, i.e. optimal recycling,** such as the recycling of metals from complex end-of-life products.

Figure 1: The circular economy as described by Ellen MacArthur Foundation



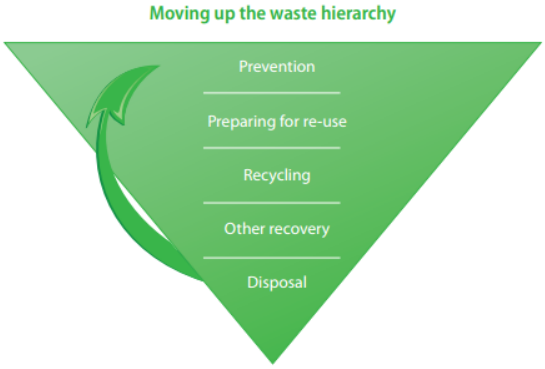
Source: Ellen MacArthur-foundation[2]

The European Union is moving towards becoming a circular economy, which, together with cradle-to-cradle movements[1], focus on how to change the way we consume and create waste through influencing the whole chain from the design and production of products, consuming patterns to re-use and recycling.[3] The circular economy maps an alternative way of approaching the lifecycle of products – rather than shown as a linear chain from production to waste, it is described as two circles (Figure 1). The green circles relate to biological products that can be composted, and the blue relate to technical products that needs to be taken care of in an industrial manner for reuse or recycling. This paper will focus on the latter, i.e. the recycling of technical products.

[1] Cradle to cradle movements relate to educating companies and consumers about the advantages of a biomimetic approach when designing products and services.

In trying to establish a proper waste management system that is geared towards a circular economy and optimal recycling rates, many international bodies and governments promote the application of a so-called waste hierarchy[4] (Figure 2). The first step in the waste hierarchy is prevention, e.g. by design using less material in design and manufacturing which can play a part in improving access to raw materials in Europe.[5] The second step is preparing it for reuse to give the product a second life rather than it becomes waste. The third step relates to recycling products through extraction and reuse of embedded raw material. If this is not possible, the product embedded energy load is extracted in incineration; disposal of products in landfills is viewed as a last resort (last step in the waste hierarchy).[6]

Figure 2: Waste hierarchy



Source: European Commission[7]

The aim to move up the waste hierarchy is also a response to the often great technological end-of-pipe recycling challenges posed by certain difficult-to-separate waste types. Technology developers are moving more upstream in the waste cycle so as to produce products and materials that are easier to separate, re-use and recycle. In the waste hierarchy this would imply a higher focus on waste prevention.[8] One example is the reluctance of manufacturers to use recycled plastic as it is sometimes perceived by consumers as low-grade and may thereby ruin the machinery or make processes less efficient.[9] To achieve optimal recycling rates recycling processes need to deliver materials of high and stable quality to create a demand for the recycled material on the market.

While overall recycling rates throughout Europe are rising, there is still a huge difference between recycling rates across countries and products. For instance, the recycling of

plastic packaging increased from 28 per cent to 84 per cent in Flanders, Belgium between 1995 and 2006. But for batteries the recycling rate is still less than 3 per cent in UK.[10] The differences in recycling rates between different products is partly caused by the challenges of separating certain waste types at source in order to recycle the raw material. Other aspects include the presence of an efficient collection system, and economical incentives for recycling.

One example is e-waste, the waste of electronic products, which including everything from computers to "singing" gift cards. It is one of the fastest growing types of waste and is also a potential environmental threat over a long period of time if the hazardous material used in these products leak into the land and have an impact on nearby communities if landfilled inappropriately.[11] The increased use of electronics, rapid innovation and frequent product and software updates together with lower prices for goods driving the increasing amount of e-waste globally.[12] E-waste is often difficult to recycle because of the diversity of materials used and the frequent use of hazardous chemicals. This means that the pre-treatment and recycling must take place in purpose-built plants with adequate risk management measures, but even then some part of the e-waste is not always recycled because of lack of available economically viable technology.. As a result of high labour costs and health and safety standards in Europe combined together with lack of effective instruments (including EU legislation) to ensure that equivalent recycling conditions are established in third countries, a significant portion of e-waste is sold to developing countries for recycling or for 'reuse', with approximately 1.5 million tons of e-waste exported from Europe in 2012.[13] The exported WEEE and electronic products often end up on poor quality landfills in places with no or low possibilities to properly handle the hazardous waste.[14]

