IO1 Module

Use waste as a resource

Substance of circular Economy concept as Efficacious
Determinant for the development of Successful entrepreneurship

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1. Introduction

Materials thrown away, not kept or not seen as useful are referred to as “waste“. It is generated by private households, companies, and bigger entities such as communities and states. The definition of waste varies among different cultures. In their legislation states often define what they understand by waste, how it is generated, managed and treated. Put simply, what is or what is not considered as waste depends on our attitudes, customs, and beliefs. In the past, people might have used what we now treat as waste and in the future we might find it useful or necessary to rethink what waste is. In some cases, we can also look into other countries and cultures to start rethinking about waste.

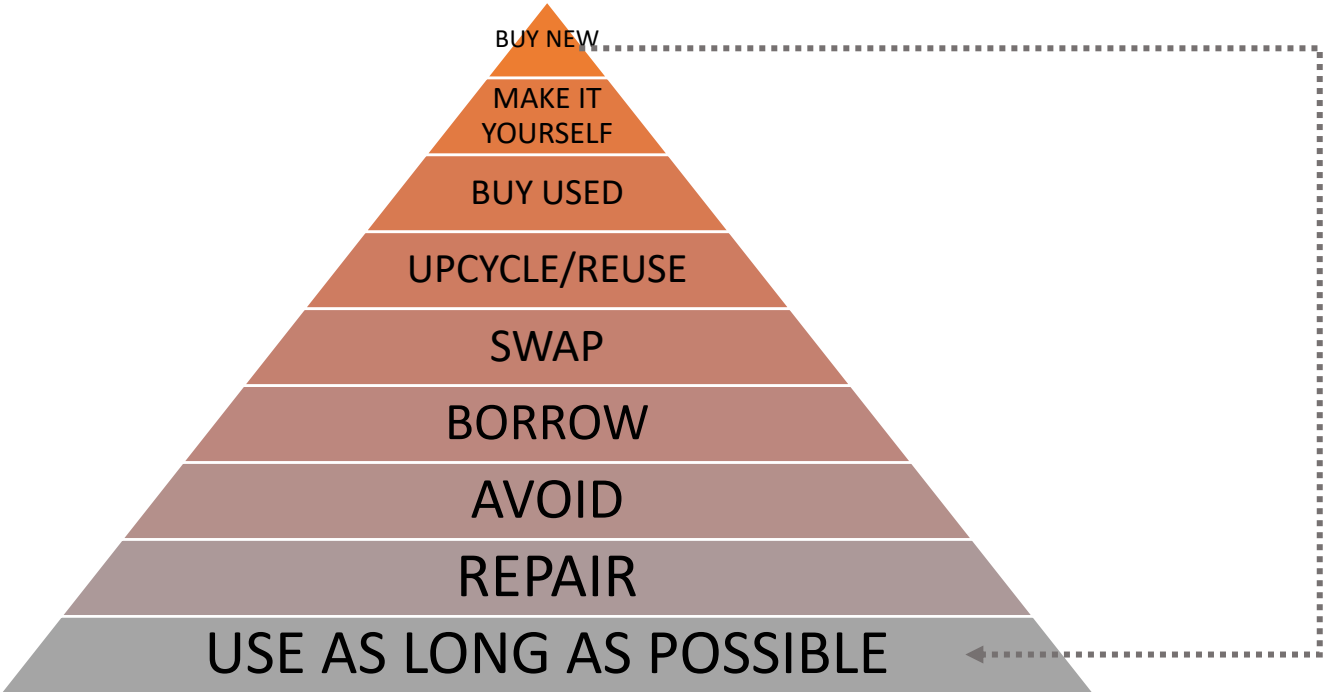
In this case, the concept of circular economy can be helpful. Circular economy aims at maintaining products, materials, and resources in the product cycle by keeping and returning them in full or by their individual elements in process, for example. That way it works towards minimising waste and the exploitation of new raw materials today and in the future. It is a big economic factor that is inter alia bringing business opportunities to start-uppers.

No special requirements are needed for this module. It provides the learners with the introductory information about the concept of waste reuse and circular economy, legal framework developed by the EU on this topic, and examples of best practice. This module will show you how to:

- rethink waste as a resource
- find example practices in which waste is used as a resource
- learn how to re-use waste yourself.

2. Circular economy and the use of waste as a resource

Circular economy is an economic system in which resources needed for creating products are used more than once. In contrast to the linear economy that implements the “take-make-dispose” business model, circular economy is based on **recycling, reuse,** and **re-manufacture of old products**.



Pyramid for saving resources [1]

Why Is It Time To Start Thinking Circular?

Humans extract billions of tons of natural resources from Earth every year; the resources will become scarce if no progress is made.

It is time to rethink the way we use natural resources and work on their conservation. The world economy has been mostly linear. In order to preserve natural resources and reduce the amount of waste we generate, our economy must become circular. In the following chapter, we will take a look at how we can move from linear to circular economy and see a couple of examples of good practice and brands that have been embracing the concept of circular economy.

A lot of products we use on a daily basis, from plastic packaging, clothing, electronics, and furniture are disposable. There is a tendency to replace old disposable good for the new ones. The 'take-make-dispose' model, in which natural resources are extracted, turned into products, sold to consumers, and used until they are discarded as waste (see our diagram below) is no longer sustainable. Linear economy has enabled companies to produce and sell large amounts of inexpensive and unsustainable products.

