Interreg
Baltic Sea Region

Co-funded by
the European Union

CIRCULAR ECONOMY
Circular spaces

Circular makerspaces:
training program

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Empowering makerspace communities with a comprehensive view on circular economy principles, fostering sustainable innovation, resource efficiency, and a circular mindset

This education program was developed under the Circular Spaces project, funded by Interreg Baltic Sea Region programme 2021-2027

FOREWORD

Welcome to the training program on circular economy designed specifically for makerspaces! In a world where sustainability and resource efficiency are paramount, this program is tailored to empower makerspace enthusiasts with the knowledge and skills to thrive in the dynamic intersection of creativity and circular principles. Explore the essential concepts and working methods driving sustainable innovation and join us in reshaping the future of making through this immersive learning experience.

In the changing field of innovation, makerspaces play a crucial role in shaping the future of creative projects. As we navigate a world increasingly focused on sustainability and responsible resource management, the need for a circular mindset within makerspaces becomes ever more apparent. This circular training program is designed to empower makers with the knowledge, skills, and inspiration to infuse circular principles into their projects, fostering a community of innovators committed to both creativity and environmental responsibility. Welcome to a transformative journey, where making meets sustainability, and together, we shape a more circular and thoughtful future.

Circular Spaces Project Team

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How to make use of this program?

Circular makerspaces training program consists of 9 Topics closely complementing each other. Topics 1-4 and 9 focus on building trainees' theoretical knowledge regarding different aspects of circular economy, while Topics 5-8 target practical application of gained insights.

1. Circular Economy and Sustainability
2. Waste as a Resource in Circular Economy
3. Circular Value Chains, Ecosystems, and People
4. Circular Business Models
5. Life Cycle Thinking and Environmental Footprint
6. Design Thinking for Circular Products
7. Reusability, Repairability, Recyclability
8. Integration of Circular Approaches into Everyday Work Life
9. Circular Economy Policies across Baltic Sea Region Countries

While the most benefits for trainees come from the exploration of all Topics, each trainer can decide individually how to structure their organization of trainings by utilizing different selected topics. Examples below suggest a few formations of such option.

Circular design-oriented training structure

- Waste as a Resource in Circular Economy
- Life Cycle Thinking and Environmental Footprint
- Design Thinking for Circular Products
- Reusability, Repairability, Recyclability

Circular behaviour-oriented training structure

- Circular Value Chains, Ecosystems, and People
- Circular Business Models Integration of Circular
- Approaches into Everyday Work Life
- Circular Economy Policies across Baltic Sea Region Countries

Introduction to circular economy training structure

- Circular Economy and Sustainability
- Integration of Circular Approaches into Everyday Work Life
- Circular Economy Policies across Baltic Sea Region Countries

Each Topic begins with methodological notes which serve as a guiding material for trainers during the preparation and the organization of training activities. These notes include a summary of each Topic, expected training outcomes, defined training benefits for different target groups, training plan and other necessary information for carrying out the training.

Action required tasks, such as discussions, workshops or case analyses, are marked with blue text and activity icon. It is up to the trainer to decide how these tasks will be carried out. For example, trainees can go through the theorical materials individually and implement action required tasks in groups.

Activity icon

In addition to this document, **each Topic is accompanied with slides** which can be utilized as a supporting material for trainers when presenting training content. The slides can be freely accessed **here**.

This document can be used both as an **instruction manual for the trainer** and as **informational material for the trainees**. Training organisers are invited to add their own insights, local best practices or creative practical exercises to the material presented.

Circular Economy and Sustainability

Developed by
Technical University of Applied Sciences Wildau

Topic 1

This Topic targets makers and innovators unfamiliar with the circular economy approach. Tailored for a proactive audience in the era of lifelong learning, the Topic focuses on enhancing the knowledge and competitiveness of makers through seminars, workshops, and crucial information for the effective integration of circular economy ideas into makerspaces.

Expected training outcomes

After completing this Topic, trainees will have...
... proficient understanding of circular economy principles;
... practical knowledge for integrating circular economy ideas into makerspaces;
... enriched understanding of practical cases and real-life examples in the realm of circular makerspaces and projects;
... ability to apply best practices for sustainable outcomes in Circular Maker business.

Notes for target groups

Different target groups can achieve the following benefits of this training Topic.

Makers
Acquiring knowledge on circularity principles.

Makerspaces
Transitioning towards an ecologically and circularity-focused approach.

Suppliers
Grasping the circular strategy through real case studies.

Students/Pupils
Developing an understanding of circular practices and case studies.

Business support organizations
Embracing a new circularity strategy and identifying opportunities.

Other relevant stakeholders
Familiarizing with circular economy principles and case studies.

Training plan		
Introduction (10 min / 1-4 slides)	**Main part** (90 min / 5-43 slides)	**Conclusion** (10 min / 44-45 slides)
Introducing the presentation's purpose and addressing current issues or challenges relevant to the topic.	In the main segment, the presentation navigates from abstract theoretical frameworks to practical real-life applications, elucidating various focused theories along the way.	The Q&A session is designed to clarify doubts and gauge audience reactions, providing valuable insights into the reception of the presentation.
Presentation.	*Presentation.*	*Discussion, Q&A.*
Total duration for the Topic 1: approx. 2 h		

Training modes		
In person	**Online**	**Hybrid**
10 minutes reception + 90 minutes class	90 minutes + 10 minutes for questions	90 minutes class + 10 minutes for questions

Notes for the trainer		
Required previous experience and theoretical knowledge	**Ethical aspects of carrying trainings**	**Training tools and resources**
Openness and willing to hear.	Reviving personal values for a greener tomorrow, sharing principles sparks a new wave of eco-awareness and action.	*For trainer:* computer, projector or any other screen (used for presentation) *For trainee:* notebook, computer or smartphone (used for case studies' research)

Circular economy

Circular economy model involves sharing, leasing, reusing, repairing, refurbishing, and recycling to extend product life cycles. The main goal is to minimize waste by keeping materials within the economy through recycling and creating further value. When departing from linear economic model, traditional Take-make-dispose pattern is replaced.

> "When my battered 1969 Toyota car approached the age of 30, I decided that her body deserved to be remanufactured. After 2 months and 100 hours of work, she returned home in her original beauty. "I am so glad you finally bought a new car," my neighbour remarked. Quality is still associated with newness not with caring; long-term use as undesirable, not resourceful."
>
> *Stahel, W. The circular economy. Nature 531, 435–438 (2016).*
> *https://doi.org/10.1038/531435a*

Two key circular economy groups include:

1. Extend Service Life: focus on reuse, repair, remanufacture, upgrades, and retrofits with the goal to prolong the lifespan of goods.

2. Transform into Resources: emphasis on recycling materials from old goods with the goal to turn them into new resources.

People-Centric model in circular economy means the shift from ownership to stewardship – moving from owning to managing goods. In this context, consumers become users and creators with active in product use and creation.

Remanufacturing benefits within circular economy include the support for the development of new infrastructure and the creation of new skills-intensive jobs.

Global initiatives on circular economy can be found all around the world. For example, South Korea, China, and the United States implement research programs to boost circular economies with a focus on remanufacturing and reuse, while Europe is taking gradual steps, such as initiatives from the Swiss foundation MISTRA and the EU Horizon 2020 Program since 2014.

Circular Economy vs. 'Take-make-dispose': circular economy emphasizes sustainability and recycling, while linear focuses on efficiency in resource use.

Benefits of Circular Model:

- Infrastructure and Jobs – promotion of development and job creation.
- Sustainability – reduction of waste and environmental impact.
- Cost Savings – offer of economic efficiency.

When **Scaling this Concept**, it is important to identify and replicate successful circular business models, understand elements contributing to success, and to identify sectors and products suitable for circular practices.

When **Leveraging Shifts** in: (1) technology, advancements to accelerate circular transition are being used, (2) consumer behaviour, alignment with changing consumer preferences takes place.

EU Research Highlights, typically compiled by review of products, conducted economic analysis, and interviewed experts, suggest that potential savings could reach up to USD 630 billion in advanced scenarios for EU manufacturing sectors.

Linear Economy

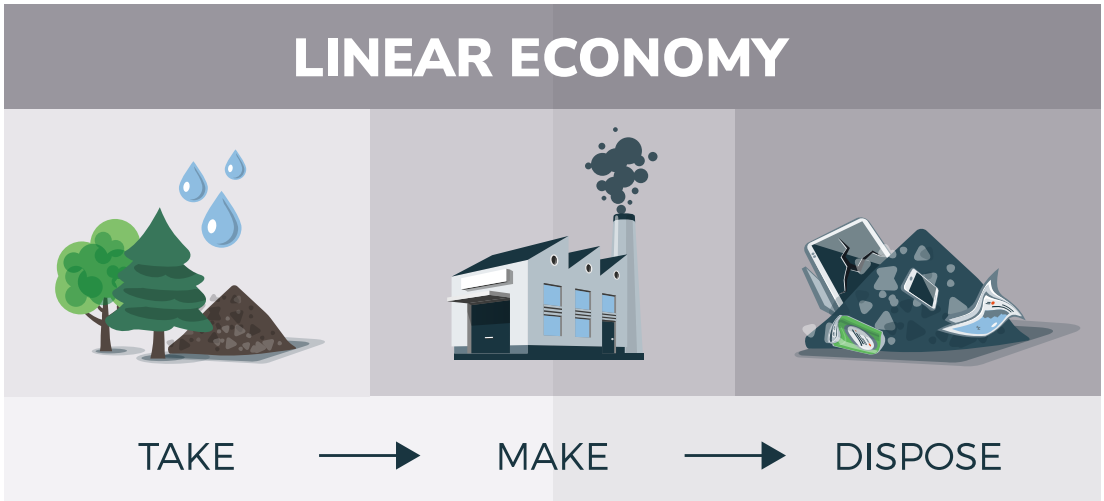
Linear economy features operation type that is linear, resembling a river, where natural resources are transformed into products through a series of value-adding steps. Linear economy is based on values driven by the "bigger-better-faster-safer" syndrome, influenced by fashion, emotion, and the pursuit of progress. It is efficient at overcoming scarcity challenges but tends to be profligate in resource usage, particularly in markets already saturated with products.

In linear economy, companies thrive by focusing on the mass production and sale of inexpensive and fashionable goods in large quantities. Ownership and responsibility for risks and waste is transferred to the buyer at the point of sale, allowing them to decide on the fate of the product, such as reuse, recycling, or disposal.

Linear Consumption Limits: The industrial economy is primarily based on a 'take-make-dispose' model. Despite improvements in resource efficiency, this linear model lacks systematic approaches to eliminate material leakage and disposal.

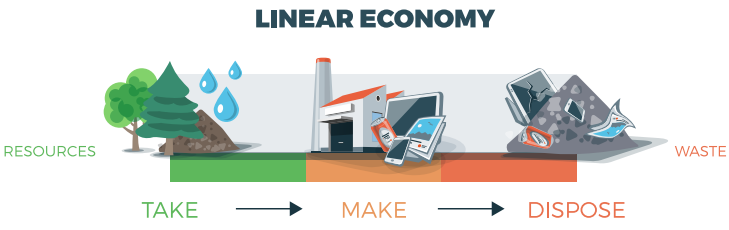
Business Risks in the Linear System: Companies face an increased exposure to risks, including higher resource prices and supply disruptions. Rising and unpredictable resource prices, combined with competition and stagnant demand, pose challenges. Since the turn of the millennium, real natural resource prices have risen, reversing a century of decline.

Price Volatility and Future Concerns: The first decade of the 21st century saw unprecedented price volatility for metals, food, and non-food agricultural output. Prices are expected to remain high and volatile due to rapid growth, population growth, urbanisation and rising extraction costs. With three billion new middle-class consumers expected by 2030, addressing these challenges becomes crucial for meeting growth requirements.



Linear vs. Circular economy

Linear Economy	Circular economy
Pros: ✔ Familiarity ✔ Simplicity ✔ Established Processes ✔ Immediate Returns ✔ Lower Initial Costs ✔ Clear Supply Chains	**Pros:** ✔ Resource Efficiency ✔ Environmental Benefits ✔ Innovation, Job Creation ✔ Cost Savings ✔ Resilience to Disruptions
Cons: ✘ Resource Depletion ✘ Environmental Impact ✘ Waste Generation ✘ Vulnerability to Disruptions ✘ Dependence on Scarce Resources ✘ Limited Long-Term Sustainability	**Cons:** ✘ Initial Costs ✘ Resistance to Change ✘ Complexity, Coordination ✘ Job Displacement ✘ Consumer Behaviour ✘ Limited Applicability



Plan obsolescence

Planned obsolescence is a strategy where products are intentionally designed to have a limited lifespan, encouraging consumers to replace them with newer models, thus driving continuous demand and sales. Transitioning to circular design involves resilient product design, modular production, and a shift in ownership dynamics. Addressing specific obsolescence types—planned, fashion, and economic—is essential for sustainability and circularity.

Factors driving premature obsolescence:

1. Technical Weaknesses: Products prone to technical failures may be discarded prematurely, contributing to unnecessary waste.

2. Fashion Trends: Rapidly changing styles and trends can lead to the premature retirement of functional products for aesthetic reasons.

3. Economic Considerations: High maintenance costs or perceived inefficiencies may render products economically obsolete, leading to early disposal.

4. Regulatory Factors: Regulations or policies may influence product lifecycles, potentially leading to premature obsolescence based on compliance requirements or incentives.

Real limits to circularity include physical constraints (Second Law of Thermodynamics), i.e., the natural tendency of systems to move towards disorder, imposing limits on the perpetual reuse of materials and energy. Achieving complete circularity is currently uncommon, with most systems falling short due to various challenges and constraints.

Mitigating Premature Obsolescence:

- *The "Weakest link" component* **->** Planned obsolescence often results from the failure of a single component, leading to the discarding of the entire product. To counteract this, mitigation strategies include designing for even wear, promoting the sale of individual components, and reconsidering business models to encourage ownership retention.

- *Fashion Obsolescence* **->** To combat premature product retirement due to evolving fashion trends, consider refreshing products through cosmetic redesign. This approach provides consumers with a renewed sense of novelty and added value without the need for new material inputs.

- *Economic Obsolescence* **->** When the cost of ownership surpasses that of purchasing a new item, economic obsolescence occurs. Mitigation involves designing products for easy disassembly and strategic part replacement. Additionally, creating infrastructure to facilitate the return of products to manufacturers can support the reuse of components and simplify exchanges or upgrades, aligning with technological progress.

Addressing Plan Obsolescence requires a multifaceted approach, encompassing technical, fashion-related, economic, and regulatory considerations. By emphasizing even wear in design, refreshing products cosmetically, and implementing strategies for disassembly and part replacement, the transition towards a more circular and sustainable product lifecycle becomes feasible.

Right to repair

Sustainable development urges a transformation in how society fulfils its needs. The traditional 'take-make-dispose' model is no longer a viable option for meeting evolving demands. Over the past 40 years, various approaches have been developed to promote sustainable products and services. Circular economy models stress the importance of longer product lifespans through technical and biological cascades. Repairability is a fundamental aspect of technical cascades, minimizing the demand for new resources in the production of goods. The ability to repair products is contingent on multiple variables, including design, business models, and consumer behaviour.

Factors Inhibiting Repairability:

1. Lack of Knowledge: Consumers often lack knowledge about how products function, hindering their ability to carry out repairs.
2. Limited Access: Insufficient access to spare parts, technical information, and restrictive contracts restricts repair options.
3. Economic Incentives: Economic factors, such as the cost of repair compared to buying new products, often discourage repair efforts.
4. Emotional and Economic Attachment: Consumer attachment, both emotionally and economically, influences decisions to repair or replace products.
5. Design and Manufacturing Challenges: Poor design and manufacturing features, such as non-modular structures, can impede the repairability of the product.

EU Directive – Right to Repair

The new EU directive, known as the "Right to Repair", underscores the importance of repairability in fostering a circular economy. The Directive is expected to address current barriers to repairing products, facilitating a shift in consumer-producer-product dynamics. "Right to Repair" has the potential to transform relationships between producers, users, and products by promoting repair as a sustainable practice.

Circular Raw Materials

Raw materials are the foundation of Europe's current and future economy, essential for job creation, competitiveness, and enhancing the quality of life. Some raw materials are of particular concern due to their high economic importance and supply risk – these are termed **Critical Raw Materials (CRM)**.

Circular use of raw materials in the EU is estimated by the **End-of-life Recycling Input Rate (EOL-RIR)** which is a key indicator for assessing circular use, measuring the proportion of total material input from recycled post-consumer waste. Despite the potential for high recycling rates, challenges include the lack of cost-effective sorting and recycling technologies, locked-up supply in long-life assets, and growing demand in various sectors. Specific examples like vanadium, tungsten, cobalt showcase notable recycling input rates.

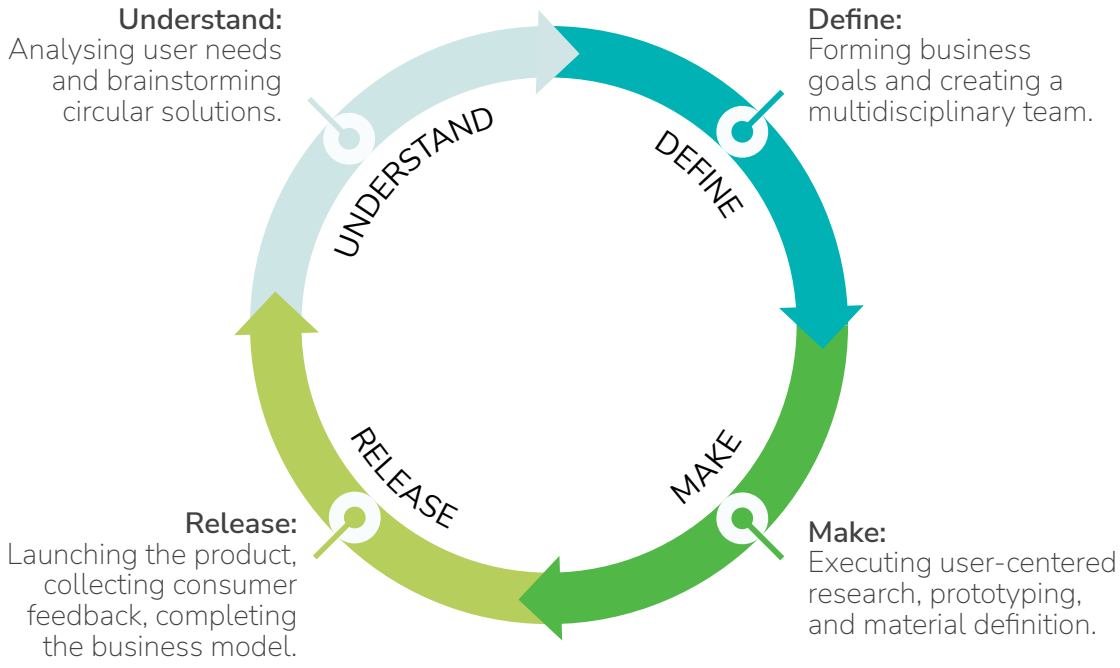
Understanding CRMs within specific sectors (e.g., automotive, renewable energy) is crucial for a comprehensive view. Highlighting critical raw materials in specific sectors, emphasizing the diverse raw material needs across industries. Advocate for complementary sector-specific assessments to capture nuances that are missing in an economy-wide analysis.

Policy Recommendations:	Research and Development:	Public Awareness:
Enhancing legislative frameworks, developing prevention initiatives, and supporting standardization activities.	Emphasizing the importance of supporting innovative, efficient, and cost-effective technologies for CRM extraction and material-efficient solutions.	Highlighting the need to raise public awareness about the fundamental role of CRMs.

Circular Design

Circular design is the cornerstone of the circular economy that encompasses shifts from product-focused sustainability to holistic business models. By applying circular design, designers strategically plan for products with a minimal environmental impact.

The Essence of Circular Design is a four-stage process:



Case Study: Local Roots - Transforming Agriculture with Circular Design

Circular Design Implementation
Reusing shipping containers as sustainable farms. Full refurbishment and quality checks ensure longevity. Remanufacturing: Parts reused in the manufacturing process. Recycling: Materials recycled for use in other industries.

Sustainable Impact
Year-round, resource-efficient farming. 97% less water, no pesticides, and herbicides.

Business Model Innovation
Circular design integrated into the core of Local Roots' business. Example of successful circular economy principles in action.

Conclusion
Local Roots stands as a prime example of circular design fostering sustainability.

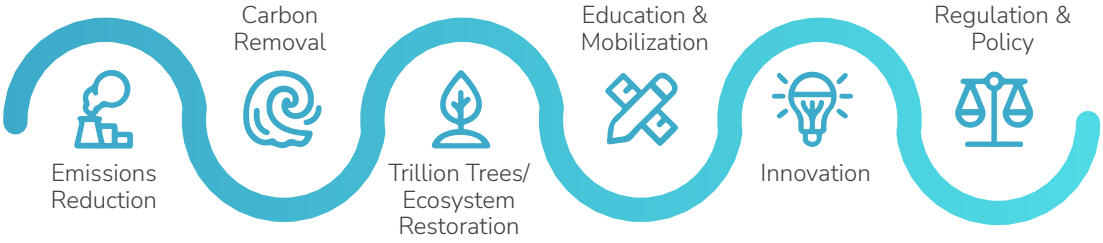
Circularity vs Sustainability

Understanding both concepts is crucial for businesses and societies to address environmental challenges and foster responsible resource management.

Sustainability	Circularity
Sustainability is the pursuit of practices that meet current needs without compromising the ability of future generations to meet their own needs.	Circularity, within the context of the circular economy, emphasizes regenerating resources and minimizing waste through a closed-loop system.

Sustainability is a holistic concept, covering three pillars: environmental, social, and economic. Examples of sustainable practices: renewable energy, responsible sourcing, and ethical labour practices.

SUSTAINABILITY PRIORITIES



Circular economy is a system designed to minimize waste and make the most of resources by keeping them in use for as long as possible. Circular economy principles include designing for longevity, recycling, and reusing materials to create a closed-loop system. Circularity aims to reduce environmental impact, enhance resource efficiency, and create a more sustainable economic model. Circular economy practices are integral to achieving broader sustainability goals.

Case Studies

Case	Concept	Results	
Bringing Circularity to Events: Circular Scenography at Maison & Objet	**Challenge:** Addressing material waste in events. **Innovation:** Repurposing wood from the previous edition. **Design:** Collaborated with WAO for circular scenography. **Execution:** Collected 4 tons of wood, stored at Re-Store. **Curation:** Enriched with circular economy-themed designs. **Visual:** 3D projections of the designed scenography.	**Date:** Revealed on March 22, 2022, at Maison & Objet. **Feedback:** Positive responses from stakeholders and visitors. **Interest:** Growing interest in circular practices in the event industry. **Collaborations:** Opportunities for similar projects emerged. **Next Steps:** Furniture moved to Fab City Hub for extended use. **Commitment:** Deepening commitment to circular principles. **Call to Action:** Open for collaborations, inviting others to embrace circularity.	  SOURCE
Circular Isolation Gowns: A Sustainable Shift	**Challenge:** Environmental impact of disposable isolation gowns in healthcare. **Solution:** Introduce reusable cotton gowns for a circular textile economy. **Partners:** Collaboration with Cleanlease, healthcare institutes, creative agency Makers Unite, ReBlend, Waternet, Purfi, and Reflow.	**Prototypes:** Successful development of 100% recyclable cotton gowns (25 prototypes). **Environmental Impact:** Aiming to replace 5 million oil-based gowns, reducing over 1000 tons of CO2 annually. **Next Steps:** Preparing a 3000-gown demonstrator phase for larger production, actively seeking funding.	 SOURCE

Case	Concept	Results	
Danish Deposit System	**EU Directive & Challenge:** Responding to the EU directive on single-use plastics (2021) and aiming for a 90% collection rate by 2029. **Danish Model:** Emulate Denmark's 100-year-old deposit system for disposable bottles and cans.	**High Collection Rate:** Since 2002, consistently achieving a 90% collection rate for plastic, glass, and aluminium containers. **Closed Loop System:** Preserves value; refillable bottles reused up to 30 times; cans and bottles recycled into new ones. **Record Return (2021):** 93% return rate, recycling 1.9 billion bottles, saving 210,000 tonnes of CO2. **Circular Economy Benefits:** 95% less energy for recycled cans; effective cooperation reduces fees for manufacturers.	 SOURCE
Leuven River Upcycling	**Collaborative initiative** launched on Oct 3, 2021. Partnership between KSKCL, Dijlejutters, JCI Leuven, and various local organizations. **Objective:** Combine sport with waste reuse by collecting and processing river waste for community benefit. **Evolution:** Merged efforts of Dijlejutters and JCI Leuven, with developed water routes and support from key stakeholders.	**Waste Processing:** High Tech Lab transforms collected plastic waste into raw materials. **New Product Creation:** Sticks, pallets, and paddles produced, benefiting local sports clubs. Circular City Vision: Aligns with Leuven 2030's sustainability model, fostering diverse partnerships. **Public Engagement:** Raises awareness about river ecosystem threats, emphasizing collective responsibility. **Climbing Towards Circular City:** Advances Leuven's journey to a sustainable, circular city.	  SOURCE

Case	Concept	Results	
HP Brazil & Sinctronics: A Circular Partnership	**Challenge:** 50M tons of e-waste/year globally. HP Brazil & Sinctronics join forces. **Solution:** HP's outreach + Sinctronics' recovery expertise. Circular design collaboration for increased efficiency.	**Efficiency:** 50% reduction in collection times. Up to 30% cost reduction. **Material Reincorporation:** 97% of collected materials are reused. Closed loop for plastics success. **Environmental Impact:** Recycled material in HP products to increase to 45% by 2023.GHG emissions reduction. **Operational Benefits:** Cost reduction and stability for HP. Sinctronics decreases client costs by 30%. **Integrated Ecosystem:** Sinctronics as Flex's circular solution unit technology for e-waste transformation. **Achievements:** Recycled white plastic with 94% recycled material. 97% recovered material back into the supply chain.	 SOURCE
SodaStream's Circular Economy Efforts	**Addressing E-waste Surge:** E-waste, including plugs, batteries, and bulbs, is a rapidly growing waste stream globally. Over 50 million tonnes of electronic waste annually. **SodaStream's Circular Approach:** If the sparkling water maker is in perfect working order, it is thoroughly cleaned and fitted with a new cylinder and carbonating bottle before being sold through an approved reseller. **Refurbishment and Recycling:** Initiative to refurbish returned working machines. Recycling end-of-life sparkling water makers.	**Returns Testing and Refurbishment:** 7022 machines were returned and rigorously tested. 28% (2016 machines) were successfully refurbished. **Efficient Recycling Process:** Utilizing local e-waste recycler (eWastec). Shredding process extracts maximum value. Materials like metals and plastics are separated for reuse. **Environmental Impact:** 29,432 kg of end-of-life sparkling water makers recycled since July 2020. Substantial reduction in landfill waste. **Certification for Accountability:** Recyclers provide certificates documenting landfill diversion. Assurance of SodaStream's commitment to sustainability.	 SOURCE © SodaStream Inc.

Used references and additional resources

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- Empowering Sustainable Consumption by Giving Back to Consumers the 'Right to Repair' Ricardo J Hernandez 1,2,* , Constanza Miranda 1 and Julian Goñi DILAB School of Engineering, Pontificia Universidad Católica de Chile,
- Journal of Cleaner Production Business model innovation for circular economy and sustainability: Technical University of Denmark Marina P.P. Pieroni, Tim C. McAloone, Daniela C.A. Pigosso
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- https://www.cleanup.org.au/sodastreamsustainability

Continue exploring other Topics

Topic 1

Circular Economy and Sustainability

Topic 2

Waste as a Resource in Circular Economy

Topic 3

Circular Value Chains, Ecosystems, and People

Topic 4

Circular Business Models

Topic 5

Life Cycle Thinking and Environmental Footprint

Topic 6

Design Thinking for Circular Products

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Waste as a Resource in Circular Economy

Developed by
Kaunas Science and Technology Park

Topic 2

Efforts to use the potential of waste as resources by putting in place circular design incentives that promote sustainable resource use and improve resource productivity in the long term require a good understanding of the resource basis of the economy, supported with high-quality information on material flows in the waste stream. The selection and engineering of materials is a critical component in the development of a circular economy model. The redesign of both consumer commodity goods and advanced products may not only require engineering feats in terms of advanced structures but also the implementation of safer and more facile recycled materials (especially from waste). Which material groups (from the waste streams) play an important role in circular design solutions, and what are their properties or development trends, is revealed in this training Topic. Products must be designed to enable complete recycling of materials and novel synthesis strategies free from toxic precursors or by-products to regenerate new raw materials. The training material also provides information on which materials in Europe are considered critical and how to avoid them in circular economy business models or circular design projects.

Expected training outcomes

After completing this Topic, trainees will...

... understand and explain the role of different materials in circular economy;

... understand the main principles for plastic waste, bioplastic, steel, metals, wood, pulp, paper, and glass use in circular economy;

... find out about Critical Materials and their role in circular economy.

Notes for target groups

Different target groups can achieve the following benefits of this training Topic.

Makers

N/A

Makerspaces

N/A

Suppliers

N/A

Students/Pupils

N/A

Business support organizations

N/A

Other relevant stakeholders

N/A

Training plan

Introduction	Main part	Conclusion
1. Short description of the training course. 2. Learning objectives 3. Introduction topic - Role of waste as a resource in circular economy.	1. Technical and organic materials in waste. 2. Plastic waste in circular economy (structure of plastic waste, different types of plastic and its recyclability properties, pollution prevention and eliminating possibilities). 3. Bioplastics in circular economy (types, modifications, labelling and potential in circular economy) 4. Steel and metals in circular economy (types and potential in circular economy) 5. Wood, pulp and paper in circular economy (types, labelling and potential in circular economy) 6. Glass in circular economy (types, labelling and potential in circular economy) 7. Critical materials and their role in circular economy (what is "critical material" impact and possibilities to eliminate). 8. What are eco-materials? (Definition of superior properties of eco-materials)	Practical Recommendations and Tips - Selection of low-impact materials as resources (from waste) in Circular Economy How to choose: Cleaner materials, Renewable materials, Lower energy content materials, Recycled materials, Recyclable materials, Materials with positive social impact, i.e., generating local income, Reduction of materials usage.

Total duration for the Topic 2: N/A

Training modes

In person	Online	Hybrid
Yes	Yes	Yes

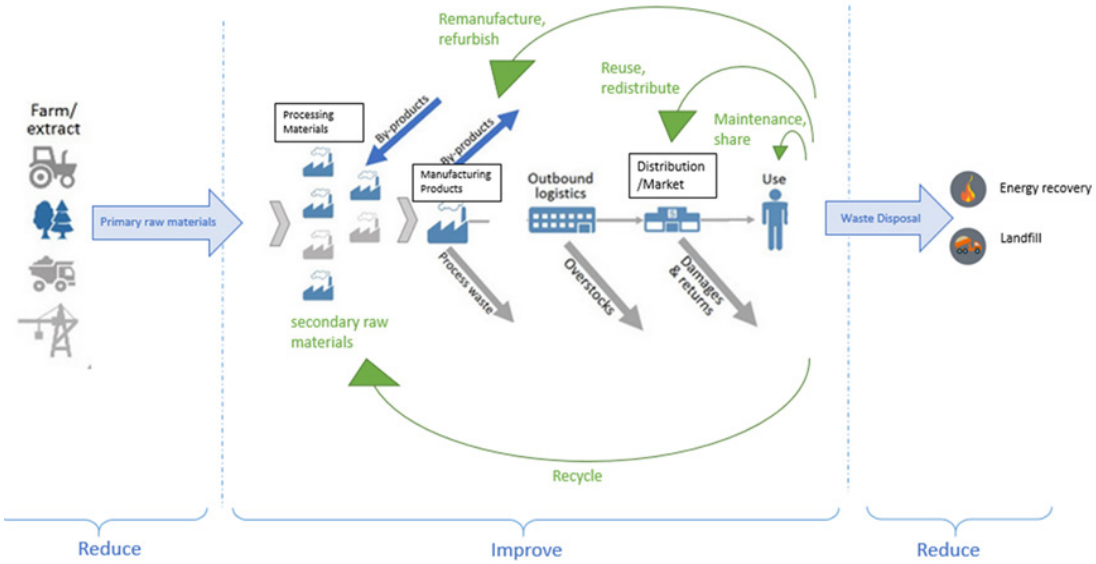
Notes for the trainer

Required previous experience and theoretical knowledge	Ethical aspects of carrying trainings	Training tools and resources
Understaning of Linear and Circular Economy, business models, stakeholders.	None.	*For trainer:* slides, learning materials. *For trainee:* links with additional material and external resources.

Introduction

The circular economy pursues a harmonious intergrowth and sustainable development of both the economic and the social system without harming the natural ecosystem. By improving the productivity of materials and products (as shown in the graph below), not only the extraction of virgin resources but also the generation of waste can be reduced.

Conceptual scheme of the components of a circular economy
(Circular Economy: a smart way of using materials, materialflows.net)



An increase in material productivity is achieved by elaborating various looping opportunities within the life cycle of materials. These loops are not thought to be run through only once by materials and products, but to be repetitive as often as possible. The further the material is processed along the supply chain, the bigger the looping can become for reusing the materials. However, the tighter the circle, the faster materials return to consumption and the less resources are required. A tight circle of sharing or reusing products among consumers, for example, does not need new materials and requires less energy than the bigger loop of recycling those products. In a circular economy, materials circulate in two separate cycles: the bio-cycle and the techno-cycle. The distinction between these cycles helps to understand how materials can be used in a long-lasting and high-quality way. A general rule of thumb is: the less process steps needed for a material's reuse, the higher the quality of the remaining material will be.

