MUNICIPAL SOLID WASTE MANAGEMENT IN CIRCULAR ECONOMY (3 ECTS)

Learning objectives

Our existing waste management systems, including the regulatory framework, are mostly built to suit the model of linear economy. Taking natural resources, turning them into something for us to use and to discard as waste once used. The trouble with this, obviously, is that it cannot be carried out indefinitely. The aim of this learning nugget is to familiarize students with the basic concepts and techniques of waste management and to gain an understanding about how waste is to be managed in circular economy. The term "waste" refers to municipal solid waste, so industrial waste and waste liquids are excluded from the scope of this learning nugget.

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Arrangements

There are three sections that all have to be completed.

PART 1: THE CONCEPT OF CIRCULAR ECONOMY

PART 2: WASTE MANAGEMENT IN LINEAR ECONOMY

PART 3: WASTE MANAGEMENT IN CIRCULAR ECONOMY

The course is evaluated accepted/to be completed/failed and the course grade is marked after all sections have been fully completed.

PART 1: THE CONCEPT OF CIRCULAR ECONOMY

Why don't you start by asking yourself and perhaps even a few friends or family members about what they think circular economy means.

How many of them responded that is has something to do with recycling?

In a way those who answered this are right, but only partly so. Circular economy is much more than recycling, but recycling certainly plays an important role in it. It's not a new invention either, even if it is so very trendy. You might even say that it is a return to the "olden days", when the supply of products, energy and material was more scarce than today.
Return to the time of our grandparents.

(Photo by Liisa Routaharju)
Why a picture of wooly socks? Because my grandmother used to very carefully recover the yarn of worn out socks to make new ones. The value of yarn for her was all the effort put into sheep rearing, yarn spinning and everything in between.

Several organizations have created models to describe circular economy and the phenomena around it. Just a few examples are the Ellen MacArthur Foundation, which has developed a circular economy system model and published a variety of circular economy publications and the EU Commission working towards circular economy with an Action Plan.

Visit the EMA Foundation and the EU Commission Circular Economy websites.

The fundamental idea of circular economy is a way of life that enables sustainable use of the finite resources of this planet we inhabit. The finite nature of our resources has long been understood, it's been nearly half a century since the "Limits to Growth" was published, yet action towards sustainability hasn't reached the level that it should have.

Why? People simply aren't willing to reduce their standard of living and the rate of population growth means there is an increasing amount of people sharing the same resources. We don't have another planet to use and the only resource we have a steady supply of is the energy provided by sunlight. Everything else has to be found on this planet. Our only planet.

On the other hand, we haven't run out of food, even if the world population is closing in on eight billion people*. How can this be? The human race is very good at coming up with solutions to the problems they identify. Finding new technologies to overcome difficulties and new action plans for continuous improvement. This is where our hope lays.

**Yes, there are areas where people are starving, but on other places food is wasted at a disgraceful pace. There would be enough for everyone if it was evenly distributed.*

Maintaining value: resource efficiency and economics

"Limits to Growth" was already mentioned. The message by the Club of Rome was succeeded by the "World Commission on Environment and Development" (a.k.a. "the Bruntland commission"), which in their report "Our Common Future" presented the concept of sustainable development for current and future generations alike.

> *Development that ensures we are able to meet our needs, but without endangering the ability of future generations to do the same.*

Since we only have this one planet and have to do with the finite resources on it, linear economy is an extremely short-sighted way to go. It may work for our generation. Perhaps even the next one, but how about their children?

Finite resources seems like an easy concept to grasp, however, some resources are more finite than others. This results in differences in valuation: we tend to value the more scarce resources more than those than we an abundant supply of. Let's discus the idea of value for a bit.

The goal of any business is to add value to the stakeholders - to make money. This added value is obtained through providing consumers with a product they will buy - choose over the alternatives - and setting the selling price on a level that will not only cover the cost of production, marketing, etc., but bring return on the investment made. Often this is achieved by minimizing the production and other costs so the product competes on the market as the cheaper alternative. In terms of sustainability and sustainable development this has the trouble of not including the environmental costs (i.e. the environmental damage caused and natural resources used) and social impacts of production to these costs.