It is therefore necessary to switch to circular economy, which is beneficial for the people and the environment in many ways. Most importantly, it protects the environment. Circular economy promotes sustainable growth by creating green industries, cleaner production technologies, and resource efficiency. Circular economy is financially beneficial as well. According to the Ellen MacArthur Foundation, implementing this system can lead to $700 million cost savings in consumer goods industry and a €3000 increase in disposable income per annum for EU households [2]. Finally, circular economy opens new perspectives. It can create new jobs and eradicate poverty, increasing job opportunities for people across all social groups.

2.1 Waste by EU definition

There are many definitions of waste. Based on the EU terminology in the *Waste Statistics Regulation* substances and materials defined as waste are "'any substance or object which the holder discards or intends to or is required to discard" [3]. It distinguishes waste from residue (i.e. "substances and materials, which are residues of production or consumption processes") [4]. Waste can also be classified as "primary waste" (from consumption and production residues in private households and businesses) and "secondary waste" - waste from waste treatment residues (incl. waste for disposal and for recovery).

Source: https://www.pexels.com/de-de/foto/nahaufnahmefoto-der-plastikflasche-2409022/
Catherine Sheila

In this sense, waste stops being waste after it has undergone specific recycling or other processes. It can then "recover" and be "re-used" for general or specific purposes on the market, keeping in mind that it abides by the rules of existing legislation and standards and that its use does not have any negative environmental or human health impacts. Specific criteria that determines when the respective material ceases to be waste, and encourages recycling by creating legal framework for recyclable materials is given by Article 6(1) of the *Waste Framework Directive.*

Source: https://www.pexels.com/de-de/foto/mann-person-menschen-frau-7475167/
Mikhail Nilov

Even though EU regulation encourages reuse of waste, there are still difficulties in implementing such policy. For example, the EU food industry wastes about 88 million tons of food per year, with costs estimated at 143 billion euros [5]. In countries such as Austria or Germany, it is legally prohibited to take thrown away food. Such 'wasted food' that supermarkets, restaurants, or agricultural businesses discard cannot be taken by anyone else, as it is still considered as owners' property.

Reusing plastic waste is difficult as well. Some plastics cannot be recycled at all, while some can be reused. To know the differences and ways to process different types of plastic, start-uppers would need to have a technical and legal know-how.

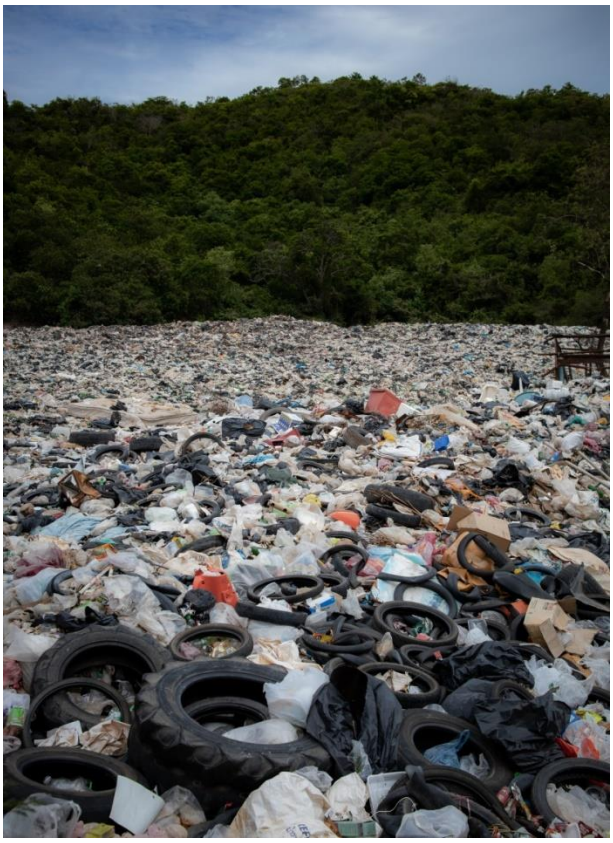
Outside of the EU, one of the dangers in developing Asian countries is the growing issue of shipbreaking. First World countries discard old vessels and send them to China and Bangladesh, two main shipbreaking hubs in Asia. One of the main issues here lies in the fact that these ships were constructed at a time with less environmental regulation. Researchers show that such action causes immensely negative impact on workers and the environment in this toxic trade sector. The older ships contain health hazardous substances such as asbestos, lead oxide, zinc chromates, mercury, arsenic, and tributyltin. In addition, shipbreaking workers in China and other developing countries often lack proper equipment or protective gear to handle such toxic substances.

2.2 Monitoring waste generation & treatment at the EU level

To monitor waste generation and treatment, the EU provides statistics and definitions with legal requirements on waste generation, treatment and management. The *European Waste Classification* for statistical purposes (EWC-Stat) is being performed regularly to inform of community waste generation. The "Guidance on classification of waste according to EWC-Stat categories" differentiates waste in regards to its chemical or physical characteristics or properties, the main sources (technical processes, industrial branches), and information about potentially hazardous components of the waste stream.

The EU classifies waste treatment based on the treatment type (recovery, incineration with energy recovery, other incineration, disposal on land and land treatment). The EU has defined 51 categories of waste and waste generation, and 18 industrial or household actors that perform such activities. The EU implements these definitions and Eurostat maintains a set of EU Sustainable Development Goals (SDGs) [6] - set of 100 indicators structured along the 17 SDGs [7].