Recycling of metal scrap is much easier and common. Metals are an example of materials that are well-suited for recycling as their quality normally does not deteriorate when recycled. For some metals such as aluminium, the recycling process takes only a fraction of the energy needed to produce new metals.[15]

2.2. Overview of the companies

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

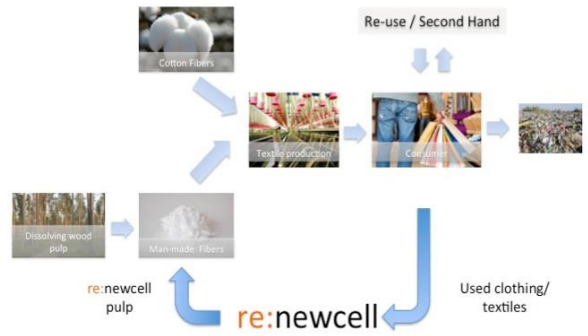
Company	Location	Business innovation	Signals of success
Re:newcell	Sweden	Developed a process for recycling cotton and other cellulosic textiles by dissolving them into pulp that can be used to make new textile fibres of high quality.	- Has produced first prototypes of 100% recycled garments - Is planning to build demonstration plant during 2016
Orege	France	Innovative treatment and recovery of wastewater and sludge in an economic and environmental friendly manner.	- Successfully incorporated in several urban wastewater treatment plants. - Contracts with major firms in the chemical and oil and gas sectors.
Urban Mining Corp	Netherlands	Recycles plastic waste by shredding it and separate different types of plastic materials.	- In cooperation with Delft University. - Working together with Rom Waste Solutions, the largest processor of plastic waste in Romania. - Winner of the Ocean Exchange competition in 2014.
AkkuSer Oy	Finland	Recycles batteries through a method called Dry Technology that does not need heating nor generate any waste water or other pollution.	- Winner of European Responsible Care Award 2011. - In cooperation with large recycling organisations in the Nordic countries. - Their largest markets are Finland, Sweden and Germany, but they also process waste in New Zealand, Austria, Lithuania and Estonia.

Problem 1 – The demand for textile has increased the last decade and consumption is expected to grow at a rate of 3 per cent per year. Production of cotton textiles has a heavy environmental impact on the local water supply, demands irrigations and fertilising chemicals. Today only a small portion of the textiles is reused or recycled, with a large part down cycled or ending up in landfills.

Innovative solution 1 – Re:newcell's patented process of recycling the textile fibres can decrease the environmental impact from textile production. The company's technology enables the recycling of textiles with a high cellulosic portion by dissolving them into a pulp, which can be later on fed into the common textile production chain. The recycled fibres can either be blended with new fibres or sold as pure recycled fibres which can then be knitted and sewn into new textile products.

The innovation has the potential of minimising textile waste and increasing textile production while limiting the use of scarce water resources often associated with cotton textile production. The recycling method is affordable and does not require any chemicals that are environmentally harmful.

Figure 3: Re:newcell's recycling model



Source: Re:newcell

Problem 2 – Fresh water is a scarce resource and households and industries are causing huge water pollution with their activities. Large quantities of sludge are costly to treat, and may also cause an unpleasant odour. Industries also use a lot of toxics and/or non-biodegradable effluent in their processes which often ends up at an incineration plant or as landfill. The cost to recover the sludge and effluent is increasing for the industrial companies and society as the regulations for pollution are getting stricter.

Innovative solution 2 – Orege is offering two different cost-effective and environmental-friendly technological solutions to treat and recover sludge and effluent. Their customers are industries, operators and municipal players, which all have to meet regulations regarding pollution.

One is the technology for the treatment of complex, toxic and/or non-biodegradable effluent, SOFHYS, which aims to improve the biodegradability. This is a viable and cost effective alternative of incineration and activated carbon, and is more than 50 per cent cheaper compared to alternative treatments.

