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CIRCULAR ECONOMY

Learning material for the study module “Start-ups for sustainable environment created by youngsters”

Circular Economy

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Current learning material is prepared for the teachers of high-school and gymnasium level students participating in Interreg Central Baltic project CB851 “ChangeMakers - Start-ups for sustainable environment created by youngsters” to introduce the field of circular economy. Materials are compiled by the experts of Tallinn University of Technology and meant for a 75-90-minute lesson and are supplemented with presentations and a learning video, available at the Interreg Central Baltic ChangeMakers project’s web page https://sites.utu.fi/changemakers/

Tallinn University of Technology, 2020

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TABLE OF CONTENT

PROPOSED OUTLINE OF THE LESSON

Table below proposes outline of the Circular economy lesson and the estimated duration of each sub-session. In the following chapters, you can find the topics we recommend you cover under each stage. Adaptions to the learning material are encouraged, please inform the CM team if you alter the materials, so we could consider the adaptions to be included for the course to be carried out in 2021.

ORDER	SUB-SESSIONS	ESTIMATED DURATION[1]
0	**Preparation:** students are expected to watch EMAF videos and submit personal reflections on the matter	Prior to class
I	**Introduction:** general discussion based on everyone's personal experience and the homework students were invited to complete (see previous chapter)	20 min
II	**Circular economy and sustainable design**: Explain the circular economy idea further, using the slides and learning material provided	30 min
III	**Circular economy exercise**: hand out different products for students to assess their present impact and assess how this could be improved towards circularity	30 min
IV	**Watch TalTech circular economy learning video:** Applying circular economy principles in Urban Water management. Feed of thought for the follow-up.	10 min

[1] The study material does not propose the possible breaks that might be needed to keep the focus and good pace. Teachers are expected to estimate the need for breaks based on school and group specific needs.

0 - PREPARATION

All students at the age of 15-18 are welcome to take part in the course. No previous experience is required. Only an open mind and curiosity to learn something new are needed to complete the proposed assignments.

Voluntary homework prior to the lesson

Still, it is strongly recommended for the teacher to prior to the lesson instruct students to independently watch introduction to the theme from the Ellen McArthur Foundation (EMAF)[2] course materials available free at: https://www.youtube.com/playlist?list=PLD2C43638C526D33F (links to the independent videos are provided below, videos can be downloaded and saved to a device).

This material includes 10 videos (each ~ 1 minute) that open the main ideas behind circular economy and help further advancing the topic during the current course. The recommended videos are part of a lesson 1 of EMAF course and explain the different way of thinking about how our economy could work. The video set covers following topics:

1. What is Circular economy https://youtu.be/zCRKvDyyHml.
2. Linear economy, take-make-dispose model of living and alternatives to it https://www.youtube.com/watch?v=PU-hevOX0Qo;
3. Recycling: https://www.youtube.com/watch?v=RX14rA-tylo;
4. Using less: https://www.youtube.com/watch?v=mJFdW_Y4JDY;
5. Long-lasting: https://www.youtube.com/watch?v=a4dbNnIfcbc;
6. Efficiency factor: https://www.youtube.com/watch?v=u-qCn2tRp0w;
7. Green products: https://www.youtube.com/watch?v=LS7d2ZHEpQM;
8. Fewer people: https://www.youtube.com/watch?v=1fzj2ZLYLzQ;
9. How do other species live: https://www.youtube.com/watch?v=N6GNb0zTc2s;
10. The big picture and new perspective: https://youtu.be/KIp7Bjexf3Y;

[2] The Ellen McArthur Foundation provides an elaborate learning platform for the circular economy theme for college and high-school level students: https://www.ellenmacarthurfoundation.org/resources/learn/schools-colleges-resources. If further interest exists towards the topic, we strongly advise teachers to support the students completing the lessons provided there.

VOLUNTARY HOMEWORK

Each student must watch the videos linked to the current material and prepare a short (~1 page) essay on what they saw and what they personally think about the topics explained there.

This entry essay can be later used for evaluating the quality of the study module explaining students the idea of circular economy.

Students are not to be graded.

Most of the listed videos end with a question of thought. These questions are:

Video 2: We can't sustain this 'take-make-dispose' model – what's the solution?

Video 3: What would have to change to make recycling work better?

Video 4: What would have to change to allow for using less to be ok?

Video 5: Could longer lasting products work? How?

Video 6: What would we have to change to make efficiency really helpful?

Video 7: Although many green products are moving in the right direction, what does the destination look like?

Video 8: How can we change things to make our newest members of the human race welcome on our planet?

Video 9: What are the rules [for benign production]?

Based on the questions provided, instruct students to write a short essay (~ 1 page) answering at least one or generalizing personal reflection based on all of the watched videos.

Submitted essays can be used to evaluate the efficiency of the course in making students understand the circular economy concept. Teachers are encouraged to forward the submitted ideas to the CM team.

I – INTRODUCTION

Estimated duration of the session ~20 minutes

Slides: I_circulareconomy_introduction.pptx

Proposed progress of the sub-session

Slide 1-2 Welcome to the course

Explain briefly where the circular economy lesson places in the whole ChangeMakers study module. *ChangeMakers e-Platform will provide study materials on selected topics of circular economy, cross-cultural working rules, cross-border communication, innovation management, entrepreneurship, prototyping, market research and pitching. The project aims to find a balance between economic and environmental interests and to use the potential of the young generation to make the Central Baltic region more entrepreneurial and competitive in the coming years.*

Slide 3 Linear economy

Open the lesson with briefly explaining the background of linear economy[3]. Open the idea of limited recourses (to be explained further in the following slides) and encourage students to give their opinion on how long it is possible to continue the way of living we are used to.

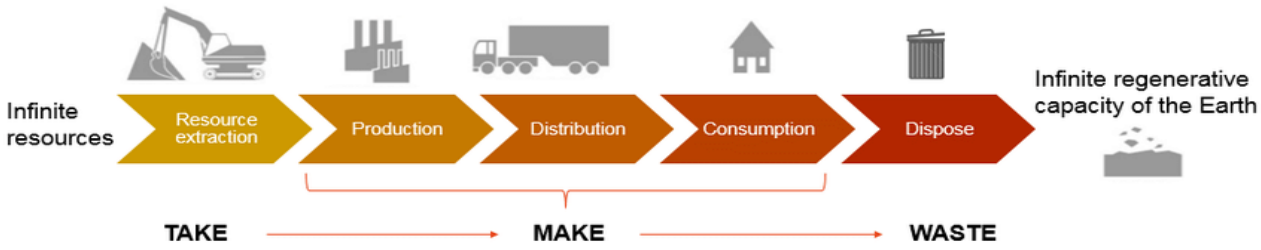


FIGURE 1 THE LINEAR ECONOMY-THE 'TAKE, MAKE AND WASTE' APPROACH OF PRODUCTION [2]

Figure 1 is presented on slide 3. Explain to students how such kind of linear economic model follows the *'take, make, waste'* pattern and how its foundations are two assumptions: infinity of resources (energy and virgin materials) as well as a limitless regenerative capacity of the Earth. Accordingly, as the world population, its demands and the economy grow, more and more raw materials are needed to produce goods and the amount of waste will similarly increase.

Ask students whether these are valid assumptions?