The Eurostat Waste Data [8] and "Guidance on classification of waste according to EWC-Stat categories" [9] may be of interest for start-uppers looking for a job in the waste management industry. The Eurostat Waste Data is an extensive database that provides more information about the regulations and legal requirements of waste treatment and management, including a number of EU Directives, which introduced producer responsibility measures for waste streams, related to Batteries (BATT), end of life vehicles (ELVs), packaging waste (PACK), and waste from electrical and electronic equipment (WEEE). "Guidance on classification of waste according to EWC-Stat categories" on the other hand provides a good overview of the waste categorisation.



Source: https://www.pexels.com/photo/landfill-near-trees-2768961/

Leonid Danilov

2.3 Reuse of waste

Based on the EU legislation concerning waste management, there are five waste treatment categories: *Recovery* (including recycling, composting and anaerobic digestion, industrial processes to recover solvents, acids or bases, catalysts and oils), *disposal on land* – other operations than recovery with even a secondary consequence of substances or energy reclamation and *land treatment* (e.g. at agricultural or ecological benefit), *incineration with energy recovery* – for the reclamation of substances or energy by e.g. landfilling, and *other incineration* [10]. Reporting would have to be made referring to:

- waste use to generate energy
- solvent reclamation/regeneration
- recycling/reclamation of organic substances
- recycling/reclamation of metals and metal compounds
- recycling/reclamation of other inorganic materials
- regeneration of acids or bases
- waste components used for pollution abatement
- recovery of components from catalysts
- oil re-refining or other reuses of oil
- land treatment resulting in benefit to agriculture or ecological improvement
- use of waste obtained from any of these listed operations

Some activities to use waste might not be found in the aforementioned directives for reporting but could still be considered as "use of waste" following this project's idea; it might be e.g. the incineration of waste as fuel [11]. Other uses of waste such as internal waste processing, which is organised at the site where it was generated and can be seen for example in reprocessing or regeneration of production waste in the same or similar process it was generated through (re-use of gravel or disposal of by-catches for example).

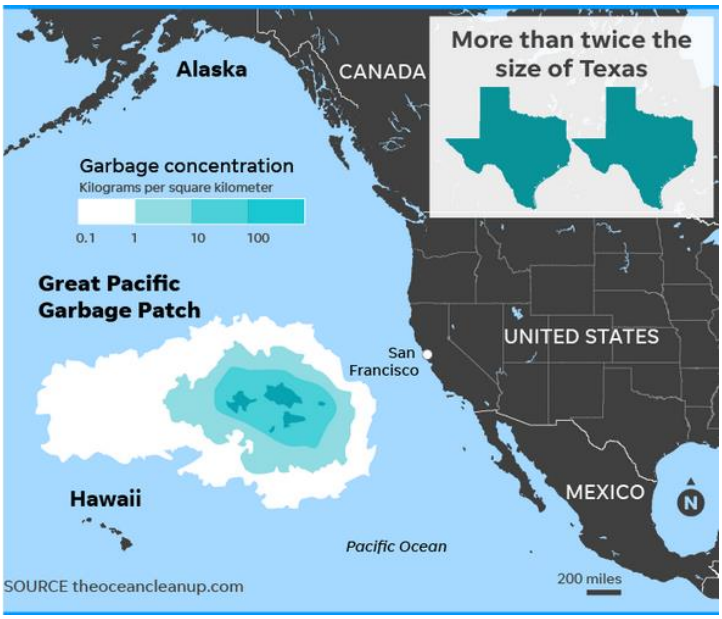
Apart from waste categories and treatment or management operations, start-uppers will also have to be aware of the most recent EU legislatives and national, regional, and local regulations (including legislation other than waste legislation) which we will not be able to cover in detail in this module.

However, in this module we will further discuss materials and treatment categories that might be of interest to start-uppers opening micro or small businesses without large investment needs.

One of the materials that are the most commonly used on a global scale is plastic. Its consumption, as well as its disposal is rapidly increasing.

Source: https://korotkinassociates.com/great-pacific-garbage-patch/

The *Great Pacific Garbage Patch* – plastic debris more than twice the size of Texas floating around the Pacific Ocean– is made out of plastic waste. In 1997, racing boat captain Charles Moore discovered this pile of trash - he called *the Great Pacific Garbage Patch* - in one of the most remote parts of the world. Returning from a trans-pacific race, he and his crew encountered a large body of plastic debris in the ocean.



Source: https://eu.usatoday.com/story/tech/science/2018/03/22/great-pacific-garbage-patch-grows/446405002/

Charles Moore wrote:

> **"As I gazed from the deck at the surface of what ought to have been a pristine ocean, I was confronted, as far as the eye could see, with the sight of plastic. It seemed unbelievable, but I never found a clear spot. In the week it took to cross the subtropical high, no matter what time of day I looked, plastic debris was floating everywhere: bottles, bottle caps, wrappers, fragments." [12]**

If nothing is done, research suggests [13] that the levels of plastic flowing into the ocean will triple by 2040; the Ellen MacArthur Foundation [14] report suggested that there could be more plastic by weight swimming around than fish by 2050.

2.4 Reusing plastic – Seven plastic types [15]:

PET (polyethylene terephthalate) is the most common plastic used for food and drink packaging purposes. It is inexpensive, lightweight, and most importantly easy to recycle. PET bottles are the most widely recycled plastic in the world.

Found in: soft drinks, water, ketchup, and beer bottles; mouthwash bottles; peanut butter containers; salad dressing and vegetable oil containers.