The other is a technology for the conditioning and treatment of sludge. The SLG process consists of instantly facilitating the separation of organic and mineral matter from water by acting on the sludge structure.

The company today helps treat waste effluent for a wide range of sectors, from oil and gas to cosmetics, in a way that meets the strict regulations governing the reduction or removal of toxic and/or bio refractory molecules.

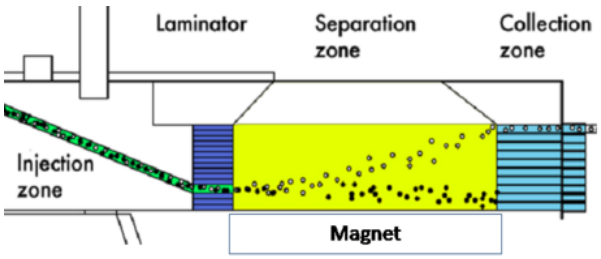
Figure 4: SLG reduces sludge treatment costs by up to 60 per cent and improves sludge quality for recovery purposes

Source: Orege

Problem 3 – There are many different kinds of plastic materials – if only counting packaging plastics there are 250 different kinds of polymers. As such, during recycling, different kinds of plastics tend to get blended together as it is difficult to separate them in the recycling process. Processes which try to separate polymers generally involve first melting the plastic and then separating the polymers through a chemical process. However, the output is not as high quality as virgin material, which limits its use and decreases the demand for recycled plastic. A large part of the packaging plastic instead goes to landfills or for incineration.

Innovative solution 3 – Urban Mining Corp has a solution that makes it possible to sort different kinds of plastic material.

Figure 1: Separation of plastic materials



Source: Urban Mining Corp

The technique involves separating different materials in a diluted mixture of water and ferrous oxide and takes place in a magnetic field where the placement of the magnet determinates the density of the water in the tank. Particles lighter than the liquid in the tank will float, otherwise it will sink. The denser the particle, the deeper it will sink.

The main advantages of this technique is the ability to directly sort up to five different kinds of materials without using chemicals while not compromising on accuracy. In addition, the process is cheaper and more efficient than other processes used today, as well as scalable to meet the increased demand for high quality recycled plastic.

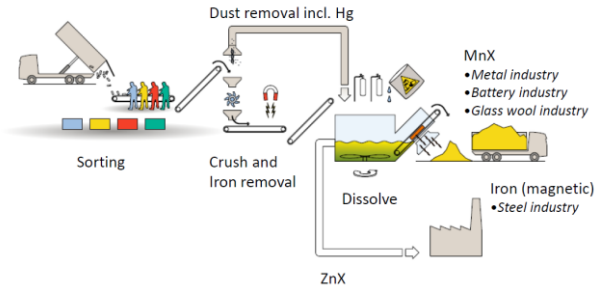
Problem 4 – The most common way to recycle batteries is to crush and melt them at high temperatures. This process consumes a lot of energy, and pollutes the air and water. The residual product of this process is called black mass and contains several minerals, but the residues have been mostly deposited at landfills since there has not been a process able to separate them.

Innovative solution 4 – AkkuSer has developed a recycling solution called Dry Technology that can handle almost all kind of batteries.

The technology enables highly efficient and safe material recovery. They started recycling with Dry Technology in 2006 and has since then also developed a complementary method for better recycling of alkaline batteries. Both of them involve chemical processes, as opposed to the old smelting process, that take place at room temperature and makes the process more environmentally friendly and cost effective than the process most commonly used today.

The process of recycling alkaline batteries has been sold to AkkuSer's subsidiary Rec Alcaline and will be commercialised in 2016. This process will be able to handle the black mass and produce manganese and zinc, minerals for which the global demand is high as they can be used as natural fertilisers.