According to Max Borders, the founder of Social Evolution, "things have value because individuals want them". In essence, the economic system has the aim of trying to use resources as efficiently as possible.

The economic system mentioned is reliant on the services and values (ecosystem services, natural resources, other values) provided by the environmental system. The environmental system also receives all the waste and emissions caused by production, so it really is the foundation for the economic system. The trouble in incorporating environmental concerns, or costs/ profits, into business is the lack of a common currency. So, when you are choosing a product to buy, you don't really know how much water or energy has been used to produce it, or how much greenhouse gas and other emissions caused.

Valuation also has to do with which parts of obtaining a resource we choose to include in our value chain. The result is going to look very different if we only consider spinning wool into yarn, neglecting the part of rearing the sheep. Very often the negative impacts cased to the environment are neglected as a cost of acquiring a raw material or producing a product. Our economic systems are reliant on the environmental systems for resources and acting as a waste sink.

In the big picture resources could be categorized based on where and how they are obtained. Energy provided by sunlight is the only resource that is added to our planet, the other resources belong to one of the spheres of the earth. They can be geological resources, water, air or biological resources.

Geological Resources

Geological resources are the metals and metallic ores, industrial minerals, high-tech-metals, rocks, stones and precious stones of the Earth's crust as well as materials storing energy (oil, natural gas, coal) once captured from sunlight through biological processes, essentially photosynthesis.

They are utilized in a variety of ways. Fossil fuels are
mainly burned as such or after refinement to produce energy for transportation, heating or electricity generation. Metals and minerals are used in construction or industrial production of a variety of products. A material of particular interest is plastic, which is produced as a by-product of the oil refining industry.
Sustainable use of geologic resources can be looked at through a few key process points. Firstly the extraction of the material used is often quite damaging to the environment. Just imagine a mine or an oil drilling platform. Another aspect is the use of natural resources. Refinement and enrichment of these raw materials is often energy consuming and results in air, soil and water emissions. Before a product is in a store to be bought it has been transported several times. All this environmental damage and logistics will be wasted as soon as the product is disposed of. Reducing marine debris is not to only good thing to come out of single use plastic reduction.

Air
Climate change is the THE topic of discussion these days and rightfully so. Increased greenhouse gas concentration in the atmosphere force mankind to take emission reduction action. This will affect our way of life mainly through energy consumption and production methods and transportation.
Air quality is a concern of equal proportion. According to the World Health Organization about 7 million people per year die prematurely due to poor air quality.

Water
Like the air we breathe, water is essential for life. According to the Finnish Statistics Center the average water consumption is about 150 l/p/d. This amounts to about 55m³ annually. This, however, only refers to the direct water use. A bulk of our water consumption is water used when making the products we use. To, again, refer to our wooly socks, the water used to water sheep feed fields, water used in processing the wool, yarn, socks… would have to be added to my personal water footprint to bring it closer to the actual water consumption. The average water footprint of a Finn is about 1 700 m³.

Biological Resources
Biodiversity is defined as the variability among living organisms. It lays the basis for the ecosystem services provided to the economic system by the environment. The Living Planet report published by the WWF 2018 presents an alarming view on the state of biodiversity.

How DO Materials Circulate?
The Ellen MacArthur Foundation has established a butterfly shaped diagram, which “illustrates the continuous flow of technical and biological materials through the ‘value circle’.” As opposed to the linear economy model, where everything simply flows through the economy, this model points out a way to maintain value in the system.
The EU action plan for circular economy describes a similar approach of enhanced circulation and maintaining value with chosen key areas to get started from.
Technical cycles concentrate in the use, collection and return-to-reuse of technical materials, essentially materials that originate from the geosphere. Biological cycles relate to cycles that utilize biological materials, in other words materials from the Earth’s biosphere.

Barriers to Circular Economy

How and why have we slipped from circular to linear economy? There are a variety of reasons, but population growth and ever increasing standard of living are among the heaviest. Economic growth is good for societies, since it allows an increase in general well- being of people by enabling water treatment, health care, education, and several other services. People, being the innovative species they are, have come up with easy ways of providing more and more products to the market often creating an artificial demand for products people don't really need or at least in an excessive quantities. The basic needs of a person are relatively easily met: clean air, water, food, shelter.
The use of natural resources has been quantified by comparing consumption to the available resources on the planet and measured as the ecological footprint. The world overshoot day is used to establish at which point each year natural resources for that year have been used.