[3] Important concepts and definitions linked to the idea are explained in the end of the chapter, with recomendations given for further reading.

ALTERNARIVE TO THE SLIDES

Ask students who have completed the homework to draw the linear economy model and circular economy model to the black- / whiteboard to follow the topics to be covered under introduction sub-session.

ADVANCED

Discuss whether students know what “greenwashing” means.

Slide 4 Re-thinking the economy

Continue with watching jointly the video provided among Ellen McArthur course materials which introduces the students into the topic of circular economy. The video was also part of the material students were expected to watch independently as homework - **Re-thinking progress: What is Circular economy https://youtu.be/zCRKvDyyHmI** (can be previously downloaded).

Slide 5 Entry discussion based on the homework

Encourage a discussion to follow. The illustration of the circular economy model used on the slide is explained in further slides of the course. Presently use it just as the background illustration that helps to develop ideas for discussion.

Options to expand discussion (take one topic in depth or go through all of them):

- **PERSONAL:** Encourage students to think if they know somebody who masters reduce-reuse-recycle lifestyle? Meaning the ability to repurpose things left out of use or broken. Grandparents? Other crafty acquaintances/family members/friends? Can the students do this themselves as well? Have they done it? If not, what hinders it?

- **PERSONAL:** how long do you use your phone/other equipment/clothes? If you get new, what happens to the old?

- **WORLD ECONOMY**: Ask students if they know large companies who apply circular economy principles in everyday practices.

Good examples to use for discussion:
H&M - https://hmgroup.com/sustainability/circular-and-climate-positive/circularity-and-our-value-chain.html

Burberry –
https://www.burberryplc.com/en/news/news/responsibility/2019/burberry-and-the-realreal-join-forces-to-make-fashion-circular.html/?utm_source=luxe.digital

- **BENIGN PRODUCTION RULES**: Discuss with students, if they know which species groups outnumber humans in the planet. Consider both population numbers and biomass. How is it possible that the species that outnumber us do not harm the planets ecosystems?

References to prepare for the discussion:
Along With Humans, Who Else Is In The 7 Billion Club? -
https://www.npr.org/sections/thetwo-way/2011/11/03/141946751/along-with-humans-who-else-is-in-the-7-billion-club?t=1595238792899&t=1596982796355

The biomass distribution on Earth -
https://www.pnas.org/content/115/25/6506

IMPORTANT CONCEPTS AND DEFINITIONS

***Finite resources** [3], **Renewable resources** [4]*

Finite resource(non-renewable resource) A resource that is concentrated or formed at a rate very much slower than its rate of consumption and so, for all practical purposes, is non-renewable.

Renewable resources are elements that can be replenished over time through natural processes such as farming. We tend to envision those little blue bins with the recycle symbol on them, but renewable resources span far beyond what we toss in the recycling bin.

***Compostable/ biological vs technical materials** [5]*

Biological materials are made from things that grow and which ultimately can go back into the soils (perhaps by composting, or through anaerobic digestion) and improve it. They are natural materials that can be safely disposed of in a manner, which allows the soil to regenerate; thus, they must not contain any toxins.
Technical materials are metals, polymers, etc. They are materials designed to continually flow at high quality in closed industrial cycles.

***Circular economy** [6]*

The circular economy refers to an industrial economy that is restorative by intention; aims to rely on renewable energy; minimises, tracks, and hopefully eliminates the use of toxic chemicals; and eradicates waste through careful design. In a circular economy there is a need for a 'functional service' model in which manufacturers or retailers increasingly retain ownership of their products and act as service providers, selling the use of the products, rather than the products themselves. It also requires changes in product design and business models to generate more durable products that are designed for disassembly and remanufacture or refurbishment.

Throw-away culture [7]

is a human society strongly influenced by consumerism. The term describes a critical view of overconsumption and excessive production of short-lived or disposable items over durable goods that can be repaired.

***Greenwashing** [8]*

Greenwashing is the process of conveying a false impression or providing misleading information about how a company's products are more environmentally sound. Greenwashing is considered an unsubstantiated claim to deceive consumers into believing that a company's products are environmentally friendly.

II - CIRCULAR ECONOMY AND SUSTAINABLE DESIGN

Estimated duration of the session ~30 minutes

Slides: II_circulareconomyandsustainabledesign.pptx

Proposed progress of the sub-session

Slide 1

Explain that the course is now going to explain the concept of circular economy a bit further, we will discuss the circularity in natural processes and whether there's waste in functioning natural ecosystems. Then we will show in comparison, the way people operate, how much waste is produced and where does this waste go. After understanding the environmental pressure, the waste is causing, we will investigate the road to circular economy and explain how it works. Finally, we look into how one should think when expecting to design something for sustainability and circularity.

Slide 2 Examples of natural circulation

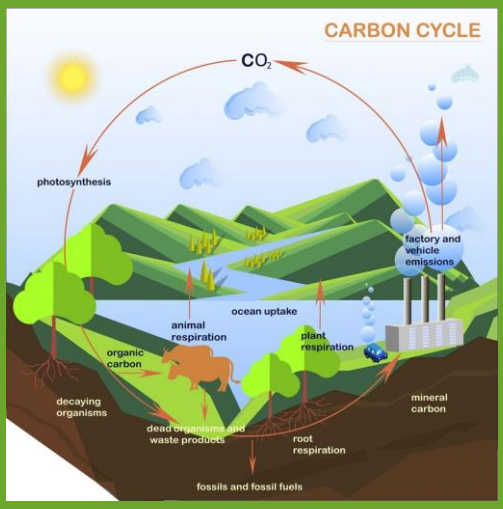
Nature is an excellent example of circular economy (everything functions organically without producing any waste). *A major outcome of taking insights from living systems is the notion of optimising systems rather than components, which can also be referred to as 'design to fit'—by analogy, the tree is nothing without the forest.*

Ask students to describe the cycles in the slides. See the brief descriptions and further reading on the cycles given on the slide on next page.

DISCUSSION OPTIONS

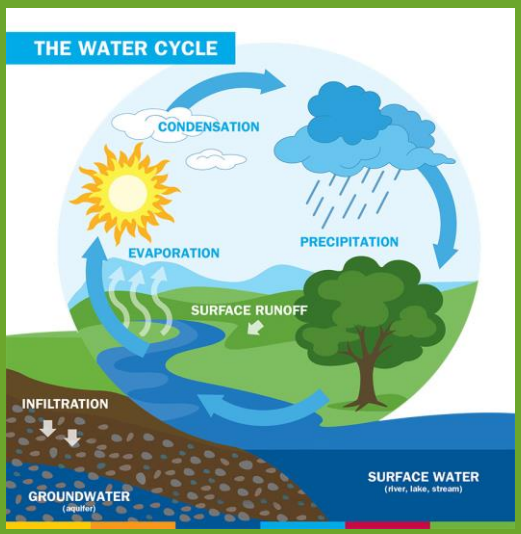
Name the cycles shown on slide, let students explain them briefly:

Carbon cycle [9]: The carbon cycle is the cycle by which carbon moves through our Earth's various systems. The carbon cycle is influenced by living things. Atmospheric changes, ocean chemistry, and geologic activity are all part of this cycle. The levels of carbon are at an all-time high, largely due to human activities. Carbon is an element found in many different forms and locations within our Earth's atmosphere and biosphere. The carbon cycle is essentially nature's way of reusing carbon atoms in different ways and in varying places. Carbon travels from the atmosphere into organisms and the earth and then back into the atmosphere in the process.