Figure 5: Recycling of batteries by AkkuSer



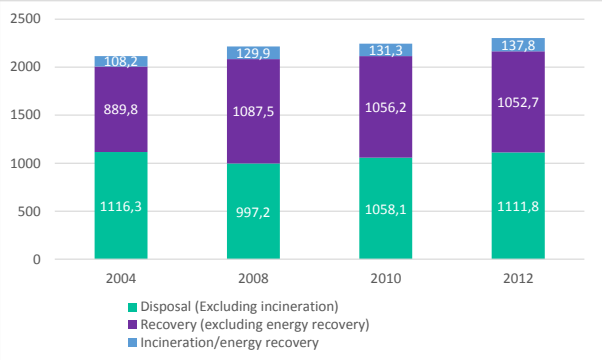
Source: AkkuSer

3. Impact of the trend

3.1. Environmental impact

There is a growing awareness that there are limited resources available today and thereby the increased need for the reuse and recycling of the raw material already produced. Producing goods from recycled sources is often less energy intensive than manufacturing from raw material and can thereby reduce production costs, carbon emissions and decrease the exposure to price volatility and disruption of supply of primary raw materials.

Figure 6: Development of waste treatment

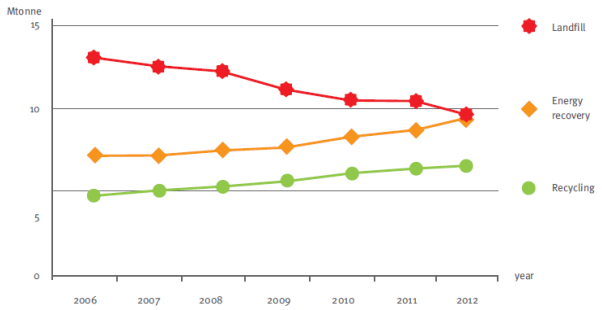


Source: Eurostat[16]

In 2012, a total amount of 2,302 million tons of waste was treated in Europe (Figure 6), with approximately 36.4 per cent of the waste recovered via recycling (not used for energy recovery or similar).[17] In turn, while plastic production and consumption has been increasing in Europe since the 1950s and shows no sign of declining. Only about 14 per cent of plastic waste is recycled, with over 65 per cent of plastic waste going to landfill. Packaging plastic comprises 62 per cent of all plastic waste, but in 2012, the EU only recycled 34.7 per cent of used packaging plastic.[18]

Recovery rates of the packaging plastic also differ in different countries, with the nine top countries recovering more than 90 per cent of the waste (less than 10 per cent goes to landfill), while seven countries landfilled more than 50 per cent of their plastic. The largest part of the packaging plastics comes from households. Since packaging plastic is a large part of all plastic waste, a change in recycling behaviour will have a great impact on the amount of plastic that ends up at landfills.[19] There is a large potential in increasing the recycling of plastic if it is collected and recycled properly as it is a material that can be recycled several times without its quality declining in optimal conditions.[20] Pushed by the recycling targets set by the European Union and certain Member States individually, the recycling of plastic is increasing and less plastic ends up in landfill (see Figure 7).

Figure 7: Plastic post-consumer waste recycling and recovery 2006-2012

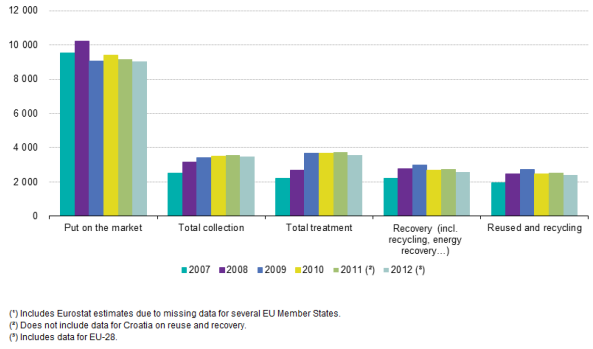


Source: Plastic Europe[21]

Fresh water is a scarce resource and in Europe a lot of water is used in industries. Approximately 40 per cent of total water abstraction is used by industries, and about 60 per cent of this is polluted to the extent it needs to be treated afterwards.[22] An efficient treatment of wastewater, sludge and other effluents is necessary to keep the chemicals from leaking out into the nature and harming the environment.