HDPE (high density polyethylene) plastic used in many ways, especially in packaging. It is accepted in most recycling centres, and has one of the easiest plastic polymers to recycle.

Found in: milk jugs; juice bottles; bleach, detergent, and other household cleaner bottles; shampoo bottles; certain trash and shopping bags; motor oil bottles; butter and yogurt tubs; cereal box liners.

PVC (polyvinyl chloride) and **V** (vinyl) is resistant plastic and it is commonly used for things such as piping and siding. Because chlorine is part of PVC, it can release highly dangerous dioxins during manufacturing and it is therefore very difficult to recycle.

Found in: shampoo and cooking oil bottles, blister packaging, cable insulation, siding, windows, or piping.

LDPE (low density polyethylene) is a flexible plastic with many applications. It is most famously found in plastic bags and is difficult to recycle.

Found in: squeezable bottles; bread, frozen food, dry cleaning, and shopping bags, or furniture.

PP (polypropylene) has a high melting point, so it is often used for containers with hot liquid. It's gradually becoming more accepted by the recyclers.

Found in: certain yogurt containers, syrup and medicine bottles, caps, or straws.

PS (polystyrene) can be made into rigid or foam products — in the latter case it is popularly known as Styrofoam™. Styrene monomer (a type of molecule) is possibly carcinogenic and can contaminate food. It is not biodegradable and almost impossible to recycle.

Found in: disposable plates and cups, meat trays, egg cartons, carry-out containers, aspirin bottles, compact disc cases.

PET No. 6 is commonly used in food packaging

Source: https://pixabay.com/de/photos/h%c3%bchnchensalat-lebensmittel-kasten-6016585/

Miscellaneous – a wide variety of plastic resins that do not fit into previous categories are lumped into this one. **Polycarbonate** (hard plastic) and **PLA** (polylactic acid) are number seven plastic, which are hardly ever recycled.

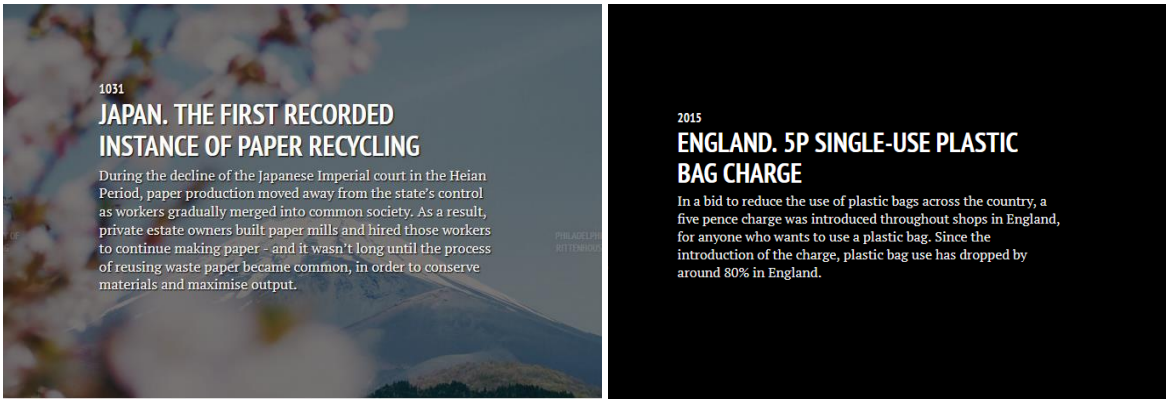
Found in: three- and five-gallon water bottles, bullet-proof materials, sunglasses, DVDs, iPod and computer cases, signs and displays, certain food containers, nylon.

3. Innovative use of waste – problem or resource?

The meaning of the term 'waste' has tremendously changed in the last 35 years. While people from the Third World countries reuse goods that have been thrown away, people from the First World countries became aware that (plastic) waste has become a huge problem. This leads to the creation of a whole new industry of "upcycling". The paradigm has shifted from a linear to a circular economy resulting in to what began as "waste management" is now declared as "sustainable materials management" focusing on resource, environmental, and human health impacts over the entire life cycle of materials.
In this unit we will take a look at some innovative ideas of using waste as resource.

Reusing waste efficiently

Although recycling waste dates back to the 11th century, when people recycled paper, nowadays there are more types of waste. In the past, people produced only bio composed and soluble waste. Today, we generate waste such as plastic – that takes around 400 years to decompose.



Source: https://www.hintonswaste.co.uk/news/history-of-recycling-timeline/#timeline

Waste becomes a resource - innovation ideas; upcycling social status [16]

Even though waste is generated on massive scales, there are some examples of organisations and businesses around the world that reuse and upcycle the waste. In this part, you will learn about different examples of material reuse.

Reusing materials in the workplace

There are different ways to reduce the waste in your workplace and reuse the materials. Half of all printed documents are thrown away within 24 hours, and 30% are never picked up from the printer at all. To optimise use of paper products, provide a recycling container designated just for paper recycling in copy rooms and a designated receptacle beside each person's desk (or at the end of a row of desks). Printing double sided and only making copies and prints when necessary will also drastically reduce your output. Paper and cardboard— free from any coffee spills—can be **recycled around five to seven times** before it degrades in quality.

To make compost in the workplace, set up an office-composting plan to recycle your food scraps. Compostable items include: vegetable trimmings, coffee grounds, food scraps, fruit peels, flowers, plants, and non-treated cardboard.