Read more: https://study.com/academy/lesson/what-is-the-carbon-cycle-diagram-process-definition.html

Water cycle [10] - Earth's water is always in movement, and the natural water cycle, also known as the hydrologic cycle, describes the continuous movement of water on, above, and below the surface of the Earth. Water is always changing states between liquid, vapor, and ice, with these processes happening in the blink of an eye and over millions of years.



Read more: https://www.usgs.gov/special-topic/water-science-school/science/fundamentals-water-cycle?qt-science_center_objects=0#

Ask students if the can name additional circular processes in nature?

Ideas [11]: Nitrogen cycle, Food chain, Phosphorus cycle, Nutrient cycle, Oxygen cycle, Sulfur cycle, Rock cycle.

Slide 3 Waste in natural cycles?

Biochemical cycles and other circular processes in nature do produce "waste" at least in form of loss of energy. This, however, is not harming the Earth's atmosphere and biosphere. The figure on the slide explains the ecological pyramid.

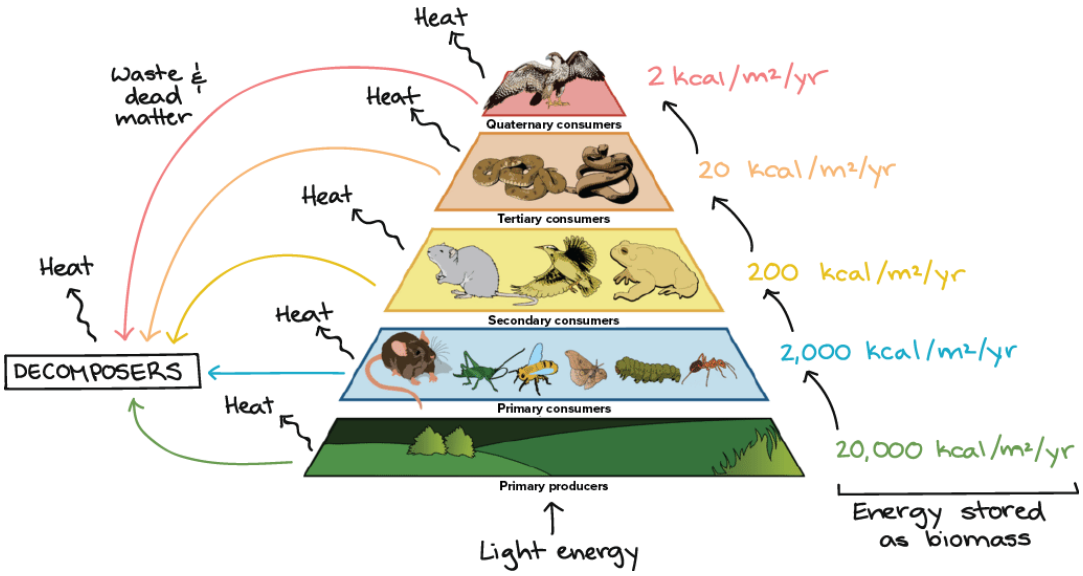


FIGURE 2 ECOLOGICAL ENERGY PYRAMID [12]

Energy is passed up the food chain from one trophic level to the next. However, only about 10 percent of the total energy stored in organisms at one trophic level is transferred to organisms at the next trophic level. The rest of the energy is used for metabolic processes or lost to the environment as heat. As a result, less energy is available to organisms at each successive trophic level. This explains why there are rarely more than four or five trophic levels. The amount of energy at different trophic levels can be represented by an ecological energy pyramid. Such energy loss directs the adaptation of ecosystems and ecological balance.

Slide 4 How much waste is produced?

The mankind operates in a much different way.

In 2014. **EU produced 2 500 000 000 tonnes of waste in a year** [13]. From 2005 onwards the average amount of municipal waste as measured per capita declined by 7% in the EU. However, trends can vary by country. For example, while municipal waste per capita increased in

EMPHASIZE

EU produced 2 500 000 000 tonnes of waste in a year. Compare the pyramid of Cheops that weighs 7 million tonnes and covers 5 hectares. To calculate the amount of waste only EU produces in one year it can be measured with 357 pyramids.

COME BACK

Throw-away-society

The throw-away society is a human society strongly influenced by consumerism. The term describes a critical view of overconsumption and excessive production of short-lived or disposable items over durable goods that can be repaired. In its August 1, 1955 issue Life magazine published an article titled "Throwaway Living". This article has been cited as the source that first used the term "throw-away society".

Today, we would expect an article of this title to be critiquing the throwaway society that we live in. But no, in the 1950s the new disposability of items was nothing but positive. The article focuses on the idea that these new throwaway items give us (or, more specifically, 'housewives') back time which would have been spent cleaning plates, towels, diapers, ash trays, and even 'a feeding dish for dogs'…

Denmark, Germany, Greece, Malta and the Czech Republic, it decreased in Bulgaria, Spain, Hungary, Romania and the Netherlands.

The EU wants to promote the prevention of waste and the re-use of products as much as possible. If this is not possible it prefers recycling (including composting), followed by using waste to generate energy. The most harmful option for the environment and people's health is simply disposing of waste, for example on landfill, although it is also one of the cheapest possibilities.

Slide 5 Objectives of waste management

Slide shows the waste hierarchy, or waste management pyramid, is a tool used in the evaluation of processes that protect the environment alongside resource and energy consumption from most favourable to least favourable actions.

The aim of the waste hierarchy is to extract the maximum practical benefits from products and to generate the minimum amount of waste. The proper application of the waste hierarchy can have several benefits. It can help prevent emissions of greenhouse gases, reduces pollutants, save energy, conserves resources, create jobs and stimulate the development of green technologies.

FIGURE 3 WASTE MANAGEMENT PYRAMID [14]

Explain to students the life-cycle-thinking (see next page).

IMPORTANT CONCEPTS & DEFINITIONS

Life-cycle thinking [15]

All products and services have environmental impacts, from the extraction of raw materials for production to manufacture, distribution, use and disposal. Following the waste hierarchy will generally lead to the most resource-efficient and environmentally sound choice but in some cases refining decisions within the hierarchy or departing from it can lead to better environmental outcomes.

Life cycle thinking and assessment can be used to support decision-making in the area of waste management and to identify the best environmental options. It can help policy makers understand the benefits and trade-offs they have to face when making decisions on waste management strategies. Life-cycle assessment provides an approach to ensure that the best outcome for the environment can be identified and put in place. It involves looking at all stages of a product's life to find where improvements can be made to reduce environmental impacts and improve the use or reuse of resources.A key goal is to avoid actions that shift negative impacts from one stage to another. Life cycle thinking can be applied to the five stages of the waste management hierarchy.

For example, life-cycle analysis has shown that it is often better for the environment to replace an old washing machine, despite the waste generated, than to continue to use an older machine which is less energy-efficient. This is because a washing machine's greatest environmental impact is during its use phase. Buying an energy-efficient machine and using low- temperature detergent reduce environmental impacts.