The cultivation of cotton also requires a large amount of fresh water. In 2013, the average person purchased some 6.7 kilograms of clothes. The majority of these end up in landfill once they are discarded. This is number is expected to increase in the future.[23] Increased recycling of cotton would thereby have an impact on fresh water supply as well.

Figure 8: Electrical products put on the market and e-waste collected and treated in Europe



(*) Includes Eurostat estimates due to missing data for several EU Member States.
(*) Does not include data for Croatia on reuse and recovery.
(*) Includes data for EU-28.

Source: Eurostat[24]

In 2012, 9.1 million tons of electrical products were put on the European market; in the same year, 3.6 million tons of e-waste were treated, of which 2.6 million tons were recovered (Figure 8).[25] Even though there is a time lag between when the product is put on the market and when it becomes waste, there still exists a big potential for an increase in recycling of e-waste. The disposal of electronic products is still common and has an impact on the surrounding environment as they may lead to the leaking out of toxic substances which pollute water and air.

Adopting optimal recycling solutions would have a positive impact on the environment in several ways. It will lead to a decrease in disposal of waste in landfills and a reduction in energy consumption and greenhouse gas emissions. There will also be a decrease in demand of new raw materials as recycled material available on the market is an easier and cheaper source for manufacturers and producers.

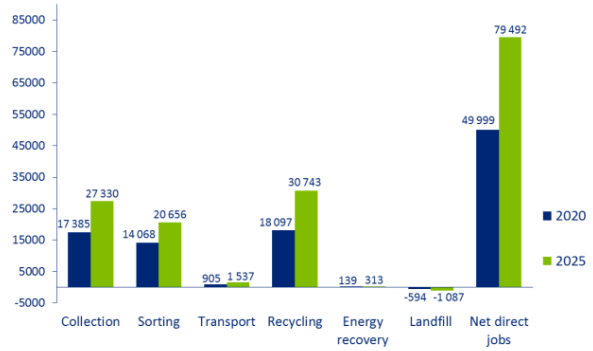
3.2. Socio-economic impact of the trend

Moving towards a more circular economy and increasing recycling rates will create economic value by generating more employment and using less resources. Increased recycling will have a direct impact on employment in the waste management sector as well as an indirect impact in fields such as construction, maintenance and administrations of the recycling facilities.[26]

Creating a more circular economy, with better eco-design, waste prevention and reuse could bring net savings in EU businesses of up to EUR 600 billion and boost the GDP by nearly 1 per cent while creating 2 million additional jobs. [27] If the current development path for the circular economy in Europe continues, then by 2020 the sector could create some 160,000 jobs.[28]

There currently exists a lack of capacity for recycling of plastic material and a lot of plastic waste is thereby exported outside of Europe.[29] Adopting optimal recycling solutions which are closer to the consumer can therefore positively impact employment in recycling and waste management industries, as well as decrease Europe's dependency on imported raw material from other parts of the world.[30] Europe is the second largest producer of plastics materials globally[31], and with refining capacities decreasing in Europe the demand for high quality plastic materials will continue to rise. Optimal recycling solutions which produce high quality recycled plastic that is on par with virgin plastic will therefore be essential.[32] The recycling of waste in Europe instead of outsourcing this outside of the continent would help create employment, as shown in Figure 9 .[33]

Figure 9: Number of direct jobs created along the plastic recycling value chain in Targets 2020 and Targets 2025 compared to respective BAU (Business As Usual)



Source: Plastic recyclers[34]

In addition, recycling and using recycled material can make the production process less energy-intensive and more resource efficient than if raw materials are used.[35] As such, maintaining recycling solutions in Europe will keep material available for further use and thereby reduce the dependence on the import of virgin material.[36] Further, as optimal recycling solutions strive to generate recycled material of the same high quality as virgin raw material, the demand for such recycled material (and the profitability of recycling companies) will increase accordingly.[37] For instance, revenues on the e-waste markets is expected to grow from EUR 1.23 billion in 2012 to EUR 1.69 billion in 2020 driven by the demand for scarce metals.[38]

4. Drivers and obstacles

Sustainability is becoming a business imperative with pressure from consumers and investors for companies to adopt more corporate socially responsible practices. In turn, price and resource scarcity concerns will continue to drive demand for high quality recycled materials, as well as stricter regulation which impose costs on disposal and subsidies which provide incentives for recycling efforts. However, existing legislation may not necessarily promote increased efficiency and innovation in recycling. Existing business practices that promote the exporting of waste overseas instead of recycling them locally may also hinder the growth and demand opportunities for local recycling firms. Further, existing waste collection systems may not be optimal in providing wider access to recyclable products.