Learn which plastics are accepted (the types have been explained in the Section 2.4) and designate a commingled recycling bin for all of the business's containers, bottles, cans, and jars made of metal, plastic, or glass. Whenever possible, choose to use durable items instead, bring and use your own aluminium or glass water bottles, rigid and washable food containers, and reusable bags.

When it comes to **general waste**, is estimated that **70% of a business's landfill waste can be recycled**. Understand the types of waste your business is creating through a waste audit and try to reduce it. Go a step further by asking your shipping providers to cut down on unnecessary packaging that's hard for your business to recycle, and talk to your building manager about a collection program for anything your waste service does not accept.

3.1 Best practices of waste reuse

- **Reverse Vending Machines by UN-Habitat Lebanon Office [17]**

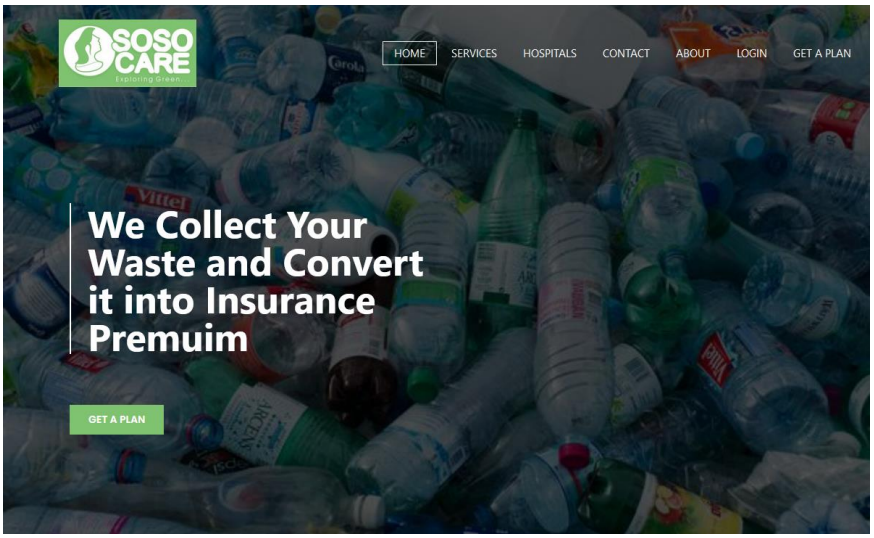
Since July 2015, Lebanon has been confronted with a solid waste crisis, characterised by temporary measures and landfills as well as a lack of serious intention to recover raw materials from solid waste. Sorting at source is the cornerstone of effective and comprehensive solid waste management practice. Reverse Vending Machines are devices that accept used empty containers (metal, plastic or glass) and return mobile call credit to the user. The Ministry of Environment has signed an agreement with Lebanese telecommunications services (Alfa and Touch) in coordination with UN-Habitat in order to realize the transformation of waste to mobile phone credit. A fine example of making profit out of waste.

- **ETrash2Cash, Nigeria [18]**

Only about one third of reusable or recyclable waste in Nigeria is collected and repurposed. eTrash2Cash, a social enterprise in the city of Kano, Northern Nigeria, incentivises residents and households to collect their waste and transfer it to kiosks provided around the city, in exchange for cash. 3,000 low-income individuals earn around $ 8 per month for providing their waste, and over 11,000 metric tonnes of waste have been diverted to the collection points, where it is treated as a valuable resource and recycled.

- **SOSO Care, Nigeria [19]**

In Lagos, Nigeria, 1,400 metric tonnes of waste is generated each day. Only five per cent of such waste is collected and recycled, severely impacting the environment and public health. At the same time, only three percent of Nigerians have health insurance. Trying to address both crises simultaneously, SOSO Care treats the donation of recyclable garbage as a resource and exchanges it for micro health insurance and food stamp points. This tech social enterprise transfers the money generated by the sale of the collected valuables into a health fund which, in turn covers the $ 3 premium for access to health services.



Source: https://sosocare.com/

Reusing electronic waste

Electronic manufacturers, from Apple to IBM, organise [20] mail-in collections, store drop-offs, and e-waste event recycling. Additionally, with half of states around the globe mandate ongoing collection, there is a strong chance that your municipality or local government has a program your business can seek out. There are also plenty of refurbishing stores that take old laptops or smartphones to repair them and make them work properly.

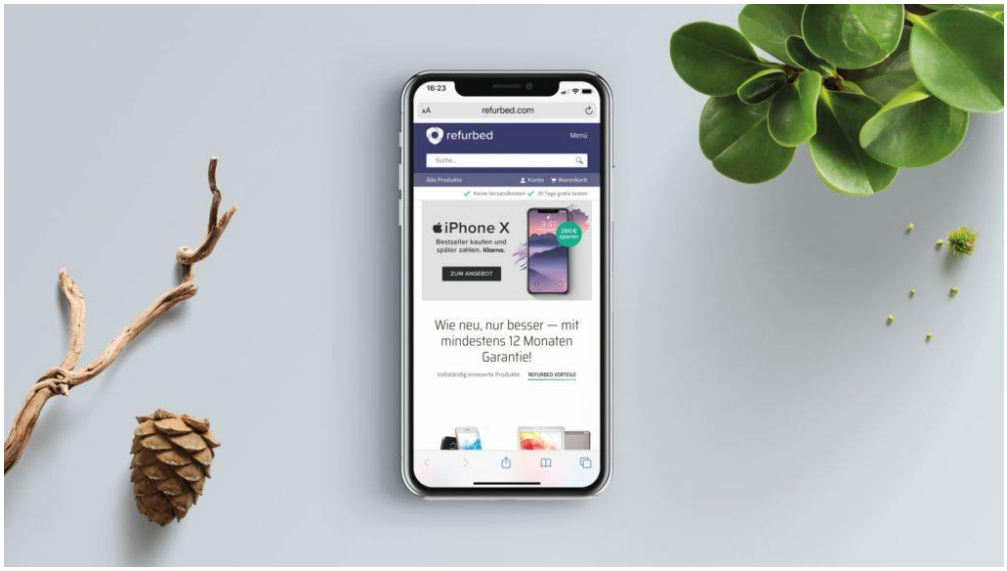
Some examples are:

- **AfB social & green IT [21]**

AfB is Europe´s biggest recycling company for E-Waste. Specialization lies in refurbing business laptops and those that cannot be used as laptops get disaggregated. AfB stands for Work for disabled people and is therefore environmentally as well as socially very friendly.

- **Refurbed –operating only in Austria, Germany, Italy and Poland [22]**

Refurbed is an Austrian start-up that refurbishes and sells old smartphones, laptops, and tablets. Their products are not only 100 per cent sustainable, but also 40 per cent cheaper in comparison to the new products.



Source: https://www.startups.co.at/refurbed-wie-neu-nur-besser/

3.2 Reusing plastic waste

Battling Plastic Waste in Solomon Islands [23]

Rendy Solomon works as an Environmental Health Officer at the Ministry of Health, Solomon Islands. Solomon is also the founder and chairwoman of PlasticWise Gizo, an initiative to educate communities on waste management that also turns plastic waste into colourful handicrafts.

She and a group of friends started collecting plastic across the beaches. After a while they came up with creative solutions and started making bags, purses, or fans. Women started selling the plastic handicrafts to tourists from the cruise ships, which provided them not only with income, but also raised the awareness of the plastic problem.

Earrings from recycled plastic bottles!

Source: https://www.facebook.com/pages/category/Community/Plasticwise-Gizo-476985899347783/

Bracelets from ghost nets

Ghost nets are fishing nets that have been left or lost in the ocean by fishermen. Millions of these nets are endangering fish and humans. “On the one hand, sea creatures of all kinds get caught in the nets and die,” said Madeleine von Hohenthal and Benjamin Wenke, co-founders of Bracenet GmbH [24]. “On the other hand, they litter the oceans. It takes 600 to 800 years for the nets to decompose and then they transform into dangerous micro plastics.” The Great Pacific garbage patch or the Pacific trash vortex is a gyre of marine debris particles in the Pacific Ocean and consists to 46 per cent of ghost nets, according to Bracenet. The German start-up creates a wide range of products, from key rings to dog leashes made from the ghost nets. That way they protect the oceans and reuse materials discarded in the waters worldwide.

Face masks into roads

Especially at the time of the Covid-19 pandemic, single-use face masks have been massively used. According to a new study, we are using and disposing 6.8 billion face masks per day. Researchers at the RMIT University in Melbourne found a solution to reuse these masks and use them in road construction. Face masks contain polypropylene – plastic polymer that does not decompose and can hardly be recycled. Adding the masks to the concrete concoction needed to build roads would improve roads strength, ductility, and flexibility [25].

MUD JEANS creates 'LEASE-A-JEANS'

In 2013, Mud Jeans introduced their 'Lease-A-Jeans' concept, which allows consumers to rent or replace their jeans whenever they want a new pair. This concept enables Mud Jeans to properly recycle or refurbish old denim. Over the past three years, Mud Jeans [26] saved 12,000 jeans from landfill and incineration and turned them into new denim.

ADIDAS X PARLEY FOR THE OCEAN

Adidas has teamed up with an environmental organization Parley for the Oceans to make athletic shoes made exclusively from plastic collected from the oceans. Adidas recently announced they have committed to using only recycled plastics in all of their products by 2024. “When you wear out this product, you give it back to us. And we recycle it,” says Tanyaradzwa Sahanga, a materials engineer at Adidas [27].

TIMBERLAND: FROM TIRES TO SHOES [28]

Did you know the tire and footwear industry are two of the largest users of virgin rubber? Timberland has collaborated with Omni United tires to create the first line of tires designed to be recycled into footwear outsoles at the end of the product life cycle. According to Timberland Tires, rather than exported, or ending up in landfills, the tires are re-claimed, separated, and recycled into Timberland footwear.