The European Union Waste Framework Directive has introduced the concept of life-cycle thinking into waste policies.This duality approach gives a broader view of all environmental aspects and ensures any action has an overall benefit compared to other options. The actions to deal with waste along the hierarchy should be compatible with other environmental initiatives.

Slide 6 Waste reality

Waste pyramid describes the ideals of the waste management. The reality is much different. For example, when it comes to plastic waste, which takes more than 400 years to degrade and only 12 percent has been incinerated[4] and even less, 9%, has been recycled [16]

Slide 7 Where the waste ends up?

Further, globally, most waste is currently dumped or disposed of in some form of a landfill. Some 37 percent of waste is disposed of in some form of a landfill, 8 percent of which is disposed of in sanitary landfills with landfill gas collection systems. Open dumping accounts for about 33 percent of waste, 19 percent is recovered through recycling and composting, and 11 percent is incinerated for final disposal. Adequate waste disposal or treatment, such as controlled landfills or more stringently operated facilities, is almost exclusively the domain of high- and upper-middle-income countries. [17]

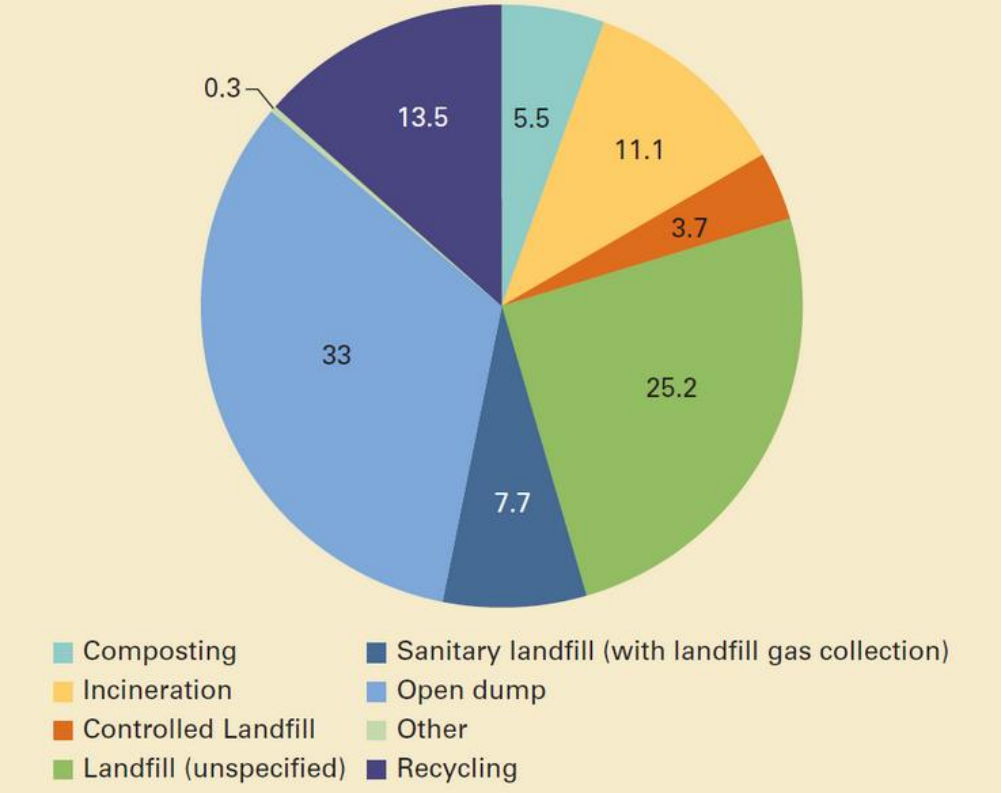


FIGURE 4 GLOBAL TREATMENT AND DISPOSAL OF SOLID WASTE (PERCENT) [17*]

[4] Incinerate - to burn something completely

Slide 8

Lower-income countries generally rely on open dumping; 93 percent of waste is dumped in low-income countries and only 2 percent in high-income countries. Three regions openly dump more than half of their waste—the Middle East and North Africa, Sub-Saharan Africa, and South Asia. Upper-middle-income countries have the highest percentage of waste in landfills, at 54 percent. This rate decreases in high-income countries to 39 percent, with diversion of 36 percent of waste to recycling and composting and 22 percent to incineration. Incineration is used primarily in high-capacity, high-income, and land-constrained countries. [17]

FIGURE 5 WASTE MISMANAGEMENT [18]

Slide 9 Global ecological footprint

Explain the global trends in the context of waste. The world population has reached up to 7,8 billon people [19], if you want to be more up to date with the number, you can check the more precise estimate for the lesson from the world population meter. The projection for the future proposes the world population is about to grow up to 9 billion by 2050. See figure 6 for illustration.

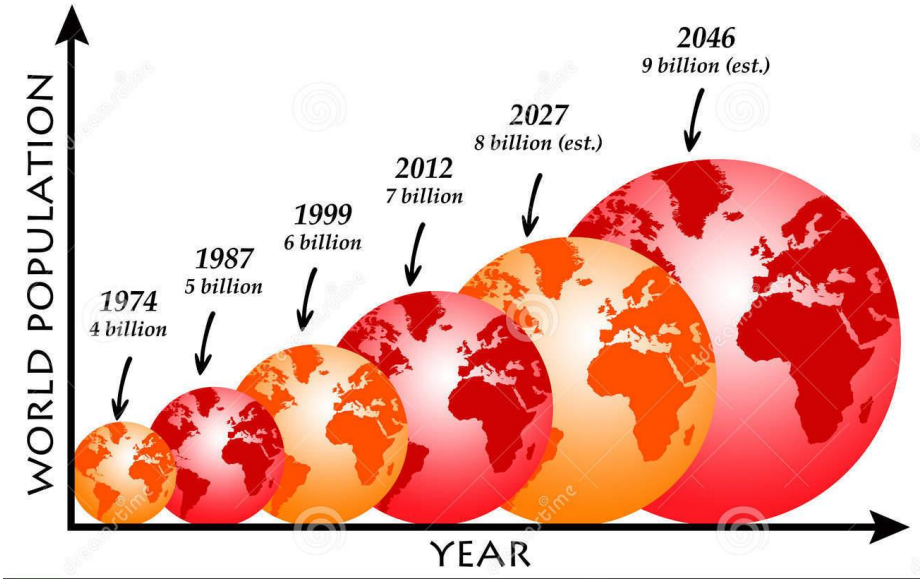


FIGURE 6 WORLD POPULATION PROJECTION [20]

In the same time the progress and economic development does not decrease the need for resources (materials, food, energy), but rather increases the consumption and provides additional pressure to the planet.

The slide shows a map describing comparison of average CO^2 emissions of world countries estimated per capita (figure 6). The study on which the illustrative map is designed, included 138 countries and was first ever global approach to find connections between growth, prosperity, and ecological sustainability, using data from the World Bank, the Global Footprint Network and OECD. Though it is already evident that growth is not always the expected scenario and degrowth might be needed, then the rich and overdeveloped countries do not have the right to stop the development of poor and developing countries.