Why, then, is so difficult to just stop consuming? Returning to our wooly sock example, one of the answers is simply money. Socks are so cheap at the store, it simply doesn't make sense to me to try and mend mine. I'll buy a new pair. Or two, since they are on sale. Even if I knew how to mend my socks (which I don't, since I'm really, really bad at crafts like that) the opportunity cost of doing so is too high. Another reason, which I already mentioned, is that in addition to time people nowadays lack the skills to mend and repair. Single use culture has replaced the way of life of past generations, so younger people haven't learned how to mend socks or other broken down items. This bring us to attitudes and lack of awareness as barriers to circular economy. Consumers alone are not to blame, though. My socks are designed and made in a way that makes it very difficult to mend them, even if I was handy. It is in the producer's interest to sell more sock, and the longer my socks last, the longer it takes me to buy new ones. This planned obsolescence needs to be overcome just as our attitudes.

PART 2: WASTE MANAGEMENT IN LINEAR ECONOMY

Introduction to Waste and Waste Management

Any introduction starts with defining the concepts discussed, so why not set of our journey to understanding waste and waste management in our sustainable future based on the model of circular economy by finding a few relevant definitions to "waste" and "waste management".
Worldwide several international treaties, agreements, conventions and such have been put in place in order to agree on certain "ground rules" for dealing with waste. Just a few examples of these include the Basel convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal, The London Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter and general principles of international environmental law, like the "polluter pays" principle. Each nation has set it's own regulatory framework on waste and waste management, but commonly the definition of what is considered to be waste is similar. A few example of how waste is defined:

- DIRECTIVE 2008/98/EC: "'*waste' means any substance or object which the holder discards or intends or is required to discard*"
- Merriam-Webster Dictionary: "*damaged, defective, or superfluous material produced by a manufacturing process, an unwanted by-product of a manufacturing process, refuse from places of human or animal habitation*"
- Cambridge Dictionary: "*unwanted matter or material of any type*"

Basically all of these definitions indicate waste to be material, item, substance without value. What does one do with something that holds no value? Finds a way to discard it before it piles up and causes harm. The thing is – living on this planet, we have finite resources at our disposal, so nothing is ever REALLY valueless. The fact that it holds no value for me or you personally, doesn't mean it can't be valued by someone else.

Our existing waste management systems, including the regulatory framework, are mostly built to suit the model of linear economy. Taking natural resources, turning them into something for us to use and to discard as waste once used. The trouble with this, obviously, is that it cannot be carried out indefinitely.

Before exploring the current practices of waste management, let's discuss a few important concepts related to waste management. The abovementioned "**polluter pays**" principle can be commonly found in environmental regulation and the simple idea of it is that whoever is responsible for causing the negative environmental impacts in question, is also responsible for the remediation costs. In waste management this, in the simplest meaning, means that those operating a waste management facility, have to operate it in a way that prevents negative environmental impacts. A wider meaning to the term is given in "**extended producer responsibility**" – the producer of a product has to take responsibility of dealing with that product once it has become waste. In practice this means, for example, that anyone producing and selling car tires, has to pay for the waste management costs of worn out tires. This is something we'll also discuss in more detail later. Waste is not a homogenous mixture of substances or items, but everything and anything once used or usable by people. As a result, waste can (and should) be categorized based on the characteristics and qualities it holds. Different waste streams require different approaches of collection and management, especially if our goal is to maintain the value of whatever material we have. A common principle, regardless of the type of waste, is the hierarchical approach to dealing with it: The first option to explore is finding ways to avoid or prevent waste in the first place. If this can't be achieved, the value contained should be recovered and if all else fails, the waste is disposed of.