4. Case studies

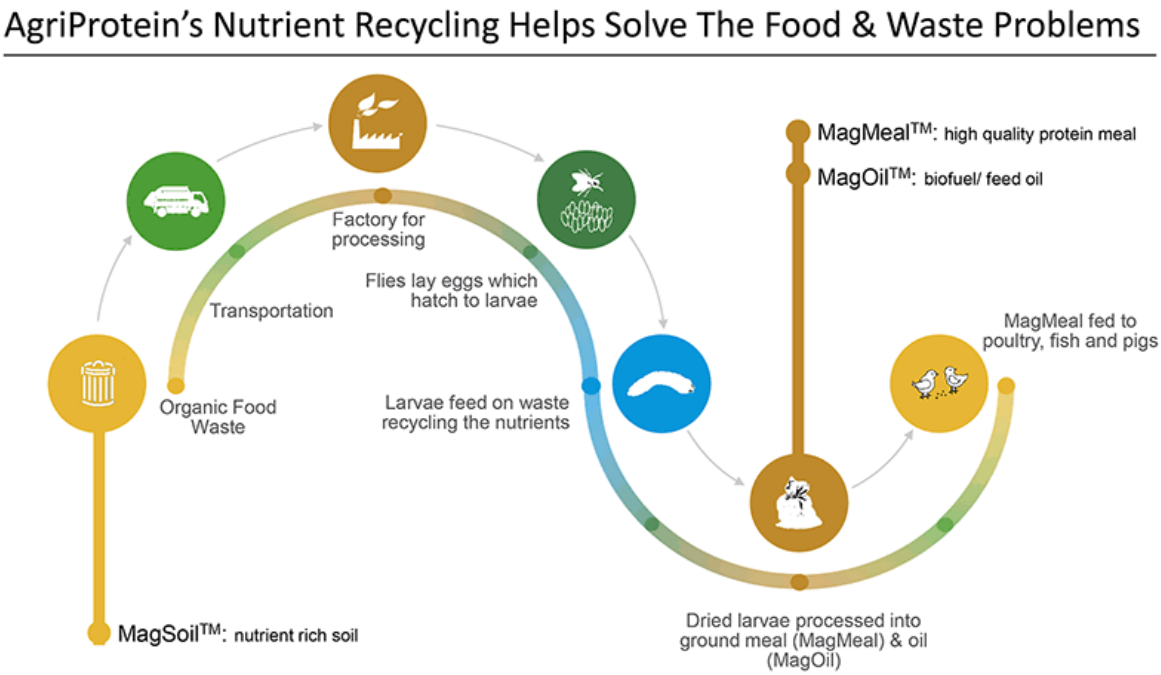
In this chapter, we will take a closer look at three case studies that will demonstrate that waste can be efficiently reused. The business ventures described below have demonstrated that using waste as a resource is not a complex process and can be done in a relatively inexpensive and simple manner.

Case study no.1: Intelligent reuse of biogenic waste

Case study: Agri Protein (a British-South African agricultural company - https://www.agriprotein.com/-) uses Christof Industries industrial plants (https://www.christof.com/en/ from Graz, Austria) in Philippi, a township in Cape Town, South Africa with about 200,000 inhabitants.

The company uses biogenic waste as a food resource for fly larvae, which are processed into protein-rich animal feed and thus contribute to combating overfishing of the oceans. The larvae meal serves as a high-quality substitute for meat meal, which is still used on a massive scale in both chicken and fish farming.

In concrete terms, this means that the company collates around 250 tonnes of waste from food factories, supermarkets and restaurants every day. Various sorts of organic waste are fully recycled here. Firstly they do a quality control check and then process the waste into a suitable and safe feed substrate. It uses this waste as a resource to feed more than 8 billion black soldier flies, which buzz through tent-like hatcheries simulating a natural habitat (e.g. specific light wavelengths mimic dawn and dusk). In a neighbouring hall larvae crawl in neatly labelled shelves at 35 degrees and eat their way through their special menu: within their ten-day lifespan, they increase their weight 200-fold. After ten days, the larvae and the substrate are separated into various product streams. The flies become a biological feedstock for the production of high-quality protein or for soil preparation.



Source: https://circle-lab.com/node/3977

Around 50 tonnes of feed are produced every day this way and sold to farmers in the neighbourhood.

Lessons learnt:

Recycling food from overproduction or misproduction and not letting it rot in the landfills has a great potential and should be practiced globally. Waste is seen as a recyclable material and solutions are sought for the increasing food demand of a growing world population for a "zero waste" system.

https://www.agriprotein.com/

Case study no.2: Case study Coffee brew for mushroom production

Only about 6% of the mushrooms sold in Austrian supermarkets come from Austria; the majority are imported. "Hut und Stil" initiated by Manuel Bornbaum and Florian Hofer runs workshops on mushroom cultivation based on coffee brew. A similar approach is taken by the German micro-business Chido's Mushrooms.

Every day, Bornbaum and Hofer collect coffee grounds in plastic containers from canteens, hotels, restaurants, coffee houses, hairdressers and similar businesses by cargo bike and exchange them for empty plastic containers on site for refilling. The coffee grounds still contain many valuable nutrients, which are especially good for growing oyster mushrooms.

Source: https://pixabay.com/de/photos/austernpilze-pilze-essbare-pilze-5725948/

They empty the coffee grounds into converted mixing machines to add lime and loosening coffee husks and mushroom spores, or cereal grains such as millet or rye are "inoculated" with it and mixed well. This mixture is then put into large black plastic bags, which are sealed and labelled. These plastic bags are first placed in the "incubation room", where the fungi are allowed to spread at the temperature of no more than 27° Celsius, i.e. the oyster mushroom is able to grow its hyphae, white, thread-like cells that form the mycelium.

About four to five weeks after filling, the plastic bags are moved to another room, the fruiting chamber - where the plastic bags are hung on metal shelves and stored in a significantly cooler place, as the fungi like it cool and damp in this phase. In order to let the mushroom fruiting bodies sprout, the plastic bags are now also perforated in some places to give it a light stimulus (two to four crosses in each of the bags). After about a week the fungi are ready for harvesting; the fungi have grown through the entire substrate with its mycelium, and have formed the so-called primordia, or pinheads.

The mushrooms are in turn delivered to the companies by the young entrepreneurs when they collect new coffee grounds, or are sold to supermarkets. Sixty kilograms of mushrooms per square metre can be harvested annually, or from about 1,000 kg of coffee grounds, about 150 kg of mushrooms can be grown. Instead of large areas and lots of water, they grow in dark, damp cellars.