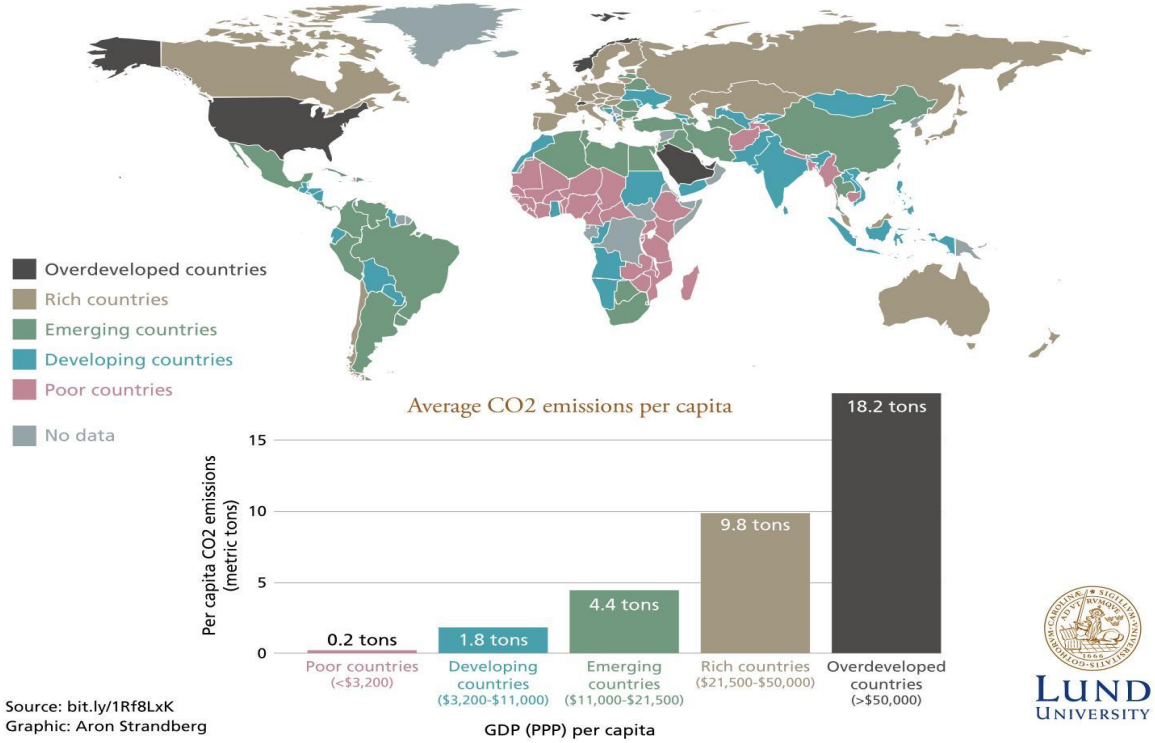


FIGURE 7 ECONOMIC DEVELOPMENT AND CARBON FOOTPRINT OF COUNTRIES [21]

Virgin ecological resources and energy needed to cover the needs for both growing population and growing world economy, exceeds by far what Earth manages to regenerate.

If everyone would consume energy, materials, services etc as do the overdeveloped countries, we would need far more space on Earth. See figure 7 for the extreme examples comparing the poor countries and the overdeveloped countries.

The figures 5 and 7 are not given on the slides, but teachers can easily illustrate their content to the blackboard whilst explaining the background information to the slide.

Earth Overshoot Day

Earth Overshoot Day marks the date when humanity's demand for ecological resources and services in a given year exceeds what Earth can regenerate in that year [22].

22nd of August 2020

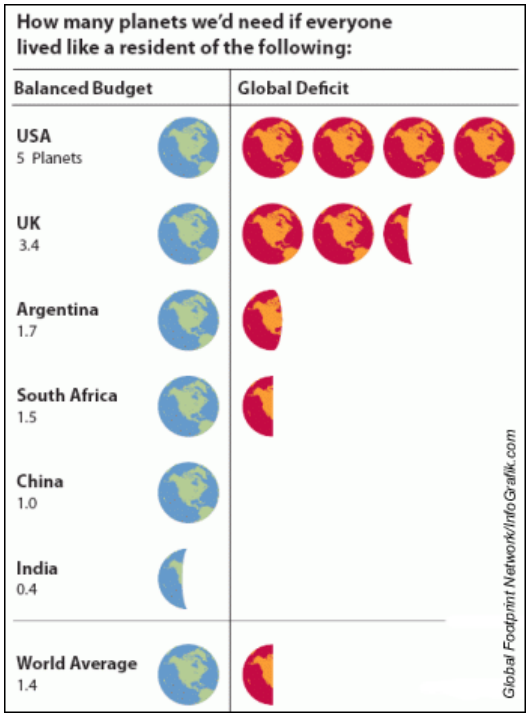


FIGURE 8 HOW MANY PLANETS WE'D NEED IF EVERYONE LIVED LIKE A RESIDENT OF THE FOLLOWING COUNTRIES [23]

Slide 10 Way of thinking

On the slide is given a very famous quote from Albert Einstein. It is actually not proven, that the exact words have been said by the famous physicist and some authors consider that the famous quote is a paraphrase from the "A new type of thinking is essential if mankind is to survive and move toward higher levels.", which is documented from "Atomic Education Urged by Einstein", New York Times (25 May 1946), and later quoted in the article "The Real Problem is in the Hearts of Man" by Michael Amrine, from the New York Times Magazine (23 June 1946). [24]

Still we propose we use the famous quote, as it might inspire students towards the right direction. Teachers can modify the slides to use the proven wording if they consider it necessary. Also, teachers can use this example to demonstrate the students to proof their references!

Slide 11 Development of circular economy concept

The concept of a circular economy cannot be traced back to one single date or author, rather to different schools of thought. Many scholars considered that the circular

economic system was primarily introduced by the environmental economists Pearce and Turner, who built their theoretical framework on previous studies of the ecological economist Kenneth Boulding. Despite of some divergences, the various schools of thought all have the same starting point: our present industrial economic system is not sustainable, and we have to re-establish a positive interaction with the environment. [2]