Waste Management in Linear Economy

Waste management is a system of all the operations that take place in order to deal with waste. Returning to Directive 2008/98/EC we find a definition: "*waste management means the collection, transport, recovery and disposal of waste, including the supervision of such operations and the after-care of disposal sites, and including actions taken as a dealer or broker*". This process begins with the decision to discard an item or substance valueless to us. On individual scale this item or substance end up in the waste pin (hopefully, not just anywhere causing litter). Who empties this pin? Well, it all depends on the waste management arrangement agreed on. In some places the property owner is responsible for emptying the pin, very commonly there is a company that empties pins. A few basic rules apply here:

1) Emptying the pin is essential for human well-being and the environment. If you've seen photos of the Naples waste management crisis, you'll agree on this.

2) Someone has been assigned to or taken on the responsibility of emptying the pin and has an incentive to do so. Often waste legislation plays a vital role in defining roles and responsibilities of waste management starting from this point.

3) The contents of the emptied pin ends up somewhere. This is the interesting part of waste management – where the actual *management* happens. Again, there are regulations in place to guide this and various considerations to take into account.

Some Waste Management Considerations

Do you choose a different waste pin based on what material the waste is? By doing this you are participating in the initial steps of the waste management process: separation. Separating different waste streams from each other is elemental for a successful management of waste due to the different characteristics of waste materials. The two major concerns in this are the potential hazards caused by waste and the ability to recover value from it.

The first choice to make is weather the producer of waste is required to separate it and how, or if all waste should be collected and possible separation organized in a centralized facility. In the early stages of waste management the main concern was to collect and transport waste somewhere out of sight, so there was little need for source separation. Early landfills were, as the word suggests, convenient places to dump waste in and leave it there. As waste amounts grew it was realized that some separation and more careful management was necessary to prevent hazards from becoming harms, sadly as the aftermath of some disasters (e.g. Love Canal) caused by poor waste management. Landfilling waste became a regulated activity and structural requirements were set for landfill sites. It was also realized that some materials can quite easily be reused, provided they are kept separate from the other waste materials.

ASSIGNMENT:

Find an international agreement concerning waste management or the international principles of environmental law mentioned in the reading material. Start a discussion presenting an example of how this agreement or principle is implemented.

Read discussions started by other students and comment on at least three focusing on how well, in your opinion, this example could boost circular economy.

PART 3: WASTE MANAGEMENT IN CIRCULAR ECONOMY

As established in section 1, the core concept of circular economy is maintaining value or, if possible, increasing it. What does this mean in terms of waste management? How does one maintain value of something that has been deemed valueless? Let' return to the idea of "closing the loop" in biological and technical cycles.

Biological Cycles in Circular Economy

(Since liquid wastes are excluded from the scope of this course, wastewater treatment or other aspect of blue circular economy are not discussed more than a notion of waste water sludge as an input to biological cycles.)

In an ideal circular economy all biological materials are circulated in a closed loop. Some considerations have to be kept in mind in this, though. Nutritional value of biological materials should be optimized when used in the food chain, but more importantly toxic and harmful substances have to be controlled, so as not to accumulate them in the closed loops. A simple example of closed biological loop is composting gardening waste and using the compost as soil improvement agent. In municipal waste management biological wastes are often composted to recover the nutrient content, but other options are available as well. Biomass can be used for fuel production (biogas, biodiesel, bioethanol) and the remaining mass still composted to recover some of the nutrients.

In terms of maintaining or increasing value this collection and treatment of biowaste seems like a perfect example: waste material put to use and the value of material recovered…or is it? According to OECD "Bio-waste constitutes the highest percentage of individual components

comprising MSW" (OECD website). Composition of organic waste naturally varies based on season and location, but on average it can be stated, that the majority of organic municipal waste is kitchen waste. Organic fraction of municipal solid waste is about a third of all the waste generated, from which follows that each Finn (as an example) generated over 80 kg of kitchen organic waste year 2018. It's safe to assume that amount of food waste per capita is at least the estimated 20-25 kg per person and according to the Natural Resources Institute Finland the monetary value of this wasted food is about 100 €. In other words, this is the monetary value we should be able to maintain in treatment of this waste.
Treatment options for biowaste include biogas production and/or composting for nutrient recovery. Composting 25 kg of organic matter will yield less than 25 kg of composted soil as an end result. Most likely significantly less, since by weight organic waste is mostly water that is evaporated in the process, but even assuming the end result would be about the same amount of soil, how much is the monetary value? The current market price for garden soil products varies, but typically a 45 l (weighing about 17 kg) bag of garden soil can be bought under five euros. In other words the value of this biological material has now decreased to about 5% of what it was, and this did not happen without any further production costs. Collecting and treating biowaste into soil products takes energy, time and materials, so the actual value of the biowaste fraction is lower.
Biogas production helps a bit, since in there are two end products, but then again biogas production facility increases the costs. The amount of biogas extractable from organic waste depends on the waste itself (the calorific content) and the design of the digester system, but if you check the current selling price of biogas, you'll soon understand that the original value of food put to the biowaste pin is far from being maintained and ever further from increasing.