4.1. Sustainability as a business imperative is driving the adoption of increased recycling

Companies are increasingly adopting corporate social responsibility as part of their core business agenda, and there environmental and sustainability goals are often a key component, such as greater material recyclability and greater use of renewable resources and recycled materials. This may be driven by both customer and investor pressure. In surveys performed by Environics International, more than one in five consumers said that they rewarded or punished companies based on perceived social performance, while more than one in four share-owning Americans took ethical considerations into account when buying and selling stock.[39]

4.2. Price volatility and resource scarcity concerns will continue to create demand for high quality recycled materials

The circuit boards in the e-waste contains a lot of valuable materials such as gold, silver and palladium but also scarce material such as indium and gallium is becoming more common, due to their implications in new technologies such as flat screens. Even though the expensive and scarce material is only a small fraction of the material, the concentration of it is still higher in the e-waste then found in a natural mineral ores.[40] Price and scarcity of raw material is a big driver for the e-waste market and this is likely to be a future driver in other waste markets as well.

For example, there already exists a large demand for used aluminium on the market, partly because of the high quality of the recycled material but also because it saves up to 95 per cent of the energy compared to production of new aluminium.[41] Technological advances in recycling will continue to increase the likelihood for material quality to be maintained during the recycling process. This together with an efficient and cost-effective process will most likely create an increase demand of recycled raw material.

4.3. EU regulations are creating incentives to move up the waste hierarchy

The EU's approach to waste management is based on the waste hierarchy which is inscribed in EU regulations.[2] The aim of the waste management policies is to reduce the environmental and health impacts of waste and improve EU's resource efficiency.

Stricter regulations has therefore been a key driver of many recycling markets. Example of this is the e-waste market where stricter regulation, including producer responsibility, increasing landfill prices and awareness of the environmental impacts have increased the demand for recycling of e-waste.[42] Other is recycling of batteries and plastic which is regulated and/or subsidised. The use of Extended Producers Responsibility has shown to be as successful way to improve recycling rates and build markets for secondary raw material and promoting innovation in waste transformation processes.[43]

"The regulation of battery recycling might be the largest driver in our market."
*– **AkkuSer***

However, regulations sometimes promote existing technologies which involve down cycling, instead of innovative solutions that better optimise recycling. For instance, the regulation regarding plastic recycling in the Netherlands where the recycling companies is reimbursed per kilo plastic recycled, regardless recycling method. In 2014 about 145.000 tonnes of plastic waste were recycled in the Netherlands and this has increased almost every year since 2001.[44] In the recycling process, different polymers and colours are mixed, resulting in a grey plastic of lower quality than virgin plastic and with limited areas of use. The recycled plastic is of such low quality that the companies are selling it for less than the cost of the process. It could actually be more profitable to use it as energy recovery, but the subsidies is large enough to make it worth recycling.

"It's crucial to make regulations that encourage not only a high amount of recycling but also good quality of the recycled material."
*– **Urban Mining Corp***

4.4. The export of waste overseas hinders local optimal recycling investments

A large amount of both plastic and e-waste is shipped overseas to be recycled. In 2012, the EU-27 collectively exported approximately of plastic collected for recycling to a value of about EUR 1.7 billion.[45] In the UK, recyclers exported close to 13 million tonnes of reprocessed metal in 2011/2012.[46] While such waste exports is said to contribute to national revenues (with the later said to have contributed EUR 5 billion to the UK's balance of trade)[47], It also leaves the European market with less waste to turn into new raw material as well as makes it hard for recycling business to achieve the economy of scale they would have had if the waste is retained locally for treatment. Export of plastic waste for recycling is today seen as economically beneficial and therefore the demand for local recycling facilities, and hence opportunities for scaling up and achieving economies of scale for recycling companies, becomes difficult. As long as the trend is to export the waste overseas, the market and employment opportunities associated with optimal recycling efforts will be limited.[48] In addition, regions such as Asia which currently import waste will in time develop their own domestic recycling and processing capacities, impacting the demand for waste imported from aboard.[49] A focus on reusing local waste in Europe instead of exporting it may thus help mitigate the risk from potential fluctuations in the waste export market.