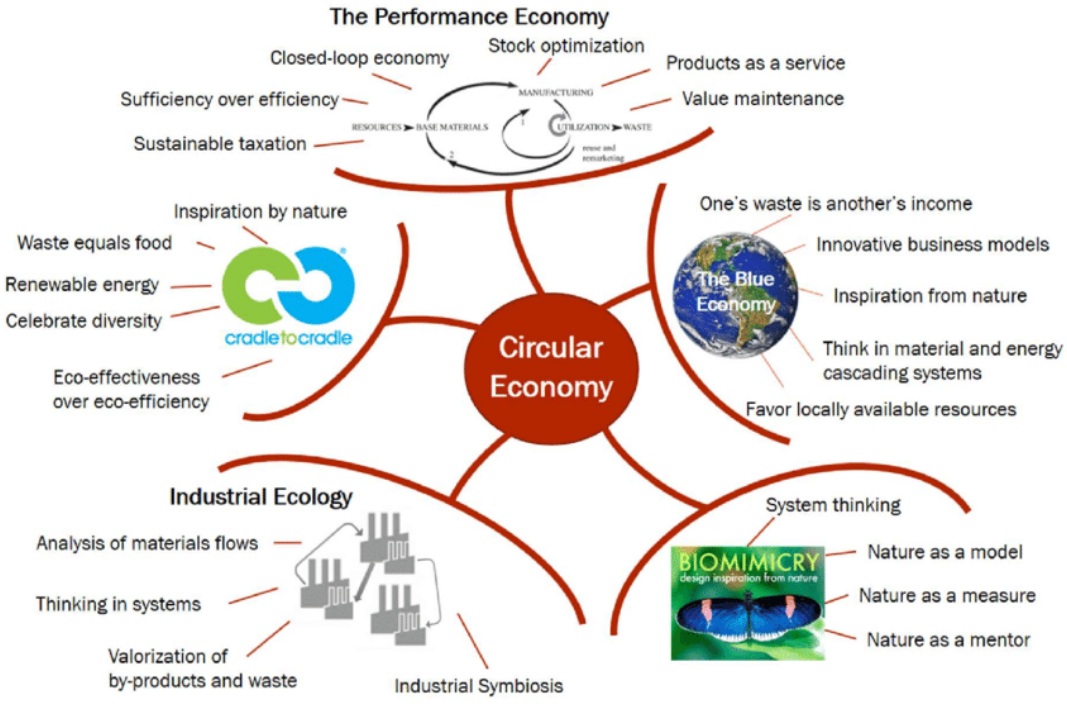


FIGURE 9 THE DIFFERENT SCHOOLS OF THOUGHT THAT HAVE INFLUENCED THE DEVELOPMENT OF CIRCULAR ECONOMY [2]

IMPORTANT CONCEPTS & DEFINITIONS

Cradle-to-cradle [25]

Cradle-to-cradle design is a biomimetic approach to the design of products and systems that models human industry on nature's processes, where materials are viewed as nutrients circulating in healthy, safe metabolisms – without any loss in quality. The term itself is a play on the popular corporate phrase "cradle to grave", implying that the C2C model is sustainable and considerate of life and future generations—from the birth, or "cradle", of one generation to the next generation, versus from birth to death, or "grave", within the same generation.

This model is based on nature where everything is a nutrient and waste simply does not exist. Cradle to Cradle differentiates between two separate cycles:

- The biological cycle comprises products of consumption which can be returned to this cycle after they have been used. They become compost or some other kind of nutrient so they can be used to promote plant growth.
- The technical cycle comprises products of service and materials which can be recycled again and again – with all their individual parts able to be recovered and separated exactly according to type so they can be re-used to make new products.

First mention, 2002, McDonough, William; Braungart, Michael

See video about the concept LINK

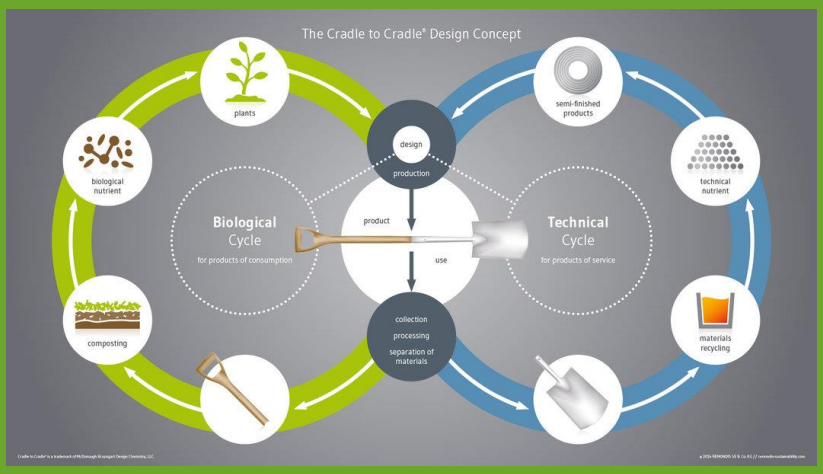


FIGURE 10 CRADLE TO CRADLE DESIGN CONCEPT [26]

Performance economy [27]

How can we create the highest possible use value for the longest possible time while consuming as few material resources and energy as possible? The objectives of this “performance” economy are to exploit science and knowledge as drivers to uncouple revenue and wealth creation from resource throughput, by focusing on smart materials, smart goods and smart solutions.

First mention 2010, Walter Stahel

See video about the concept LINK

IMPORTANT CONCEPTS & DEFINITIONS

Blue economy [28]

All economic activities related to sustainable use oceans, seas and coasts. Blue economy covers a wide range of interlinked established and emerging sectors and is adapted in the policies of various international organizations in the world European Commission, World Bank, Commonwealth of Nations etc.

First mention, 2012, United Nations

Industrial ecology [29]

Industrial ecology is a nascent and challenging discipline for scientists, engineers, and policymakers. Often termed the “science of sustainability. Industrial ecology attempts to induce balance and cooperation between industrial processes and environmental sustainability, such that neither violates the other. This approach, thus, aims to develop industrial processes that minimize material waste and pollutants in materials, according to the cradle-to-cradle concept.

First mention, 1989, Frosch and Gallopoulos

Biomimicry [30]

Biomimicry is a practice that learns from and mimics the strategies found in nature to solve human design challenges. It is a practice that learns from and mimics the strategies used by species alive today. The goal is to create products, processes, and policies — new ways of living — that solve our greatest design challenges sustainably and in solidarity with all life on earth. We can use biomimicry to not only learn from nature’s wisdom, but also heal ourselves — and this planet — in the process.

Slide 12 Circular economy

Understanding why the concept has evolved and what are the main schools of thought that have influenced the development of the concept we finally can start looking into what is circular economy and what are the main principles behind it.

Circular economy is an economy that is restorative and regenerative by design. In a circular economy economic activity builds and rebuilds overall system health. The concept recognises the importance of the economy needing to work effectively at all scales – for big and small businesses, for organisations and individuals, globally and locally.

It is based on three principles:

- Design out waste and pollution;
- Keep products and materials in use;
- Regenerate natural systems.

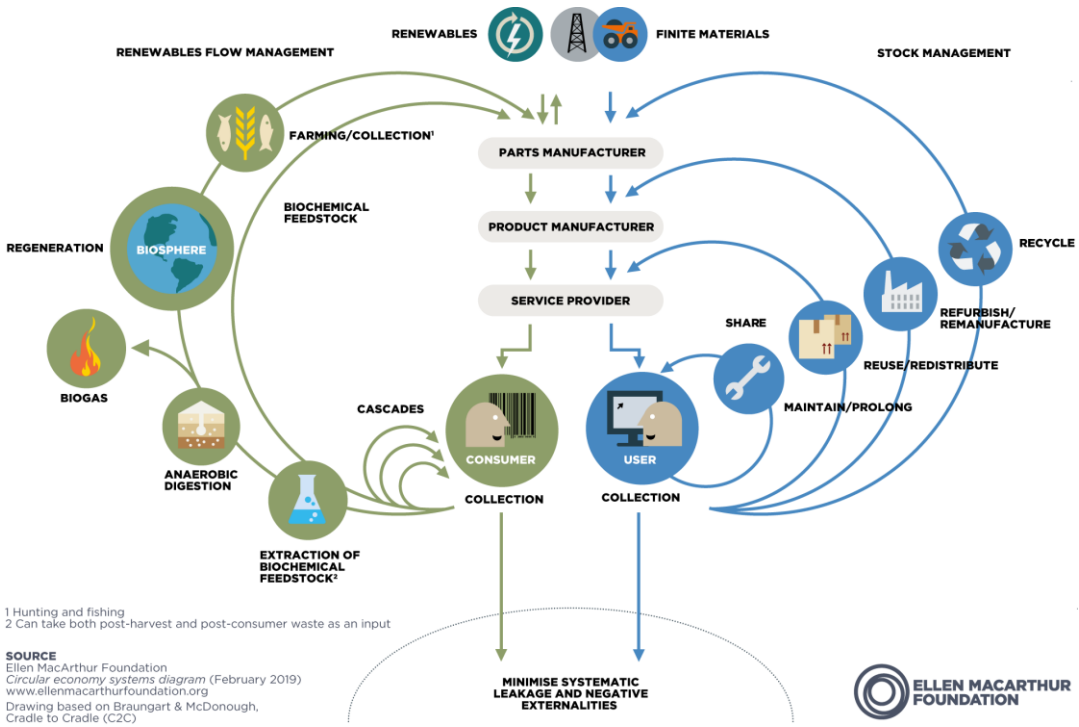


FIGURE 11 CIRCULAR ECONOMY [31]