How, the, should biowaste be managed according to circular economy principles? It's clear that in an ideal situation no food would end up being wasted and all organic material treated in waste treatment facilities would be biological material of lower value. While waiting for this to happen, let's consider a few examples of biomass valorization.

Black Soldier Flies (*Hermetia illucens*), BSF for short, have been used to break down organic matter in composting for a long time. It's now been noticed, that while decomposing organic waste, their larvae build up a high protein content and could be used as fish feed for cultivated trout or salmon. In fact this protein could also be used as protein in human food. In essence: feeding organic waste to BSF and harvesting protein from the larvae will increase the value of waste, not diminish it. Another similar example is growing seaweed that utilizes the fertilizer run-off in eutrophicated water systems and using this biological material directly as feed or food or as a raw material for biogas or soil products. Closing the loop, without the loss of value.

Technical Cycles in Circular Economy

Technical cycles of circular economy ensure valorization of all technical materials, i.e. anything comprising of material derived from geological natural resources. This includes a wide variety of materials and would require changes in product design from raw material selection to remanufacturing possibilities.
Closing technical loops would, again, call for maintaining or increasing the value of materials. Many materials in technical cycles are of relatively high value to begin with, so it's easy enough to justify the cost of collecting them separately and going through the steps needed before the material is reusable as a recycled raw material. Easy enough if you imagine a metal being collected, separated, cleaned, melted, and shipped back to a metal product producer as raw material. Use of recycled metals is

sustainable also in the sense that virgin raw material extraction is quite invasive ecologically and often energy intensive. Metal material also hold their value quite well.
Most of the products are not made of a single elemental raw material, but components of a variety of materials. Closing the technical loos requires a cost effective way of separating these materials or ensuring products are designed durable, repairable and that they are maintained and used in a way that keeps them usable for a long time. One good example of this is the remanufacturing service provided by Valtra.
In addition to design aspects, a key consideration in closing technical loops are optimizing logistic chains. Even if a raw material could be separated, it has to be transported to whoever uses it as a raw material.

Circular Economy Waste Management
The ability to fully utilize waste as raw material requires information sharing about what is being left over and where. I'll use the example of ResQ Club here, even though it only deals with avoiding food waste. The idea is simple: restaurants very often have food left over and instead of tossing it to the biowaste pin, they advertise it using the ResQ mobile application. Application users get an alert on their phone about the type of food offered, and are able to purchase it. There is an attempt of a similar approach in left over materials, in fact the updated Waste Act requires for certain left over materials to be announced in a material database (e.g. Materiaalitori by Motiva), so that whoever is in need of such a material will be able to use it.
Waste management in circular economy is, in fact, an oxymoron. There is no waste in circular economy, only raw materials and closed loops.

ASSIGNMENT:
Study the waste management system where you live. Prepare a short (max 10 minutes) introduction video to your fellow students introducing:

- what types of wastes belonging to a biological cycle are collected separately?
- what types of wastes belonging to atechnical cycle are collected separately?
- what is the main method for treating mixed municipal waste?

Post your video (or a link to it) in this discussion forum as a new discussion. Then watch videos posted by other students and comment on at least three focusing on the similarities and differencies between their and your local systems. Do these systems promote circular economy?

ASSIGNMENT:
Choose two example wastes you typically generate, so that one is a part of a technical cycle and the other a part of a biological cycle. Make a table comparing the circular economy challenges related to the life cycles of these waste types including at least raw material extraction, production, use and waste management. Based on your table write a discussion of about 5 pages.

You'll need to research reference material to do this, please make sure you list all references and mark them in the text also. Your essay will be subjected to an URKUND check.