Organic materials follow a different reuse process than technical materials. Technical materials are also called synthetic materials. Because of this difference in the reuse process, it is important that after use, organic and technical materials can be properly separated from each other after use.

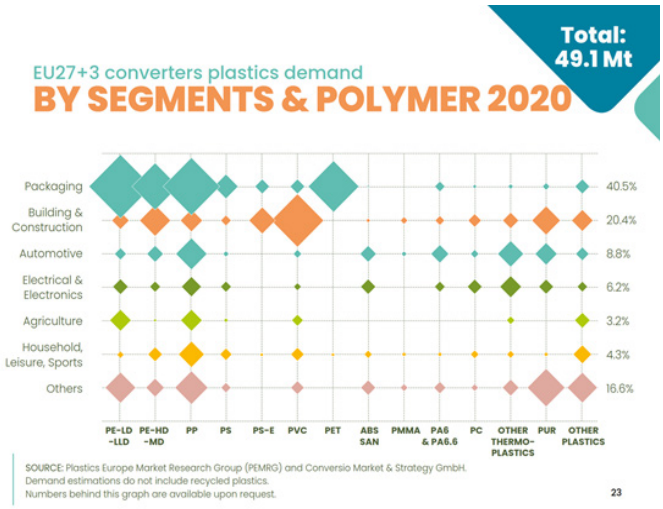
Technical materials such as fossil fuels, plastics and metals have limited availability and cannot be easily recreated. In the techno-cycle it is important that stocks of such finite materials are properly managed. In a circular economy, these materials are only used instead of being consumed. After use, materials are recovered from residual flows at their original value.

Organic materials such as wood, food and water can be incorporated into the ecosystem and re-generated through biological processes. In the biocycle it is important to let the ecosystem do its work as well as possible. Consumption may take place during this cycle (fertilization, food, water) as long as the streams are not contaminated with toxic substances and ecosystems are not overloaded. Renewable organic raw materials can then be regenerated (Ellen MacArthur Foundation, 2015a).

Plastic in Circular Economy

The use of plastics in the modern society is ubiquitous. Is it in fact remarkably difficult to find anything we use or interact with daily that is not made of or contains one or more types of plastic. With increased knowledge has come a greater utilization and exploitation of these plastics. Consider the annual production of plastics per capita. The global population has increased from about 2.5 billion in 1950 to 7.7 billion people today, i.e., a threefold increase. By comparison, the normalized plastics production, i.e., the mass produced per capita per year averaged across the global population, shows that there has been an almost 50-fold increase in the mass of plastics per capita generated over this period.

In the context of plastics, achieving a circular economy presents enormous challenges, not least because our current approaches to plastic production, usage and fate generally do not meet most, if any, of the principles of a circular economy. A case in point is the dominance of fossil fuels as plastics feedstocks, which clearly contradicts a key principle of circular economy of only using renewable resources. Other contradictions can be seen with the current fate of plastics after use, i.e., their end-of-life. Even with the rise in recycling practices over recent years, most end-of-life plastics are currently either still sent to landfill or increasingly incinerated for energy recovery, both practices that not only damage the environment in different ways, but also represent an enormous loss of a valuable resource. To achieve a circular economy of plastics, significant changes to current practices will need to be employed that include new and sustainable approaches to eco-design, reuse, repair and maintenance, leasing and sharing, recycling, and chemical conversion, quite apart from the necessary social and economic changes that will be required (Bucknall, 2020).



Larger scale picture can be found on: Plastics - the Facts 2021. An analysis of European plastics production, demand and waste data

SOURCE

Applications of plastics can be grouped together into different sectors of use as shown in figure. While these usage data represent EU 28, NO and CH countries, they are similar to all developed nations. As can be seen, the largest sector of use for plastics accounting for approximately 40% of annual global production is in packaging. Although a huge range of plastics is known, with hundreds listed in materials databases, the vast volume of plastics that are used is limited to a small number. As shown in figure, over 80% of all plastics used are polyethylene (low-density, LDPE and high-density, HDPE), polypropylene (PP), polystyrene (PS and EPS), poly (vinyl chloride) (PVC), and poly (ethylene terephthalate) (PET). For most of the era of modern synthetic plastics, their fate has largely been one of a linear economy, i.e., take-make-dispose. As discussed above, this short-sighted attitude has led to the global issues we are now facing. If fully implemented, a circular plastics economy would not only maintain use of plastics for a vast range of applications without having to use a different, potentially more expensive, or less optimal material, but also reduce the harm the loss of plastics is causing to the environment. The question therefore is, can a circular plastic economy be implemented and, if so, what are the hurdles to achieving it?

Plastic brings many benefits. At the same time, there are some problematic items on the market that need to be eliminated to achieve a circular economy, and sometimes, plastic packaging can be avoided altogether while maintaining utility.

While improving recycling is crucial, we cannot recycle our way out of the plastic issues we currently face. Wherever relevant, reuse business models should be explored as a preferred solution (or 'inner loop' in circular economy terms), reducing the need for single-use plastic packaging. Reuse models, which provide an economically attractive opportunity for at least 20% of plastic packaging, need to be implemented in practice and at scale. Innovate to ensure that the plastics we do need are reusable, recyclable, or compostable. This requires a combination of redesign and innovation in business models, materials, packaging design, and reprocessing technologies. Compostable plastic packaging is not a blanket solution, but rather one for specific, targeted applications, because an effective collection and composting infrastructure is essential but often not in place. Circulate all the plastic items we use to keep them in the economy and out of the environment. No plastic should end up in the environment. Landfill, incineration, and waste-to-energy are not long-term solutions that support a circular economy. Governments are essential in setting up effective collection infrastructure, facilitating the establishment of related self-sustaining funding mechanisms, and providing an enabling regulatory and policy landscape. Businesses producing and/or selling packaging have a responsibility beyond the design and use of their packaging, which includes contributing towards it being collected and reused, recycled, or composted in practice.

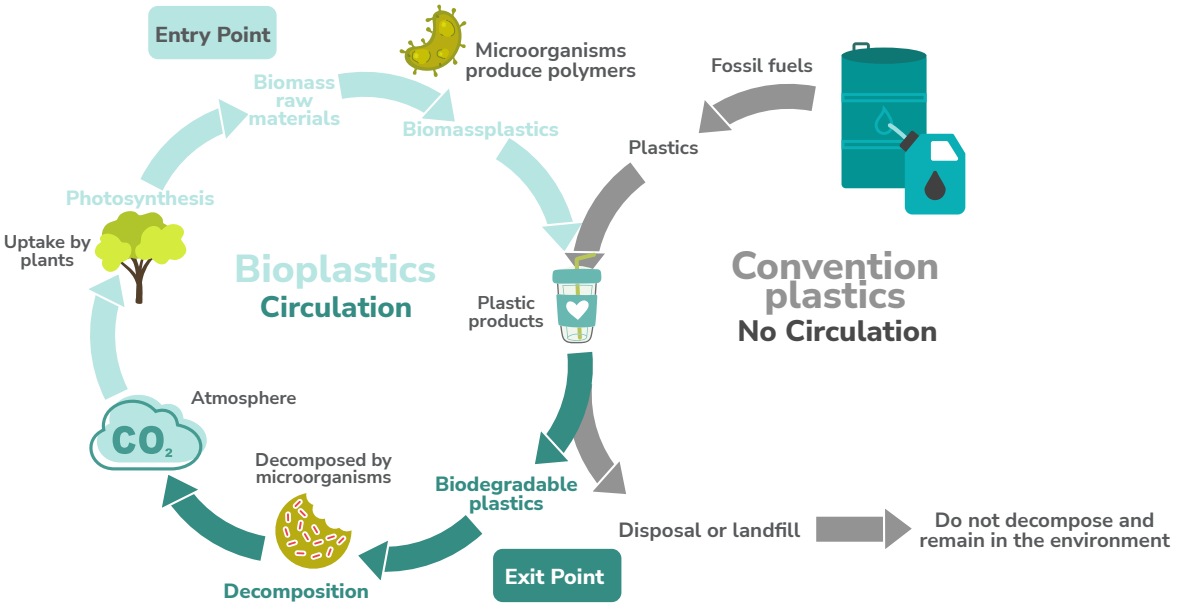
The vision for a circular economy for plastic has six key points:

1. Elimination of problematic or unnecessary plastic packaging through redesign, innovation, and new delivery models is a priority
2. Reuse models are applied where relevant, reducing the need for single-use packaging
3. All plastic packaging is 100% reusable, recyclable, or compostable
4. All plastic packaging is reused, recycled, or composted in practice
5. The use of plastic is fully decoupled from the consumption of finite resources
6. All plastic packaging is free of hazardous chemicals, and the health, safety, and rights of all people involved are respected.

Bioplastics in Circular Economy

Bioplastics — typically plastics manufactured from bio-based polymers — stand to contribute to more sustainable commercial plastic life cycles as part of a circular economy, in which virgin polymers are made from renewable or recycled raw materials. Carbon-neutral energy is used for production and products are reused or recycled at their end of life (EOL) (Rosenboom, Langer & Traverso, 2022). Compared with fossil-based plastics, bio-based plastics can have a lower carbon footprint and exhibit advantageous material properties; moreover, they can be compatible with existing recycling streams and some offer biodegradation as an EOL scenario if performed in controlled or predictable environments. However, these benefits can have trade-offs, including negative agricultural impacts, competition with food production, unclear EOL management and higher costs. Emerging chemical and biological methods can enable the 'upcycling' of increasing volumes of heterogeneous plastic and bioplastic waste into higher-quality materials.

The plastics industry has traditionally been based on linear life cycles (grey arrows): crude oil is cracked and refined into monomers and polymer products using fossil energy, which, at their end of life, are either disposed of (~80%) with potential environmental leakage, incinerated (~10%) or, in the minority of cases (10% globally), mechanically recycled into lower-grade products, which also end up landfilled (World Economic Forum, 2016). In a 'circular plastic economy' (orange arrows), plastic waste becomes raw material for a recycling process at its end of life, and all production and recycling processes are supplied with renewable energy 21,47,62 (Bucknall, 2020). Renewable resources (lignocellulosic biomass and pyrolysis oils) are the starting materials for polymer products, which all have a defined circular end-of-life scenario. CO2 generated through bioplastic incineration (blue arrows), aerobic composting or incineration of CH4 from anaerobic composting is a net-zero addition to the carbon cycle, as it is captured by photosynthesis into new biomass. Advanced recycling routes enable upcycling plastic waste: polymers with functional backbones (such as polyesters or polyamides) can be depolymerized biologically or chemically, and the subsequent monomers are polymerized into tailored high-quality or virgin-quality products (Coates & Getzler, 2020). Polymers with non-functional backbones such as polyolefins (including polyethylene (PE), bio-based PE, polypropylene (PP) and polystyrene) are better suited for cracking into hydrocarbon oil and gas by thermolysis and can then follow a similar upcycling path (Sharuddin et al., 2016).



Among the different types of bioplastics, biodegradable plastics are classified into different categories according to their origin and their compostability properties. The term bioplastic should preferably be avoided as it is a general term that can refer to materials that are either bio-based (related to how the material is sourced — wholly or partly from biomass), biodegradable (related to whether a material can be broken down into carbon dioxide, water, and biomass by the natural action of microorganisms), or both. Because not all bio-based plastics are biodegradable, and some biodegradable plastics are fossil-based (for example, PBAT), the term bioplastic can be confusing.

Bioplastics are not just one single material. They comprise of a whole family of materials with different properties and applications. According to European Bioplastics, a plastic material is defined as a bioplastic if it is either biobased, biodegradable, or features both properties.

Biobased: The term 'biobased' means that the material or product is (partly) derived from biomass or biowaste. Biomass used for bioplastics stems from e.g. corn, sugarcane or cellulose. Bioplastics can also be produced by microbes or based on CO2 or methane.

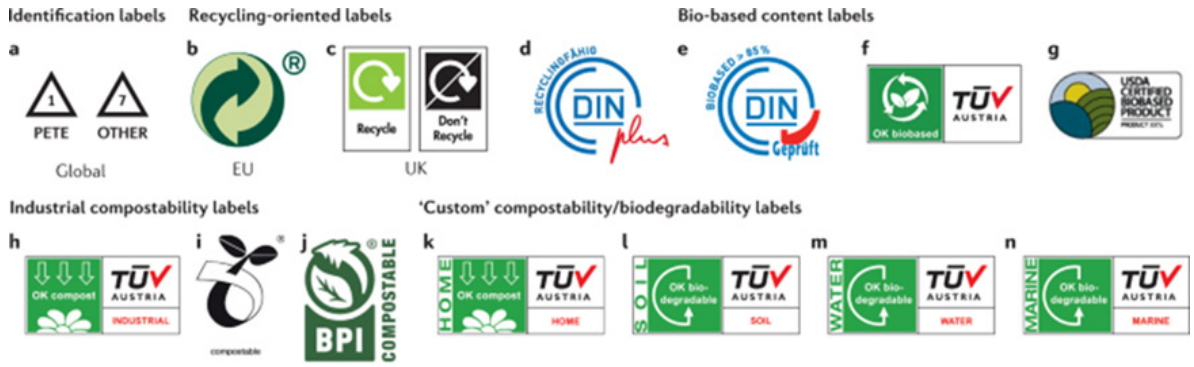
Biodegradable: Biodegradation is a chemical process during which microorganisms that are available in the environment convert materials into natural substances such as water, carbon dioxide, and compost (artificial additives are not needed). The process of biodegradation depends on the surrounding environmental conditions (e.g. location or temperature), on the material and on the application.

'Biobased' does not equal 'biodegradable': the property of biodegradation does not depend on the resource basis of a material but is rather linked to its chemical structure. In other words, 100 percent biobased plastics may be non-biodegradable, and 100 percent fossil-based plastics can biodegrade.

Today, almost every monomer required to produce drop-in polymers — that is, chemically equivalent replacements for fossil-derived polymers — can be obtained from biomass. Additionally, biomass can support the synthesis of novel polymers that are not easily derived from fossil resources. The methods for processing biomass to obtain vinyl monomers, carboxylic acids, alcohols, amides and rubbers have been extensively reviewed (Harmsen et al., 2014).

'Custom' compostability/biodegradability labels: The 'home' compost label (panel k on figure) has seen an increased use but is not based on a legislative standard. This label was proposed by TÜV Austria as a modification of EN 13432, with tests performed at 20–30 °C over time frames that are twice as long as those in the original tests. Similarly, TÜV Austria has developed further labels and certification procedures for different environments in which plastics may end up (panels l–n of figure). New bioplastic testing standards are under review, such as prEN 17427 (2020) by the European Committee for Standardization (CEN), which focuses on tests aimed to inform home compostability specifically for plastic bags.

Examples of different biodegradability labelling (Rosenboom, JG., et al.2022)



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Biodegradation is no 'silver bullet' to curb plastic pollution and typically ranks as the least desired fate of bioplastics, especially in anaerobic landfill scenarios without gas capture. Industrial anaerobic digestion offers a potential route for CH4 and energy recovery. True and fast biodegradation without releasing toxic chemicals may prove useful in settings where there are no other forms of recycling, but more research on the impact of microplastics as intermediates is required. Besides recycling, behavioural changes towards using less plastic, and the strict usage of renewable energy for polymer and plastic production remain essential strategies to mitigate plastic waste and carbon emissions.

Plastic products are often labelled to indicate their chemical composition, whether they can be recycled, are bio-based and/or can be biodegraded and under which conditions. Consumers and converters are currently faced with various labels for bioplastics based on different industrial testing standards, some of which are referenced by major legislators, including the United Nations, the European Union (EU) or the US government. Some of these standards, particularly those certifying biodegradation established around 2000, are currently under investigation, with the aim of revision and harmonization. It is important to understand the basis for these certifications and what the agencies behind them are.

Identification labels: The most common labels on plastic products are the plastic resin identification codes (examples from ASTM D7611/D7611M-20 in panel a of figure 6), which identify the polymer but provide no information on the recyclability. The older version of these labels — the 'chasing arrows' — still appears on products, and many consumers still falsely believe that products with these labels are recyclable, which may cause 'wishcycling' and lead to consumers placing non-recyclable items in recycling bins. In the USA, only products labelled '1' (polyethylene terephthalate (PETE)) or '2' (high-density polyethylene) have a viable market and are, therefore, recycled. Environmental organizations such as Greenpeace as well as some US states, such as California and New York, favour laws to prevent companies from using recycling symbols for non-recyclable products, and instead aim to use extended producer responsibility (EPR) laws to foster the design of recyclable materials. Bioplastics such as polylactic acid are currently labelled as '7' (other) and are typically not recycled.

Recycling-oriented labels: The 'green dot' symbol (panel b of figure) used in the EU indicates that the producer has paid an EPR fee that is intended to fund collection and recycling programs, but not that the product can be recycled. The on-pack recycling label ('OPRL') used in the UK (panel c of figure) indicates whether consumers should place individual plastic packaging components into trash or recycling bins, based on the nationwide probability that the component is successfully collected, sorted and reprocessed into a new product with a viable market. The German certification body DIN CERTCO has established new labels to certify the recyclability of a plastic product based on the polymer and existing infrastructure to recycle the latter (panel d of figure). Similarly, new labels to certify the recycled content are being proposed. The US-based How2Recycle label aims to provide more information on the recyclability of individual packaging parts.

Bio-based content labels: The labels shown in panels e–g of figure certify the bio-based carbon content in plastic products. The DIN biobased (panel e) and OK biobased (panel f) labels are granted by DIN CERTCO and the Austrian technical service company TÜV Austria, respectively. The US Department of Agriculture's BioPreferred program issues a label based on third-party analysis (panel g) and, in Japan, labels are issued by the Japan BioPlastics Association (JBPA). All these labels follow standards such as EN 16640 (Europe), ISO 16620 (international) and ASTM D6866 (USA).

Industrial compostability labels: The 'OK compost' (panel h of figure) and 'seedling' (panel I) labels used in the EU and the 'BPI compostable' (panel j) label used in the USA have become more prevalent in recent years, yet consumers must understand the need for industrial capacity to biodegrade. The 'industrial' sub-label is based on four tests specified in the standards EN 13432 and ASTM D6400: biodegradation (90% of material is converted into CO2 in inoculum derived from compost at 58 °C after 6 months), disintegration (90% of material is smaller than 2 mm after 3 months at 40–70 °C, depending on the standard), ecotoxicity (90% of regular plant growth in soil with plastic present) and the heavy metal content must not exceed a certain threshold.

Steel and metals in Circular Economy

Steel has excellent circular economy credentials both as a material which is strong, durable, versatile and recyclable and, as a structural framing system, which is lightweight, flexible, adaptable and reusable. One of the key benefits of steel is that it can be designed to meet the specific strength, durability, and end-of-life recycling requirements of almost any application. The combination of strength, recyclability, availability, versatility and affordability makes steel unique.

Circular economy promotes longer product lives. The longer a product lasts the lesser raw materials are needed to be sourced. Product durability contributes to reducing the depletion of raw materials. Maintaining products at their highest utility and value for as long as possible is a key component of the circular economy. Putting it simply, the longer a product lasts the lesser raw materials are needed to be sourced and processed and less waste is generated. Steel products are inherently durable meaning not only that they last a long time but also that several steels can be reused after their first life.

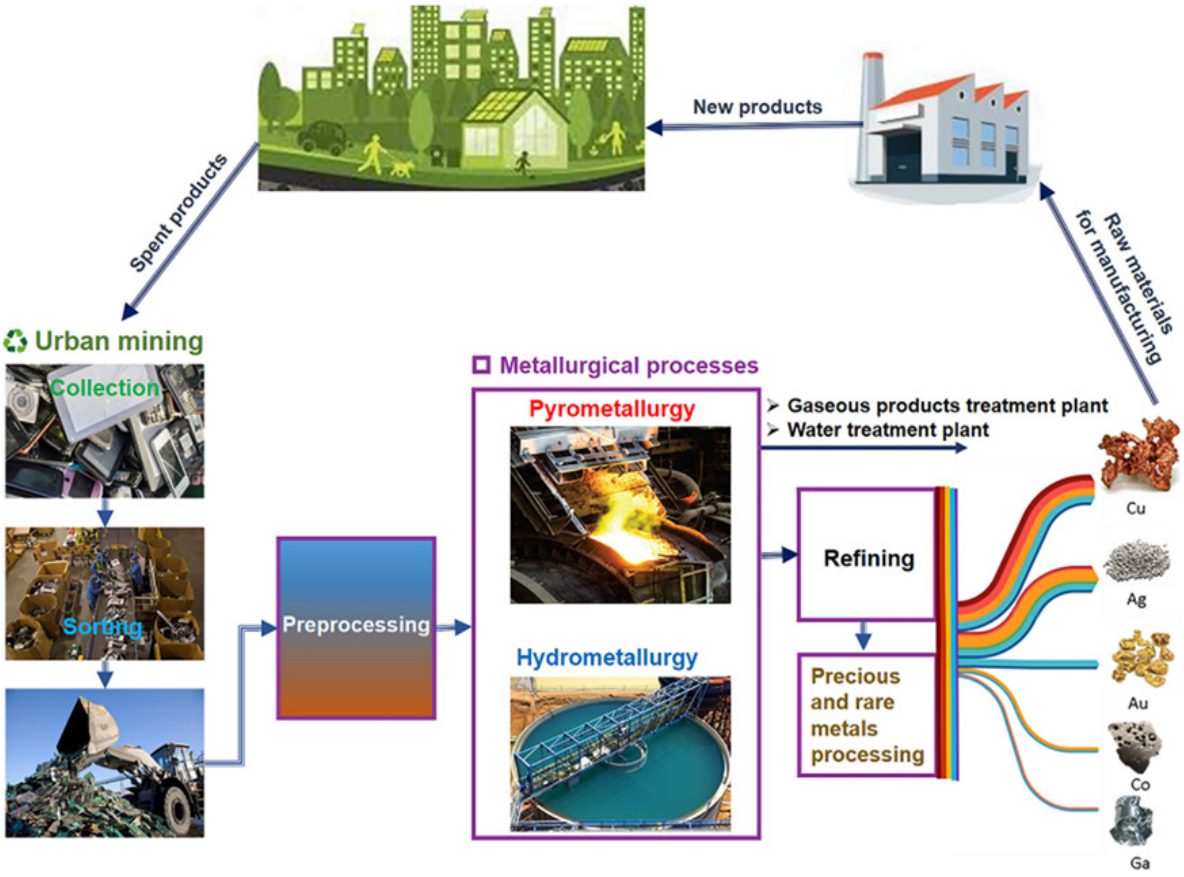
Steel also facilitates its own longevity. Steel-framed buildings can be easily adapted if the configuration of the structure needs to be changed. The building can be taken apart and rebuilt with minimal disruption to local communities and the environment. Strong, durable exterior steel structures can accommodate multiple internal reconfigurations to suit changing needs. Warehouses or industrial buildings made with steel can be easily converted into modern living or working spaces. This extends the useful life of the building (and the life of steel it contains) to save resources and reduce costs.

Extending the life of the products is another key aspect of the circular economy. In theory, all new steel can be made from recycled steel. However, this is not practically feasible due to the long life of steel products, given the strength and durability of steel. Around 75 % of steel products ever made are still in use today. Buildings and other structures made from steel can last from 40 to 100 years or longer if proper maintenance is carried out.

Extending the life of the products can be achieved by making the products which are both flexible and adaptable to change so that they can last longer, and greater value can be extracted from the materials and resources used to produce them. The pace of change in all walks of life has never been greater. Changing work patterns, new building services and information technologies, changing demographics and new legislation are all putting new and different demands on steel products. Sustainable products should be flexible to change of use and adaptable to future needs and requirements whether they are regulatory or market driven.

Large, heavy structural steel components need planning for end-of-life management. However, with steel scrap having value, the incentive to recover and recycle these components is high and more cost effective than paying for them to be placed in landfill sites.

Metal materials found in bulk parts are typically easier to recover and valorize. The processing steps required at high temperatures facilitate elimination of organic or polymeric contamination (Veasey, 1997), but the presence of ceramics as anticorrosion coatings or as friction controllers may again affect the final mix purity. The very large bulk of produced metal parts will be made of stainless steel, copper and its alloys, as well as aluminium and titanium. Metals are typically much easier to recycle compared to polymeric or ceramic materials due to the broad range of metal grades used and available in engineering and manufacturing. The recycling of aluminium or stainless steel are examples of this ability to recycle metals despite the need for chemical treatments to reduce or remove oxides and the energy penalty arising from heat treatments required for melting and ingots generation. The recyclability of metals is also not as challenging as polymeric materials, which can only be recycled so many times without degrading the molecular structure of the polymer (depolymerizing or over-polymerizing for instance). Most metals, unless again oxidized or contaminated during their operation as a product or recycling, may be recast nearly indefinitely. Separating metals from alloys is rarely done since the composition of the materials developed may be adjusted based on elemental analysis of the recovered materials. However, the recovery of solid metal from composite materials represents a key challenge since it is energy-demanding, whilst the sorting of metals at the source is equally difficult, with the exception of ferromagnetic material extraction from non-ferromagnetic materials, which is well mastered (Zhan & Xu, 2009). The sorting of metals such as aluminium or copper from titanium, becoming increasingly used in high value structural materials, is very challenging and must involve selective separative steps; such metallurgical, electrochemical or physical approaches have been well developed and work at scale (Ali, 2018). Thus, metals do not represent a key challenge and valorization is nonetheless dependent on energy inputs required to deconstruct alloys into single metallic species.



Tesfaye, F., Hamuyuni, J., Iloeje, C.O. et al. Technology Metals in the Circular Economy of Cities. JOM 74, 596–598 (2022)"

Processing of Metals in Makerspace

Choosing the right metal: To choose the right material for your project, it is essential to understand the basic properties of workable metals. Metals can be split into two categories:

- Ferrous metals (those which contain iron). This group is characterised by its tensile strength and durability; making it popular for structural applications. Its iron content makes it both magnetic (with the exception of stainless steel) and susceptible to oxidisation, better known as rust.
- Non-ferrous metals (those which do not contain iron). This group is characterised by its malleability, making it easy to work with. Non-ferrous metals do not contain any iron and therefore are not magnetic and do not corrode through oxidisation (rust). Many non-ferrous metals are alloys, meaning that they are a mix of different metals; for example, brass, which is a mix of copper and zinc. Different ratios of these mixes create different working qualities which can be matched with a specific project or application.

Common Ferrous Metals:	Common Non-Ferrous Metals:
• Alloy Steel – such as stainless steel and core-ten. • Carbon Steel – commonly used in fabrication. Mild Steel or Carbon Steel is manufactured in two ways: o Hot Rolled – Typically used for making larger structural members, it is cheaper but less dimensionally stable. o Cold Rolled – Very dimensionally consistent, it has sharper corners and cleaner finish quality. Typically used for detailed applications and furniture.	• Aluminium • Brass • Copper • Titanium • Gold • Silver

Metal welding: Not all metals can be machined or welded using the same tools or processes. Currently, makerspaces have the capabilities to machine and weld ferrous metals, such as carbon steel (mild steel) and stainless steel. It is possible to cut, grind and machine any other metal, including non-ferrous metals, however, the process for welding these is currently not available. Consult with a makerspaces' technician if you have questions about materials.

Which metals can be welded?

Mild Steel (Hot/Cold Rolled)	Comes in a large selection of dimensions and profiles. Typically requires minimal preparation if the material is new. Large pieces can be cut to length by the supplier where needed. Ideal for structural components or details which are hidden. The best choice if you have bends in your design. Cost effective and easy to work with. Easy to clean and finish. It will oxidise (rust) if left unfinished, so this is a good choice if you plan to powder-coat or paint the component. Can be welded with MIG or TIG.
Stainless Steel (304 and 316)	Comes in a limited selection of dimensions and profiles. Requires minimal prep. Ideal for components which can be seen, or where a raw metal finish is desired. Does not oxidise, ideal for outdoor applications. Harder and more challenging to work than mild steel. More susceptible to distortion when heated. More expensive than mild steel. More challenging to weld. Can be Tig or Mig welded.
Aluminium	Difficult to weld
Titanium	Difficult to weld

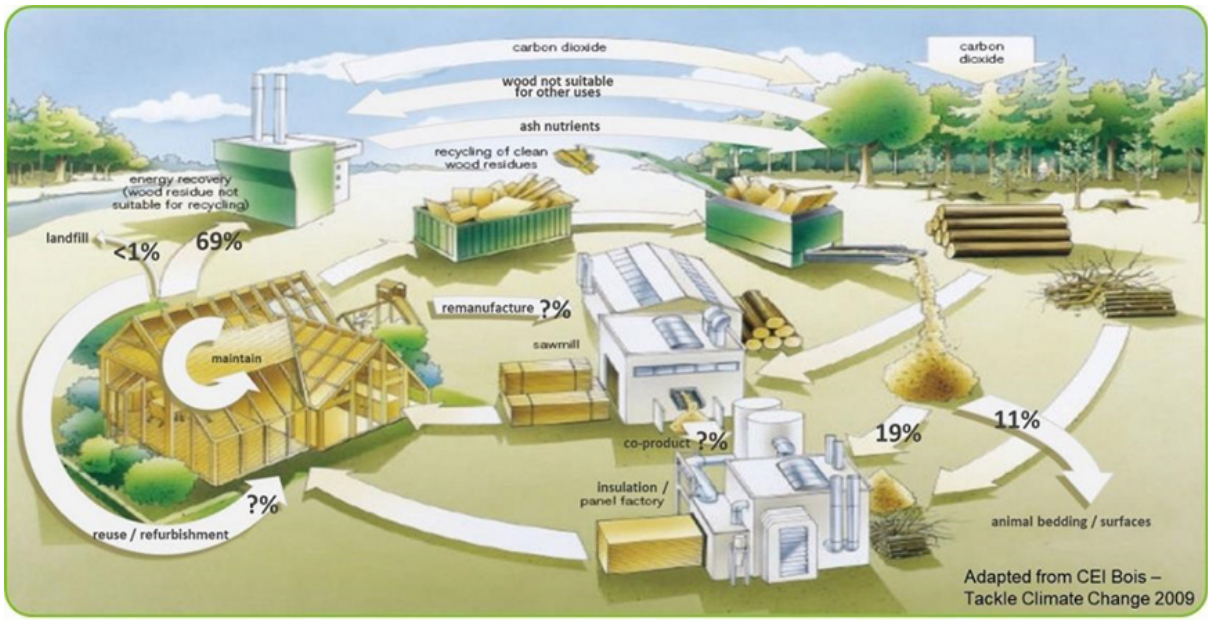
Wood, pulp and paper in Circular Economy

Timber is a biological nutrient and therefore follows the biological cycle, with the possibility of some 'cascading' recycling (down-cycling). As can be seen by the CEI Bois diagram from 2009, which shows waste timber and by-products from the processing industry being reused for panel production and energy recovery, the timber industry has been promoting what could be termed a semi-circular business model years. However, when you look at the numbers, it is clear that more could be done with the timber that has been extracted. The Wood Recyclers Association estimates that 4.5 million tonnes of wood waste was generated in 2018. Of this 877,000 tonnes (19%) was recycled and used for panel board manufacture and 500,000 tonnes (11%) used for animal bedding, equine surfaces, and other recycling purposes. 2.1 million tonnes (47%) went to UK biomass and 313,000 tonnes (7%) was exported for biomass. We know from the Environment Agency waste interrogator data that less than 1% of 'waste' timber ends up in landfill. This leaves approximately 665,000 tonnes (15%) unaccounted for, which is likely to have ended up in the 'refuse derived fuel' element of waste from materials recovery facilities (MRFs) that is either used in the UK or exported for use as a fuel in energy production.