4.5. Organisation of waste collection affects recycling efficiency

The organisation of collection of waste is a factor that largely affects how efficient the recycling market can be. If collection is not effective a lot of recyclable material might end up at incineration instead of being recycled properly, thus affecting supply of material for scaling up recycling. For instance, in some places in Germany all fabric is collected together. An initial sorting determines whether the clothes can be reused or needs to be recycled. Reusable clothes will be sold to second hand stores and the rest will be sorted according to material type and sold and recycled depending on material type. This differs from Swedish markets where the second hand stores collect only reusable clothes and the rest is to be thrown in the regular garbage, with the larger part of it ending up being incinerated. The German example illustrates how an efficient waste collection and sorting system can create easy access to recyclable material.

*"The sorting and collection-process of old garments has the potential to have a huge impact on how large part of all fabric will be recycled." – **Re:Newcell***

As such, well-organised waste collection systems are crucial for optimal recycling to reach scale and make the recycling of waste efficient. Initiatives that already exist put the main responsibility on the producers, where the manufacturer is responsible for the cost of recycling of his sold products. Another initiative is refunding consumers a small amount of money when they submit their plastic bottles for recycling. The initiatives may not always be publicly organised or funded, but are generally influenced by policies and regulation, with the waste collection system often set up in close collaboration with local governments.

[2] The Waste Framework Directive

5. Policy recommendations

Existing policies and regulations should be expanded to incentivise not just recycling volumes, but also the quality of recycled materials, in order to increase the demand for recycled materials by manufacturers and the value added of the recycling process. This principle should also govern data collection and monitoring of recycling efforts. Furthermore, a strong waste collection and sorting system is important in ensuring that recyclable products reach optimal recycling companies. Finally, local government is an important partner in encouraging optimal recycling efforts.

5.1. Lower the opportunity cost of recycling and increase subsidies for high quality recycling

One of the crucial factors in recycling relates to the legislations and costs of waste disposals.[50] The cost of disposing the waste in landfills or sanctions for illegal landfilling needs to be higher than the cost of reusing and recycling in order to encourage optimal recycling efforts. The right incentives and innovations can make the waste a valuable resource worth paying for. As all Member States have different regulations for recycling and landfill an EU policy intervention could be a complement to national policies.

There are already markets in Europe where legislation puts responsibility on the producer to take care of the waste at the end of the product's life, with Extended Producer Responsibility often stemming from EU waste directives. This incentivises the producer to make the product more recyclable and ensure that it will be taken care of in a sustainable way. As the produces will have to pay for the cost of the recycling this is an incentive to make a product that can be recycled in an efficient and economical way. In Sweden for instance the producers of electronically products are responsible for the cost of collecting and recycling the product in the end of life. Since there is a lag between the sale and the product becoming e-waste the producer has to financially guarantee there will be funding for handling the e-waste. Similar legislation could be used successfully in other markets. For instance, the Nordic Council of Ministers have been looking into if this could be applicable for textile waste in the Nordic countries.

In other countries, there are subsidies for the recycling of certain products, such as plastic recycling in the Netherlands where waste companies are paid per kilo for recycled plastic. However, these subsidies are not dependent on the quality of the recycled products, and as such create the incentive to recycle as much as possible at the lowest possible cost regardless of the quality of the recycled product. In addition, they create a system with economic unsustainability built-in. In this case the recycled plastic is often mixed and thereby down cycled as it will have limited applications and cannot be used to substitute virgin plastics. Accordingly, there could be different economic instruments and legislations that complement existing recycling efforts by incentivising the maintenance of high quality material in the recycling process, taking in account efficiency, effectiveness and economical aspects, as well as the similarities and differences between different waste types and more aligned to the polluter pay principle.