With mouth guards, scalpels and disinfectants, tiny pieces are carefully cut from the previously harvested oyster mushrooms. These are placed in Petri dishes with a so-called agar nutrient solution and sealed tightly. Once everything has been sterilised, you can watch the mushroom form its little pelt - the hyphae - and clone it.

https://www.arche-noah.at/kalender/kurse-und-seminarehttps://www.bluehendesoesterreich.at/naturmagazin/pilzzucht-auf-kaffeesatz-mit-schirm-charme-und-melange

Lessons learnt:

Using coffee brew to grow mushrooms demonstrates that waste reuse can be inexpensive and easy to implement. What start-uppers need to do is invest time in developing a detailed strategy and business model and use the already available know-how to start their own businesses.

Case study no.3: Plastic waste as resource

Plastic bottle granulate in 3D

PET plastic fibres can be processed and used in production of new new PET products [29]. These new PET products could be for example clothing items like T-shirts or athletic shoes, automotive parts like carpet fibre or upholstery, industrial strapping, sheet and film, packaging as well as bottle for food/non-food products etc. It can also be used to turn normal plastic bottles into 3D printing filament.

(Fleece) pullovers are made of recycled PET bottles

Source: https://pixabay.com/photos/jeans-fashion-ruptured-modern-828693/

PET is one of the few polymers that can be recycled into the same form over and over again. In some cases, new PET granulates might be added. A producer of plastic bottles in Austria (Vöslauer) e.g. recycles 95% of their PET packaging. The PET-to-PET lifecycle of Vöslauer bottles looks like this: used PET bottles are collected via the collection system across the country. After disposal, PET bottles are sorted by colour, pressed into large bales that weigh around 250 kilograms and contain about 10,000 PET bottles, and transported to the recycling plant in Müllendorf. There, they are converted into PET flakes and PET pellets and undergo two different processes. While one plant cleans the PET flakes, the other melts them and converts them into pellets. The PET flakes and pellets are ultimately delivered to the bottle manufacturer and used in production of new bottles [30].

Source: https://www.ots.at/presseaussendung/OTS_20190228_OTS0056/voeslauer-schafft-den-naechsten-nachhaltigkeits-meilenstein-umstellung-aller-ohne-pet-flaschen-auf-100-repet-bild

PET flakes and pellets can be made on a micro-level as well. The procedures needed to be implemented are the same as the ones on performed on the industrial scale. What start-ups willing to start a business of plastic reuse need to do is:

- collect water bottles
- remove any external caps or seals
- clean them properly
- vacuum seal and heat the bottles to reduce in size
- cool the bottles
- cut them into smaller chunks with a saw and a pair of scissors
- shred the pieces into tiny pieces
- dry the pieces at a temperature of 160°C for 4 hours
- feed the PET into a Next filament extruder
- The machinery needed to process plastic waste is available and relatively affordable to new businesses too. Precious Plastic, a Dutch open hardware recycling project, offers detailed solutions for other start-ups to build their own shredder, extrusion, injection, and compression machines [31].

https://3devo.com/blog/pet-recycling-bottle-filament/

Lessons learnt:

Cleaning the bottles takes a great deal of effort, as the plastic waste coming from dumps is contaminated and in many ways impure. From the legal perspective, bottle processing may be complex, as start-ups need to meet stringent regulatory requirements. What one also hast to keep in mind is that different types of plastic produce different types of filament. High-density polyethylene, found for example in shampoo bottles, is relatively easy to turn into filament, but difficult to print with, because it shrinks more than other plastics as it cools down. On the other hand, PET prints better, but is brittle, which makes it difficult to spool as filament.

5. Quiz

1. What is circular economy?
    a. Economy based on “take-make-dispose” business model
    b. Concept based on reuse, recycle, and remanufacture principles
2. How does the EU define waste?
    a. Any substance or material the holder discards, intends to, or is required to discard
    b. Substances and materials, which are residues of production
    c. Consumption and production residues in private households and businesses
3. How does the EU define waste reuse?
    a. A process of using materials again for the same purpose for which they were created.
    b. Reprocessing of products, materials or substances for their original or other purposes.
    c. A process of replacing other materials and using them in wider economy.
4. Reuse of waste requires following strict guidelines, but is cheap and efficient.
    a. True
    b. False
5. According to the EU legislation, recovery, disposal on land, land treatment incineration with energy recovery and other incineration are main waste treatment categories.
    a. True
    b. False
6. On a global level, what type of plastic is being recycled the most?
    a. PVC
    b. PET
    c. Styrofoam™
7. What is upcycling?
    a. A process of collecting and processing waste materials and turning them into new products
    b. A creative process of reusing waste materials and transforming them into products of greater value and quality
    c. A recycling process during which the quality of reused materials becomes lower than that a material had in original state.
8. Machinery for processing plastic waste is inexpensive and can be built by the start-uppers themselves.
    a. True
    b. False
9. Fishing nets left in the sea by fishermen pose a serious threat for marine life. How much time ghost nets need to decompose?
    a. 6-8 years
    b. 100 years
    c. 600-800 years
10. Reusing waste is a process that can protect the environment *and* ensure social justice.
    a. True
    b. False

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• The principal objective of a recovery operation must be that the waste serves a useful purpose in replacing other materials which would have had to be used for that purpose. Judgment in case C-6/00 found in Manual on waste statistics - A handbook for data collection on waste generation and treatment, p. 37, Eurostat EU, Luxembourg, 2013.

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