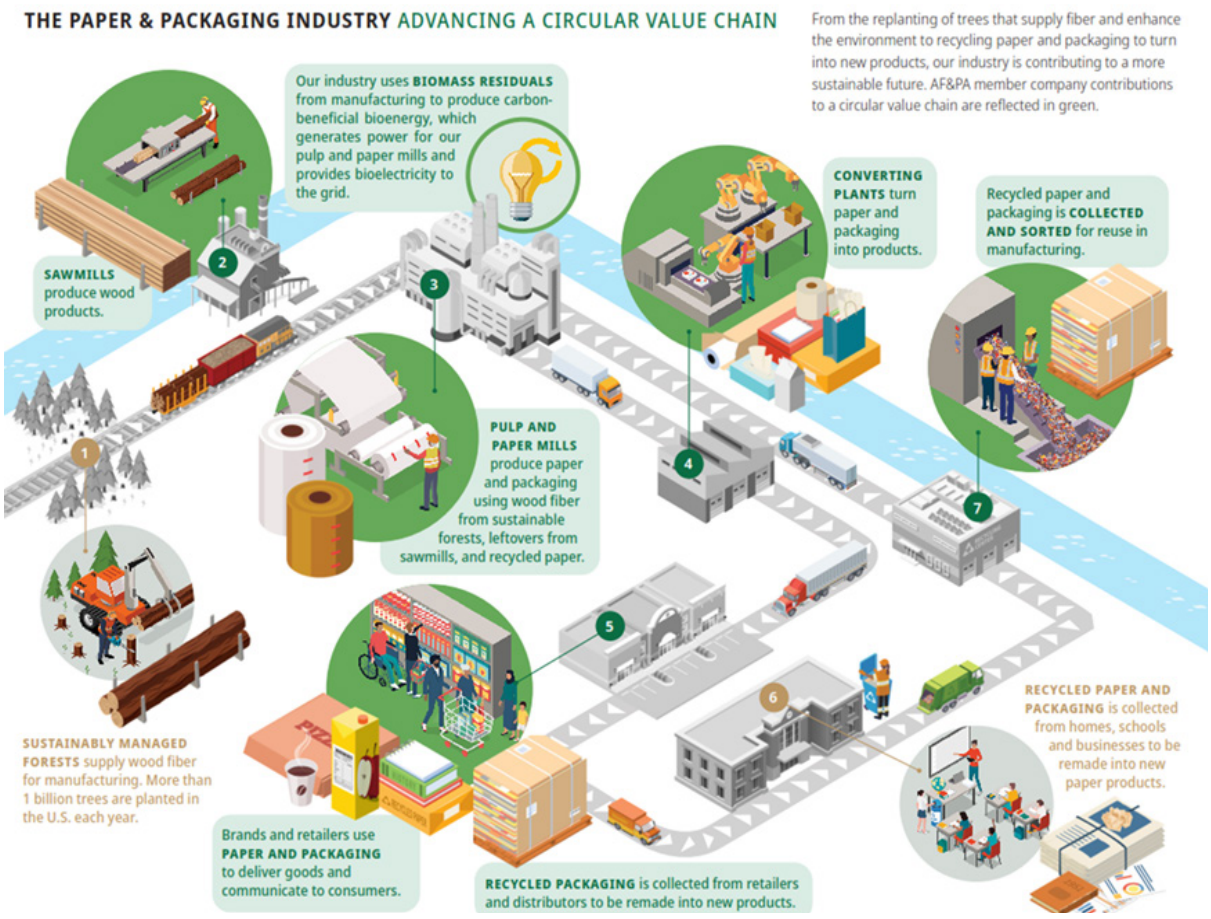
With ever-increasing energy and resources going into timber production generally, and engineered timber products, should designers look at how these products could be developed to follow the technical cycle, at least initially, and aim to:

- maintain timber products in place for longer,
- refurbish and reuse timber components,
- look at how certain components could be remanufactured.

In addition, the timber industry must ensure that it becomes more self-sufficient in its timber production, with the UK being second only to China as the largest net importer of timber and timber products, with more than 60% of our timber requirements being sourced from elsewhere.



The forest products industry is inherently circular in its supply chain. Trees are replanted to supply fiber and enhance the environment. Paper and packaging are recycled to make new products. This is how this industry is contributing to a more sustainable future.



Source: The American Forest & Paper Association (AF&PA)

Let's break it down:

It starts with sustainably managed forests that supply wood fiber for manufacturing. Most forests in the U.S. are privately owned by small landowners. More than 1 billion trees are planted in the U.S. each year.

Sawmills use sustainably harvested wood to make wood products. Wood fiber from sawmills is also used, often with recycled paper, to manufacture paper and packaging. Converting mills turn this paper into products.

The paper and packaging industry uses renewable biomass energy residuals – leftover wood fiber and other manufacturing materials – to power mills.

Paper-based packaging is a sustainable option that allows brands to deliver products safely and communicate with consumers. After use, packaging is collected and sent back to mills to be recycled.

In the United States, 94% of the people have access to community recycling programs for paper. And 79% of Americans have access to residential-curbside programs, making it efficient and effective to recycle paper at home. Many of companies own and operate material recovery facilities and collection programs.

As this process comes full circle, the recycled paper is sorted and fed back into our manufacturing process to make new products.

Sustainably managed forests

The foundation of a sustainable paper cycle is the use of wood from sustainably managed forests, where after trees are felled, they are being replaced with seedlings that eventually grow into mature trees, ensuring that the forest is constantly renewed. Such carefully and skilfully managed forests can ensure that tree growth exceeds the rate of extraction, enhances the long-term storage of carbon, and protects biodiversity to maintain forest health. And it of course provides a source of renewable raw material.

Pulp production

Pulping is the process of breaking down solid wood into the individual cellulose fibres that will be used to make paper. Different types of paper require different types of pulp. Fresh pulp (sometimes called Virgin pulp) is produced from pulp wood in one of two basic ways. The first is by mechanical grinding of pulpwood to produce mechanical pulp. This sort of pulp is used mainly for papers which have a short life span such as catalogue papers and newspapers. The second is by cooking the wood with chemicals to dissolve the material which binds fibres together in wood. This produces chemical pulp, usually referred to as Wood Free pulp. This type of pulp is normally used for papers with a longer life span, such as office papers and high-quality marketing material.

Paper production

The basic principles of papermaking have remained almost unchanged for two thousand years. Fibres are distributed evenly in water and the water is drained, leaving the fibres bonded together. Today, we utilise the most advanced technology, not only to make paper, but also to ensure that the process utilises raw materials in the most sustainable way, with minimal impact on the environment at every stage from resources to recycling. Papermaking today requires more technology than a jumbo jet. The paper machine is as wide as a two-lane highway and operates 24 hours a day, seven days a week, almost all year long. The three main resources used in papermaking are water, energy and cellulose fibres. Sustainably managed forests provide the cellulose fibres. Lakes and rivers provide the water. Much of the energy used is generated from by-products and side-streams created by the pulp and papermaking processes themselves.

Printing and converting

Printing and converting are important stages in the paper life cycle because they can influence how easily a product can be recycled after use. Printing and converting processes can change the characteristics of the paper in a way which may then hinder their recycling. For instance, the use of water-based inks, and extensive use of foil printing, or laminates.

Consumer

The reader plays a crucial role in maintaining a sustainable paper cycle, because without their conscientious actions after use, paper would never be recycled.

Collection and sorting

One basic rule in using recovered paper is that you can only make a high-quality product from high quality raw material. So if you want to recycle used paper into graphic papers, then you need to sort out the higher quality use paper from lower quality packaging. Only light-coloured recovered papers (newsprint, magazines, advertising materials) are suitable as a raw material for graphic paper products. Collection and sorting of used paper is also needed in order to remove and separate other valuable recyclable materials such as glass, metals and plastic.

Recycling and deinking

Recovered paper needs to be de-inked before the cellulose fibres in it can be reused in papermaking. This process needs some chemicals and a certain amount of energy and water, and removes the inks, fillers and coatings from the paper to leave clean fibres. The by-product resulting from this process can be used as a fuel to generate energy for the mill, and in many cases the fillers and coating removed find reuse in the cement or construction industry, or even back in the papermaking process itself. It's important to remember that some cellulose fibres are also lost during the deinking process and so the use of virgin fibres will always be necessary to maintain the paper cycle.

Paper packaging fits into the circular economy model seamlessly. Its raw material, wood fiber, is a renewable, natural, and sustainable resource. Paper packaging is easily collected and recycled, ensuring these valuable fibers are used time and time again.

Well-designed, efficiently produced, appropriately used and responsibly disposed-of packaging provides multiple benefits. It is essential to prevent product damage and can help extend a product's life. It helps improve efficiency in the supply chain and provides safe and convenient access to goods. Packaging communicates vital information to the customer whilst providing a great 'unboxing experience' to those receiving gifts or luxury items. However, poor material choices are damaging to both brands and the planet.

Paper packaging utilizes an exceptional amount of recycled material, but paper fibers cannot be recycled indefinitely, so there will always be a need for fresh/virgin wood fiber from sustainable sources to enter the cycle. Certification is important to communicate and demonstrate to stakeholders and final wood-product consumers the sustainability of forest management and its products. The **most common forest certification schemes in Europe** are FSC® (Forest Stewardship Council) and PEFC™ (the Programme for the Endorsement of Forest Certification).

Glass in Circular Economy

Glass stands out as one of the best examples of the closed loop production model because it is one of the most effectively recycled materials in Europe (67% on average). This is not only because of its natural characteristics - it is 100% and infinitely recyclable - but also because of well-established separate collection schemes. However, more can be done. Increasing recycled glass brings major benefits to the environment because when recycled glass is used, fewer raw materials are extracted, less waste is generated, less energy is used, and less CO2 is emitted.

Once produced, glass is one of those rare materials that can be 100% and infinitely recycled in a bottle-to-bottle loop without any loss of quality: recycled glass is not waste, but a precious resource the industry requires to replace virgin raw materials. Glass recycling has many benefits: more than 70% of all post-consumer glass packaging is recycled in the EU, thus keeping valuable resources out of landfills. One ton of recycled glass saves 1.2 tons of virgin raw materials and cuts CO2 emissions by 60%. The container glass manufacturing model fits perfectly with the EU's ambition to build a circular economy.

It is 100% recyclable, again and again.

Recycling means the economy can continue to flourish in a sustainable way, by reusing supplies and creating jobs to remake and resell products that we all rely on as consumers. In fact, most of Europe's glass is already recycled (recycling rates are at 80% and rising in Europe!) – but with your help, we can reach 100%.

It's reusable and refillable.

In addition to its recyclability properties, glass can be reused and refilled without losing quality. Bottles can be used up to 50 times before recycling and remelting them into new containers at the end of their lives – closing the loop on a complete circular economy.

It is good for the environment.

Recycling saves energy, natural resources, and substantially lowers carbon emissions. As cullet requires less energy to be melted and shaped, every tonne of cullet used saves 670 kg of CO2!

Glass's inherent properties make it an ideal fit for the EU's circular economy ambitions. Not only can glass be reused up to 50 times; it can also be endlessly recycled in a closed bottle-to-bottle loop, meaning a used glass bottle never has to be waste. Made from all natural resources, glass is impermeable, virtually inert, and always food safe – no matter how many times it is recycled.

To close the loop and achieve a complete circular economy for glass packaging in Europe, the European container glass industry calls on the European Institutions to consider the following points as essentials for a Circular Economy:

- Multiple recycling of a permanent material is the best option for resource efficiency.
- Separate collection and a ban on backfilling for recyclable materials are key to ensure that the best quality recycles are re-introduced into the production process.
- Manufacturing industries, such as glass packaging which produce sustainable products, create jobs and bring added value to Europe, and need to be supported as they already are successful examples of a European Circular Economy.

Critical materials

The EU is aiming to ensure a secure and sustainable supply of critical raw materials for Europe's industry. The EU is heavily dependent on critical raw materials from a number of third countries. Our dependency, combined with the growing global demand due to the shift towards a digital and green economy makes supply chains vulnerable.

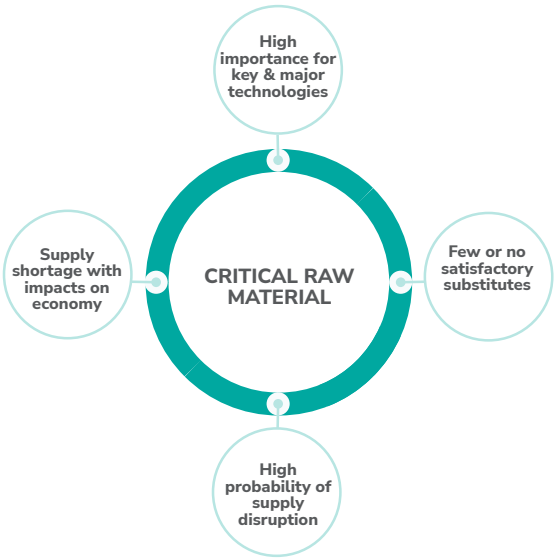
There is a great demand for metals and minerals in today´s society. In Europe, we consume about a quarter of the world´s raw materials but produce only three percent. This means a large dependency on imports. According to the EU, European production of raw materials needs to increase.

The EU has listed 34 minerals and metals as critical and/or of strategic importance for European society and welfare. These critical raw materials (CRMs) constitute ingredients in key technologies necessary for securing the green transition, digitalisation, space industry and defence capabilities. They are critical because of their economic importance in relation to the risk of supply interruption (the supply risk).

The latest list, which was determined in 2023, also includes a group of 16 so-called strategic raw materials (SRMs) of even greater priority. Two metals in this group are not classified as critical, only as strategic: copper and nickel. Their global production is sufficiently diversified not to have a high supply risk, but they are considered to be so fundamental, above all for electrification, as to be included in the strategic classification.

2020 EU Critical Raw Materials

Antimony	Hafnium	Phosphorus
Baryte	Heavy Rare Earth Elements	Scandium
Beryllium	Light Rare Earth Elements	Silicon metal
Bismuth	Indium	Tantalum
Borate	Magnesium	Tungsten
Cobalt	Natural Graphite	Vanadium
Coking Coal	Natural Rubber	Bauxite
Fluorspar	Niobium	Lithium
Gallium	Platinum Group Metals	Titanium
Germanium	Phosphate rock	Strontium



Source: U.S. Geological Survey, 2022

This list is based on the assessment described in the U.S. Department of Energy's (DOE's) most recent critical materials assessment, the 2023 DOE Critical Materials Assessment. The results of the assessment are shown in the criticality matrices above. The Final 2023 Critical Materials List includes all materials that were assessed as "critical" or "near critical" in either the short or medium term – with the exception of uranium.

This list includes critical materials for energy, as determined by the Secretary of Energy, as well as those critical minerals on the 2022 final list published by the Secretary of Interior, acting through the director of the U.S. Geological Survey. The Final 2023 Critical Materials List includes the following:

- **Critical materials for energy ("the electric eighteen"):** aluminium, cobalt, copper, dysprosium, electrical steel, fluorine, gallium, iridium, lithium, magnesium, natural graphite, neodymium, nickel, platinum, praseodymium, silicon, silicon carbide, and terbium.
- **Critical minerals:** The Secretary of the Interior, acting through the director of the U.S. Geological Survey, published a 2022 final list of critical minerals that includes the following 50 minerals: "Aluminium, antimony, arsenic, barite, beryllium, bismuth, cerium, caesium, chromium, cobalt, dysprosium, erbium, europium, fluorspar, gadolinium, gallium, germanium, graphite, hafnium, holmium, indium, iridium, lanthanum, lithium, lutetium, magnesium, manganese, neodymium, nickel, niobium, palladium, platinum, praseodymium, rhodium, rubidium, ruthenium, samarium, scandium, tantalum, tellurium, terbium, thulium, tin, titanium, tungsten, vanadium, ytterbium, yttrium, zinc, and zirconium."

The circular economy for critical minerals does not just denote 'recycling.' The principle of waste reduction should occur throughout the entire supply chain, and many circular economy practices for critical minerals arise well before a product reaches the end-of-life.

For example, at the primary production stage, mines that typically focus on base metals have the opportunity to extract lesser known 'critical minerals' from their waste as by-products. This reduces the amount of waste rock and the number of new mines needed for critical minerals. Mineral wastes, such as tailings, are rich sources of critical minerals that, in comparison to primary sources, have been pre-processed, offering an easy to access, low-cost option to secure critical minerals. However, adding new technologies to extract by-products to a company's operations for critical minerals may not immediately compensate for additional costs, therefore, it needs encouragement and support from government.

At the midstream stage, when mined materials are transformed into the compounds needed by manufacturers, there are many circular economy opportunities. Instead of being wasted, offcuts from the manufacturing process can be remanufactured. This is also where recycled materials can be reintroduced into the supply chain as secondary feedstock.

When advanced high-tech products like batteries, solar panels, mobile phones, and computer hard drives reach their end-of-life, these items can be processed to recover minerals and materials and sold back to the manufacturing sector as secondary feedstock. This reduces the pressure on primary inputs and supports the circular economy.

Consumers also have an essential role to play. Demand for critical minerals will continue to increase as the population grows and more people look forward to higher living standards. For example, there will always be an element of waste in buying new mobile phones and discarding not-quite-outdated phones each year. People who are serious about the tenets of a circular economy should remember the principles of repair and reuse and recognize that hefty consumerism is ultimately fueling our increasing need for critical minerals.

As the volume of end-of-life high-tech technologies and the critical minerals contained therein are relatively small, recovery and recycling efforts are nascent. A vicious circle arises when companies are unable to invest in a recycling plant because the feedstock is small and unreliable. Products are not being collected for recycling because there are not enough recycling plants for these niche materials. With the demand for advanced technologies expected to increase over the coming decades, governments now have opportunities to work with industry and consumers to foster a circular economy approach for critical materials.

Recycling for critical metals needs to be seen as a system which begins with collecting, sorting and dismantling, pre-processing to separate components containing valuable metals, and upgrading relevant fractions before final metallurgical processing.

Integration of the roles of the key stakeholders at all stages of the cradle-to-cradle cycle:

- primary metals producers of both base and rarer metals;
- product designers to optimize critical material use and recyclability into the design phase;
- retailers and local government to provide the facilities for collection and separation to provide the raw materials for recycling;
- consumers to cooperate in separation and return programs for EoL goods;
- governments to provide an appropriate societal and legislative framework to deliver high rates of recycling (e.g., Extended Producer Responsibility schemes, effective collection and sorting and public education);
- recyclers applying best available techniques (BAT) to recover critical materials from separated waste streams.

What are eco-materials?

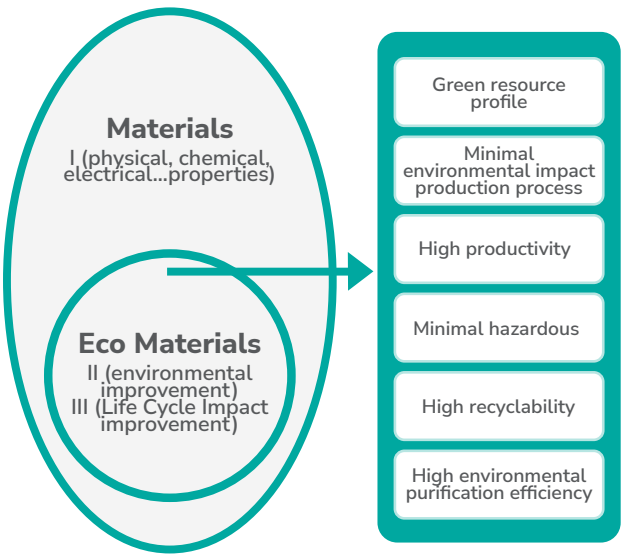
Eco-materials are defined as those materials that enhance environmental improvement throughout the whole life cycle, while maintaining accountable performance (Halada & Yamamoto, 2001). Eco-materials play a key role in material science and technology to minimize environmental impacts, enhance the recyclability of materials, and to increase energy and material efficiency. In North America and Europe, eco-materials are often called 'environmentally-friendly materials' or 'environmentally preferable' materials.

Definition of superior properties of eco-materials:

1. Energy saving ability to reduce total life cycle energy consumption of a system or device.
2. Resource saving ability to reduce the total life cycle material consumption of a system or device.
3. Reusability to allow the reuse of collected products as similar functions.
4. Recyclability to allow the use of collected product of material as a raw material.
5. Structural reliability to be used on the basis of its reliable mechanical properties.
6. Chemical stability to be used over the long term without chemical degradation.
7. Biological safety ability to be used without causing negative effects to the ecological system.
8. Substitutability to be used as an alternative to 'bad' materials.
9. Amenity to ensure the comfort of working environment.
10. Cleanability to separate, fix, remove and detoxify a pollutant for the environmental treatment process.

Eco-materials are those that can contribute to reduction of environmental burden through their life cycles. In other words, any material could be an eco-material as long as it satisfies the pre-requisites (I) and necessary conditions of eco-materials (II and/or III). The pre-requisites of eco-materials include the optimization of physical and/or chemical properties and best technical performance (I).

Conceptual model of eco-materials within the context of material science
(Nguyen, X. H.,T. Honda, et al. (2003))



Practical Recommendations and Tips: Selection of low-impact materials in Circular Design

How to select: **Cleaner materials?**

1. Do not use materials or additives which are prohibited due to their toxicity. These include PCBs (polychlorinated biphenyls), PCTs (polychlorinated terphenyls), lead (in PVC, electronics, dyes, and batteries), cadmium (in dyes and batteries), and mercury (in thermometers, switches, fluorescent tubes).
2. Avoid materials and additives that deplete the ozone layer such as chlorine, fluorine, bromine, methyl bromide, halons and aerosols, foams, refrigerants, and solvents that contain CFCs.
3. Avoid the use of summer smog-causing hydrocarbons.
4. Find alternatives for surface treatment techniques such as hot-dip galvanization, electrolytic zinc plating and electrolytic chromium plating.
5. Find alternatives for non-ferrous metals such as copper, zinc, brass, chromium, and nickel because of the harmful emissions that occur during their production.

How to select: **Renewable materials?**

6. Find alternatives for exhaustible materials.

How to select: **Lower energy content materials?**

7. Avoid energy-intensive materials such as aluminium in products with a short lifetime.
8. Avoid raw materials produced from intensive agriculture.

How to select: **Recycled meterials?**

9. Use recycled materials wherever possible, to increase the market demand for recycled materials.
10. Use secondary metals such as secondary aluminium and copper instead of their virgin (primary) equivalents.
11. Use recycled plastics for the inner parts of products which have only a supportive function and do not require a high mechanical, hygienic or tolerance quality.
12. When hygiene is important (as in coffee cups and some packaging) a laminate can be applied, the center of which is made from recycled plastic, covered with or surrounded by virgin plastic.
13. Make use of the unique features (e.g., variations in color and texture) of recycled materials in the design process.

How to select: **Materials with positive social impact, i.e., generating local income?**

14. Make use of materials supplied by local producers.
15. Stimulate arrangements for recycling of materials by local companies which can substitute (part of) the raw materials of the company.

How to select: **Reduction of materials usage?**

16. Aim for rigidity through construction techniques such as reinforcement ribs rather than ‘over dimensioning’ the product.
17. Aim to express quality through good design rather than over dimensioning the product.
18. Aim at reducing the amount of space required for transport and storage by decreasing the product’s size and total volume.
19. Make the product foldable and/or suitable for nesting.
20. Consider transporting the product in loose components that can be nested, leaving the final assembly up to a third party or even the end user.

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External resources

- https://www.circulardesignguide.com/post/material-selection
- http://www.planningnotepad.com/2013/01/sustainability-design-3-redesigning.html
- https://blogs.helsinki.fi/inventionsforcirculareconomy/circular-economy/biological-and-technical-cycles/
- https://simplicable.com/new/upcycling-vs-downcycling
- https://www.conserve-energy-future.com/recyclingmaterial.php
- https://www.goodstartpackaging.com/biodegradable-vs-compostable-what-is-the-difference/
- https://www.ecoenclose.com/blog/8-things-to-know-about-compost-facilities-and-6-tips-to-be-a-responsible-composter/
- https://www.geeksforgeeks.org/biodegradable-and-non-biodegradable-materials/

Continue exploring other Topics

Topic 1	Topic 2	Topic 3
Circular Economy and Sustainability	Waste as a Resource in Circular Economy	Circular Value Chains, Ecosystems, and People
Topic 4	**Topic 5**	**Topic 6**
Circular Business Models	Life Cycle Thinking and Environmental Footprint	Design Thinking for Circular Products
Topic 7	**Topic 8**	**Topic 9**
Reusability, Repairability, Recyclability	Integration of Circular Approaches into Everyday Work Life	Circular Economy Policies across Baltic Sea Region Countries

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Circular Value Chains, Ecosystems, and People

Developed by
Valmiera County Council

Topic 3

This training Topic is aimed at explanation and analysis of the value chain and stakeholders' role from circularity aspects. Different examples of businesses and society are presented and discussed. When analysing circularity for local communities, the question of ecosystems becomes important. Also, barriers and drivers of CE are observed and compared.

Expected training outcomes

After completing this Topic, trainees will...
... ability to recognize and analyse stakeholders ir circular eocnomy;
... understanding of circular value chains;
... ability to identify / recognize barriers and ecosystems;
... examples of ideas on how to involve companies, and people in circular thinking;
... skills on how to perform changes in people's attitudes.

Notes for target groups

Different target groups can achieve the following benefits of this training Topic.

Makers

Acquiring knowledge on value-chains, stakeholders in circular economy.

Makerspaces

Transitioning towards an ecologically and circularity-focused approach in value chains.

Suppliers

Grasping the circular strategy through the circular value chain and real examples.

Students/Pupils

Developing an understanding of circular practices in value-chain and stakeholders' analysis and examples.

Business support organizations

Embracing new circular value chains and helping businesses to become more circular.

Other relevant stakeholders

Familiarizing the circular strategy through the circular value chain and real examples.

Training plan

Introduction (Slides 1-2)	Main part (Slides 3-11)	Conclusion (Slides 12-18)
Introducing the presentation's purpose and addressing current issues or challenges relevant to the topic.	In the main segment, the presentation navigates from abstract theoretical frameworks to practical real-life applications, elucidating various focused theories along the way. The exercise is designed to identify the practical benefits of the circular economy, the challenges involved and the first circular economy solutions that can be implemented.	Final discussion about examples for CE and integrated learning approach is used for check-up.
Presentation, discussion.	*Presentation, discussion.*	*Presentation, discussion.*

Total duration for the Topic 3: approx. 2 h

Training modes

In person	Online	Hybrid
10 minutes reception + 90 minutes class	90 minutes + 10 minutes for questions	90 minutes class + 10 minutes for questions

Notes for the trainer

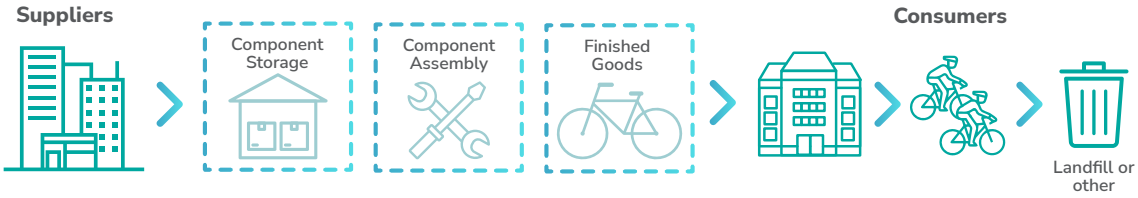
Required previous experience and theoretical knowledge	Ethical aspects of carrying trainings	Training tools and resources
Understanding of Linear and Circular Economy, business models, stakeholders.	An evident eagerness for knowledge acquisition and an inquisitive exploration of creative design methods, accompanied by a keen understanding of the nuanced demands of present-day societal dynamics.	*For trainer:* computer, projector or any other screen (used for presentation) *For trainee:* notebook, computer or smartphone (used for case studies' research)

Concepts of value chains

Circular economy model involves sharing, leasing, reusing, repairing, refurbishing, and recycling to extend product life cycles. The main goal is to minimize waste by keeping materials within the economy through recycling and creating further value. When departing from linear economic model, traditional Take-make-dispose pattern is replaced.

Discussion

Discover value chain in linear economy and find out which parts of value chain must be influenced at first in order to make changes to circularity.

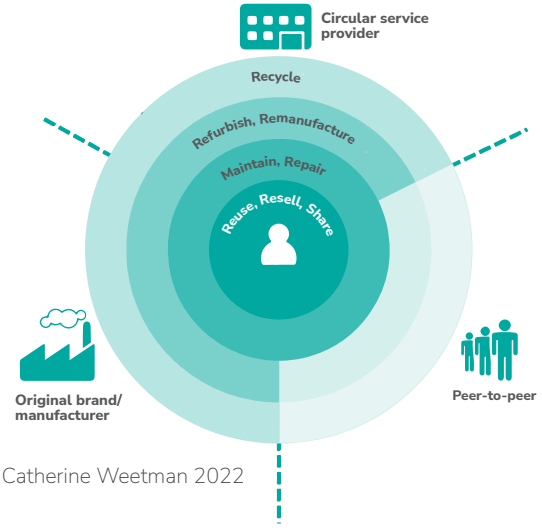


Suggested reading: Weenk, E., & Henzen, R. (2021). Mastering the Circular Economy. Kogan Page, 5-34 pages.

The basic idea of value chain changes in order to close the loop or maintain everything in chain as in circle. This slide introduces the idea of service providers as main players instead of manufacturers. It also increases part of society's role – sharing economy.

Most products flow through four typical loops:

- Reuse, resell, and share – ways to keep the original product in use, such as reselling it, returning it after its use for someone else to use it, or sharing it, so more people can use it.
- Maintain and repair, to keep the product working efficiently and effectively for a longer time.
- Refurbish and remanufacture, which needs deeper levels of intervention.Refurbishing involves cleaning, surface-level repairs, and maintenance, perhaps repainting and polishing the product or equipment.
- Recycling is the outermost and least effective loop. Recycling requires lots of energy and may need expensive labour or equipment to sort and separate different materials. There are different 'levels' of recycling too. Ideally, we want to recycle materials to use them again in the same kind of application; and avoid 'downcycling' them into a lower-grade, lower-value material with inferior functional specifications.



More reading: Weetman, Catherine. *A Circular Economy Handbook*. Available from: VitalSource Bookshelf, (2nd Edition). Kogan Page, 2020, 13-44 pages

There are currently five leading value creation concepts that reconceive business's value to society.

1. Stakeholder Value. Central to this concept is how stakeholders (e.g. customers, suppliers, employees, financiers, communities, and management) work cooperatively to create value. This means that business is a 'set of value-creating relationships among groups that have a legitimate interest in the activities and outcomes of the business and upon whom the business depends to achieve its objectives' (Phillips et al, 2019).

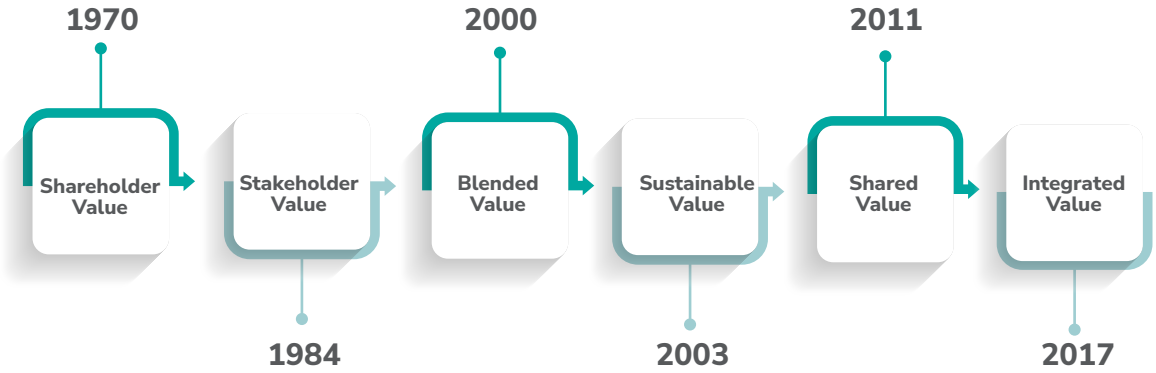
2. Blended Value. In this conceptual framework – also known as mission-related investing, impact investing, aligned capital, and social investments – businesses, investments, and non-profit organizations are evaluated based on their ability to generate a blend of social, environmental, and financial value (Emerson, 2000). This holistic approach is sometimes used interchangeably with the triple bottom line people, planet, and profit.

3. Shared Value. Creating Shared Value already has an acronym, CSV, and it's a framework in which a business's success and social progress are interdependent. It enhances the competitiveness of a business while 'simultaneously advancing the economic and social conditions in the communities in which it operates. Shared Value creation focuses on identifying and expanding the connections between societal and economic progress' (Porter and Kramer, 2011).

4. Sustainable Value. The framework views global sustainability challenges through the business lens, which helps to identify the right strategies and practices that contribute to a more sustainable world while simultaneously driving shareholder value. This win-win approach is defined as the creation of sustainable value (Hart and Milstein, 2003).

5. Integrated Value. Creating integrated value is the simultaneous building of multiple 'non-financial' capitals (such as human, ecological, social, technological, and infrastructural capital) through synergistic innovation across the nexus economy (including the circular, well-being, access, exponential, and resilience economies) that result in net-positive effects, thus making our world more satisfying, sustainable, shared, smart and secure (Visser, 2017a).

Suggested reading: Weenk, E., & Henzen, R. (2021). *Mastering the Circular Economy*. Kogan Page, 34-91 pages



Weenk, E., & Henzen, R. (2021). Mastering the Circular Economy.

Stakeholders & CE strategies

The picture below illustrates that all identified stakeholders have the possibility to affect the value chain by different strategies.

	Waste management	Waste Biochemical experts/Labs	Waste Renewable material products	Users	Service providers	Product manufacturers	Part manufacturers	Recycling Facilities
			■	■	■	■	■	
Maintain & Prolong			■	■	■	■	■	
Reuse & Redistribute			■	■	■	■	■	
Recycle	■			■	■	■	■	■
Cascades			■	■		■	■	
Biochemical extraction	■	■	■	■				
Return to biosphere	■			■				

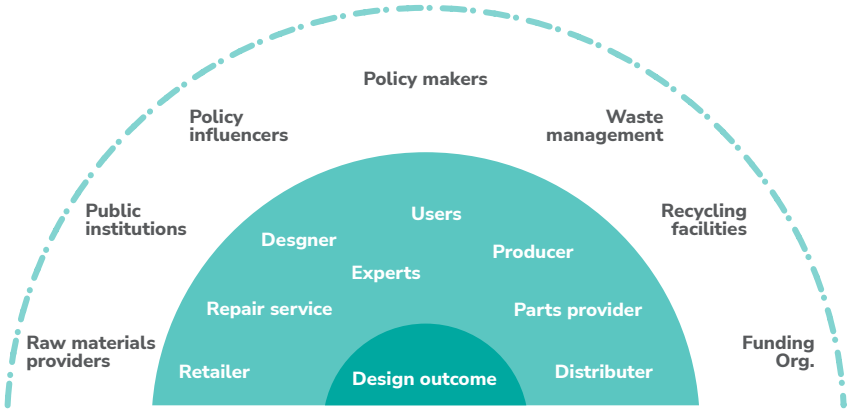
SOURCE

Discussion

Each organization involved in the value chain should be considered in terms of its power or influence on the collaborative product. The above matrix can be used as an example when examining own company / organization by identifying and defining intervention points.