"The largest gain from recycling at high quality is that we'll get a product that pays for itselfes as the market will demand it and be willing to pay for it."
– Urban Mining Corp

Further, if financial incentives are set in the way that they are dependent on the amount of recycled material, what is being measured is then a vital aspect of how the recycling is performed. Data collection should go beyond capturing recycling volumes to looking further at how this helps drive innovation in the more recyclable products and contributes to objectives higher in the waste hierarchy – notably waste prevention. This shifts the focus from only maximising quantity to also maximizing quality and value added, thus further encouraging the uptake of optimal recycling solutions without the need of systemic subsidies.

5.2. Common definitions and interpretations waste to reach an economy of scale

Multiple interpretations as to what constitutes waste under EU law, as well as questions surrounding who owns the waste and how it could and should be used, are challenging in some markets today. This is especially common with previously unrecyclable materials that are now recyclable thanks to technological advances. Retaining old habits in the determination and required treatment of waste leads to unnecessary wastage of materials that could have otherwise been recycled.

As recycling is getting more common in a wider range of products that would typically have been incinerated or deposited in landfills, the system for collecting and sorting waste has to upgrade accordingly in order to meet the needs of these new markets, with clear guidance on which parties are responsible for collecting, sorting and recycling the waste, e.g. in the context of transparent Extended Producer Responsibility Schemes. For recycling companies to reach an

economy of scale they need access to their raw material - the waste. As such, providing support to encourage efficient public collection and sorting systems, which also incorporate partners offering innovative recycling solutions, would be beneficial in more optimised treatment of waste, as well allowing innovative recycling companies to more easily access the material they need to scale up their processes.

The market size might also be an obstacle as the waste stream within one single country might be too small to reach an economy of scale depending on the product and a consolidated European market then becomes a necessity. To get to a single market the definition of when waste ceases being waste and becomes a product must be common across all member states. End-of-waste criteria is specified for a range of products but is missing for a whole range of products that could benefit from a clearer definition, e.g. plastics.

5.3. Create a public accelerator program and an even playing field between public and private sector providers

In the process of inventing new recycling processes, companies are often reliant on funding from private investors or public support initiatives. For most recycling companies, finding the necessary funding to build and run their factories or machines is one important obstacle. Another is getting access to enough waste to demonstrate their proof of concept at an industrial scale.

Encouraging close collaborations with producers, waste generators, waste management companies and local governments and access to their waste could be one way to support the innovative recycling companies as they scale up their processes. This is not only helping the recycling company to scale up but also give the public sector an insight in relevant recycling opportunities and innovations, which is the benefit of increased private sector involvement in waste management. One way to is to create an accelerator program offering innovative SMEs the opportunity to scale up their recycling process in close collaboration with the local waste organisation, producers, waste generators or waste management companies. The program should be implemented at a national level, given the differences in waste management practices between EU member states; however, such a program should be promoted at an EU level to also provide the opportunity for the sharing of best practices.

Encouraging an even playing field between private and public sector service providers for waste and recycling would also allow for increased private sector investment, and hence innovation, in the waste and recycling industry. This could mean opening up municipal and public waste collection to private players, as well as ensuring that public sector actors which have a monopoly over household waste do not use that advantage to subsidise commercial waste operations. To address concerns in allowing for private sector involvement, standards around hygiene and environmental protection could be set and applied to all waste and recycling service providers.

6. Appendix

6.1. Interviews

Company	Interviewee	Position
Re:newcell	Henrik Norlin	Board member
AkkuSer	Jarmo Pudas	Founder and Manager Director
Orege	Antoine Legrand	Chargé d'Affaires
Urban Mining Corp	Jaap Vandehoek	Managing Director

6.2. Websites

Company	Web address
Re:newcell	http://www.renewcell.se/
AkkuSer	http://www.akkuser.fi/
Orege	http://www.orege.com/
Urban Mining Corp	http://www.umincorp.com/

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