The slide illustrates the concept with the famous butterfly diagram developed by Ellen McArthur Foundation. The diagram captures the flow of materials, nutrients, components, and products, whilst adding an element of financial value. It builds on several schools of thought but is most recognisably influenced by Cradle to Cradle's two material cycles. The important concepts illustrated in the diagram are described on the next page.

IMPORTANT CONCEPTS & DEFINITIONS [31]

Maintain / Prolong – innermost loop of the technical cycle shows the strategy of keeping products and materials in use by prolonging their lifespan for as long as possible through designing for durability as well as maintenance and repair.

Reuse/redistribute – technical products and materials can also be reused multiple times and redistributed to new users in their original form of with little enhancement of change (eBay);

Refurbish/remanufacture – two similar, but slightly different processes of restoring value to a product. When a product is remanufactured, it is disassembled to the component level and rebuilt. Refurbishment is largely a cosmetic process, whereby a product is repaired as much as possible, but usually without disassembly.

Recycle – process of reducing a product all the way back to its basic material level, thereby allowing those materials (or a portion of them at least) to be remade into new products.

Cascades – this loop, within the biological cycle, refers to the process of putting used materials and components into different uses and extracting, over time, stored energy and material order. Along the cascade, this material order declines until the material ultimately needs to be returned to the natural environment as nutrients.

Biological and technical material flows - The first thing that most people notice about the diagram is the separation into two distinct halves, or cycles, which represent two fundamentally distinct flows of material: biological and technical.

- Biological materials - represented in green cycles on the left side of the diagram - are those materials that can safely re-enter the natural world, once they have gone through one or more use cycles, where they will biodegrade over time, returning the embedded nutrients to the environment.
- Technical materials - represented in blue on the right hand side - cannot re-enter the environment. These materials, such as metals, plastics, and synthetic chemicals, must continuously cycle through the system so that their value can be captured and recaptured.

Access vs ownership - One subtlety of the diagram is the distinction between consumers and users. In a circular economy, biological materials are the only ones that can be thought of as consumable, while technical materials are used. It makes no sense to say that we consume our washing machines and cars in the same way that we consume food. This is a subtle, but important distinction in how we view our relationship to materials.

Further to this, it raises questions about the necessity of owning products in the way that we traditionally do. What benefit is there in owning a drill when you just want to put holes in your wall to hang a picture? It is access to the service a product provides that is important, rather than the product itself.

Explain the students the diagram in detail. Ask questions like the ones provided below, to understand if they follow the ideas presented:

Where on the butterfly diagram would you place:

- a mobile phone repair service?
- a car-sharing scheme?
- plastic bottle recycling?
- Wastewater treatment?

On following slides are given a few examples how the circular economy could be translated into possible products and what kind of values it can create.

Slide 13 – Pure flows of materials. Power of pure circles.

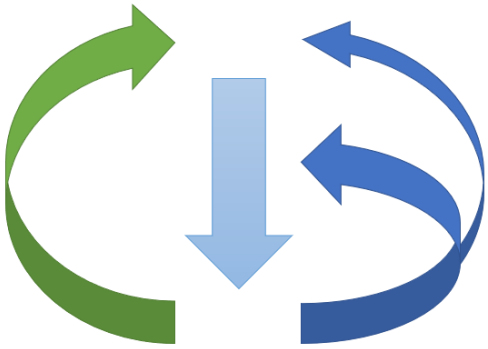


FIGURE 12 POWER OF PURE CIRCLES (PURE MATERIAL FLOWS)

Explain the idea behind the power of pure circles Design products so the materials keep their quality. Products should be planned and designed for disassembly and maintaining their original properties.

Ask students about the example on the slide: When building a house, should gypsum boards be set up with adhesive or screws?

Slide 14 – Repairing, redesigning, reusing existing products. Power of inner circles

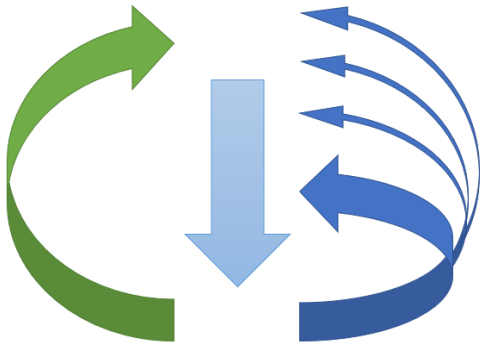


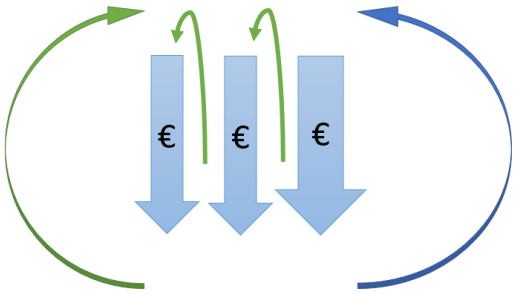
FIGURE 13 POWER OF INNER CIRCLES (REPAIR, REUSE, RECYCLE)

Explain the idea behind the power of inner circles. Products should be designed in a way that they are repairable, the material do not use their properties if reused in diferent form. As important are also development and running of the repair services (offer of replacement parts, skills etc), or reuse networks for collecting, storing and redistibuting/reselling the products.

Explain the example on the slide: Patagonia declares it stands behind everything they make, but sometimes you want to take matters into your own hands. Patagonia provides DIY repair and care guides and proovides campaign WornWear.com to trade in the used gear for credit you can put toward something new. [32]

Ask if students can propose similar examples.

Slide 15 – Upcycling waste into new products. Power of cascaded use.



The prerequisite of upcycling is keeping the material flows pure and products suitable for disassembly. If this is covered the solutions can be developed to process the used products and develop new products from the disassembled materials.

Explain the example on the slide: Presereve plastics partners with companies who use plastic packages (eg yoghurt cans) collects their waste and turns it into new products [33]

FIGURE 14 HOW THE PRESERVE PLASTICS WORK [33]

The preserve plastics collects polypropylene plastics, recycles it into products and also has a collect and recycle procedure established for their own products. Ideally this could be a closed loop system.

Discuss

How wastewater treatment is organized in your town.