Suggested reading: G2: Stakeholders and collaboration, https://upcommons.upc.edu/bitstream/handle/2117/179149/Handbook-in-IDfSpdf;jsessionid=F6DFB47D850447FD5C055455F65484EB?sequence=1

Stakeholders in circular economy can be both direct and indirect. Picture below illustrates the variety of such stakeholders for particular product outcome.



SOURCE

Discussion

Discuss why stakeholders in the circular economy are separated into direct and indirect ones. Examine each stakeholder, their role and importance in the specific product development process.

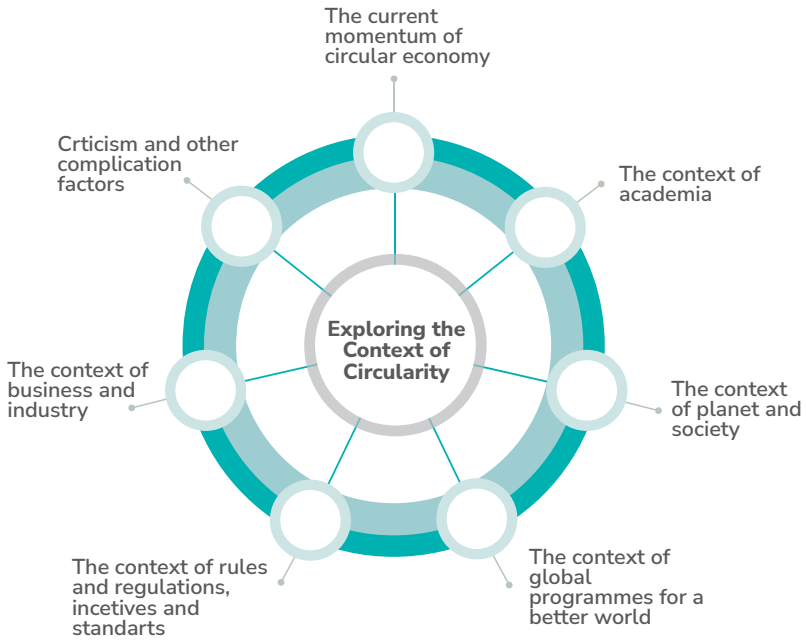
Suggested reading: G2: Stakeholders and collaboration, https://upcommons.upc.edu/bitstream/handle/2117/179149/Handbook-in-IDfSpdf;jsessionid=F6DFB47D850447FD5C055455F65484EB?sequence=1

Implementing circular economy

Discussion

Investigate the scheme below and discuss its components as well as relations. Explain different aspects or views on circular economy and its development stage.

Suggested reading: Weenk, E., & Henzen, R. (2021). Mastering the Circular Economy. Kogan Page, 5-34 pages



Discussion

Instructions for trainees	Instructions for trainers
Discuss in groups answers to the following questions: 1. What are the benefits of being circular for (1) entrepreneurs, (2) local government, (3) citizens 2. What are the problems to become circular faced by (1) entrepreneurs, (2) local government, (3) citizens? 3. Where would you start to act more circular in your closest surrounding? Please, mention 3-5 examples.	The biggest group can be divided into three smaller groups – entrepreneurs, local government and citizens. Each group should find answers to these three questions. Groups can also be formed from the representatives of different stakeholders who can work on these three questions. Exercise all together takes 40 min: 15-20 min for discussing answers and other 15-20 min for presentations; additional 5-10 min for trainer summary.

European Union planning documents has set circular economy implementation milestones, which must be followed by all stakeholders. They are:

- Established legal framework
- Administrative support and conditions
- Economic and financial instruments
- Educated and involved society

Barriers to circular economy, based on the research by Ritzén S. et al. (2017):

Theoretical		Research findings
Financial	Measuring financial benefits of circular economy	1.Attitude and knowledge 2.Integration between functions 3.Value chain structure 4.Values and finances 5.Technology
	Financial profitability	
Structural	Missing exchange of information	
	Unclear responsibility distribution	
Operational	Infrastructure/Supply chain management	
Attitudinal	Perception of sustainability	
	Risk aversion	
Technological	Product design	
	Integration into production processes	

Discussion

Discuss the results of barrier analysis. Compare and agree on the key aspects of successful circular economy implementation, based on information provided above.

Additional reading: Ritzén S. et al. (2017) Barriers to the Circular Economy – integration of perspectives and domains, Elsevier, Procedia CIRP 64

Ecosystems

Drivers of ecosystem change: habitat destruction, invasive species, pollution, population, overexploitation, climate change.

Conservation and restoration: disturbance, structural complexity, connectivity, resilience.

Living together (reconciliation ecology): yards and parks, birds, bats, green roofs, cemeteries, military sites, golf courses, agricultural lands, public lands, utility corridors, roads and wildlife crossings.

Discussion

Investigate and comment on drivers of ecosystem change by using one of mentioned aspects – e.g. invasive species. Then conservation and restoration aspects should be discussed, again from one of mentioned aspects – e.g. disturbance. The third ecosystem aspect is reconciliation – how all mentioned aspects can live together – e.g. expanding military sites.

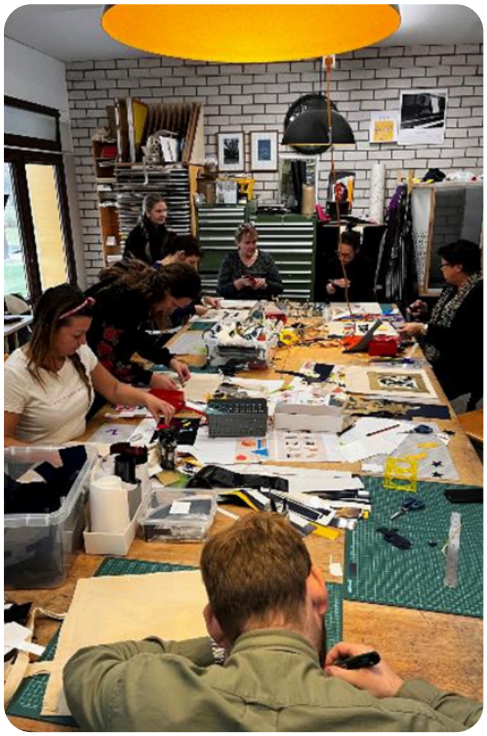
Suggested reading: Robertson M. (2021) Sustainability Principles and Practice, 3rd Edition. Routledge, 137-169 pp.

Examples of circularity

Title	Description	Pictures
Business: Hotels	This is a real, existing hotel in global environment, which presents solution, how to co-exist with nature.	
Business: Packaging	Different examples of packaging, which can be more sustainable and eco-friendlier.	   www.pixabay.com
Society: Energy effiency	Examples of how society as a whole can change its everyday life by saving energy, water. Small discussion about examples.	  www.pixabay.com
Society: Re-using	Examples of how society in general can change its everyday life by giving a new life to second-hand objects - a second, third life. Small discussion about the examples in the pictures.	  
Urban communes, society: Kitchen garden	Urban gardening, small-scale gardening is a good example of how citizens can reuse their bio-waste.	 

Makerspaces example: DARE and local families

Makerspace DARE has already been setting up great examples of circularity in the past by promoting more environmentally friendly decision-making through workshops. There have been various activities for adults and families with children. For example, creating interior elements from used glass bottles (such as vases, glasses and light objects), upcycled lamps with new design elements from different scrap materials. Another form of workshop is using scrap material left from printing stickers and creating new designs with these colourful pieces on fabric.



Change management

An integrated learning approach should always be taken into account when engaging with stakeholders and trying to change their attitudes.

Integrated learning approach

Meaningful & relevant	Need to appeal to learner's perspective: business, society, citizenship
For now & the future	Not only the basics, but link to future changes & challenges
'Feel' the complexity!	Everything looks simple, until you're in the driving seat
Knowledge & skills	Not only '*know the concepts*', but also '*able to decide*' (trade-offs)
Individual & team activities	Individual view versus team & cross-functiional alignment
Engaging & fun	Motivate: through the *content*, but also through the *methodology* ('gamification')

Discussion

Discuss different aspects of integrated learning approach and define next steps to be taken.

Suggested reading: Weenk, E., & Henzen, R. (2021). Mastering the Circular Economy. Kogan Page, Preface, 286 pages

Used references and additional resources

- Ritzén S. et al. (2017) Barriers to the Circular Economy – integration of perspectives and domains, Elsevier, Procedia CIRP 64
- Robertson M. (2021) Sustainability Principles and Practice, 3rd Edition. Routledge, 137-169 pp.
- Weenk, E., & Henzen, R. (2021). Mastering the Circular Economy. Kogan Page, 5-34 pages
- Weetman, Catherine. A Circular Economy Handbook. Available from: VitalSource Bookshelf, (2nd Edition). Kogan Page, 2020, 13-44 pages
- Teching circular design: https://upcommons.upc.edu/bitstream/handle/2117/179149/Handbook-in-IDfS.pdf;jsessionid=F6DFB47D850447FD5C055455F65484EB?sequence=1
- Hotels: planet-friendly ideas for lowering your carbon footprint: https://www.dawnvale.com/news/hotels-planet-friendly-ideas-for-lowering-your-carbon-footprint/
- 25 ways to reuse common household items: https://maximizeminimalism.com/25-ways-to-reuse-common-household-items/
- How To Start A Permaculture Garden: https://grocycle.com/how-to-start-a-permaculture-garden/

Continue exploring other Topics

Topic 1

Circular Economy and Sustainability

Topic 2

Waste as a Resource in Circular Economy

Topic 3

Circular Value Chains, Ecosystems, and People

Topic 4

Circular Business Models

Topic 5

Life Cycle Thinking and Environmental Footprint

Topic 6

Design Thinking for Circular Products

Topic 7

Reusability, Repairability, Recyclability

Topic 8

Integration of Circular Approaches into Everyday Work Life

Topic 9

Circular Economy Policies across Baltic Sea Region Countries

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Circular Business Models

Developed by
Ventspils High Technology Park

Topic 4

This training Topic provides a comprehensive understanding of circular business models, enabling participants to apply circular principles in their professional activities or entrepreneurship ventures. It is adaptable to different educational settings and can be customized to meet specific learning objectives and time constraints.

Expected training outcomes

After completing this Topic, trainees will...
... circular and linear business models;
... types of linear business models;
... possibilities to transfer from linear to circular business models;
... where to look for information about circular economy.

Notes for target groups

Different target groups can achieve the following benefits of this training Topic.

Makers

Information and samples that can be used for transferring to circular economy.

Makerspaces

Ideas on how to inform makers about circular business models, help to use reusable materials in the prototyping phase.

Suppliers

Ideas for offering more reusable materials.

Start-ups

Suggestions on how to use reusable materials in the prototyping phase, circular business thinking in developing their product.

Small and medium-sized enterprises (SMEs)

Suggestions on how to reuse leftovers and to rethink the product cycle.

Business support organizations

Stipulation of less materials that cannot be recycled, more businesses with less pollution in the region.

Training plan

Introduction (45 min / 1-11 slides)	Main part (2 h 30 min / 12-41 slides)	Conclusion (45 min / 42-45 slides)
Linear and Circular Business Models; Principles of Circular Business Models; Benefits of Circular Business Models.	Circular business models; Economical models and good practices; How to transfer from linear to circular business model; Circular business model innovation challenge task.	Challenges and considerations; Opportunities; Conclusion.
Presentation.	*Presentation, workshop.*	*Presentation, discussion.*

Total duration for the Topic 4: 4 h

Training modes

In person	Online	Hybrid
In person training involves face-to-face sessions conducted in a physical location. This traditional approach allows direct interaction between trainers and participants, fostering real-time engagement, hands-on activities, and immediate clarification of doubts. It provides a social learning environment and is ideal for building interpersonal skills.	Training is conducted through digital platforms, enabling participants to access content remotely. It offers flexibility in scheduling, self-paced learning, and the convenience of accessing materials from any location with an internet connection. Interactive modules, multimedia elements, and virtual simulations enhance the online learning experience.	Hybrid trainings make it possible for participants from different geographical locations to join, including those who might not be able to travel due to distance, health concerns, or budget constraints. This inclusivity enhances the diversity of perspectives and experiences shared during the training.

Notes for the trainer

Required previous experience and theoretical knowledge	Ethical aspects of carrying trainings	Training tools and resources
Theoretical knowledge about Circular business models. Deep understanding of its principles. Practical knowledge about Circular business models. Sector-specific expertise. Previous experience in lecturing.	Inclusivity and diversity; transparency and honesty; voluntary participation; informed concent; confidentiality; trainer's competence; avoidance of discrimination and bias; feedback and continious improvement. By adhering to these ethical principles, trainers can create a positive and inclusive learning environment that respects the rights and dignity of all participants.	*For trainer:* presentation slides (use the existing presentation or add additional information to the presentation as needed); equipment for showing the presentation; access to video conferencing platform (if people are attending online); paper and pens for activity "Circular Business Model Innovation Challenge". *For trainee:* Computer, good internet connection, headset (if attending online).

Introduction

A **linear business model** is characterized by a straight-line approach to production and consumption, operating on a "take-produce-use-dispose" framework. In this model, resources are extracted, transformed into products, sold to consumers, and eventually discarded as waste after their useful life. The linear model has been the dominant economic model for centuries, driven by a focus on short-term consumption and efficiency. However, it often leads to significant environmental challenges, including resource depletion, waste accumulation, and pollution, because it fails to consider the finite nature of resources and the environmental impact of waste. The Linear business model has been prevalent since the Industrial Revolution (1760-1840).

Key Features of the Linear Business Model:

- Resource Extraction: The model begins with the extraction of natural resources from the environment. This step is foundational to the production process but often leads to the depletion of natural resources and environmental degradation.
- Manufacturing and Production: The extracted raw materials are transformed into products through manufacturing processes. This stage is typically energy-intensive and can contribute to pollution and waste.
- Consumption: Products are sold to consumers, who use them until they are no longer functional or desirable. The focus is on maximizing sales, often encouraging a culture of overconsumption.
- Waste Generation: Once products reach the end of their life or are no longer wanted, they are discarded. The linear model rarely incorporates mechanisms for reusing, recycling, or repurposing materials, leading to significant waste accumulation.

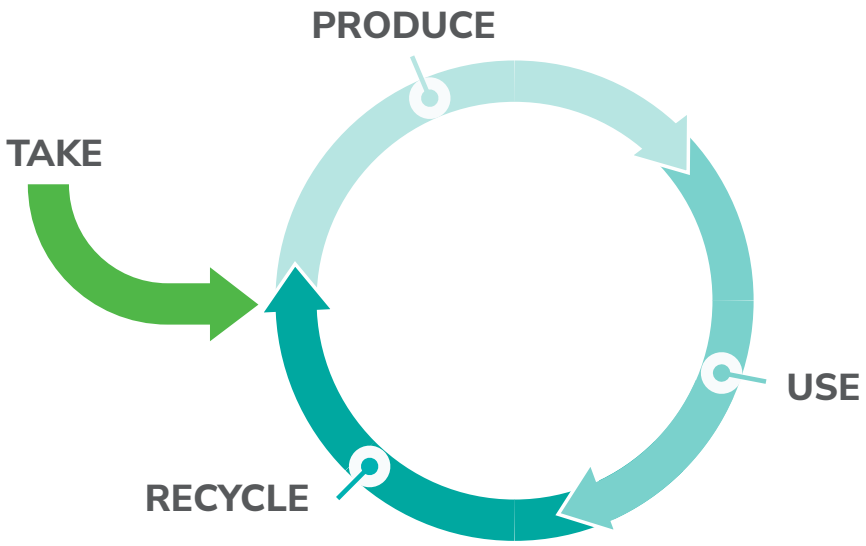
Implications of the Linear Business Model:

- Environmental Impact: The linear model contributes to resource depletion, pollution, and waste. It puts pressure on the environment by not efficiently using resources and not managing waste sustainably.
- Economic Efficiency: While the linear model can be economically efficient in the short term, it faces long-term sustainability challenges, including resource scarcity and the increasing costs of waste management.
- Social Considerations: The model often overlooks the social implications of unsustainable production and consumption patterns, such as health problems related to pollution and the unequal burden of waste management on certain communities.

Given its limitations and unsustainable nature, there is a growing shift away from the linear business model towards more sustainable practices. The circular economy model is one such alternative that aims to address the shortcomings of the linear model by designing out waste, keeping materials in use, and regenerating natural systems. The circular model encourages the development of products and business practices that are sustainable over their entire lifecycle, from design through to disposal or, ideally, reintegration into new products.

The transition from a linear to a circular model is seen as essential for achieving long-term sustainability, reducing environmental impact, and fostering economic resilience in the face of diminishing natural resources.

A **Circular Business Model** emphasizes sustainability by designing out waste and extending the lifecycle of resources. Unlike the traditional linear model, circular models aim to create economic value through a regenerative approach, focusing on the reuse, repair, refurbishment, and recycling of products and materials. This model is foundational to the circular economy, which seeks to maintain the value of products, materials, and resources for as long as possible, thus minimizing environmental impact and resource depletion.



Key Characteristics of Circular Business Models:

- Design for Longevity: Products are designed from the outset to be durable, repairable, and upgradeable, extending their usable life and reducing waste.
- Resource Efficiency: Materials are used more efficiently across the production and consumption process. This includes the use of renewable resources and the reduction of raw material consumption.
- Closed-loop Systems: Emphasis is placed on creating closed-loop systems where waste is minimized, and products or materials at the end of their life are recycled or reused for as long as possible.
- Business Model Innovation: Circular models often involve innovative business strategies, such as product-as-a-service (where products are leased rather than sold), take-back schemes (where companies take back products for recycling or refurbishing), and collaborative consumption (sharing or renting products).

The principles of Circular business models are grounded in the broader philosophy of the circular economy, which aims to redefine growth by focusing on positive society-wide benefits. These principles challenge the traditional linear "take-produce-use-dispose" model, advocating for a systemic shift towards sustainability that designs out waste, keeps products and materials in use, and regenerates natural systems.

Principles of the Circular business models:

- Design out waste and pollution: From the outset, products are designed to minimize waste and pollution. This involves selecting materials that are safe and recyclable, designing for easy disassembly, and employing manufacturing processes that reduce waste and emissions.
- Keep products and materials in use: Circular models prioritize extending the life cycle of products through repair, maintenance, refurbishment, and remanufacturing. This principle aims to maximize the utility of products, components, and materials, keeping them circulating in the economy for as long as possible.
- Regenerate natural systems: Beyond minimizing harm, circular business models strive to have a positive impact on natural systems. This can involve using renewable energy, supporting regenerative agricultural practices, and using materials in a way that improves the environment.
- Rethink the business model: Businesses are encouraged to innovate their business models for circularity. This could mean adopting product-as-a-service models, where the emphasis is on leasing or sharing rather than ownership, or implementing take-back schemes to ensure products are returned, reused, or recycled.
- Design for adaptability and disassembly: Products should be designed so that they can be easily adapted to different uses or disassembled for repair or recycling. This flexibility extends the useful life of products and supports the efficient recovery of materials.
- Use waste as a resource: Waste materials from one process are seen as inputs for another, creating a closed-loop system where materials are continually reused and recycled. This principle aims to eliminate the concept of waste entirely.
- Promote systems thinking: Recognizing that businesses operate within broader ecological and economic systems, circular models advocate for a system thinking approach. This means considering the impacts of business activities holistically and working collaboratively across supply chains and sectors to enable circularity.
- Foster innovation and collaboration: Transitioning to a circular economy requires innovation in technology, business models, and collaboration among stakeholders, including businesses, governments, and consumers. Sharing knowledge and resources can accelerate the adoption of circular practices.

Implementing these principles requires a shift in mindset from all stakeholders involved - from designers and manufacturers to consumers and policymakers. It involves rethinking product design, business models, and consumption patterns to create a more sustainable and resilient economy.

By adhering to these principles, circular business models not only contribute to environmental sustainability but also offer economic opportunities through cost savings, new revenue streams, and enhanced competitiveness. The transition towards circularity is seen as a crucial step in addressing global challenges such as resource depletion, climate change, and biodiversity loss.

Benefits of implementing circular business models

Environmental Benefits

Reduced Waste and Pollution: By emphasizing reuse, recycling, and the efficient use of resources, circular business models significantly reduce the amount of waste generated and the associated environmental pollution.

Conservation of Resources: These models encourage the sustainable use of resources, minimizing the extraction of raw materials and preserving natural habitats and biodiversity.

Lower Carbon Footprint: Circular practices, such as extending product lifecycles and using renewable energy sources, contribute to a reduction in greenhouse gas emissions, helping to combat climate change.

Social Benefits

Job Creation: The transition to circular business models can create new jobs in areas such as repair services, remanufacturing, and recycling, contributing to economic development.

Improved Quality of Life: Circular models promote the development of products that are more durable, repairable, and adaptable, offering consumers greater value and contributing to higher standards of living.

Innovation and Collaboration: Encouraging innovation in product design, business practices, and collaboration across industries and sectors, circular business models drive progress towards a more sustainable future.

Strategic and Operational Benefits

Enhanced Brand Image and Reputation: Companies leading in sustainability and circularity often enjoy an enhanced brand image, attracting customers, investors, and talent who prioritize environmental responsibility.

Regulatory Compliance and Incentives: Circular business practices can help companies stay ahead of regulatory requirements, benefit from government incentives for sustainability, and avoid potential fines or sanctions related to environmental compliance.

Long-term Viability: By aligning with the principles of sustainability, companies position themselves for long-term success in an economy that increasingly values resource efficiency, environmental stewardship, and social responsibility.

Circular Business Models:
Recycling model

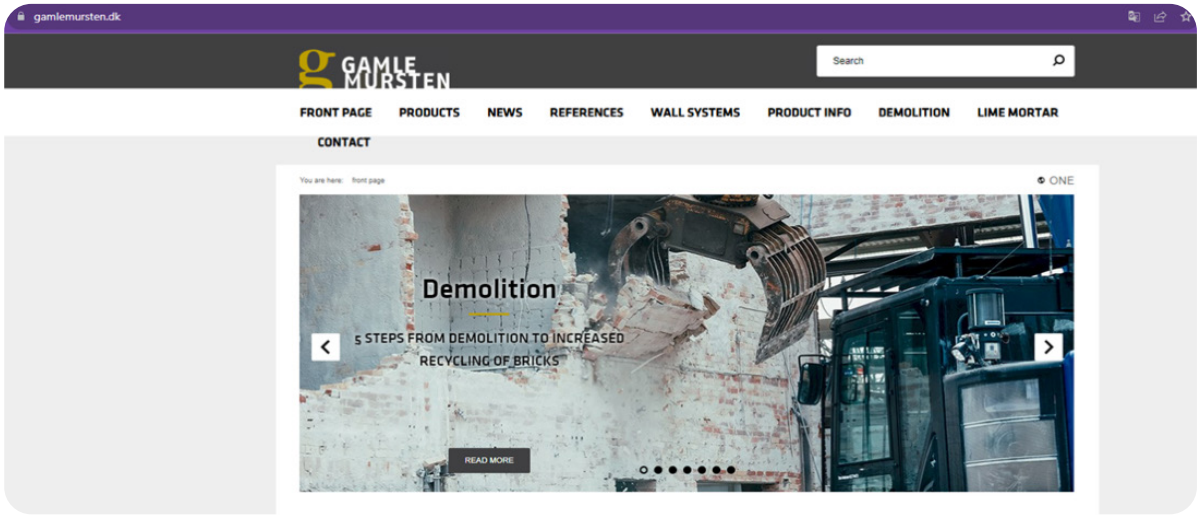
The recycling business model is centered on the collection, sorting, processing, and conversion of waste materials into usable or sellable products or raw materials. It plays a crucial role in the circular economy by ensuring that materials, otherwise considered as waste, are brought back into the economy, thus reducing the need for virgin materials and minimizing environmental impact. This model not only contributes to sustainability but also presents economic opportunities through the creation of jobs and the development of green technologies.

Key Features of the Recycling Business Model:

- *Collection and Sorting:* The initial step involves the collection of recyclable materials from various sources, including households, businesses, and construction sites. Efficient sorting is critical to separate materials by type and quality, which determines their value and recyclability.
- *Processing:* Once sorted, materials are cleaned and processed to remove impurities. The processing methods vary depending on the material, ranging from mechanical shredding and melting for plastics and metals to pulping for paper.
- *Manufacturing:* Processed materials are then transformed into new products. This can involve manufacturing entirely new items from recycled materials or producing secondary raw materials that are supplied to other industries as inputs for new products.
- *Sales and Distribution:* The final products or secondary raw materials are sold to consumers or businesses. The success of this stage depends on market demand for recycled products, which can be influenced by factors such as price, quality, and consumer awareness.

Good practice (example):

Every day, Gamle Mursten makes sure that bricks taken from demolition sites are not downcycled and crushed, but instead are upcycled and reused as a valuable building material that brings both rustic aesthetics and history to new Danish buildings. Since 2003, Gamle Mursten has been cleaning bricks for recycling, because it is against all common sense not to do so. Each recycled brick saves the environment 0.5 kg of CO2.



Circular Business Models:
Refurbishment model

The refurbishment business model focuses on extending the lifespan of products and components by restoring them to a like-new condition. This model not only reduces waste and conserves resources but also meets consumer demand for more sustainable and cost-effective products.

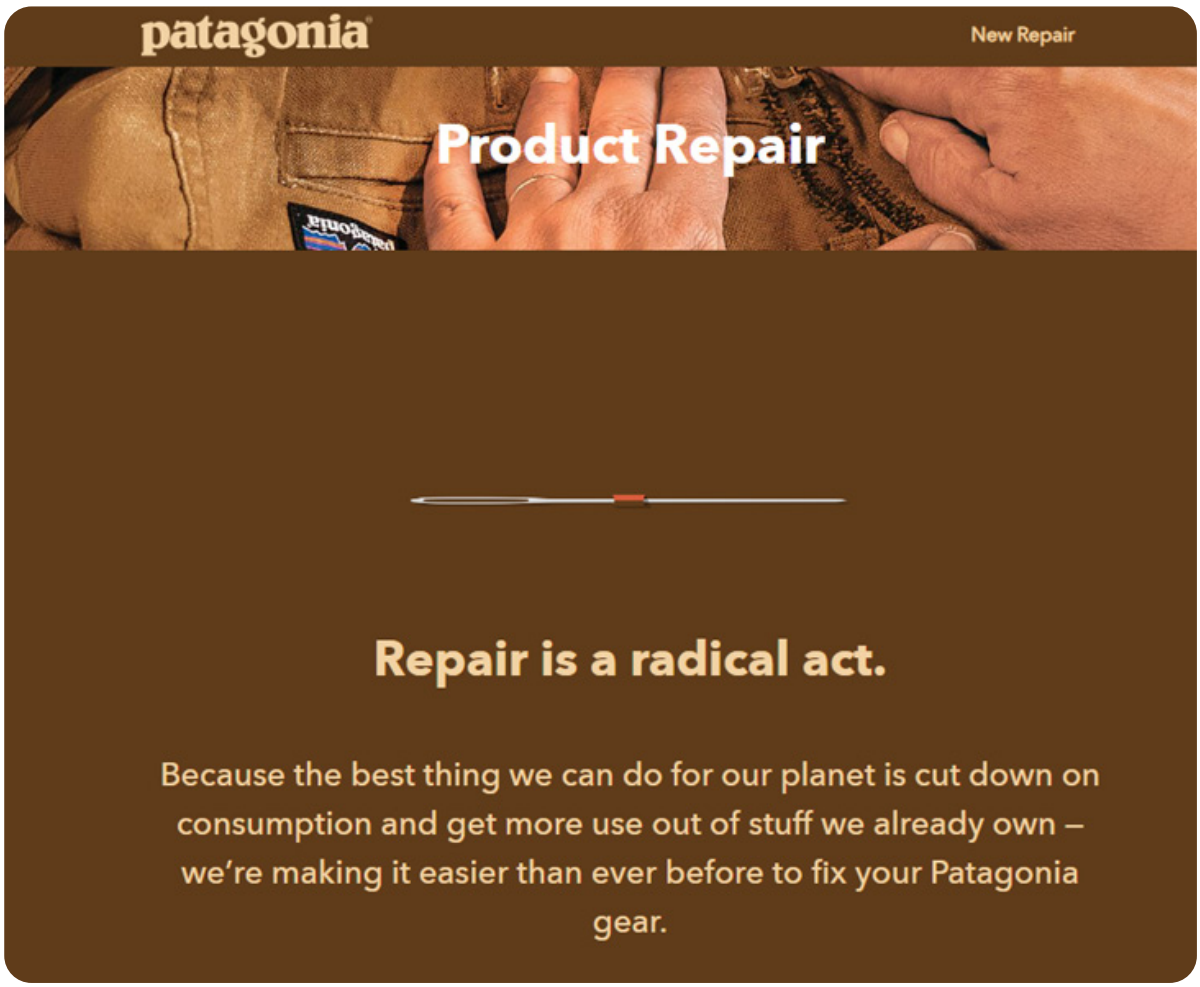
Refurbishment involves repairing, cleaning, and restoring used products to good working condition. It may include replacing worn or defective parts, cosmetic improvements, and updating software. The aim is to make the product fully functional again, although it might not necessarily meet the original factory specifications. Refurbished products are typically sold with a warranty, offering consumers a more affordable alternative to new products.

Key Features of the Refurbishment Business Model:

- Focus on extending the useful life of products.
- Less extensive than remanufacturing, often limited to surface or minor repairs.
- Products may show signs of previous use but are functional and reliable.

Good practice (example):

Patagonia is a designer of outdoor clothing and gear for silent sports: climbing, surfing, skiing and snowboarding, fly fishing, and trail running. It also offers to repair the gear.



Circular Business Models:
Remanufacturing model

The remanufacturing business model is a pivotal component of the circular economy, focusing on extending the lifespan of products and components by restoring them to a like-new condition. This model not only reduces waste and conserves resources but also meets consumer demand for more sustainable and cost-effective products.

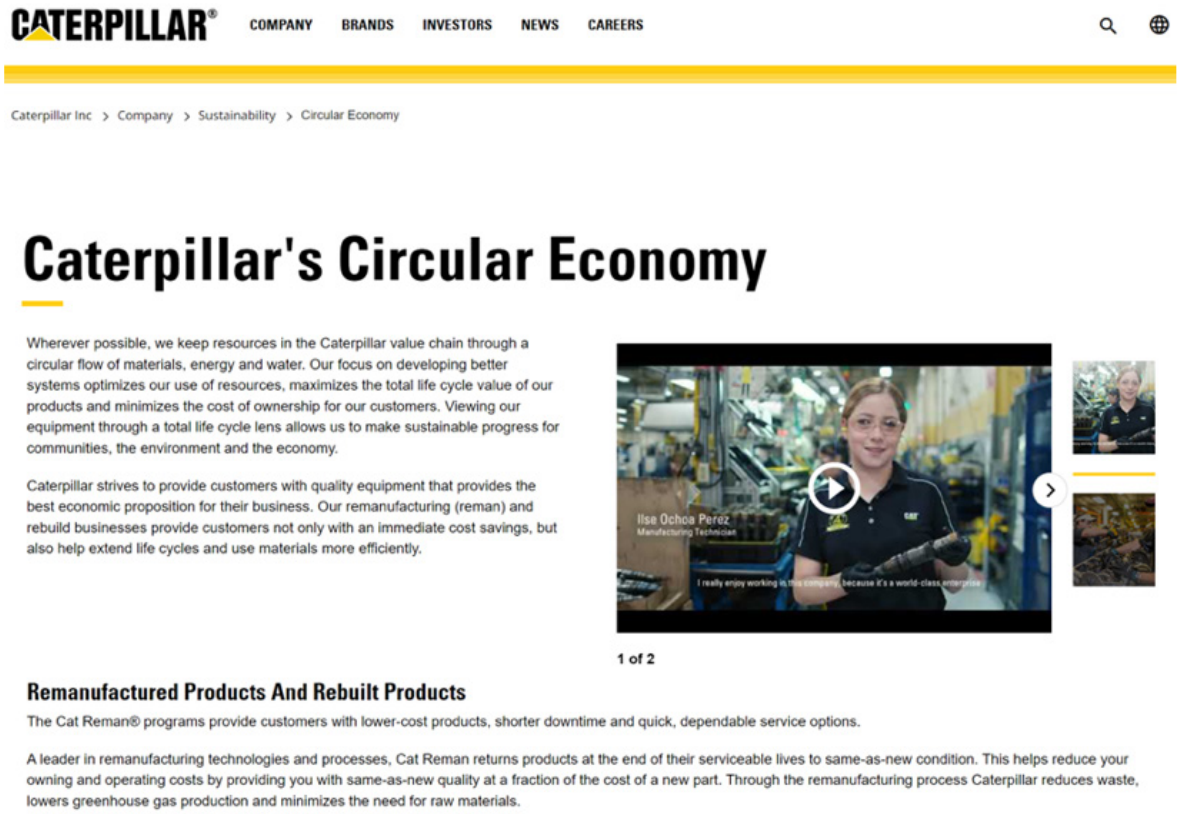
Remanufacturing is a more comprehensive process that involves disassembling, cleaning, inspecting, repairing, or replacing components, and reassembling products to meet the original manufacturer's specifications or better. This process can significantly extend the product's life and often results in products that are comparable to new ones in terms of performance and warranty.

Key Features of the Remanufacturing Business Model:

- More intensive than refurbishment, involving complete disassembly and restoration.
- Products are brought up to current standards, often indistinguishable from new products.
- Supports sustainability by reducing the need for new materials and minimizing waste.

Good practice (example):

Caterpillar is the world's leading manufacturer of construction and mining equipment, off-highway diesel and natural gas engines, industrial gas turbines, and diesel-electric locomotives. The Cat Reman programs provide customers with lower-cost products, shorter downtime, and quick, dependable service options. It returns products at the end of their serviceable lives to same-as-new condition. This helps reduce your owning and operating costs by providing you with same-as-new quality at a fraction of the cost of a new part.



Circular Business Models:
Product-as-a-service (PaaS) model

The Product-as-a-Service (PaaS) business model represents a shift away from traditional ownership to a service-oriented approach. In this model, customers pay for the use of a product without owning it outright. Companies maintain ownership of the products and are responsible for their maintenance, repair, and eventual recycling or disposal, encouraging the design of more durable and sustainable products. This model is part of the broader trend towards service-based models in the circular economy, aiming to reduce waste and resource consumption while providing flexibility and sustainability for consumers.

Key Features of PaaS Model:

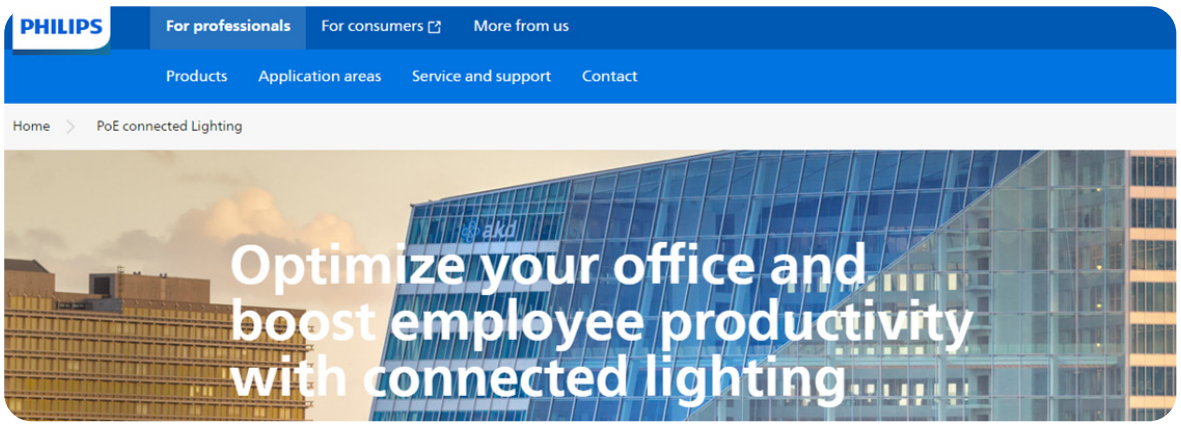
- *Access Over Ownership:* Customers access the benefits of a product through subscriptions, leasing, or pay-per-use arrangements, eliminating the need for ownership.
- *Extended Producer Responsibility:* Manufacturers or service providers retain ownership of the product, incentivizing them to create durable, repairable, and easily upgradable products.
- *Circularity and Sustainability:* By focusing on product longevity and end-of-life recovery, PaaS models contribute to the circular economy, reducing waste and encouraging the efficient use of resources.
- *Customization and Flexibility:* PaaS often allows for greater customization to meet customer needs, with flexible terms that adapt to changing consumer demands or usage patterns.

Examples of PaaS Model:

- *Technology and Electronics:* Companies offer devices (e.g., printers, computers, smartphones) as a service, including maintenance and upgrades as part of the subscription fee, allowing customers to always have access to the latest technology without the burden of ownership.
- *Transportation:* Car-sharing and bike-sharing services are examples of PaaS in the mobility sector, where users pay for access to vehicles or bikes on an as-needed basis, reducing the need for personal vehicle ownership.
- *Furniture and Appliances:* Some companies offer furniture or appliances as a service, targeting both consumers and businesses. This model is particularly appealing for temporary needs or for reducing upfront investment costs.

Good practice (example):

Philips is a diversified technology company known for its wide range of healthcare, consumer lifestyle, and lighting products. Philips' connected lighting systems is a prime example of the PaaS business model in action. This approach represents a shift from selling light fixtures as products to providing lighting as a service. Philips offers this innovative service primarily to business and municipal customers, emphasizing energy efficiency, sustainability, and smart technology.



Circular Business Models:
Biological Cycles model

The Biological Cycles business model is an integral part of the circular economy, focusing on the use and management of biological resources to create value in a way that mimics natural processes. It is designed to ensure that biological materials - such as food, wood, fibers, and bioplastics - can be returned to the ecosystem after their use in economic activities, where they biodegrade and regenerate new resources. This model contrasts with technical cycles, which focus on the recycling and reuse of non-biological materials like metals and plastics.

Key Features of Biological Cycles Business Model:

- *Regenerative by Design:* This model emphasizes processes that regenerate natural systems, improving soil health, increasing biodiversity, and enhancing ecosystem services rather than depleting them.
- *Safe and Compostable Materials:* Products are made from materials that are safe for composting or anaerobic digestion, ensuring they can return to the earth without causing harm to the environment.
- *Maximizing Resource Efficiency:* It focuses on maximizing the utility of biological resources through practices like cascading use, where materials are used sequentially for different purposes, extracting the maximum value at each stage.
- *Promoting Local Production and Consumption:* Encourages local sourcing and consumption of biological materials to reduce transportation emissions and support local economies while ensuring materials are processed in a way that is compatible with local ecological conditions.

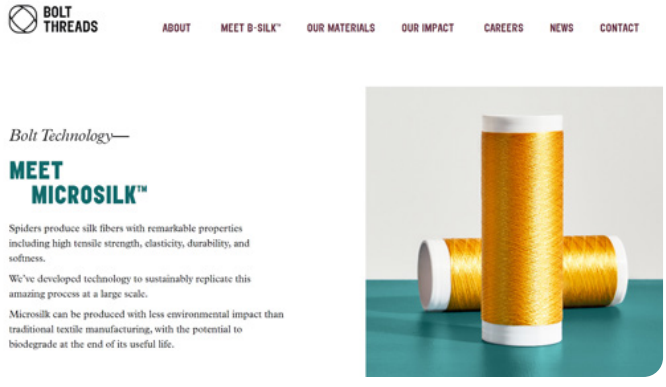
Examples of Biological Cycles Business Models:

- *Agriculture and Agroforestry:* Implementing regenerative agricultural practices that restore soil health, sequester carbon, and increase biodiversity, while producing food, fiber, and other biological materials.
- *Biodegradable Packaging:* Developing and using packaging solutions made from biological materials that can safely decompose in natural environments or through industrial composting processes.
- *Bioenergy and Biochemicals:* Producing renewable energy and chemicals from biological sources, such as biofuels from crop residues or biogas from organic waste, in ways that ensure nutrient cycling and reduce dependency on fossil fuels.

Good practice (example):

Bolt Threads is a biotechnology company that specializes in developing sustainable and innovative materials inspired by nature for use in the fashion and textiles industry. Founded in 2009 and based in Emeryville, California, Bolt Threads harnesses the power of biotechnology, materials science, and engineering to create high-performance fibers and fabrics with a lower environmental footprint compared to traditional materials.

One of their most notable innovations is Microsilk™, a protein-based material inspired by spider silk's properties, known for its strength, elasticity, and durability. Unlike natural spider silk, which is impractical to produce on a large scale, Microsilk™ is produced through a fermentation process using genetically engineered yeast, sugar, and water. This process allows Bolt Threads to manufacture silk protein in large quantities without relying on spiders, offering a sustainable and animal-friendly alternative to traditional silk. Another significant development by Bolt Threads is Mylo™, a leather-like material made from mycelium, the root structure of mushrooms. Mylo™ mimics the feel and appearance of leather but is created through a more sustainable process that significantly reduces the environmental impact associated with animal leather production and synthetic leather made from petroleum-based plastics.



Circular Business Models:
Resource Recovery model

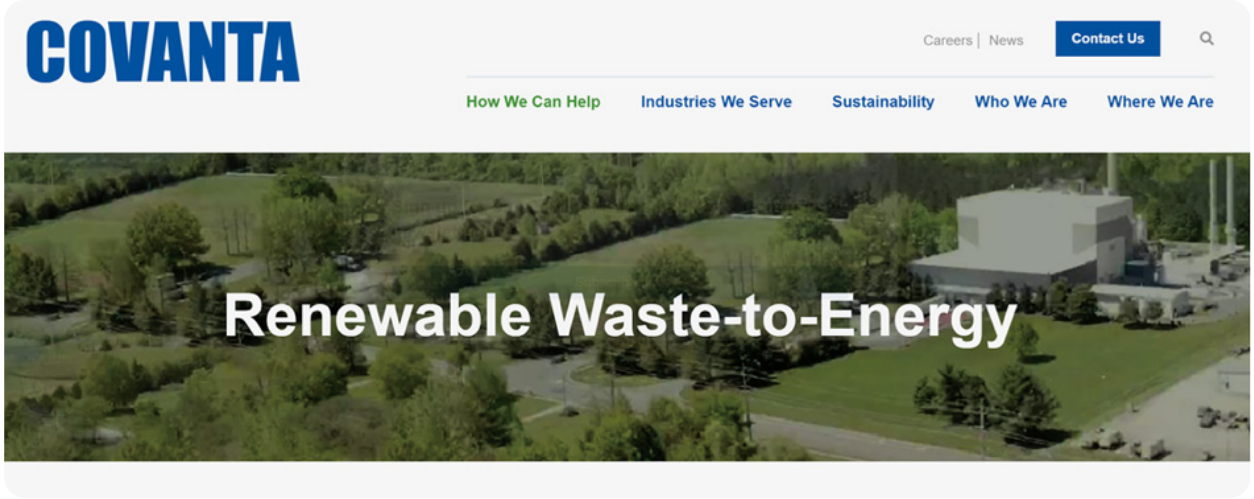
The Resource Recovery business model is a cornerstone of the circular economy, focusing on extracting valuable materials or energy from waste streams that would otherwise be discarded. This model transforms waste into resources, thus minimizing the environmental impact of waste disposal, reducing reliance on virgin materials, and promoting sustainable production and consumption cycles. It encompasses a broad range of activities, from recycling and composting to energy recovery and the extraction of useful substances from waste products.

Key Features of Resource Recovery Model:

- *Material recovery:* This involves collecting and processing waste materials (such as plastics, metals, glass, and paper) to recover raw materials that can be used to manufacture new products. Material recovery reduces the demand for virgin resources and cuts down on environmental degradation associated with resource extraction.
- *Biological Recovery:* Organic waste, including food scraps and agricultural residues, is processed through composting or anaerobic digestion to produce compost or biogas. These outputs can be used to enhance soil health and provide renewable energy, respectively, contributing to a closed-loop system in the biological cycle.
- *Energy Recovery:* Non-recyclable waste materials can be converted into energy through processes like incineration with energy recovery, pyrolysis, or gasification. This allows for the generation of electricity or heat from waste, reducing fossil fuel consumption and greenhouse gas emissions.
- *Chemical Recovery:* Advanced technologies are used to extract valuable chemicals or materials from waste products. For example, certain processes can recover precious metals from electronic waste or convert plastic waste into synthetic fuels or new plastics.

Good practice (example):

Covanta Holding Corporation is a company that provides sustainable waste and energy solutions, primarily focusing on waste-to-energy (WTE) services. The company operates facilities that convert municipal solid waste into renewable energy and recover valuable metals for recycling. By doing so, Covanta plays a significant role in waste management, reducing reliance on landfills, cutting greenhouse gas emissions, and generating clean energy.
Covanta's waste-to-energy facilities use municipal solid waste as fuel, burning it at high temperatures to produce steam. This steam drives turbines to generate electricity, which is then supplied to local power grids. In addition to energy production, their process significantly reduces the volume of waste, with the ash residue often used in construction materials. Moreover, Covanta's facilities are equipped to capture and recycle metals found in the waste stream, thereby conserving resources, and reducing the need for virgin material extraction.



Circular Business Models:
Industrial Symbiosis model

Industrial Symbiosis is a collaborative business model that focuses on the mutual exchange of materials, energy, water, and/or by-products among different industries or businesses to create a closed-loop system. This model is inspired by natural ecosystems, where waste from one organism serves as nutrients for another, ensuring the efficient use of resources with minimal waste. Industrial symbiosis is a key component of the circular economy, aiming to optimize resource efficiency, reduce environmental impact, and enhance economic value through collaborative networks.

Key Features of Industrial Symbiosis Model:

- *Resource Optimization:* It involves identifying and exploiting opportunities for sharing or exchanging resources between companies, such as using the waste heat from one process to power another process in a different company.
- *Waste Minimization:* By transforming waste from one industry into raw materials for another, industrial symbiosis significantly reduces the amount of waste sent to landfills and decreases environmental pollution.
- *Cost Reduction:* Companies involved in industrial symbiosis can achieve substantial cost savings through reduced raw material and waste disposal costs, as well as by sharing infrastructure and logistics.
- *Innovation and New Revenue Streams:* The model encourages innovation by identifying novel uses for waste and by-products, potentially opening up new markets and revenue streams for participating companies.
- *Collaborative Networks:* Successful industrial symbiosis relies on the creation of networks and partnerships between companies, facilitated by information sharing, trust, and coordinated management.

Good practice (example):

Often cited as the first and most well-known example of industrial symbiosis, the Kalundborg Symbiosis involves a network of companies, including a power station, an oil refinery, a pharmaceutical plant, and others, that exchange steam, water, and various materials to optimize resource use and reduce environmental impact.

Kalundborg SYMBIOSIS

English Dansk

50 years of circular production

Home page

Circular Business Models:
Design for Durability and Longevity model

The Design for Durability and Longevity business model focuses on creating products that are built to last, reducing the need for frequent replacements and thereby minimizing waste and resource consumption. This approach is a critical component of the circular economy, aiming to extend the lifecycle of products, enhance resource efficiency, and decrease the environmental impact associated with the production, use, and disposal of goods.

Key Features of Design for Durability and Longevity Model:

- *High-Quality Materials:* Utilizing durable materials that can withstand wear and tear over time, ensuring the product maintains its functionality and appearance.
- *Modular and Repairable Design:* Designing products in a way that allows for easy repair, upgrading, or replacement of components. This enhances the product's lifespan by making maintenance and updates more feasible.
- *Standardization of Components:* Employing standardized parts across product lines to facilitate repairs, replacements, and upgrades, thereby extending the products' useful life.
- *Ease of Disassembly:* Ensuring products can be easily disassembled at the end of their life for recycling or refurbishing, which is crucial for recovering valuable materials and reducing waste.

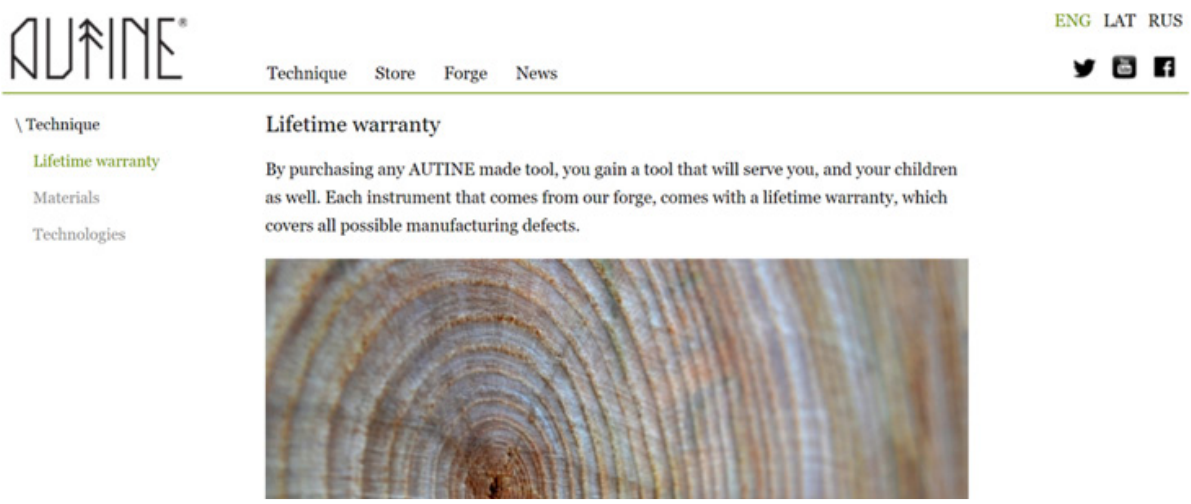
Examples of Design for Durability and Longevity models:

- *Electronics:* Companies, focusing on producing electronics that are easily repairable, upgradable, and made with high-quality components to extend their lifespan.
- *Furniture:* Designing furniture with timeless aesthetics, robust materials, and the ability to repair and refurbish, ensuring long-term use.
- *Apparel:* Creating high-quality, classic clothing items that resist wear and tear, promoting slow fashion over fast fashion trends.

Good practice (example):

Autine is a high-end tool and knife brand known for its handcrafted axes, knives, and other tools. Founded by John Neeman (also known as Janis J. Neemane) in Latvia, Autine creates tools that combine traditional craftsmanship with modern design and materials. Each piece is individually crafted by skilled artisans, emphasizing durability, functionality, and beauty.

Autine's products are highly regarded in the market for their quality and craftsmanship. They cater to a niche audience that values handmade tools for outdoor activities, bushcraft, woodworking, and culinary purposes. The brand is synonymous with excellence in material selection, including high-quality steel for blades and carefully chosen wood for handles, ensuring that each tool is not only a functional instrument but also a work of art.



Circular Business Models:
Repurchasing of Goods model

The Repurchasing of Goods business model, often associated with buy-back or trade-in programs, is a strategy where companies buy back their products from consumers after use. This model is part of a broader approach to sustainability and circular economy practices, aiming to reduce waste and extend the lifecycle of products by refurbishing, recycling, or reselling them. It reflects a shift from the traditional linear economy towards more circular systems, where the value of products is maintained or recovered, minimizing the environmental impact of production and consumption.

Key Features of Repurchasing of Goods Model:

- *Buy-Back Programs:* Companies offer customers the option to sell back used products at the end of their life or when they wish to upgrade to a new version. The company then either refurbishes the product for resale, recycles its components, or uses the materials to manufacture new products.
- *Trade-In Offers:* Customers can trade in their old product for a discount on a new purchase. This incentivizes consumers to return products, ensuring that materials are kept within the economic cycle and reducing waste.
- *Certified Refurbishment:* Returned products undergo thorough testing, repair, and certification before being resold. This ensures that refurbished products meet quality standards and can be sold with a warranty, like new items.
- *Second-Life Sales:* Products that are no longer new but still functional can be sold in secondary markets, offering more affordable options to consumers, and extending the product's life.

Examples of Repurchasing of Goods models:

- *Electronics and Mobile Phones:* Companies like Apple and Samsung have trade-in programs where customers can return their old devices for credit towards a new purchase, promoting the recycling and refurbishment of electronic devices.
- *Automotive Industry:* Car manufacturers and dealerships often offer trade-in deals where customers can exchange their old vehicle for a discount on a new car, facilitating the resale or recycling of used vehicles.
- *Fashion and Apparel:* Some clothing brands have started programs to buy back used garments for recycling or resale, aiming to reduce textile waste and promote sustainable fashion practices.

Good practice (example):

IKEA is a Swedish multinational company known for its ready-to-assemble furniture, home accessories, and kitchen appliances. IKEA has ventured into the second-hand market. In recent years, IKEA has started to open second-hand stores and initiate pilot projects aimed at selling used and refurbished IKEA furniture. These initiatives are designed to extend the lifecycle of its products, reduce waste, and offer customers more sustainable shopping options. One notable example is the opening of its first second-hand store in Sweden in 2020, located in the ReTuna shopping mall, which is dedicated entirely to selling recycled and upcycled products.
The concept behind IKEA's second-hand stores is not only to sell pre-owned furniture but also to offer repair and refurbishment services to give products a second life. This approach aligns with IKEA's broader sustainability goals, including its ambition to become a climate-positive business by 2030. Through these efforts, IKEA aims to encourage a more circular approach to consumption, where products are reused, repaired, and recycled instead of being discarded. IKEA's move into the second-hand market reflects a growing trend among businesses to adopt circular economy practices and respond to increasing consumer demand for sustainable and eco-friendly products.

Circular Business Models:
Recycling of Goods model

The Recycling of Goods business model is a foundational element of the circular economy, focusing on converting waste materials into new products or raw materials. This model reduces the need for virgin resources, minimizes environmental pollution, and lessens the volume of waste sent to landfills or incinerators.

Key Features of Recycling of Goods Model:

- *Collection and Sorting:* The initial step involves collecting recyclable materials from various sources, such as households, businesses, and industrial processes. These materials are then sorted based on type (e.g., plastics, metals, paper, glass) and quality to prepare them for recycling.
- *Processing:* Sorted materials undergo processing to clean and break them down into usable forms. This may involve mechanical shredding, melting, or chemical treatments, depending on the material type.
- *Manufacturing:* Recycled materials are used as inputs in the manufacturing of new products. The extent to which materials can be recycled into similar-quality products (closed-loop recycling) or different, lower-quality applications (open-loop recycling) varies by material type.
- *Sale and Distribution:* The final recycled products or materials are sold to manufacturers or directly to consumers. This step closes the loop by reintroducing recycled materials back into the economy.

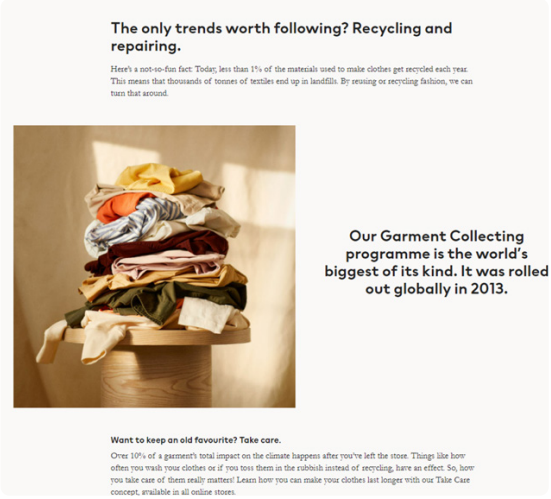
Examples of Recycling of Goods models:

- *Paper Recycling:* Used paper is collected, processed, and remanufactured into new paper products, reducing the need for virgin wood pulp.
- *Plastic Recycling:* Plastics are sorted by type, cleaned, melted down, and remolded into new plastic products, ranging from bottles to clothing fibers.
- *Electronic Waste Recycling:* E-waste is disassembled, and valuable metals and materials are recovered and used to manufacture new electronic components or other products.

Good practice (example):

H&M is a global fashion retailer known for its fast-fashion clothing for men, women, children, and teenagers. One of the key components of H&M's sustainability strategy is its garment collecting and recycling program, which encourages consumers to contribute to a more sustainable fashion future.

H&M's garment collecting program, launched in 2013, is a global initiative that invites customers to bring any unwanted clothes and textiles, regardless of brand or condition, to H&M stores. In exchange, customers may receive a discount voucher toward their next purchase. The collected items are sorted into three categories: re-wear (clothing that can be worn again), reuse (textiles that can be turned into other products), and recycle (materials that can be transformed into textile fibers or used for other purposes such as insulation).



Circular Business Models:
Equipment and Technology Sharing model

The Equipment and Technology Sharing business model, often aligned with the concepts of the sharing economy and collaborative consumption, revolves around the shared use of physical assets, equipment, and advanced technologies among multiple users or organizations. This model maximizes the utilization of resources, reduces redundancy, and minimizes the environmental impact associated with the production and consumption of goods. It is particularly relevant in today's economy, where technological advancements and connectivity have made sharing and collaboration more feasible and efficient than ever before.

Key Features of Equipment and Technology Sharing Model:

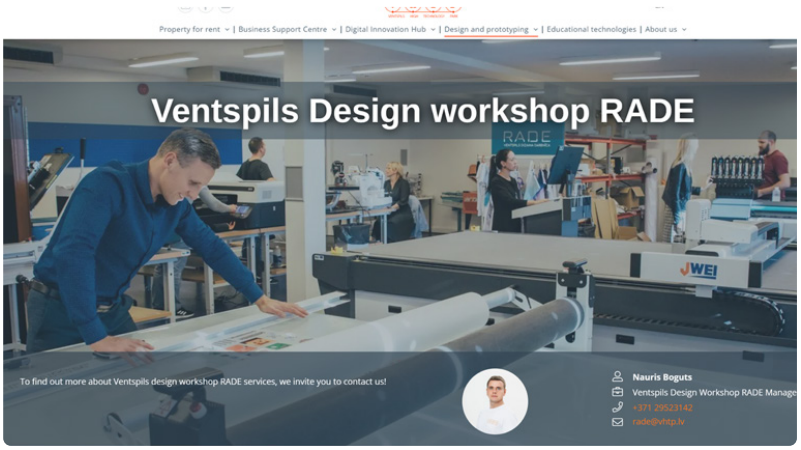
- *Access Over Ownership:* The model prioritizes access to equipment and technology over individual ownership. Users pay to access or use the equipment for a specified period, without bearing the costs and responsibilities of ownership.
- *Efficient Utilization:* By sharing resources, their utilization rate is maximized, ensuring that the embodied energy and materials in these assets are used more efficiently throughout their lifecycle.
- *Cost Reduction:* Sharing reduces the financial burden on individual users or businesses, as costs are distributed among multiple users. It enables access to high-quality or advanced technology that might be otherwise unaffordable.
- *Flexibility and Scalability:* Users can access a wide range of equipment and technologies as needed, allowing for flexibility and scalability without significant capital investment.

Examples of Equipment and Technology Sharing models:

- Co-working Spaces: Provide shared access to office equipment, internet technology, and meeting spaces for freelancers, entrepreneurs, and remote workers.
- Makerspaces and Fab Labs: Offer community access to manufacturing equipment, tools, and technology for prototyping and creative projects, including 3D printers, laser cutters, and CNC machines.
- Agricultural Equipment Sharing: Farmers and agricultural cooperatives share expensive machinery and equipment, such as tractors and harvesters, reducing individual investment costs and improving efficiency.
- Technology Platforms: Online platforms facilitate the sharing of specialized software, computing resources, and data analytics tools among businesses, enabling them to leverage advanced technologies on a subscription or pay-per-use basis.

Good practice (example):

Ventspils design workshop “RADE” is a production unit room where both individual users and entrepreneurs can create a variety of products. The workshop has various production units meant to transfer any design to either clothing, plastic, metal or wood, acrylic, various composite materials, and other accessory types, print photos, make stickers, and create packaging for any product created here. RADE offers individuals and businesses to share the equipment of the workshop, reducing the need to purchase the equipment.



How to Transfer from Linear to Circular Business Model

1. **Assess current practices**
   Begin by evaluating your current business model, focusing on how resources are used, and waste is generated. Identify areas where changes can lead to more sustainable practices.

2. **Set clear goals and objectives**
   Define specific, measurable objectives for the transition. These could include reducing waste, increasing the recyclability of products, or implementing a take-back program for used products.

3. **Rethink product design**
   Design products for longevity, repairability, and recyclability. Consider using modular designs that allow for easy repair or upgrading of parts instead of replacing whole products.

4. **Implement resource-efficient processes**
   Optimize manufacturing processes to minimize waste and resource use. This might involve adopting new technologies or rethinking production techniques to be more efficient.

5. **Develop new business models**
   Consider models like Product-as-a-Service (PaaS), where you offer services rather than selling products, or leasing models where products are returned for refurbishment and reuse.

6. **Establish closed-loop supply chains**
   Create or join networks for recovering and reusing materials. This could involve setting up systems for returning used products or collaborating with other companies to utilize each other's waste products.

7. **Engage with suppliers**
   Work with suppliers who are also committed to circular principles. Ensure that the materials you use are sustainably sourced and can be recycled or composted at the end of their life.

8. **Educate and engage customers**
   Inform your customers about the benefits of a circular model. Encourage them to participate in take-back schemes, recycling programs, or other initiatives that support the circular economy.

9. **Leverage technology for efficiency**
   Use technology to track resource flows, manage reverse logistics for returned products, and optimize the lifecycle of your products.

10. **Monitor, evaluate and adapt**
    Continuously monitor the impact of your changes. Collect data on resource use, waste reduction, and customer feedback to evaluate your progress and make necessary adjustments.

11. **Promote a Circular culture internally**
    Foster a culture of sustainability within your organization. Educate employees about the importance of circular practices and encourage innovation in this area.

12. **Collaborate and build partnerships**
    Engage in partnerships with other companies, governmental bodies, and NGOs to expand the reach and effectiveness of your circular initiatives.

Task – Circular Business Model Innovation Challenge

The aim of this activity is to encourage participants to think critically and creatively about sustainability, as well as to help them understand the practical applications of circular economy principles in business. This task fosters collaboration and problem-solving skills, as participants work together to envision innovative business models that can lead to a more sustainable future.

Materials Needed:

- Paper and pens for sketching ideas.
- A set of briefs describing traditional business scenarios across various industries.
- Access to online collaboration tools if participants are remote (e.g., Miro, Google Docs).

Task process:

1. Divide participants into small teams of 3-4 people. For remote participants, use the breakout rooms in the videoconferencing equipment.
2. Assign each team a brief describing a traditional business scenario. These scenarios should vary by industry (e.g., fashion, electronics, food) to allow for diverse solutions.
3. Teams use the circular business model principles to rethink the assigned scenario. Their challenge is to redesign the business model to make it circular, focusing on aspects such as sustainability, reducing waste, and creating a closed-loop system. Encourage teams to consider how they can extend product life, reuse materials, and create value from waste products.
4. Each team presents their circular business model solution to the group, explaining how it addresses the principles of the circular economy.
5. After each presentation, allow time for questions and constructive feedback from the other participants and facilitators.
6. Conclude the activity by summarizing the key takeaways and highlighting the innovative ideas generated during the challenge.

Discuss how these circular business model innovations can be applied in real-world contexts to drive sustainability and economic value.

Topic Summary

Challenges and Considerations

- *Upfront Investment and Cost:* Transitioning to a circular model often requires significant initial investment in new technologies, systems, and processes. The cost of designing products for durability, repairability, and recyclability, as well as establishing take-back schemes and reverse logistics can be substantial.
- *Consumer Acceptance and Behavior:* Changing consumer habits from a traditional take-produce-use-dispose mindset to one that embraces sharing, leasing, or buying refurbished products is challenging. There is also the need to build trust in the quality and performance of refurbished or remanufactured products.
- *Supply Chain Complexity:* Developing a circular supply chain involves coordination with multiple stakeholders, including suppliers, manufacturers, and waste management companies. It requires transparency and collaboration across the value chain to ensure the return, refurbishment, and recycling of products.
- *Regulatory and Policy Barriers:* Existing regulations may not support circular practices, or there may be a lack of incentives for businesses to invest in circular models. In some regions, the regulatory environment may lag behind innovation, hindering the adoption of circular practices.
- *Technical Challenges:* The complexity of modern products, with their mix of materials and components, can make disassembly, repair, and recycling difficult and costly. Developing the necessary technologies and processes for efficient recycling or remanufacturing poses significant technical challenges.
- *Market Demand for Recycled Materials:* Fluctuations in the market demand and prices for recycled materials can affect the economic viability of recycling operations. Ensuring consistent quality and supply of recycled materials is essential for building and maintaining demand.
- *Design Considerations:* Designing for circularity requires a shift in design philosophy, prioritizing durability, repairability, and the use of recyclable materials. This can sometimes conflict with other design considerations such as cost, performance, and aesthetics.
- *Intellectual Property and Data Security:* For business models based on product-as-a-service or equipment sharing, protecting intellectual property and ensuring data security for shared products can be a concern, particularly for technology and electronics companies.
- *Logistics and Infrastructure:* Setting up the logistics for collecting, sorting, and processing returned products for refurbishment or recycling requires a well-developed infrastructure. This includes challenges related to transportation, storage, and handling of used products and materials.
- *Cultural and Organizational Change:* Adopting a circular business model often requires a cultural shift within organizations. It necessitates a move away from traditional linear thinking towards a systems-thinking approach, which can be difficult to achieve and may require significant changes in corporate culture, employee mindset, and organizational structure.

Opportunities of implementing circular business models

- *Innovation in Product Design and Development:* Circular business models encourage the innovation of products designed for longevity, reparability, and recyclability. This shift opens up new avenues for businesses to explore sustainable materials, modular designs, and innovative functions that make products more adaptable to changing consumer needs and technological advancements.

- *Creation of New Business Models and Revenue Streams:* Adopting circular principles enables companies to explore new business models such as Product-as-a-Service (PaaS), where products are leased rather than sold, or take-back schemes where products are returned for refurbishment and resale. These models not only extend product lifecycles but also create continuous revenue streams from the same product multiple times.

- *Cost Reduction and Efficiency Gains:* By maximizing the use of resources and minimizing waste, circular business models can lead to significant cost savings. Efficient resource use, reduced material costs, and energy savings are direct benefits that enhance business efficiency and profitability.

- *Competitive Advantage:* Businesses that successfully implement circular models can differentiate themselves in the marketplace, appealing to a growing segment of environmentally conscious consumers. This can enhance brand loyalty, improve customer satisfaction, and attract new customers, giving companies a competitive edge.