Slide 16– Desing for lasting longer. Power of resilience

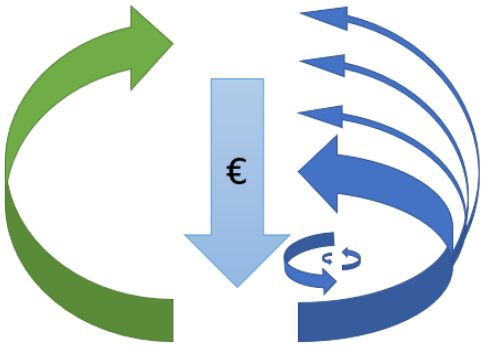


FIGURE 15 DESIGNING PRODUCTS TO LAST LONGER. POWER OF RESILIENCE.

The main motivation in the market economy – profit orientation, is interested that the market participants consume more. In linear economy products are designed with a limited timespan and are expected to be exchanged within short timespan. The circular economy promotes products to last longer, in sense of market economy it responds to high value products.

Example on the slide: vintage clothes and cars.

Slide 17 – Designing for sustainability. Means and ends.

Last but not least if you want to change the way the economy works and you do not have a great idea yet in mind then there are ways to encourage innovative thinking. We propose one option developed by Savannah College of Art and Design (SCAD) [34]

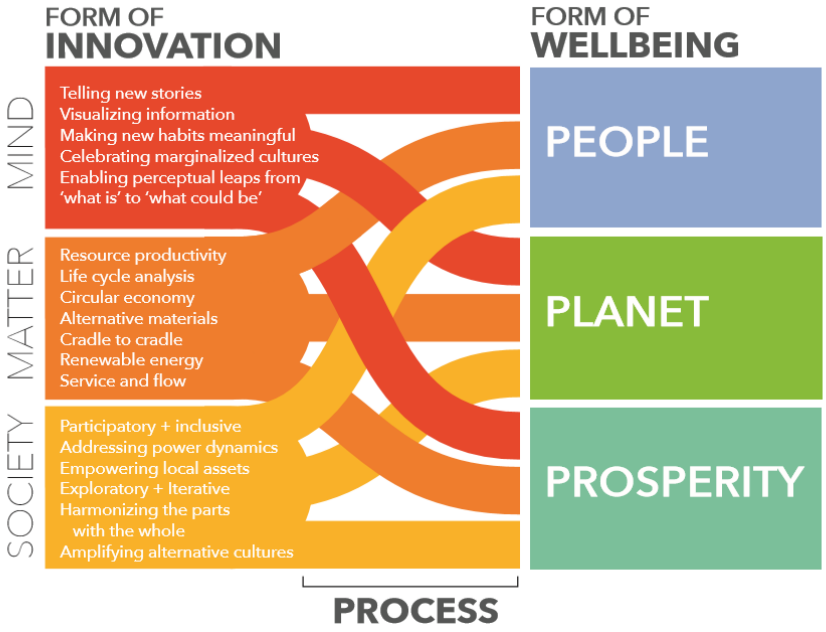


FIGURE 16 HOW TO ENCOURAGE INNOVATIVE DESIGN FOR SUSTAINABILITY [34]

Innovation generally starts with questions; why are things the way they are, and what keeps them in that state even when imperfections are obvious, abundant, and even fundamentally problematic? We're a strange species; while our desire for change is constant, dysfunctional habits whose detrimental impacts are on full display can remain sacred and ingrained.

The innovation doesn't have to equal with high tech technology, it is just one aspect of innovation. Innovation can be advancing the technologies ('matter' in the figure), but it can be also changing social systems (regulations, public services etc) or it can also be perceptual ('mind' on the slide). Also innovation could only address the saving of planet or target directly the the welfare of people and contribute to the economy. The students will work with innovation and design issues with latter lessons.

CASE EXAMPLE: Cup circulation caused opposition in Tartu [35]

In the summer of 2019, four bars in Tartu (Estonia) agreed among themselves to start selling beverages in reusable plastic cups.

The concern of the bars was that client tended to break glasses or to leave the venue with them. Disposable cups often littered the streets, especially, when the clients visited several bars during the evening. The four bars ordered 10 000 reusable plastic cups, that had the logos of all the four bars printed on them.

The idea was simple: when the client buys a beverage, it will be poured into the reusable cup and the client pays additional 2 euros deposit for the cup. If the cup is returned to the bar, the client gets their deposit back in full. In August 2019, the bars started serving drinks from these reusable cups.

In autumn, Tartu city government officials informed the bars that the cup circulation could not be conducted in this manner. The problem was that the option to return the cup in any of the four bars was believed to arouse the wish of people to stroll in between bars and drink their beverages on the street. Law however prohibits the consumption of alcohol on the city streets. Of course, the city officials did not oppose the idea of cup circulation. For the bar owners, this decision was unexpected; they had hoped to have the cup circulation work in all the venues of the city.

In this story, two opposing understandings met: the concern of bar owners over the excess waste, and the officials' concern for public order and policy. By November 2019, the city and bar owners had not reached a solution yet.

Use the possibility to discuss.

- What kind of innovation was proposed according to the SCAD sustainable design scheme?
- What kind of innovation was missing for it to be accepted?

III - CIRCULAR ECONOMY EXCERCISE

Estimated duration of the session ~30 minutes

Product Life Cycle Assessment (LCA): „From Cradle to cradle“

Divide students into groups (4 people in a group). Give each group an object (pen, toothbrush, umbrella, plastic bottle, etc). Groups can have different objects or the same object.

Explain what a LCA is (definition given in the callout) and why it is important. Talk about the 5 steps of a product life cycle: Cradle to Gradle and Cradle to Grave concept (information below).

1. Each team has 10-15 minutes to think about the life-cycle and production chain of the object.

2. The end goal is to make the object more sustainable by reducing its emissions during the lifecycle. Another goal is to manufacture it more efficiently.

3. Teams define the environmental inputs and outputs of a product at each of the 5 stages (listed below). Inputs and outputs can be:

    a. Raw materials or resources

    b. Different types of energy

    c. Water

    d. Emissions to air, land or water by substance

4. In order to simplify the exercise exact calculations are not necessary. Students will get an overall idea how complex the life cycle of a product is and how much resources are being used at each stage.

5. Students will now think of how to make the life cycle of a product more sustainable. For example, could we try to reduce the amount of electricity needed in the production, or switch to a source of green energy.

Definition

A Life Cycle Assessment (LCA) is an analysis of the impact one object has on the world around it.

Understanding the concept

Cradle to Grave is a concept where cradle is the inception of the product with the sourcing of the raw materials, grave being the disposal of the product. Transportation is mentioned as step 3, but can, in reality, occur in between all steps.

Cradle-to-cradle is a concept often referred to within the Circular Economy. It is a variation of cradle-to-grave, exchanging the waste stage with a recycling process that makes it reusable for another product, essentially "closing the loop". This is why it is also referred to as closed loop recycling. [36]

6. Guided group discussion will follow: each team has a few minutes to say what they found out and what they learned during the process.

7. Next step would be to design a sustainable alternative for the product/ object assessed (this could be done at home).

Cradle to Grave/ Gradle: the product life cycle consists of 5 stages:

- Raw Material Extraction
- Manufacturing & Processing
- Transportation
- Usage & Retail
- Waste Disposal – recycling/ upcycling/ re-using aka closing the loop

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