- *Access to New Markets and Customer Segments:* Circular business models, particularly through the offering of sustainable products and services, can open up new markets and attract customers who are willing to invest in products that contribute to a more sustainable world.

- *Regulatory Compliance and Leadership:* With governments worldwide imposing stricter regulations on waste and recycling, adopting circular business models can help companies stay ahead of regulatory requirements, avoid penalties, and position themselves as industry leaders in sustainability.

- *Enhanced Supply Chain Sustainability:* Circular models promote the development of more sustainable supply chains by encouraging the use of recycled materials, reducing dependency on virgin raw materials, and minimizing the environmental impact of logistics and transportation.

- *Social and Environmental Impact:* Circular business practices contribute positively to the environment by reducing waste and emissions. They also offer social benefits by creating jobs in recycling, refurbishment, and remanufacturing sectors and by providing affordable access to quality products through second-hand markets and product-as-a-service models.

- *Attracting Investment:* Sustainability has become a key factor for investors. Circular business models, with their focus on long-term viability and environmental responsibility, are increasingly attractive to investors looking for sustainable investment opportunities.

- *Building Resilience:* By reducing dependence on finite resources and mitigating the risks associated with raw material price volatility and supply chain disruptions, circular models build business resilience against economic and environmental shocks.

Additional references, literature

Books:

- "A New Dynamic: Effective Business in a Circular Economy" by Amory Lovins and Michael Braungart (This book is a collection of essays and case studies that explore the application of circular economy principles across various sectors. It offers insights into how businesses can transition from linear to circular models, emphasizing system thinking, innovation, and sustainability. The book serves as an inspiration and practical guide for businesses looking to embark on a circular transformation).
- "Business Models in the Circular Economy" by Roberta De Angelis (This book dives into the operationalization of circular economy concepts into practical business models. It addresses the strategic, operational, and organizational challenges businesses face in transitioning towards more sustainable, circular practices).

Guides and toolkits:

- "Circular Economy Business Toolkit" by the Circular Economy Club (This toolkit is designed to help businesses of all sizes understand and implement circular economy principles into their operations. It offers a step-by-step approach to transitioning towards more sustainable, circular business models).
- "The Circular Business Model Canvas" by Circulab (The Circulab Circular Business Model Canvas is an adaptation of the traditional Business Model Canvas, specifically tailored for designing and implementing circular business models. This tool helps businesses identify and create value from circular opportunities).

Academic journals and reports:

- "Towards a Circular Economy: Business Rationale for an Accelerated Transition" by Ellen MacArthur (This article outlines the economic and business case for transitioning towards circular business models, providing a foundational understanding of the benefits and rationale behind the circular economy).
- "Designing Circular Business Models" by Jonker, J., O'Riordan, L., & Faber, N., published in Journal of Cleaner Production (This paper discusses the principles of designing inherently circular business models, offering insights into how companies can rethink and redesign their operations for circularity).
- "Business Models for the Circular Economy: Opportunities and Challenges for Policy" by Geissdoerfer, Martin, Paulo Savaget, Nancy M.P. Bocken, Erik Jan Hultink, published in Research Policy (This article explores the intersection of circular business models and policy, examining how government actions can support or hinder the adoption of circular business practices).

Government Publications:

- "A Framework for Enabling Circular Business Models in Europe" by European Environment Agency (the publication delves into the circular economy and its significance in Europe).
- "Circular Economy Action Plan" by European Commission (the document outlines strategies and initiatives to promote a more sustainable and circular economy within the European Union).

Online courses:

- Coursera: "Business Models For Sustainability" by Copenhagen Business School (the course delves into sustainable business model theory, sustainable business model innovation, and tools and strategies).
- Coursera: "Business Sustainability in the Circular Economy" by University of London (the course delves into sustainability, circular economy, recycling, and reverse logistics).
  Futurelearn: "Tackling Climate Change: Sustainable Business Models for a Circular Economy" by University of Glasgow (the course helps to discover how circular economies and business models enable sustainability and help respond to the climate emergency).

Continue exploring other Topics

Topic 1

Circular Economy and Sustainability

Topic 2

Waste as a Resource in Circular Economy

Topic 3

Circular Value Chains, Ecosystems, and People

Topic 4

Circular Business Models

Topic 5

Life Cycle Thinking and Environmental Footprint

Topic 6

Design Thinking for Circular Products

Topic 7

Reusability, Repairability, Recyclability

Topic 8

Integration of Circular Approaches into Everyday Work Life

Topic 9

Circular Economy Policies across Baltic Sea Region Countries

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Product Life Cycle and Ecological Footprint

Developed by
Valmiera Development Agency

Topic 5

Training Topic on "Product Life Cycle and Ecological Footprint" aims to deepen participants' understanding of sustainable business practices by exploring the concepts of Life Cycle Assessment (LCA) and Ecological Footprint. The material seeks to empower diverse target groups, including businesses, interest groups, and government institutions, with the knowledge and tools to integrate environmental considerations, circular economy principles, and eco-design strategies into their daily operations and policies, fostering a more sustainable and responsible approach to production and consumption.

Expected training outcomes

After completing this Topic, trainees will...

... deepen understanding of Life Cycle Assessment (LCA);

... be able to identify what the ecological footprint entails;

... be able to provide insights into the circular economy and its significance in sustainable production, development of product eco-design;

... deepen understanding in sustainable materials, resources, and technologies;

... be able to discuss the possibilities to enhance the selection process of materials and technologies in the context of sustainability.

Notes for target groups

Different target groups can achieve the following benefits of this training Topic.

Small and medium-sized enterprises (SMEs)

Specific examples and tips on incorporating LCA and circular economy principles into daily operations.

Business support organizations

Practical tools and resources to assist companies in adopting life cycle thinking.

Interest groups

Engagement in discussions on sustainable production and possibilities of life cycle thinking.

Regional government institutions

Discussions on regional initiatives and their impact on business.

Local government institutions

Suggestions on how to utilize life cycle thinking in local policies and project development.

Training plan

Introduction (20-30 min / 1-4 slides)	**Main part** (2-3 h / 5-27 slides)	**Conclusion** (1-2 h / 28-30 slides)
Provision of training program's goals, structure, and the significance of understanding product life cycles and ecological footprints.	Presentation of key concepts, analysis of real-life case studies that demonstrate the practical application of life cycle assessment and ecological footprint. Group workshops where participants collaborate on hands-on activities, such as conducting a simplified life cycle assessment for a specific product or brainstorming eco-design ideas. Panel discussons of guest experts.	Application of circular economy canva, participants' reflections on the training, experience sharing.
Icebreaker activities, presentation.	*Presentation, case-studies, group workshop, panel discussions.*	*Workshop, discussion.*

Total duration for the Topic 5: 4-6 h

Training modes

In person	**Online**
In-person training involves face-to-face sessions conducted in a physical location. This traditional approach allows direct interaction between trainers and participants, fostering real-time engagement, hands-on activities, and immediate clarification of doubts. It provides a social learning environment and is ideal for building interpersonal skills.	Online training is conducted through digital platforms, enabling participants to access content remotely. It offers flexibility in scheduling, self-paced learning, and the convenience of accessing materials from any location with an internet connection. Interactive modules, multimedia elements, and virtual simulations enhance the online learning experience.

Notes for the trainer

Required previous experience and theoretical knowledge	**Ethical aspects of carrying trainings**	**Training tools and resources**
Proven experience in teaching or lecturing, preferably with a focus on Product Life Cycle and Ecological Footprint. Strong theoretical foundation in Product Life Cycle Assessment and Ecological Footprint methodologies. Advanced knowledge in analysing and evaluating the environmental impact of products. A relevant academic degree, preferably in environmental science, sustainability, or a related field.	Inclusivity and diversity; transparency and honesty; voluntary participation; informed concept; confidentiality; trainer's competence; avoidance of discrimination and bias; feedback and continuous improvement. By adhering to these ethical principles, trainers can create a positive and inclusive learning environment that respects the rights and dignity of all participants.	*Presentation slides:* Develop visually appealing and informative slides to guide your presentations on each topic. Include graphics, charts, and key points to enhance understanding. *Interactive Workshops and Group Activities:* Design hands-on activities and group exercises to apply concepts learned during the program. This could include case studies, product life cycle assessments, and circular economy canvas.

Introduction

Let's begin with an exercise designed to foster alternative thinking skills and ignite the creativity of trainees. Such an exercise serves as a creative method to cultivate alternative thinking skills and inspire participants' creativity. It also provides an opportunity to rethink the use of existing items or resources and to come up with new, innovative approaches. This type of task is not only exciting and creative, but also promotes the development of new and innovative ideas, as well as facilitate group dynamics and cooperation.

Instructions for trainees

1. Find your teammate and split into pairs of two.
2. Choose an object and write on the piece of paper all the possible alternatives that could be done with this object.
3. When exchanging the ideas use these phrases - **Yes, and... Yes, or...**

Instructions for trainers

Here are some ways participants can interpret this exercise:

1. Writing: Training participants write all the possible alternatives that can be done with the chosen object. This can include both practical and creative ideas.
2. Thought cloud or sketches: Encourage participants to create mind maps or sketches to visualize their ideas and connections between them.
3. Group discussions: Individual work is followed by group discussions, where participants share their ideas and proposals.
4. Innovative approaches: Challenge participants to come up with innovative and unusual ideas, challenging preconceptions about the use of the subject.

Nature and principles of life cycle assessment

Product life cycle assessment (in English - life cycle assessment or LCA) is a scientific method that allows a comprehensive assessment of the product's impact on the environment, natural resources and human health. A full life cycle assessment examines these impacts in their full cycle, that is, from the extraction of all the necessary raw materials to what and how happens to the product when it has reached the end of its useful life and has become waste.

The essential components of a life cycle assessment include:

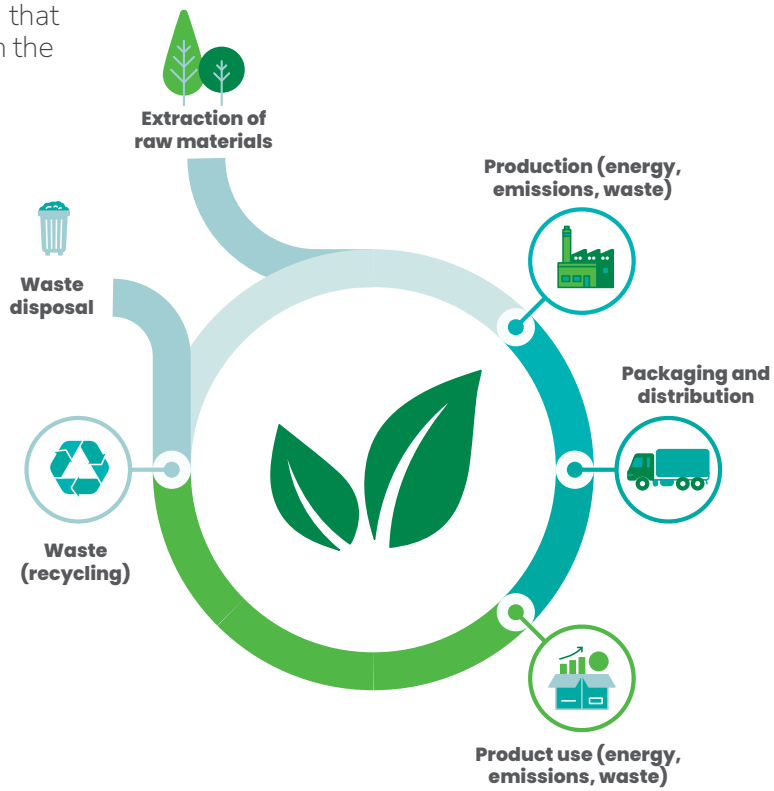
Extraction and processing of raw materials: At this stage, the raw materials needed to create products or services are analyzed. This includes extracting raw materials from nature and transporting them to the manufacturing site.

Production: At this stage, energy consumption, emissions and use of resources in the production process are evaluated. This includes both the evaluation of production technologies and the pollution caused during operation.

Usage: In this phase, the use of the product and the related impacts, such as energy consumption and emissions related to the use of the products or services, are analyzed..

Waste management: This stage evaluates how products or services are managed after their end of life. This includes waste processing, recycling methods and reuse of raw materials.

The purpose of life cycle assessment is to identify environmental aspects related to the life cycle of products or services and to provide information to producers, consumers and other stakeholders about environmental impacts. This information makes it possible to develop and choose more sustainable solutions that would reduce the negative impact on the environment.



LCA Software Tools

Life Cycle Assessment (LCA) software tools are designed to assess the environmental impacts of products and processes throughout their entire life cycle. These tools help organizations make informed decisions to reduce their ecological footprint.

When selecting an LCA software tool, organizations should consider factors such as the complexity of their analysis, the availability of databases, and the specific environmental impact categories they want to assess. Additionally, user training and support are crucial for effective utilization of these tools.

- **Ecochain** provides LCA software that helps companies measure, monitor, and reduce their environmental footprint. It offers features for product sustainability assessment and supply chain analysis.
- **OpenLCA** is an open-source LCA software that allows users to model and assess the environmental impacts of products and processes. It offers a wide range of features and databases.
- **SimaPro** is a widely used LCA software that enables users to conduct life cycle assessments, including impact assessment methods, scenario analysis, and reporting.
- **PRé Sustainability** offers LCA software solutions such as SimaPro and supports organizations in implementing sustainable practices through life cycle thinking.

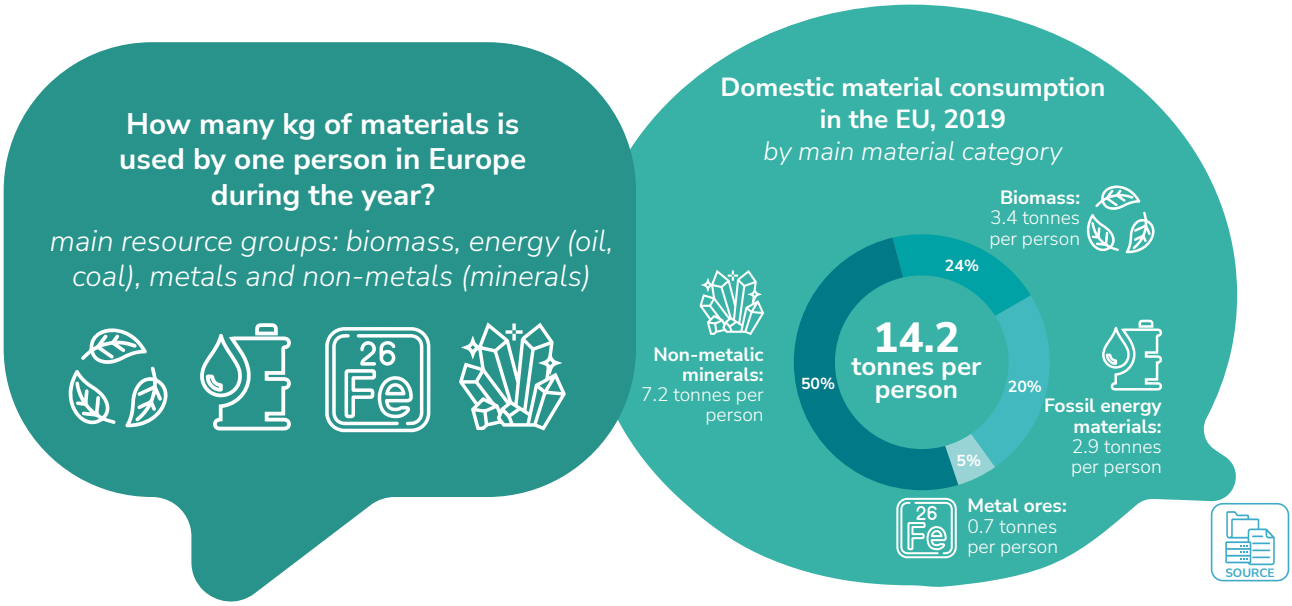
Ecological footprint

Ecological footprint is a measure of an individual's or organisation's impact on the environment, taking into account all aspects of its activities and consumption. This includes resource consumption, energy use, and the amount of emissions generated by the production of goods or services and captured during both production and usage.

The main elements of the ecological footprint are:

- **Life cycle stages:** Similar to life cycle assessment, the ecological footprint takes into account all stages from the extraction of raw materials to waste management in order to determine the full impact on the environment.
- **Resource consumption:** In this context, it is evaluated how many natural resources are needed for the production and use of the specific activity or product. This includes the amount of raw materials, water use, land use, etc.
- **Energy consumption:** Assesses energy use, including electricity and other forms of energy used in the production.
- **Emissions:** Covers greenhouse gas emissions and other forms of pollution associated with the specific activity or product.
- **Waste management:** Includes information on how waste is managed at the end of the product's life and how much waste is generated.

The purpose of the ecological footprint is to provide an overview of the environmental impact of a specific activity or product. It helps both individuals and organizations to understand and reduce their environmental impact through sustainable choices and actions. Thus, this measurement is an important tool to move towards a more sustainable and environmentally friendly lifestyle.



In 2022, the domestic material consumption of the EU economy remained relatively stable at around 14.5 tonnes per person, indicating a very slight increase of 0.4% compared with 2021 (14.4 tonnes per person). Since 2000, the EU reduced its domestic consumption of material by 0.9 tonnes per person.

By calculating how many kilograms of biomass, energy, metals and non-metals one person in Europe uses per year, could give an estimate of their ecological footprint. The Ecological Footprint is an indicator that measures the impact of human consumption and lifestyle on natural resources and ecosystems. It gives a rough idea of how much land and resources people use to meet their housing, food, clothing, energy and other needs.

Sustainable design

Why do we need sustainable design and circular economy principles?

1. To reduce greenhouse gas emissions (product production/industry is responsible for 45% of emissions).

2. To reduce plastic production (dependency on petroleum raw materials) and thus plastic consumption and pollution.

3. To make more valuable use of depleting resources.

Sustainable design and circular economy principles include environmental, economic, and social aspects. They:

- Promote resource efficiency, recycling, and reuse, which helps reduce waste and resource depletion.
- Reduce the negative impact on nature, water resources, and biodiversity.
- Improve energy efficiency, which helps reduce energy consumption and emissions that contribute to climate change.
- Promote changes in businesses and consumers behavior towards sustainable production and consumption.
- Contribute to economic stability by introducing innovative solutions in business that reflect social, environmental and economic goals.

These principles are not only part of the business strategy, but also reflect the broader sustainability goals of society and our planet. Their implementation is important to reduce the negative impact on the environment and social well-being, promoting sustainable development in business and communities.

Sustainable materials and technologies

Life Cycle Assessment (LCA) and the use of sustainable materials and technologies are closely connected, as both play pivotal roles in evaluating and promoting environmentally responsible practices. With LCA, you can evaluate the environmental impacts of your product or service from the very first to the very last stage of its life cycle, or at any stage in between.

- Identification of Environmental Hotspots: LCA helps identify the stages of a product's life cycle with the highest environmental impact. By understanding these hotspots, businesses, and industries can focus on optimizing and adopting sustainable materials and technologies in those critical areas.
- Decision-Making Tool: LCA serves as a valuable tool for decision-making, allowing companies to compare the environmental performance of different materials and technologies. It helps in selecting options that align with sustainability goals.
- Continuous Improvement: The data obtained from LCA can guide continuous improvement efforts. Companies can use this information to innovate and find more sustainable alternatives for materials and technologies at each stage of the life cycle.
- Promotion of Circular Economy: LCA emphasizes the importance of considering the entire life cycle of a product. This aligns with the principles of a circular economy, encouraging the reuse, recycling, and reduction of waste, which often involves the use of sustainable materials and technologies.
- Resource Efficiency: Sustainable materials and technologies are often associated with increased resource efficiency. LCA helps quantify resource use at different stages, highlighting areas where resource efficiency can be improved through the adoption of sustainable practices.

In summary, the integration of LCA and the use of sustainable materials and technologies is crucial for making informed decisions, reducing environmental impact, and moving towards a more sustainable and circular approach in product development and production processes.

Discussion

Sustainable materials and technologies aim to reduce the negative impact on the environment, reduce resource consumption, and promote sustainable development.

What in your opinion are sustainable materials and technologies?

The following examples show that sustainable technologies and materials can cover a wide range of industries and provide solutions to environmental problems, reducing negative impacts on nature and promoting sustainable development.

Sustainable materials

Biodegradable plastic substitutes: PLA and PHA which are biodegradable and made from natural raw materials such as corn or sugar beet.

Use of organic fabrics and textiles: Hemp, bamboo and other organic fabrics grown using sustainable methods, such as without pesticides or artificial fertilizers.

Recyclable raw materials: Materials that can be recycled and reused, such as recyclable plastics, glass, metals or paper.

Natural wood and fiber materials: Wood, fiberboard or boards that come from sustainable forestry practices.

Bioplastics and biodegradable raw materials: Biodegradable plastics or biopolymers that are made from biological sources and can break down naturally without accumulating long-term environmental waste.

Recyclable and reusable metal raw materials: Recyclable steel or aluminum that can be reused, reducing the need for new resources.

Technologies of renewable energy sources:

Use of solar and wind energy and other renewable energy technologies to reduce dependence on fossil fuels and reduce greenhouse gas emissions.

Energy efficiency technologies:

Innovative technologies that help reduce energy consumption, such as energy-efficient equipment and lighting solutions.

Virtual and augmented reality for sustainable education:

Technologies that offer virtual and augmented reality experiences to promote education about environmental protection and sustainable lifestyles.

Blockchain technologies for sustainable origin labelling:

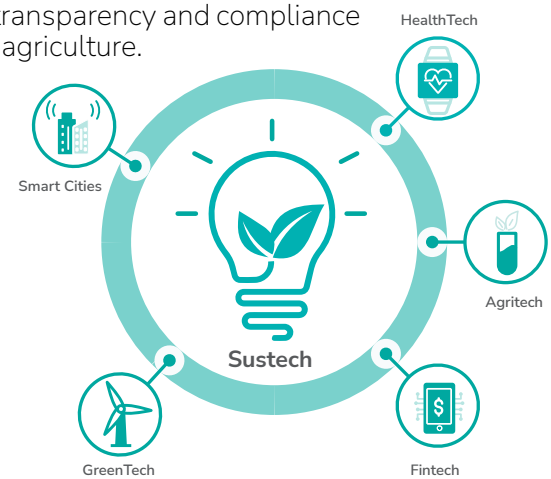
The use of blockchain to mark the origin of products to ensure transparency and compliance with sustainability standards such as fair trade or sustainable agriculture.

Using the Internet of Things (IoT) for resource efficiency:

Using IoT to optimize the use of resources, such as energy efficiency at home, water consumption monitoring or logistics optimization.

Sustainable use of 3D printing:

Using 3D printing technology to create customized and efficient products, reducing material residues and waste.



Examples

Consumer goods from secondary resources

The purchase of second-hand goods reduces the need for new resources as it utilizes existing items, thereby promoting sustainable resource use. It eliminates the necessity for new products and helps prevent the formation of waste. Companies (both Latvian and global) for which the ecological footprint and product life cycle are important:

Andele Mandele (Latvia): is an example where users can sell and buy clothes, goods, etc. from others, promoting long-lasting use of goods.

Patagonia: This company specializes in outdoor clothing and offers a "Worn Wear" program where people can sell or buy used Patagonia clothing.

The RealReal: This online store specializes in upcycled luxury clothing and accessories.

Refurbishment and repair of electronics

Refurbishment and repair of electronics align with LCA principles by focusing on extending product life, reducing environmental impact, conserving resources, minimizing waste, improving energy efficiency, and considering the entire life cycle of electronic devices. These practices contribute to more sustainable and responsible consumption patterns in the electronics industry. Companies specializing in the repair and restoration of appliances, mobile devices.

iFixit: offers tools and guides to help users repair their mobile device themselves, promoting long-term use.

Modular furniture

Modular furniture is designed with interchangeable and customizable components, allowing users to reconfigure or add elements without replacing the entire piece. This promotes resource efficiency by reducing the need for new materials and minimizing waste associated with furniture production. LCA emphasizes the importance of prolonging the use phase of products. Modular furniture is designed for adaptability, allowing it to evolve with changing needs and styles. This extends the product's life cycle, reducing the frequency of disposal and the associated environmental impact.

IKEA: the company has incorporated modular elements into its designs, allowing customers to customize their furniture as needed and change its appearance.

Transportation ecosystem

Car-sharing solutions contribute positively to LCA when they promote shared rides, reducing the number of individual vehicle trips and optimizing the use of available vehicles. Encouraging users to choose shared rides, opt for electric vehicles, or adopt eco-friendly travel practices contributes positively to sustainability. Transitioning to electric or low-emission vehicles powered by renewable energy sources can significantly reduce the carbon footprint associated with the transportation service.

Bolt, Uber or Lyft - are safe and convenient car sharing solutions.

Sustainable sports shoes

The use of completely recyclable and reusable materials in the **Adidas Futurecraft. Loop** collection is a key LCA consideration. Designing products with recyclability in mind reduces the environmental impact associated with the extraction and processing of raw materials. Glues and adhesives can contribute to environmental harm, and by avoiding them, Adidas reduces the environmental impact during production and facilitates easier disassembly and recycling. The Futurecraft.Loop collection addresses the end-of-life phase by implementing a return and recycling program. This closed-loop system helps minimize the environmental impact associated with the disposal of used shoes and encourages the reuse of materials.

Biological packaging

LCA assesses the energy and resource consumption throughout the life cycle. Recyclable packaging has a lower environmental impact compared to non-recyclable alternatives if it requires less energy and fewer resources in production, transportation, and disposal. LCA promotes the reduction of environmental impacts associated with waste. Recyclable packaging solutions aim to reduce the amount of packaging waste sent to landfills. This aligns with the principles of a circular economy by keeping materials in use for as long as possible.

V.L.T (Latvia) company specializes in the production of egg boxes and transport pallets using 100% recyclable material - waste paper.

Rēzekne meat plant (Latvia) uses 100% recyclable packaging material.

The company **EcoEnclose** (USA) offers biodegradable and recyclable packaging solutions that can be used by entrepreneurs to package their products, thus reducing the impact on the environment.

Workshop I

Taking into account the product life cycle, ecological footprint and circular economy principles, develop a product concept, for example:

- work table;
- raincoat;
- mobile phone holder;
- storage box.

Instructions:

1. Find your teammate and split into pairs of two.
2. Taking into account the principles of the product life cycle, ecological footprint and circular economy, develop a product concept.
3. Discuss the results in the group.

Workshop II

By using circular economy canvas (available for download here) map your own product or those created from during workshop I. It is important to be aware of the impact on the environment, to understand each step, to evaluate the benefits. Objective: to develop a sustainable solution for the product. Find a balance between economic viability, ecosystem and sustainability.

Instructions:

1. Choose a product.
2. Determine what is your MISSION in developing this product?
3. Put the big picture together - what is the VALUE PROPOSITION for your product? What makes it better? What else?
4. What materials will be needed for your product?
5. What could be the future life of the product?
6. What "PLAYERS" should be involved to make such a product possible?
7. Who is your client?
8. What positive, negative effects may arise from your actions?

A story of experience

Invite a representative from a company that has succeeded in implementing innovative and sustainable practices, e.g., an inspirational story that reflects the experience of implementing sustainable innovations and operating on circular economy principles. The aim of this activity is to engage and encourage others to implement sustainable practices in their company and to think about the life cycle of the product, the ecological footprint.

Additional resources

Books:

- "Cradle to Cradle: Remaking the Way We Make Things" by William McDonough and Michael Braungart
- "The Upcycle: Beyond Sustainability—Designing for Abundance" by William McDonough and Michael Braungart
- "The Circular Economy: A Wealth of Flows" by Ken Webster

Reports and Guides:

- Ellen MacArthur Foundation. (2015). "Towards the Circular Economy: Economic and Business Rationale for an Accelerated Transition."
- United Nations Environment Programme (UNEP). (2011). "Towards Sustainable Production and Use of Resources: Assessing Biofuels."

Academic journals and reports:

- Rebitzer, G., Ekvall, T., Frischknecht, R., Hunkeler, D., Norris, G., Rydberg, T., & Schmidt, W. P. (2004). "Life cycle assessment: Part 1: Framework, goal and scope definition, inventory analysis, and applications." Environment International, 30(5), 701-720.
- Wackernagel, M., & Rees, W. (1996). "Our Ecological Footprint: Reducing Human Impact on the Earth." New Society Publishers.

Online Resources:

- Life Cycle Initiative: A platform providing guidance and tools for life cycle assessment.
- Global Footprint Network: Resources and data on ecological footprint measurement.

Industry Guidelines and Standards:

- ISO 14040:2006 - Environmental management - Life cycle assessment - Principles and framework.
- ISO 14044:2006 - Environmental management - Life cycle assessment - Requirements and guidelines.

Government Publications:

- Environmental Protection Agency (EPA). (2014). "Life Cycle Assessment: Principles and Practice."
- European Commission. (2013). "Guide to the Integration of Life Cycle Thinking into Business Management."

Educational Platforms:

- MIT OpenCourseWare: Life Cycle Assessment: Open-access course materials on life cycle assessment.

Conference Proceedings:

- Proceedings of the International Conference on Life Cycle Assessment in the Agri-food Sector (LCA Food) or other relevant conferences.

Online Courses:

- Coursera: Introduction to Sustainability and Development: A course covering sustainability principles and their application.

Trade Journals:

- Explore journals related to sustainable business practices, such as the "Journal of Industrial Ecology" or "Sustainability Science."

Continue exploring other Topics

Topic 1

Circular Economy and Sustainability

Topic 2

Waste as a Resource in Circular Economy

Topic 3

Circular Value Chains, Ecosystems, and People

Topic 4

Circular Business Models

Topic 5

Life Cycle Thinking and Environmental Footprint

Topic 6

Design Thinking for Circular Products

Topic 7

Reusability, Repairability, Recyclability

Topic 8

Integration of Circular Approaches into Everyday Work Life

Topic 9

Circular Economy Policies across Baltic Sea Region Countries

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Design thinking for circular products

Developed by
Creator Makerspace

Topic 6

In today's fast-paced world, the demand for sustainable and circular products is on the rise, challenging designers and innovators to reimagine traditional approaches. This Topic is designed to explore the fundamental principles of design thinking, focusing on their practical application in the creation of circular products.

Expected training outcomes

After completing this Topic, trainees will...
... understand the fundamental principles of design thinking and its application in creating circular products;
... recognize design thinking as a human-centered approach;
... understand the iterative nature of the design process;
... know about the EU's Ecodesign requirements;
... recognize opportunities for circularity in product design;
... be familiar with how to generate ideas that align with sustainability goals;
... have explored and practiced the innovation process alone or with a group;
... be able to include sustainability as a priority in their future designs.

Notes for target groups

Different target groups can achieve the following benefits of this training Topic:

Makerspace

Training can help makerspaces attract and retain members interested in sustainable making practices

Makers

By understanding the principles of design thinking for circular products, makers can create innovative solutions that minimize waste and contribute to a circular economy.

Suppliers

By understanding the principles of circular product design, suppliers can adapt their offerings to meet the needs of businesses seeking sustainable solutions.

Start-ups

Training for start-ups can provide valuable guidance on integrating sustainability into their product development process from the outset.

SMEs

Training for SMEs can support their transition towards more sustainable business practices by equipping them with the knowledge and skills to design circular products.

Business support organizations

By offering workshops, mentoring, and resources on design thinking for circular products, business support organizations can empower their members to embrace sustainability as a key driver of innovation and growth.

Other relevant stakehodders

By fostering collaboration and knowledge-sharing across sectors, training can facilitate the development of cross-disciplinary solutions to sustainability challenges.

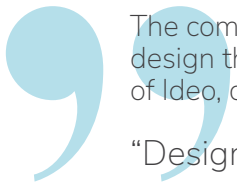
Training plan		
Introduction (1 h 30 min)	**Main part** (2 h)	**Conclusion** (30 min)
Design thinking; Circular products. *Presentation, discussion.*	Workshop regarding a product that needs redesigning, and tasks where the participants need to practice thinking as designers and and as makers. *Workshop.*	Workshop discussion. *Discussion.*
Total duration for the Topic 6: 4 h		

Training modes		
In person	**Online**	**Hybrid**
The training should be conducted in a workshop format where participants can engage in hands-on activities and group discussions.	Training participants can read the material and do the exercises on their own.	-

Notes for the trainer		
Required previous experience and theoretical knowledge	**Ethical aspects of carrying trainings**	**Training tools and resources**
None, but this training material is developed with makerspaces and similar environments in mind.	The benefits of sustainable design practices should be accessible to all communities. Participants should be encouraged to communicate about the environmental and social impacts of their products. Participants should be encouraged to consider the needs and preferences of diverse user groups, ensuring that products are accessible and inclusive. Training should emphasize the importance of education and empowerment in a time of transition in our societies, enabling individuals to make informed and ethical decisions as designers, makers or other participants of the product creation cycle.	*For trainer:* writing tools (e.g., laptop or pen and a pencil), training material (e.g., in a laptop or printed) *For trainee:* writing tools (e.g., laptop or pen and a pencil), training material (e.g., in a laptop or printed)

Design thinking

What is design thinking anyway? Design thinking is a name given to the workflow of designers. The methodology and principles of design thinking originates from academia where it was developed as early as the 1970s by studying how designers work. The concept has become increasingly popular over the last few decades.



The company Ideo was one of the first to promote design thinking as a concept. Tim Brown, executive chair of Ideo, defines Design Thinking this way:

> "Design thinking is a human-centered approach to innovation that draws from the designer's toolkit to integrate the needs of people, the possibilities of technology, and the requirements for business success."

This means design thinking is an approach, a way of thinking, a mindset when innovating.

Design thinking is also a methodology for the creative process with some defined steps. However, as Ideo notes on their web page, "There's no one-size-fits-all methodology or set approach to bringing new ideas in the world." The authors of the article "Designers in design thinking" warn against diluting the role of the designer by reducing design thinking to a few simple steps. They describe the designer as "the expert capable of navigating, managing and leveraging opportunities from the creative challenge", and point out that a designer's creative process "is iterative, messy, uncertain, and often leads to failed attempts and frustration".

With that in mind, the objective of this course is not primarily focused on teaching design thinking. Instead, it aims to draw on principles from design thinking to encourage reflection on crafting more circular products.

The principles of design thinking

The design process is an **iterative process**, generally consisting of three main phases:

- *Inspiration* - where we identify the need for a solution and the opportunities for innovation
- *Ideation* - where diverse ideas are generated, explored, and refined
- *Implementation* - where we prototype, test, and bring a solution to life

To design is to move through these phases in cycles, returning to earlier phases several times before the final product is ready.

An important aspect of design thinking is that it is human-centered. In "The field guide to human-centered design", Ideo writes: "Being a human-centered designer is about believing that as long as you stay grounded in what you've learned from people, your team can arrive at new solutions that the world needs."

To make the design process human-centered, they suggest beginning the creative process by focusing on humans:

- *Inspiration* - observe their lives, hear their hopes and desires, learn to understand them better
- *Ideation* - make sense of what you heard and from that generate tons of ideas for your product
- *Implementation* - bring your solution to the market and maximize its impact in the world

The field guide explains that human-centered designers always start from the place of not knowing the answer to the problem they're looking to solve. This approach can be uncomfortable, but it makes us listen to others and it promotes creativity.

The five phases of design thinking

The Interaction Design Foundation further delves into the innovation process in the article "Five phases of design thinking." This is a non-linear, iterative process, and the phases can be revisited many times, in parallel and in any order.

Stage 1: Empathize - Research Your Users' Needs

The goal in this phase is to set aside your own assumptions and gain real insight into users and their needs. Consult experts and observe and engage with your users. You may also want to immerse yourself in your users' physical environment to get a better understanding of their challenges.

Stage 2: Define - State Your Users' Needs and Problems

Analyze and organize the information you gathered in the Empathize stage. Define the core problem. This must be done in a human-centered manner, based on your end user's experiences and needs.

Stage 3: Ideate - Challenge Assumptions and Create Ideas

Look at the problem from different perspectives. Come up with ideas to solve the problem. Use your favorite techniques to stimulate free thinking and generate as many ideas as possible. Then choose the best ideas to move forward with.

Stage 4: Prototype - Start to Create Solutions

Prototype the product or the features of the product that can solve the problem. Prototypes are inexpensive, scaled-down versions of the product or product feature, and you can make a number of them. This is an experimental phase. The aim is to identify the best possible solution for the problems identified in the earlier stages.

Stage 5: Test - Try Your Solutions Out

Rigorously test the complete product. Although this is the final stage of the five-stage model, this is an iterative process, and you may need to loop back to previous stages several times. The test stage may reveal new insights about your users. The ultimate goal is to get as deep an understanding of the product and its users as possible, and the design process needs to be flexible.

The light bulb example: In his article "Design Thinking" By Tim Brown, Thomas Edison's approach when inventing the light bulb is an early example of what is now called design thinking. Brown writes: "Thomas Edison created the electric lightbulb and then wrapped an entire industry around it. The lightbulb is most often thought of as his signature invention, but Edison understood that the bulb was little more than a parlor trick without a system of electric power generation and transmission to make it truly useful. So he created that, too. Thus Edison's genius lay in his ability to conceive of a fully developed marketplace, not simply a discrete device. He was able to envision how people would want to use what he made, and he engineered toward that insight."

Discussion

1. How does design thinking differ from other ways of approaching innovation that you know of?
2. How is the invention of the light bulb an example of design thinking?
3. Can you think of other examples?

Circular products

What is a circular product? A circular product refers to a product designed and produced with the principles of a circular economy in mind. The concept of a circular economy is an alternative to the traditional linear economy, which follows a "take-make-dispose" model. Products for a circular economy are designed to be more durable, repairable, and recyclable, and to reduce their environmental impact.

Of course, by this definition circular products are nothing new. Planned obsolescence is a term used to describe the phenomenon where products are sometimes deliberately designed with a limited lifespan to encourage frequent replacement, whereas in the past products were often designed to last a long time.

This practice can be driven solely by profit motives, wherein a durable product that once satisfied consumers is replaced to prompt them to spend more on something with a shorter lifespan. At times, it stems from the prevailing consumer mindset, which has become accustomed to and seeks new technology and innovations. This inclination, in turn, influences the market to produce less durable items, anticipating that they will be replaced within a relatively brief timeframe.

The different light bulb example: In 2014, IEEE Spectrum, the world's leading engineering magazine published an article by Markus Krajewski with the intriguing headline: "The great lightbulb conspiracy". It lays out how the Phoebus cartel engineered a shorter-lived lightbulb and gave birth to planned obsolescence.

Krajewski writes: "The cartel's grip on the lightbulb market lasted only into the 1930s. Its far more enduring legacy was to engineer a shorter life span for the incandescent lightbulb. By early 1925, this became codified at 1,000 hours for a pear-shaped household bulb, a marked reduction from the 1,500 to 2,000 hours that had previously been common. Cartel members rationalized this approach as a trade-off: Their lightbulbs were of a higher quality, more efficient, and brighter burning than other bulbs. They also cost a lot more. Indeed, all evidence points to the cartel's being motivated by profits and increased sales, not by what was best for the consumer. In carefully crafting a lightbulb with a relatively short life span, the cartel thus hatched the industrial strategy now known as planned obsolescence."

The European Commission intends to make sustainable products the new norm in the EU. The EU wants products to last longer, use energy and resources more efficiently, be easier to repair and recycle, contain fewer substances of concern, and include more recycled content. Of special importance is the aim to boost circularity, and the EU Ecodesign requirements cover:

- product durability, reusability, upgradability, and repairability
- presence of chemical substances that inhibit the reuse and recycling of materials
- energy and resource efficiency
- recycled content
- carbon and environmental footprints
- available product information, in particular a Digital Product Passport

Application of design thinking for circular products

In designing circular products through the lens of design thinking, our goal is to employ a human-centered creation process to develop a solution for their problems, while ensuring that the resulting products are sustainable.

Stage 1: Empathize - Research Your Users' Needs

As you research the users' needs, take the broader ecological impact into consideration. How long do they expect to use the product? What are their preferences regarding eco-friendly materials? If they do not plan to keep the product for a long time, what will happen to it? Who will the next users be - are you designing for them as well?

Stage 2: Define - State Your Users' Needs and Problems

In addition to stating your users' needs in a human-centered way, based on your research describe the broader ecological impact you expect the solution's product to have.

Stage 3: Ideate - Challenge Assumptions and Create Ideas

Come up with different ideas to solve the problem. When you sort through your ideas in preparation for the prototyping phase, choose to go forward with the ones that both solve the users' problems and that show most promise in resulting in sustainable products. Do you have any ideas on how to make the product more energy and material effective? How can the product be designed to make it easier to recycle? Can it be designed with future upgrades in mind to make the product in the future to make it last longer? What attributes would make the product easier to repair?

Stage 4: Prototype - Start to Create Solutions

In this experimental phase, are there ways to create prototypes that can make the product more sustainable, for example through reuse or choosing more durable materials?

Stage 5: Test - Try Your Solutions Out

Test the products rigorously. The goal is to get a greater awareness of whether the solution solves your users' problems as well as a better understanding of this product's ecological impact. Let both be a consideration before deciding on a solution to go forward with and remember that this is an iterative process.

Makers and design thinking for circular products

Makers often have a different approach from designers. Problems don't necessarily stem from the same sources as those in a commercial setting. While the goal in a profit-oriented context often aligns the origins of problems, makers have a different incentive or lack of incentive, that drives them. Let us consider a general difference between designers and engineers as follows:

Designer = Form over function (or at least biased toward form)
Engineer = Function over form (or at least biased toward function)

Makers are simply defined as someone who makes things. They can come from any background and pop up anywhere in the process. A maker sometimes leans more towards the design/form side of the creation process, and sometimes more towards the engineer/function-side.

Makers tend to encounter very localized problems, applicable only to them and a handful of others. These are often issues that wouldn't make sense as a business venture, but the maker finds satisfaction in solving them.

An example can be that the maker has several tools or items, and wants to create handles, hangers and/or organizers for them. Another example can be when a maker prints a spare part on a 3D printer and uses it to repair a broken appliance.

There are also instances where problems for makers manifest like this:
"I ended up with three pallets of this thing for some reason. What can I solve with this?"

Here the maker's creative process begins when the maker decides to turn the waste material into something useful. This is a step in a bigger, circular process, since the waste material reached the end of a different process before it ended up in the maker's hands.

In an ideal world, the market will create an environment in which these processes will improve themselves, both internally and mutually. If for example, a company creates products that have parts that can be reused with some work, another person or company can use these parts to create different products. With awareness, the first company can ensure that the parts are easily recyclable.

Discussion

A maker in a prototype workshop is often not focused on creating commercial products, but on solving specific problems, for example, related to extending a product's lifetime.

1. Which aspects of the design thinking process can be valuable for a maker?
2. What are some examples of eco-friendly products with a great design?
3. What are some products that are not generally eco-friendly today, that you think could be with better design?
4. When creating new products for our society, to what extent do you think the users' needs will align with the eco-friendliness of a product, and to what extent do you think they will clash?

Workshop

In this exercise (workshop duration – 2 h 30 min) you are in stage 3: Ideate of the design thinking process individually or in a group. Pretend that a design team has been given the task of redesigning a fridge. In the past, each element was created in the most cost-effective fashion, but the result was that each separate part was especially designed for this particular fridge. The managers have decided to take a more eco-friendly approach for the next model of the fridge.

The product should fulfill both requirements:

- It should be easy to repair it and make it work again
- It should also be easy to use the different parts in different products when the fridge is no longer in use

A fridge typically consists of:

- A control board
- A cooling system including a compressor and refrigerant gas
- Insulation
- Metal frame
- Doors
- Interior light
- A fan
- A thermostat
- Shelves and drawers
- Some form of smart function (at least for newer fridges from tech companies)

In stages 1 and 2 we interviewed users of the fridge. These are their main observations and problems with the fridge:

- The control board stopped working and could not be replaced by the user.
- The compressor worked fine, but users had concerns about how the refrigerant gas was handled after disposing of the fridge.
- The insulation was glued to the metal frame.
- The handle had a special attachment mechanism, and when it broke, it was impossible to buy new handles because they were out of date.
- The door hinges were difficult to adjust without detaching the door first.
- The light could not be replaced because of the diffuser being fused to the interior of the fridge.
- The fan could only be operated with the fridge's controller.
- Plastic details related to glass shelves were close to impossible to replace, mostly because of how they were glued to the shelves.
- While the fridge uses a generic thermistor that is easily accessible, the work involved in replacing the thermistor makes it more reasonable to buy a new fridge.
- A concern that software changes down the road will make the fridge worse, as the hardware becomes more outdated.

Task 1: Design team - Ideate

As part of the design team that is developing the next version of the fridge,

1. Come up with ways to make the fridge more repairable.
2. Come up with ways to make the fridge more recyclable.
3. Come up with ways to make the fridge or parts of the fridge more reusable.

Come up with as many ideas as you can for each component.

Task 2: Design team - Choose some ideas to go forward with

This is a preparation for the prototype phase. Look at all the ideas you have gathered. Pick some, with these concerns in mind:

- The manager still wants the fridge to be economically viable
- The users still want a user-friendly fridge
- The users want the fridge to last at least 15 years, while the company still wants to develop new models. Keep both wishes in mind and make the necessary decisions
- The design of the fridge still needs to follow principles of reusability, recyclability, and repairability

Make a list of the best ideas.

Task 3: Makers - Reusing the product

Imagine that a few years have passed. You are a maker who has been given a fridge. It happens to be the eco-friendly model that you outlined in the previous task. This model implemented all the best designs from the list you made in task 2.

The problem with this particular unit that you are given, is that the controller is no longer working.

Come up with ideas for how you as a maker can use the fridge parts for other products or projects. Write down as many ideas as you can for each component. Then make a list of the best ideas to go forward with.

Task 4 (optional, if you have time): Begin the prototype phase

Choose one of the ideas from task 2-3 and start making a sketch for the prototype phase.

Resources

- Ideo's web page on design thinking: https://designthinking.ideo.com/
- "Design Thinking" by Tim Brown: https://hbr.org/2008/06/design-thinking (Free to read: https://designthinkingmeite.web.unc.edu/wp-content/uploads/sites/22337/2020/02/Tim-Brown-Design-Thinking.pdf)
- The Field Guide to Human Centered Design by Ideo: https://design-kit-production.s3.us-west-1.amazonaws.com/Field_Guides/Field+Guide+to+Human-Centered+Design_IDEOorg_English.pdf
- "What is design thinking?" by the Interaction Design Foundation https://www.interaction-design.org/literature/article/what-is-design-thinking-and-why-is-it-so-popular
- "The five stages in the Design Thinking process" by Rikke Friis-Dam / the Interaction Design Foundation https://www.interaction-design.org/literature/article/5-stages-in-the-design-thinking-process
- Course on design thinking by University of North Carolina at Chapel Hill https://designthinkingmeite.web.unc.edu/
- "Designers in design thinking" INTERNATIONAL CONFERENCE ON ENGINEERING AND PRODUCT DESIGN EDUCATION 4 & 5 SEPTEMBER 2014, UNIVERSITY OF TWENTE, THE NETHERLANDS DESIGNERS IN DESIGN THINKING Erika BRAUN, Jessica MORELAND, Emma SANDERS and Carolina GILL The Ohio State University, Department of Design https://www.designsociety.org/publication/35899/Designers+in+Design+Thinking
- Press release from the European Commission: "Commission welcomes provisional agreement for more sustainable repairable and circular products" https://ec.europa.eu/commission/presscorner/detail/en/ip_23_6257
- "The great lightbulb conspiracy" by Markus Krajewski, 2014 https://spectrum.ieee.org/the-great-lightbulb-conspiracy
- The circular design guide by Ideo: https://www.circulardesignguide.com/
- "Design and the circular economy - deep dive" by the Ellen MacArthur Foundation https://www.ellenmacarthurfoundation.org/design-and-the-circular-economy-deep-dive

Continue exploring other Topics

Topic 1	Topic 2	Topic 3
Circular Economy and Sustainability	Waste as a Resource in Circular Economy	Circular Value Chains, Ecosystems, and People
Topic 4	**Topic 5**	**Topic 6**
Circular Business Models	Life Cycle Thinking and Environmental Footprint	Design Thinking for Circular Products
Topic 7	**Topic 8**	**Topic 9**
Reusability, Repairability, Recyclability	Integration of Circular Approaches into Everyday Work Life	Circular Economy Policies across Baltic Sea Region Countries

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Reusability, Repairability, Recyclability

Developed by
Maker

Topic 7

This Topic focuses on reusability, repairability and recyclability and aims to inspire and educate local makers, makerspaces and business support organisations about circular design, production and business modelling.

Expected training outcomes

After completing this Topic, trainees will...
... new insights and knowledge on the theory and methods of circular design;
... new insights, knowledge, and practical experiences on the principles and tools of circular design;
... access to an open repository of tools, templates and guides within the field of circular design and production.

Notes for target groups

Different target groups can achieve the following benefits of this training Topic.

Makerspace

Makerspaces, fablabs and similar collective workshop ecosystems will benefit from getting access to a carefully curated selection of open resources and tools for a circular transition. This target group will be able to share, implement and further train their local and specific community within these open resources and tools.

Makers

Independent makers and designers will benefit from getting access to a carefully curated selection of open resources and tools for transitioning existing design, prototyping and production principals and approaches into more circular models. This target group will gain practical experiences with some of the tools, and be inspired to work with open resources for kickstarting a circular transition.

Suppliers

Will get a communicative and branding opportunity to connect directly with independent makers and designers (customers) and to educate and inspire to use more circular materials.

Start-ups

Start-ups will benefit from getting access to a carefully curated selection of open resources and tools for transitioning existing design, prototyping and production principals and approaches into more circular models. This target group will gain practical experiences with some of the tools, and be inspired to work with open resources for kickstarting a circular transition.

SMEs

SMEs will benefit from getting access to a carefully curated selection of open resources and tools for transitioning existing design, prototyping and production principals and approaches into more circular models. This target group will gain practical experiences with some of the tools, and be inspired to work with open resources for kickstarting a circular transition.

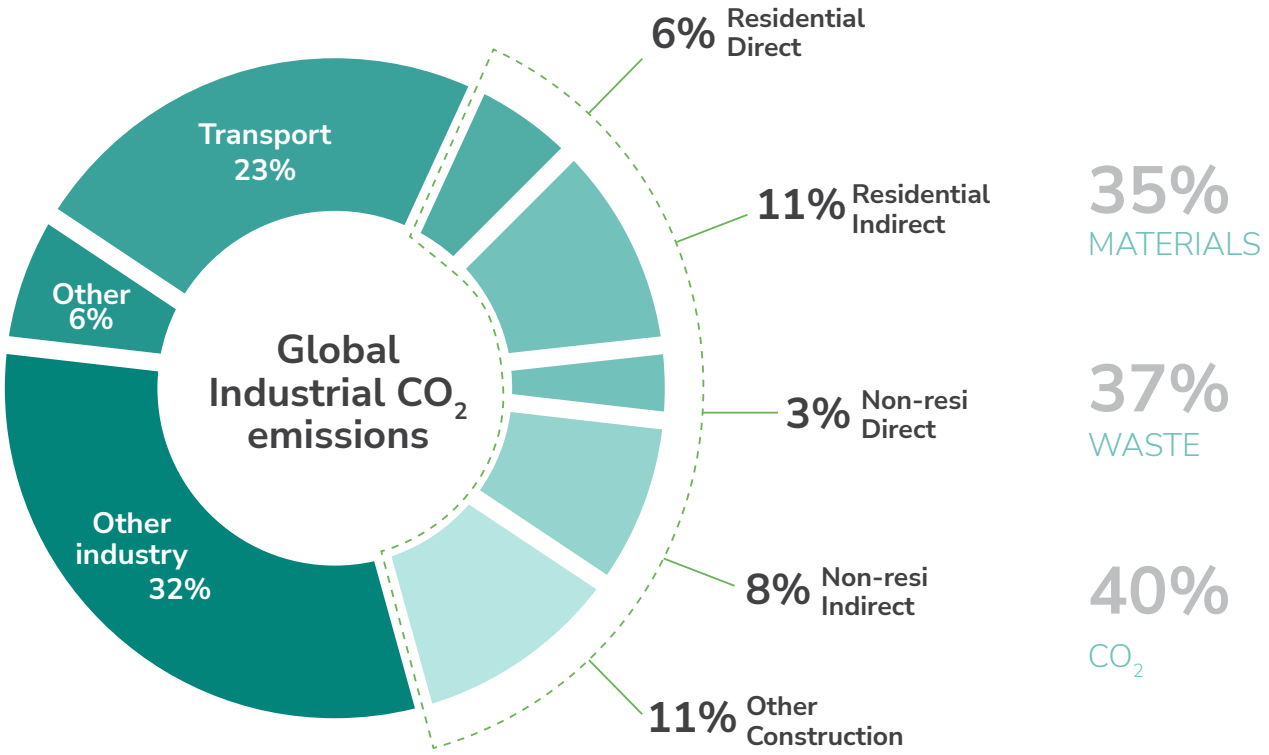
Training plan		
Introduction (15 min)	**Main part** (3 h)	**Conclusion** (30 min)
Introduction to Circular Spaces and the training program. *Presentation.*	Circular design theories and methods; Circular design principals and tools; Circular transition (business models and ecosystems); Introduction to and showcase of open resources library. *Presentation, discussion.*	Open discussion and wrap up. *Discussion.*
Total duration for the Topic 8: 3 h 45 min		

Training modes		
In person	**Online**	**Hybrid**
Yes.	N/A	N/A

Notes for the trainer		
Required previous experience and theoretical knowledge	**Ethical aspects of carrying trainings**	**Training tools and resources**
Deep understanding of tools, theory, methods and project. High level communication skills (presentation, facilitation).	High focus on "green washing" - presenting relevant and analysed cases, resources and methods. Ensuring openness, inclusivity and respectfulness. Focus on communication materials that are inclusive to ensure a diverse group of participants and engaged stakeholders.	*For trainer:* Materialepyramiden by CINARK, KADK and Vandkunsten; The Upcycl: New Waste Materials; Material Reuse Portal (CIRCuIT); Designing your circular transition by DDC; How to get started with Distributed Design? Tools by DDC and Maker. *For trainee:* Materialepyramiden by CINARK, KADK and Vandkunsten; The Upcycl: New Waste Materials; Material Reuse Portal (CIRCuIT); Designing your circular transition by DDC; How to get started with Distributed Design? Tools by DDC and Maker.

Introduction

Recyclability and reusability - the future of material flows is focusing on recirculation of materials, direct reuse and material exchange ecosystems



The ideal way of disassembly involves systematically breaking down a product or structure into its individual components or materials with the goal of maximizing reuse, recycling, or recovery. This process typically begins with thorough documentation and labelling of parts to facilitate reassembly or recycling. Disassembly should be conducted in a controlled environment using appropriate tools and techniques to minimize damage and contamination. Components should be sorted based on material type and condition to optimize resource recovery and minimize waste. Additionally, consideration should be given to safety, environmental impact, and regulatory compliance throughout the disassembly process. Ultimately, the ideal disassembly approach prioritizes efficiency, sustainability, and circularity, aiming to extend the lifespan of materials and reduce environmental footprint.

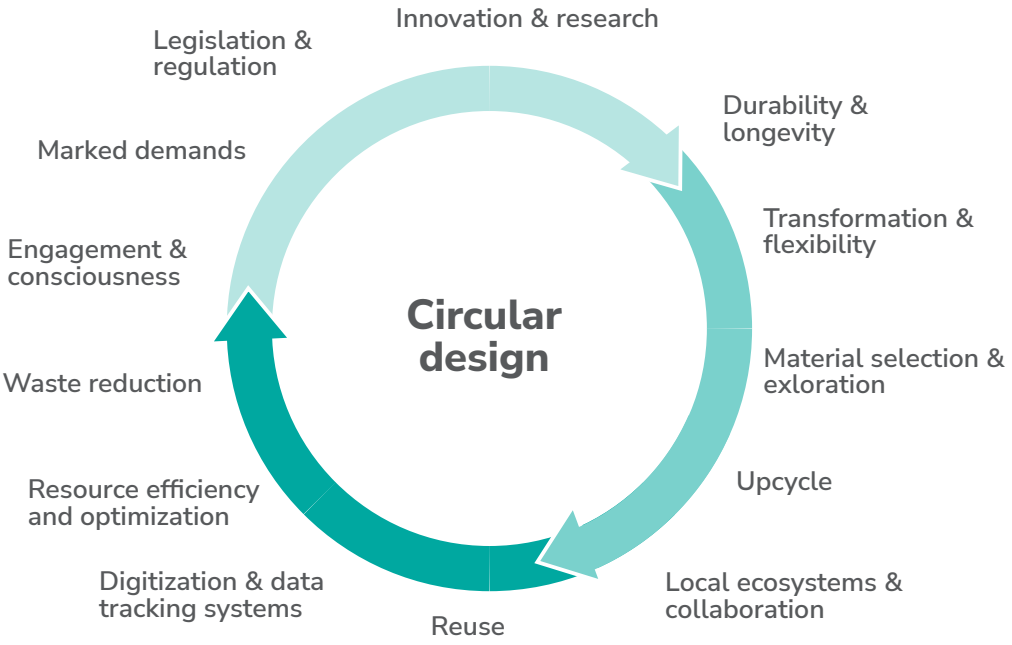
Example of a classical separation wall —> Gypsum, aluminium frames.

The reality:

Circular design principles

When designing for circularity everything must be designed for:

1) Reusability
2) Repairability
3) Recyclability
4) Upgradability
5) Transformability

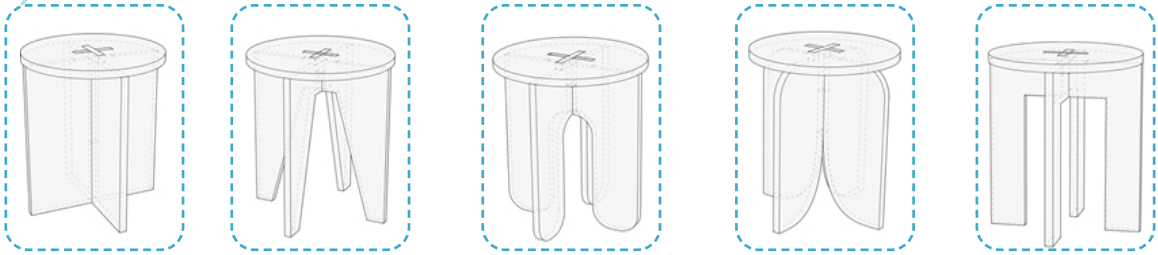


Design for reusability / repairability / recyclability principals and methods:

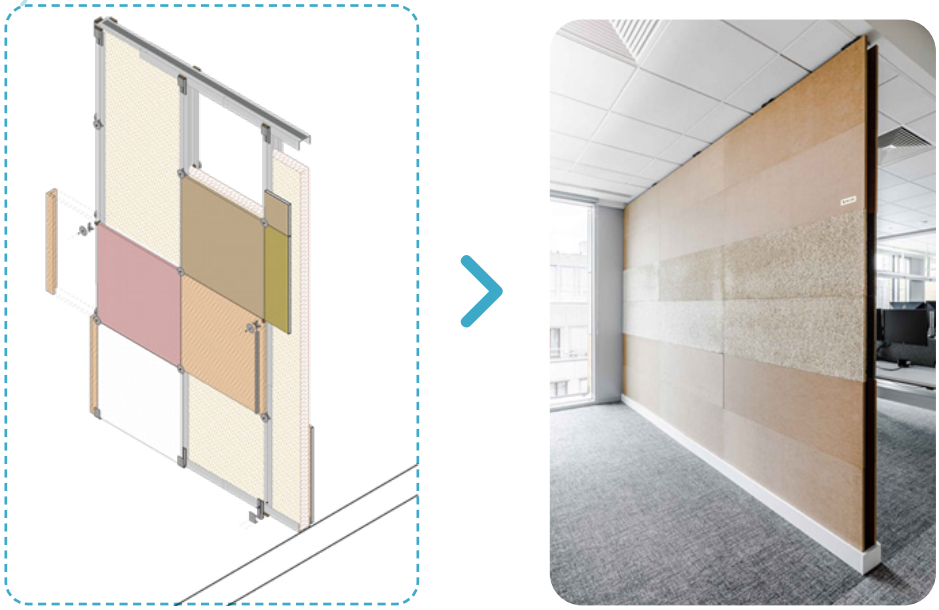
- disassembly
- future transformation and up/down-gradability
- honesty (material/parts passport, transparency)
- longevity - extended product lifespan
- open collaboration
- flexible materials
- return offerings

Good practices for reusability, repairability, and recyclability

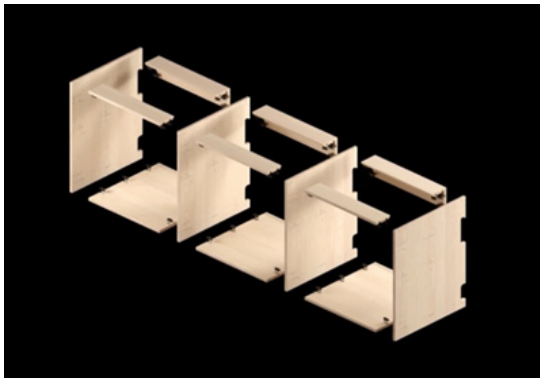
Design for disassembly, transformation and recyclability



Design for Disassembly - from hackathon to business. Plug'N'Wall by Emma Buchanan, Jan Dankmeyer, Katarina Kierulfova & Lukasz Marczuk



Stykka Loop Kitchen.



Stykka Loop Kitchen case

SOURCE

Material and parts passports and online digital twins ensure traceability, repairability, future upgradability, and material transparency for future recyclability.

"In the field of built-in fixtures, we are among the first to equip our products and parties with QR and RFID, which gives all parties a unique ID. This ensures identification and traceability and helps us keep track of what we have in circulation. The technology connects the physical product with an online digital twin containing product, material, and climate data. Traceability is a prerequisite for enabling return logistics in the future, where parts are taken back and prepared for rebuilding.

As for the design for disassembly, the right joints are a prerequisite for circular products. We assemble all our fixtures with special brackets and cut-outs so that all parts can be easily replaced or repaired. The joints are part of our modular system, which means that all holes are pre-drilled to avoid drilling during installation, where the risk of damaging a part is greatest. Plus, our installers say it saves them a lot of time. At the end of use, the fixtures can be disassembled, returned, and used for new products - without any loss of quality. With screws and dowels in chipboard, this would not be possible.

With technology and a digital production method, our goal is to produce locally to minimize transportation and carbon footprint. We see ourselves as part of a global production network, powered by technology, where we send the recipe digitally instead of shopping for tons of materials."

Good practice of design for disassembly and flexibility on building scale – Vivi house

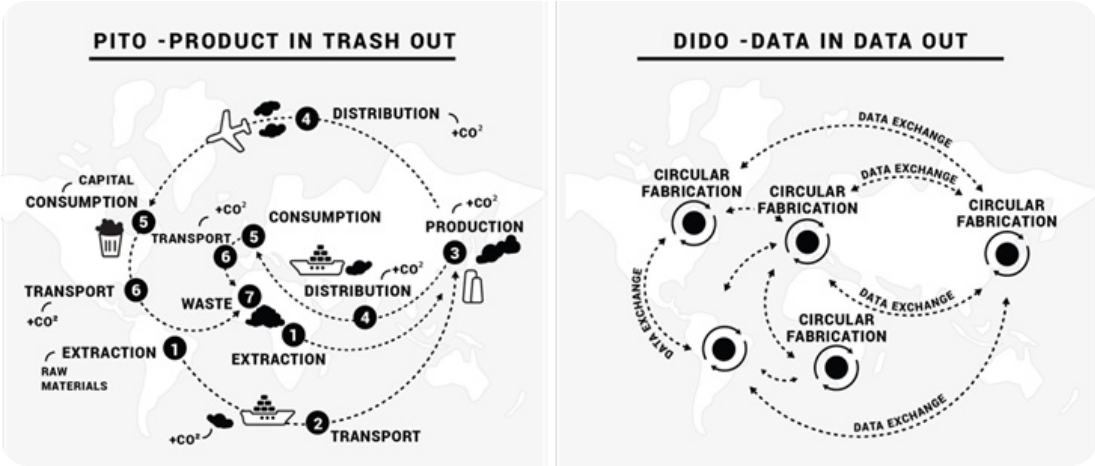
SOURCE

- Co-creating beautiful ecological buildings.
- For hybrid uses and internal flexibility.
- At the urban scale.
- Based on a reusable modular system.
- Consisting of prefabricated elements.
- As an inclusive technology for co-creation.

Good practice of distributed design, open innovation, and fab cities

SOURCE

The Distributed Design Platform is an incubator programme targeting the overall mission of Fab Cities and acting as an exchange and networking hub for the European maker movement. The initiative aims to develope and promote the connection between designers, makers, and the market.



Good practice of distributed design, open innovation and distributed fabrication

SOURCE

Our values

Open

Open refers to the mentality and approach of designers to share and make their processes transparent, repricable, and accessible, from hardware and sofware to implementation and usability.

Collaborative

Collaborative means enabling citizens to become active participants in the design process through meaningful and participatory co-design approaches.

Regenerative

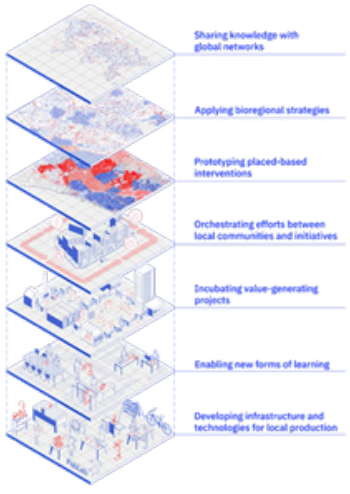
Regenerative making and design principles aspire to renew and restore the systems that we are part of, rather than just replacing or devaluing them.

Ecosystemic

Ecosystemic means acknowledging the complexity of interactions between cultural, natural, and social aspects and designing to improve the health of social and environmental systems.

Good practice of fab cities

SOURCE



FAB CITY FULL STACK

Materials

Decisions regarding material selection should be based on the following aspects:

- Organic and natural
- Recyclable
- Locally sourced
- No use of screws or nails

Construction material pyramid

Material and parts passports, used as RFID and QR codes on all parts, ensure traceability and connect the inventory with its digital twin on the operating platform. This enables repairability, future transformability, and recyclability and potentially also opens up a second-hand market of unwanted parts.

Stykka example

Workshop

Open resources and Circular Toolkit developed by Danish Design Centre. Possibility to do online training and physical workshops using the Circular Toolkit.

Access SOURCE

Circular maker toolbox of open resources

Platforms and communities for circular makers and makerspaces:

- **Wikifactory** is a product development platform built for engineers and designed for all extended team members. With no training required, you experience effortless real-time collaboration across teams, fostering efficient communication, streamlined workflows, and accelerated time to market.
- **The Distributed Design Platform** acts as an exchange and networking hub for the emerging field of distributed design. The initiative aims to develop and promote the connection between designers, makers, and emerging digital and local markets.

Found Objects - Edge Generator is a grasshopper definition that can be used to create "Found Object" parts in the space around the edge of a CNC sheet. The definition generates curves in between the edge of the sheet and the parts nested within the sheet and gives several options for adjusting the parameters of the curves.

Open resources for LCAs and material comparisons:

- **OpenLCA** platform is freely available software for Life Cycle Assessment (LCA) developed by GreenDELTA in Berlin.
- **This construction material** pyramid is an online and interactive tool for calculating and comparing the (relative) carbon footprint of various materials.

New waste materials and platforms:

- **The Material Reuse Portal** brings together construction materials from multiple marketplaces to create a single place where reusable materials can be found. Developed as part of the EU-funded project CIRCuIT.
- **THE UPCYCL** is a tool and a catalyst for the utilization of materials - even those with skewed dimensions and unrefined edges.

What to know more?
Check out these articles and websites

- https://distributeddesign.eu/how-makers-relate-their-work-to-circularity/
- https://distributeddesign.eu/cities-as-distributed-and-decentralized-material-ecosystems-supporting-local-and-circular-production-within-all-sectors/
- https://wikifactory.com/+wikifactory/stories/guide-to-design-for-disassembly-how-to-implement-it
- https://www.teknologisk.dk/design-for-disassembly-haandbog-om-affaldsforebyggelse-i-byggeriet/40730
- https://materialreuseportal.com/
- https://wikifactory.com/

Continue exploring other Topics

Topic 1

Circular Economy and Sustainability

Topic 2

Waste as a Resource in Circular Economy

Topic 3

Circular Value Chains, Ecosystems, and People

Topic 4

Circular Business Models

Topic 5

Life Cycle Thinking and Environmental Footprint

Topic 6

Design Thinking for Circular Products

Topic 7

Reusability, Repairability, Recyclability

Topic 8

Integration of Circular Approaches into Everyday Work Life

Topic 9

Circular Economy Policies across Baltic Sea Region Countries

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Integration of circular approaches into everyday work life

Developed by
Lithuanian Innovation Centre

Topic 8

The Topic focuses on equipping participants with the knowledge and skills to seamlessly integrate circular economy principles into their daily work routines. Participants will explore practical strategies for waste reduction, resource optimization, and sustainable decision-making, fostering a workplace culture that aligns with circular approaches for long-term environmental and economic benefits.

Expected training outcomes

After completing this Topic, trainees will...

... have a sound understanding of circular consumption, circular behaviour and circular approaches;

... be able to apply circular economy-oriented thinking in different everyday situations.

Notes for target groups

Different target groups can achieve the following benefits of this training Topic:

Makerspace

Stronger and more equipped facilitation of circular economy-oriented community formation. Stipulation of circular approaches' integration into everyday work life, leading to a more sustainable use of resources on the organizational level.

Maker

Broader application of circular economy-oriented thinking in various environments. Stipulation of circular approaches' integration into everyday work life, leading to a more sustainable use of resources on the individual level.

Suppliers

Stronger circular economy-oriented engagement with partners. Stipulation of circular approaches' integration into everyday work life, leading to a more sustainable use of resources both on the organizational and on the individual level.

Start-ups

Broader application of circular economy-oriented thinking in various environments. Stipulation of circular approaches' integration into everyday work life, leading to a more sustainable use of resources both on the organizational and on the individual level.

SMEs

Broader application of circular economy-oriented thinking in various environments. Stipulation of circular approaches' integration into everyday work life, leading to a more sustainable use of resources both on the organizational and on the individual level.

Business support organizations

Improved readiness to promote circular transformation of businesses. Stipulation of circular approaches' integration into everyday work life, leading to a more sustainable use of resources both on the organizational and on the individual level.

Training plan

Introduction (15 min / 1-8 slides)	Main part (3 h / 9-22 slides)	Conclusion (15 min / 23-26 slides)
Introduction to the topic and different stages of knowledge uptake, based on Bloom's Taxonomy.	Exploration of the „circular approaches" concept and the examples of circular economy-oriented activities. Workshop „Application of circular approaches in makerspaces".	Application of Continuous improvement approach to achieve long term implementation of circular approaches.
Reading/presentation, discussion, self-reflection.	*Reading/presentation, discussion, case-analysis, workshop.*	*Reading/presentation, discussion, self-reflection*

Total duration for the Topic 8: 3-4 h

Training modes

In person	Online	Hybrid
The trainer decides the format in which the trainees will be introduced to the theoretical training material (e.g., by utilizing slides or by ensuring individual learning). Tasks requiring action (marked in blue colour text) should be carried out among the trainees in a facilitated discussion manner.	Trainer decides the format in which the trainees will be introduced to the theoretical training material (e.g., by utilizing slides and online presentations or by individual reading tasks for trainees before the online session). Tasks requiring action (marked in blue colour) should be carried out online among the trainees. Trainer decides how to ensure a pro-active participation of trainees (e.g., by creating interactive polls) and ensures the facilitation (both thematic and technical) of the online session.	Trainer decides the format in which the trainees will be introduced to the theoretical training material (e.g., by utilizing slides and hybrid presentations or by individual reading tasks for trainees before the hybrid session). Tasks requiring action (marked in blue colour) should be carried out in a hybrid format among the trainees. Trainer decides how to ensure a pro-active participation of trainnes both online and on site (e.g., by utilizing digital solutions) and ensures the facilitation (both thematic and technical) of learning process.

Notes for the trainer

Required previous experience and theoretical knowledge	Ethical aspects of carrying trainings	Training tools and resources
Theoretical foundations of the circular economy. Preferably, Topics 1-7 from this training programme have been covered.	It is important to ensure equal opportunities for trainees to be involved in the activities outlined in the training, e.g. by organising workshops.	*The trainer* should utilize all materials provided in this topic; create visual presentation (optional); ensure equipment required to carry out the training in online or hybrid format (optional); provided necessary stationary for trainees participating in the workshop. *Trainees* should utilize the materials provided in this topic optionally by themselves or with the support of the trainer.

Introduction

This training Topic is aimed at facilitating practical application of circular economy-oriented practices into everyday operation of makerspaces. The following material is designed to guide makerspace communities on how theoretical knowledge about the circular economy can be integrated into existing work routines. By taking a more proactive approach on circular transformation, makerspaces can not only be more environmentally conscious, but also better align their activities with economic efficiency, innovation, and societal expectations.

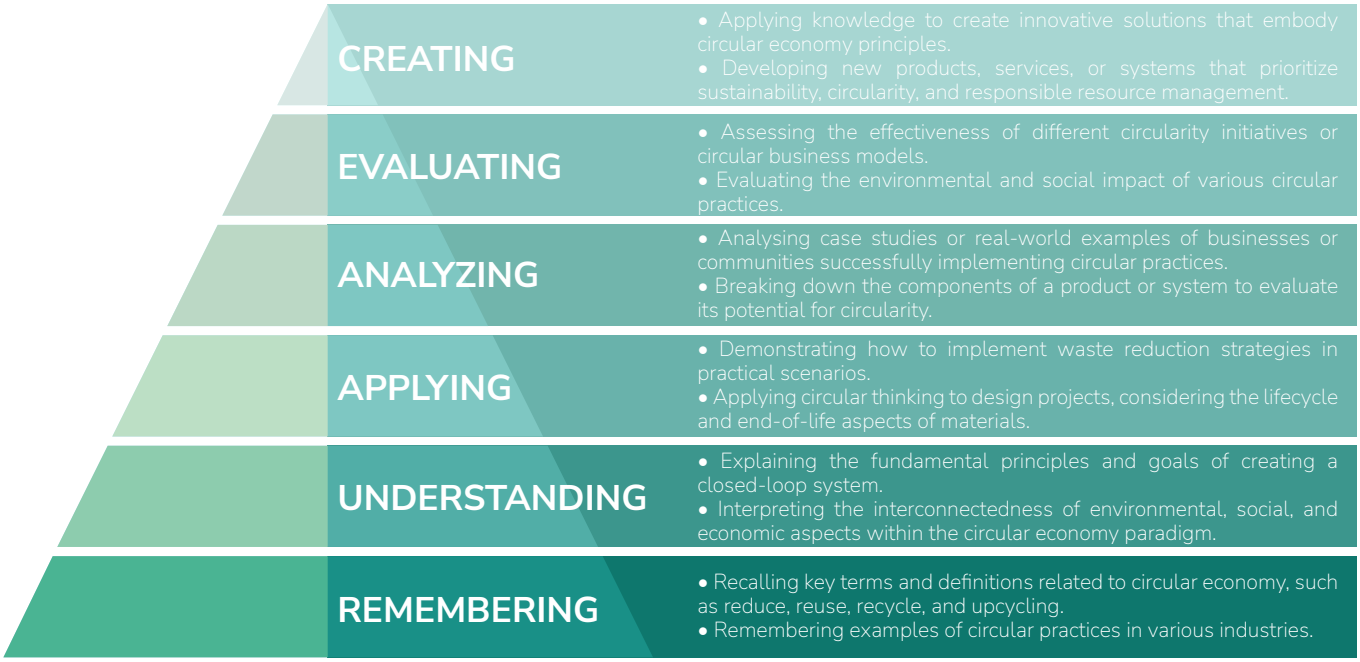
Makerspaces are by definition quite circular, as they encourage the sharing of tools, equipment, materials, knowledge, and skills within their communities. By turning creative ideas into physical products, makers are well aware of the value of the resources used and the amount of work required for this process. The unique features of makerspaces position them into a favourable setting of mainstreaming circularity ideas even broader.

Discussion

See the example of Amman Valley MakerSpace project YouTube and discuss the following question:

What are the similarities and differences between the Amman Valley MakerSpace and your local makerspace in terms of sharing (1) tools, equipment, and materials (2) knowledge and skills among the community members?

Previous topics in this training program provide a wealth of information on different circular economy subjects. In order to unlock the long-term value of this knowledge, this Topic utilizes Bloom's Taxonomy approach that provides a structured framework both for trainers and trainees to engage with the principles and concepts of circularity. Knowledge capture and the formation of competences and skills are strengthened as progress is made towards the higher steps of the pyramid.



Based on this Taxonomy, the integration of circular approaches in everyday work life depends on the individual's (or organisation's) ability to apply the knowledge in different settings. For example, when analysing the organisation's activities, setting new goals or evaluating existing initiatives, all related to mainstreaming circular economy approaches.

Discussion and self-reflection

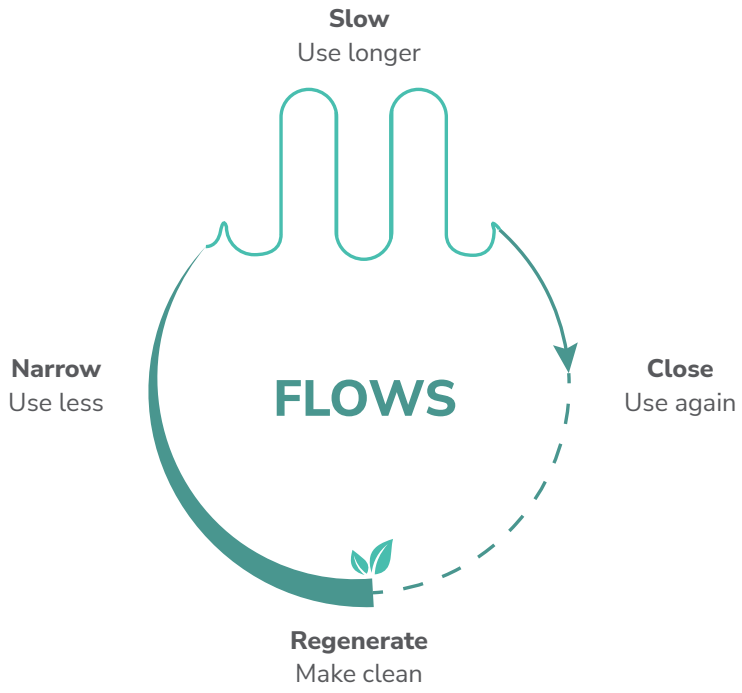
1. Based on your experiences and understanding of different circular economy ideas, where would you place yourself in Bloom's Taxonomy pyramid? Why?

2. What further actions, resources or assistance are needed for you to advance further towards the higher steps of the pyramid? How can makerspace community support your advancement?

Circular approaches

What is meant by circular approaches? In a general sense, it is the application of knowledge about the circular economy to the different decision-making processes. These processes can range from the simplest and routine, such as sorting packaging properly or using public transport, to the highly complex or large-scale, such as designing a new product or developing a sustainable business strategy. When we adopt circular approaches, we look at our actions through the lens of the circular economy, in addition to other considerations. This can be simplified to the question of "How can I reduce resource consumption and waste generation through this action?"

Circular approaches are inseparable part of circular behaviour (more about it on Topic 3 – Circular value chains, ecosystems, and people) which utilizes the rationale of responsible resource consumption. A more systemic viewpoint to circular consumption, introduced by Circle Economy Foundation, refers to 4 resource use strategies: slowing flows, closing flows, narrowing flows, and regenerating flows (more about it on Topic 1 – Circular economy and sustainability).



Examples of consumer's or user's actions to...

...slow resouce flows:
careful treatment, regular cleaning, and necessary repairing of products

...narrow resource flows:
participation in sharing and rental models, and avoidance of unnecessary purchases

...close resource flows:
passing on of pre-owned products to others, separation of waste materials

...regenerate resource flows:
use of renewable energy, selection of organic food and toxic-free products

Discussion

Usually, when we consider buying a new phone, our decision is based on economic (e.g., price) and technical factors (e.g., battery life, camera resolution). With the adoption of circular approach, we would also question the overall need for a „new" phone and evaluate the option of buying a refurbished one.

What other aspects, based on your current knowledge about circular economy, could be included into the decision-making of buying a phone?

[1] https://www.circle-economy.com/blogs/circular-consumption-in-the-linear-economy-only-a-drop-in-the-ocean

Circular approaches can be adopted not only on an individual level but also on the organisational. This usually happens when a group of managing staff agrees on common circular economy-oriented actions, contribute to them with allocated resources, and advocate them to others. In organisations, circular approaches can be integrated into almost all activities. The following examples reflect only a fraction of the variety of such possibilities.

Procurement

- Implementation of **green** and **circular** procurement by incorporating sustainability criteria into the technical requirements of procured goods, services, or works.
- Identification of more sustainable and circular product alternatives to be procured by implementing corresponding market analysis.
- Reinforcement of effective green and circular procurement implementation by strengthening procurement staff competences.
- Reinforcement of the procurement role for contributing to circular economy objectives by aligning it with other organisational agendas, regulations, or strategies.

Events

- Implementation of **zero-waste events** by eliminating single use items, such as packaging, printed agendas, name cards, etc.
- Compliance with proper waste sorting by allocating separate recycling bins for different types of waste and by displaying correct sorting information.
- Avoidance of event-specific item production, e.g., stationery, banners, souvenirs, etc., by utilizing multiple use alternatives.

Staff mobility

- Promotion of shared mobility (e.g., carpooling) by identifying such possibilities among the staff.
- Promotion of use of public transportation by creating motivational incentives.
- Encouraging cycling through the provision of bicycle parking spaces.
- Awareness creation regarding environmental impacts of mobility by mainstreaming GHG calculations (**example of GHG calculation tool**) and setting related reduction goals in the organization.
- Promotion of sustainable mobility options for staff travelling to external events by creating corresponding guidelines and recommendations.

It is evident that some of these examples are not only related to the circular economy, but also to other concepts such as sustainability or zero-waste (more on this in Topic 1 – Circular economy and sustainability). Nevertheless, they all share the objective of using available resources more efficiently, reducing waste and contributing to reducing pollution.

Makerspaces, in this respect, can integrate circular approaches not only in common organisational activities (e.g., procurement, facilities management, etc.) but also into their other typical activities (e.g., production of prototypes, education, etc.). The more of the makerspace community is involved in the application of circular economy-oriented practices, the greater environmental impact can be achieved.

Case analysis

"CircularSpaces" makerspace is a dynamic hub for innovators and creators committed to integrating sustainable practices into their projects. The makerspace is planning to initiate a challenge to encourage its community members to apply circular economy thinking to their projects. The challenge will include the creation of furniture design and participants will be tasked to design innovative and functional pieces.

Imagine that you are one of the organisers who have to set the evaluation criteria for the presented projects and choose the winner for the most well thought circular furniture. Define these evaluation criteria both from the design and production, as well as the end user perspectives. Use references or examples from different training Topics, circular consumption framework provided on page **133***, and apply your overall knowledge of circular economy.*

Workshop “Application of circular approaches in makerspaces”

This workshop is aimed at strengthening practical application of theoretical knowledge about circular economy. Workshop participants are invited to design an action plan for the local makerspace which would define key activities to support its circular transformation. When developing an action plan, workshop participants are invited to come up with ideas on how circular approaches can be applied to the everyday activities of the makerspace.

Instructions:

1. Training participants form smaller groups of 4-7 people. *(5 min)*
2. Each group discusses different makerspace activity areas in which circular approaches could be integrated and chooses 2-3 of them for further investigation (activity areas can be chosen from the indicative list or be additionally set by the participants themselves). *(5 min)*
3. Each group brainstorms the ideas and practical actions that are needed to be implemented in the makerspace in order to integrate circular economy principles in selected activity areas and creates corresponding action plan (action plans can be created by using attached template). *(45 min)*
4. Each group presents their action plan to other groups. *(10 min each group)*
5. All participants discuss most feasible/achievable actions and merge them into one action plan. *(30 min)*
6. All participants share their impressions on the activity and achieved results in an open discussion format *(15 min)*.

Template for the action plan

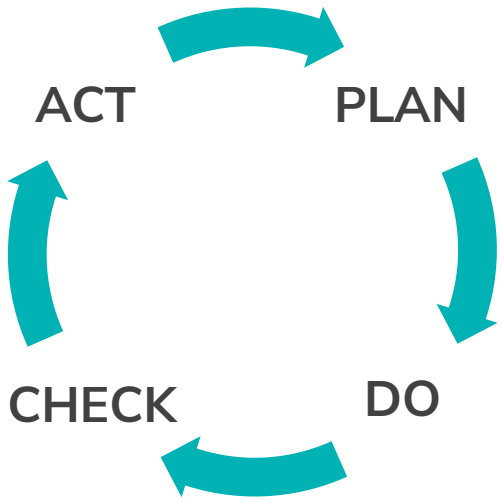
Activity area	Suggested action	Required resources for action implementation	Action implementation timeline	Action objective and measurable result (impact)	Procedures to evaluate achieved impact
E.g., Education and training	Creation of a brief circular design guideline to be used by makers	Human resources (1-2 people) for guideline creation + printing or digital display of prepared material	Guideline creation and selection of its display locations: 2 months Guideline disclosure for makers: perpetually after 2 months	To raise awareness of makers about circular design concept and to promote its application in product design (after 6 months of guideline display at least 80% of makers will know about this concept and at least 50% of makers will have been tried to apply it to their product design)	Survey of makers

Indicative lists of makerspace’s areas of activities

- Prototyping and fabrication (can be narrowed down to different materials/technologies, e.g., electronics and robotics, metalworking, woodworking, audio and video production, etc.);
- Education and training;
- Sourcing of materials, tools, and equipment;
- Community events;
- Cooperation with other organisations;
- Administration and communication;
- Facility and equipment management.

Continuous improvement

Incorporating circular approaches into makerspaces can be effectively implemented through the Plan-Do-Check-Act (PDCA) approach, fostering a continuous cycle of improvement. In the "Plan" phase, makerspace communities should establish clear goals and objectives for integrating circular principles, such as waste reduction, sustainable material usage, and product life extension. This involves designing projects with circularity in mind, setting guidelines for responsible material sourcing, and defining key performance indicators (KPIs). Moving to the "Do" phase, makerspaces implement these plans by actively engaging community members in circular projects, providing access to tools and resources that facilitate sustainable making, and promoting collaboration. In the "Check" phase, regular assessments and evaluations are conducted to measure the effectiveness of circular initiatives. This involves monitoring project outcomes, assessing adherence to circular design principles, and gathering feedback from participants. Finally, in the "Act" phase, makerspaces use the insights gained to make informed adjustments, refine existing practices, and scale successful circular projects. Embracing the PDCA approach ensures a dynamic and iterative process, fostering a culture of continuous improvement and sustainability within makerspaces.



Discussion and self-reflection

1. How the action plan developed during the workshop reflects the PDCA approach?

2. How would you assess your abilities to apply circular approaches (before and after this topic)?

Additional reading

As the training on circular approaches in everyday work life draws to an end, we encourage you to delve deeper into the diverse landscape of sustainable practices and circular thinking. Investigate more information and gain new perspectives by reading through the recommended articles, resources, and publications provided.

- A Guide to implement circular economy in your everyday life: https://ec.europa.eu/programmes/erasmus-plus/project-result-content/c76c3906-0812-458c-8566-b02e81a487c3/Guide_Circular_economy_DE-2.pdf
- Behavioural change for the circular economy: A review with focus on electronic waste management in the EU: https://www.sciencedirect.com/science/article/pii/S2590289X20300062
- Behaviour change for a circular economy - How it works and why it pays off: https://www.youtube.com/watch?v=DjyX12Sway0
- Circular consumption in the linear economy: only a drop in the ocean?: https://www.circle-economy.com/blogs/circular-consumption-in-the-linear-economy-only-a-drop-in-the-ocean
- How to Build a Circular Economy: https://www.wri.org/insights/how-build-circular-economy
- 21 circular economy solutions: changing how we eat, live and travel for a more sustainable world: https://www.weforum.org/agenda/2022/03/21-circular-economy-solutions/

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Circular Economy Policies across Baltic Sea Region Countries

Developed by

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Topic 9

This training Topic provides an overview of circular economy policies and initiatives implemented by countries across the Baltic Sea region. Training participants will gain insights into the regulatory frameworks, best practices, and key targets associated with transitioning to a circular economy model in Denmark, Germany, Latvia, Lithuania, and Norway.

Differently than in other Topics, material here is oriented towards individual exploration and investigation of information provided. Practical activities or presentations can be developed according to the trainer's preferences.

Expected training outcomes

After completing this Topic, trainees will...
... understand the key principles of circular economy policies;
... have analyzed various circular economy initiatives in different countries across the Baltic Sea Region;
... gain a broader insight into the regulatory framework associated with transitioning to a circular economy model.

Denmark

Circular material use rate[1] in 2022: 14th position in EU **(7,4%)**

Eco-innovation index[2] in 2022: 4th position in EU **(167 points)**

National aims or targets regarding circular economy

The waste curve must be bent – less waste, less disposal, and more recycling. This should be achieved, among other things, by setting quantitative waste reduction targets for Denmark, linked to the setting of such targets in the EU.
The waste sector must be climate-neutral by 2030.
Sorting out 80% of Danish plastic from incineration by 2030.

Main strategic documents regarding circular economy

The Government's Action Plan for Circular Economy constitutes the national strategy for waste prevention and management for the period 2020-2032. Circular economy involves preserving products and materials in a loop and extracting their value for as long as possible. The Action Plan for Circular Economy outlines Danish policies and specific measures based on the circular value chain, encompassing design and consumption to waste management, where natural resources are reintegrated into new products and materials. In addition to various cross-cutting initiatives within the circular value chain, the Action Plan for Circular Economy focuses on three areas with significant environmental and climate impact: biomass, construction, and plastic.

The plan includes a total of 126 initiatives, many of which are part of the political agreement on the Climate Plan for a green waste sector and circular economy from June 2020. It also incorporates initiatives from the Strategy for Public Green Procurement (November 2020), the Plastic Action Plan (December 2018), the Circular Economy Strategy (September 2018), and the implementation of waste directives and the Single-Use Plastics Directive adopted in 2018 and 2019.

Key focus areas in the Action Plan for Circular Economy include:

- Reducing waste and better utilization of natural resources
- Increasing and improving recycling
- Enhancing the use of biomass
- Promoting sustainable construction
- Addressing plastic in a circular economy

Read more (in Danish): SOURCE

Key focus areas, sectors or materials for circular transformation

- Less waste and better utilization of natural resources
- More and better recycling
- Improved utilization of biomass
- Sustainable construction
- Plastic in a circular economy

Good practices regarding public policies for circular economy

N/A

[1] Source: Eurostat
[2] Source: European Environment Agency

Germany

Circular material use rate[3] in 2022:
8th position in EU **(13%)**

Eco-innovation index[4] in 2022:
6th position in EU **(141 points)**

National aims or targets regarding circular economy

The German Federal Government is currently in the process of developing a National Circular Economy Strategy (NCES). This strategy aims to consolidate goals and measures for circular economy practices and resource conservation from all pertinent strategies. This framework will bring together the resource-policy-relevant strategies of the Federal Government in a manner that aligns with the coalition agreement's objective of reducing primary resource demand. The NCES is envisioned as an overarching strategy where the Federal Government will define objectives, fundamental principles, and strategic measures that support all resource-policy-related strategies.

Read more (in German): SOURCE

Main strategic documents regarding circular economy

Germany has developed the "Resource Efficiency Program (ProgRess)," which serves as the foundation for the country's circular economy policy. Find more information on the Federal Ministry for the Environment's website (in German): SOURCE

The German federal government has also established a National Platform for the Circular Economy to foster dialogue among various stakeholders and develop recommendations. More information can be found on their website: SOURCE

Read more: SOURCE

Key focus areas, sectors or materials for circular transformation

In Brandenburg and Germany as a whole, there is a focus on promoting the circular economy in various sectors, including electronics, construction, textiles, and plastics. Efforts are also made to advance circular economy practices in urban areas and regions.

Good practices regarding public policies for circular economy

Germany has implemented various measures to promote the circular economy, including comprehensive waste separation systems, investments in research and innovation, and incentives for businesses to improve resource efficiency. A notable example is the deposit system for beverage containers, which encourages reuse and recycling. Another example is the extensive efforts to promote the recycling of electronic waste (WEEE).

[3] Source: Eurostat
[4] Source: European Environment Agency

Latvia

Circular material use rate[5] in 2022: 18th position in EU **(54%)**

Eco-innovation index[6] in 2022: 16th position in EU **(105 points)**

National aims or targets regarding circular economy

The following targets are set in the Action Plan for the Transition to a Circular Economy 2020–2027:

- Resource productivity increase from 0,90 €/kg in 2020 to 1,55 €/kg by 2027;
- Circular material use rate increase from 6,6 % in 2020 to 11,0 % by 2027;
- Public awareness and participation - percentage of total population as a measure of CE implementation, based on Eurobarometer and other surveys.

Main strategic documents regarding circular economy

Latvia has adopted a designated circular economy strategy, the Action Plan for the Transition to a Circular Economy 2020-2027 (1) in 2020. The Action Plan contains seven initiatives in total.

Key focus areas, sectors or materials for circular transformation

1. The transition from waste management to resource management.
2. Improving resource productivity in all sectors of the economy by encouraging the development of research and innovation.
3. The establishment of pre-conditions for the reuse of goods. Measures include support for social innovation and entrepreneurship.
4. Promotion of the transition from the purchase of goods to services, i.e., the promotion of rental services and green public procurement (GPP).
5. Improving the management of materials, processes, and waste in priority sectors, such as food, textile, and furniture waste minimization.
6. Strengthening the role of municipalities in the implementation of the principles of circular economy.
7. Engagement, information, and education of the public.

Good practices regarding public policies for circular economy

Natural Resource Tax One initiative that is still under the implementation is the adoption of a law to adjust natural resource tax rates for selected natural resources and products. The adjustment includes both the taxation of new material categories for packaging, in particular packaging containing plastic, and adjusted tax rates. Once passed, the Natural Resources Tax Act will facilitate the withdrawal of non-recyclable or barely recyclable packaging from the market.

Development of several Extended producer responsibility schemes for single-use plastic packaging and plastic trays, products harmful to the environment such as batteries, and used vehicles. The participants in these EPR schemes are exempted from the obligation to pay the Natural Resources Tax.

Green procurement is widely used in municipalities and, to a lesser extent, by private companies. The share of GPP for the most necessary items and services in district administrative centres reached 61 % of all public procurement in 2019. The list of items and services concerned includes office paper, printing and computer equipment, information and communication technology (ICT) infrastructure, food and catering services, cleaning products and services, indoor lighting, street lighting and traffic signals.

[5] Source: Eurostat
[6] Source: European Environment Agency

Lithuania

Circular material use rate[7] in 2022:
21th position in EU **(4,1%)**

Eco-innovation index[8] in 2022:
17th position in EU **(104 points)**

National aims or targets regarding circular economy

- Use of secondary raw materials (circular material use) rate: from 4% in 2019 to non-lower than the EU average by 2025 and 2030.
- Eco-innovation index: from 82 in 2019 to 122 by 2025 and 133 by 2030.
  Resource productivity: from 0,82 €/kg in 2019 to 1,1 €/kg by 2025 and 1,5 €/kg by 2030.
- Total waste per unit of GDP: from 105 t/€ in 2018 to 100 t/€ by 2025 and 50 t/€ by 2030.
- Share of municipal waste ready for re-use and recycling: from 49,73% in 2019 to 55% by 2025 and 60% by 2030.

Main strategic documents regarding circular economy

Guidelines for Lithuania's transition to a circular economy by 2035. The aim of these Guidelines is to provide a targeted framework for the implementation of circular economy policies, creating the conditions for a more efficient and sustainable use of resources, covering the entire life cycle of products and materials, and ensuring stakeholder cooperation.

Read more (in Lithuanian): SOURCE

Circular economy and waste hierarchy priorities are also strongly integrated into National Waste Prevention and Management Plan for 2021–2027.

Read more (in Lithuanian): SOURCE

Key focus areas, sectors or materials for circular transformation

- Circular Industry
- Circular Construction
- Circular Bioeconomy
- Circular Transport
- Circular Use of Waste
- Circular Consumption

Good practices regarding public policies for circular economy

Green public procurement is a powerful strategic tool for greening the economy, meeting climate commitments, and fostering eco-innovation. In 2022, the total value of green procurement (€4,690.1 million) carried out by all procurers in Lithuania accounted for 60.2% of the total procurement value (€7,786.4 million). A range of measures have contributed to this achievement, such as the update and improvement of green procurement criteria, the launch of a dedicated monitoring system, and the extensive implementation of information and expert advice activities to procuring organizations.
To ensure circular waste treatment, various existing economic measures in Lithuania include charges and payments for municipal waste management, as well as different taxes on recyclable, non-recyclable packaging and chargeable goods, subsidies and grants for waste management.
The deposit refund system for single-use beverage packaging in Lithuania is a successful example that ensures a high return rate of pure, high-level secondary raw materials. Deposit systems allow to achieve higher recycling targets compared with other waste management systems. Lithuania's deposit system collects and recycles 92% of sold-to-market beverage packages (PET, metal, glass) every year.

[7] Source: Eurostat
[8] Source: European Environment Agency

Norway

Circularity rate[9] in 2020: **2,4%** (global average 8,6%)

European Innovation Scoreboard performance[10] in 2023: **119,4%** of EU average (Strong Innovator)

National aims or targets regarding circular economy

The Government's ambition is for Norway to play a pioneering role in the development of a green, circular economy that makes better, more efficient use of resources. Norway will play this role by further developing policy instruments both nationally and in cooperation with the EU, to develop a framework for value creation and green competitiveness in Norway.

Read more (in Norwegian): SOURCE

Main strategic documents regarding circular economy

Norway's strategy for developing a green, circular economy "<...> is the result of broad cooperation between several ministries. The strategy shows the potential for value creation in a more circular Norwegian business life."

Read more (in Norwegian): SOURCE

The factual basis for a strategy for a circular economy "About which industries have particular potential in the development of a more circular Norwegian economy. On behalf of the Ministry of Climate and the Environment, Deloitte has investigated the basis."

Read more: SOURCE

Key focus areas, sectors or materials for circular transformation

In the strategy, the government focus on: Sustainable production and product design; Sustainable ways of consuming and using materials, products and services; Non-toxic circular Earth cycle; Economy and value creation.

Industries:

- Bioeconomic industries (agriculture, forestry, aquaculture and fishing)
- Construction, building and property
- Batteries and vehicles
- Packaging
- Electronics
- Waste and recycling
- Digitization and technology
- Retail and service industries
- Research and innovation
- Economy and the financial sector

Good practices regarding public policies for circular economy

The EU Circular Economy Action Plan presents groundbreaking legislative initiatives for sustainable products, a more ambitious approach to using the resources in waste and continued high standards for a toxic-free environment. The Government's strategy describes how Norway's policy fits into this picture and describes the implications of the EU action plan for Norwegian policy, for Norway's positions in its cooperation with the EU, and efforts to enhance Norway's green competitiveness.

[9] Source: Circularity Gap Report Norway, Circle Economy
[10] Source: Directorate-General for Research and Innovation, European Commission

The content provided in this document is the responsibility of the respective organizations mentioned alongside each Topic. While every effort has been made to ensure accuracy and reliability, the views, opinions, and information presented by each organization are their own and do not necessarily reflect those of others involved. Readers are encouraged to verify information independently and consult with relevant experts or organizations as needed.

Feedback on the content presented can be provided directly to the respective organizations for consideration and further improvement via the following contacts:

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