

EDUCATOR MANUAL

of Circular Economy
Learning Building Blocks



BECOME

An Educator's Manual for Teaching Circular Economy

This educator manual offers:

**A FOUNDATIONAL
UNDERSTANDING
OF CIRCULAR
ECONOMY**

**PRACTICAL
EXERCISES
FOR TEACHING**

**TOOLS TO
EXPLAIN KEY
ACTIONS**

**RECOMMENDED
FURTHER
READINGS**

**REAL-LIFE
CASE
STUDIES**

**ACCESS TO ADDITIONAL
MATERIALS, INCLUDING
A SLIDE PACKAGE AVAILABLE
ON THE WEBSITE.**

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- 04** Technological Innovation and Circular Design (Module 4)

00. Introduction to Trainers Manual

What this manual offers?

The transition to a circular economy is one of today's most important learning challenges. Climate change, biodiversity loss, resource depletion, and pollution are all signs that the traditional "take-make-consume-throw away" model is no longer sustainable. Circular economy offers a different path: one where products, materials, skills, and ideas are kept in use for as long as possible.

This **Educator Manual of Circular Economy Learning Building Blocks** has been developed by the BECOME consortium to support educators, trainers, and facilitators who want to introduce circular economy in an accessible, practical, and engaging way. It is designed as a starting point for teaching, discussion, experimentation, and action.

The manual helps educators guide learners through the key question: **How can we design systems that reduce waste, keep value in circulation, and support people and the planet?**

This manual provides:

- A clear introduction to the foundations of circular economy
- Practical tools for explaining circular economy principles and actions
- Real-life case studies from companies, sectors, and learning environments
- Exercises that can be adapted for classrooms, workshops, or training sessions
- Recommended further readings for educators and learners
- Access to additional learning materials, including a slide package available through the BECOME website

Who is it for?

This manual is intended for educators who work with learners in areas such as:

- Sustainability and environmental education
- Business, entrepreneurship, and innovation
- Design, technology, and engineering
- Construction, textiles, production, and resource management
- Vocational education, higher education, and lifelong learning
- No advanced background in circular economy is required. The manual is written to help both newcomers and experienced educators build confidence with the topic.



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What learners will explore?

Across the learning building blocks, learners are invited to examine circular economy from different angles, including:

- **Circular economy principles:** reducing waste, keeping products and materials in use, and regenerating natural systems
- **Values thinking:** understanding the environmental, social, and economic values behind circular choices
- **Systems thinking:** seeing how products, people, businesses, policies, and ecosystems are connected
- **Policy and governance:** exploring how regulations and incentives can support circular transformation
- **Circular business models:** moving from ownership-based models toward repair, reuse, sharing, leasing, and product-as-a-service approaches
- **Innovation and design:** creating products and systems that are durable, repairable, reusable, and recyclable

The manual is flexible. Educators can use it:

- As a full learning pathway
- As separate modules or lessons
- As inspiration for workshops, group work, or project-based learning
- As a resource for discussion, reflection, and applied problem-solving

Each section combines explanation with practical activities, so learners do not only read about circular economy — they investigate it, question it, and apply it. After all, circular economy is not a spectator sport. It works best when everyone gets their hands, minds, and maybe even their old phone chargers involved.

How to use the manual?

Circular economy is more than recycling. It is a way of rethinking how society designs, produces, consumes, repairs, shares, and recovers value. For educators, this creates an opportunity to help learners become active contributors to a more resource-wise, inclusive, and regenerative future. This manual invites educators and learners to begin that journey with curiosity, collaboration, and practical action.

Why it matters?

Foundations and Frameworks for Circular Transformation

1.1 Introduction to Circular Economy Principles

1.2 Values Thinking on Circular Economy

1.3 Systems thinking in Circular Economy Implementation

1.4 Policy Frameworks for Advancing Circular Economy

1.1 Introduction to Circular Economy Principles

What is the meaning of Circular Economy?

Unlike the linear 'take-make-consume-throw away' model, **the circular economy seeks to close the loop by minimizing waste and maximizing resource value.**

Overconsumption of resources and energy has pushed our planet to the brink of environmental collapse, leading to multiple crises such as climate change, biodiversity loss, resource depletion, and pollution (EEA, 2023). Achieving sustainable development requires transforming how we produce and consume goods and the resources they involve.

The circular economy offers a pathway to sustainability. The European Union defines it as a production and consumption model focused on sharing, leasing, reusing, repairing, refurbishing, and recycling existing materials and products to extend their lifecycle. The EU aims to build a circular, climate-neutral economy by 2050 and has introduced various measures to reduce waste and improve product sustainability.

The Ellen MacArthur Foundation (2015) describes the circular economy as a restorative and regenerative system by design, replacing the end-of-life concept with restoration, using renewable energy, eliminating toxic substances, and aiming to design out waste through better materials, products, systems, and business models.

The circular economy draws from multiple schools of thought, including the Club of Rome's "Limits to Growth," John T. Lyle's "Regenerative Design," Walter Stahel's "Performance Economy," Braungart and McDonough's "Cradle to Cradle," Janine Benyus's "Industrial Ecology and Biomimicry," as well as the "Blue Economy" and "Natural Capitalism." (Green Growth, 2020).

Avoiding the generation of waste and pollution by design

Design-out unrecyclable and unrenovable materials and to minimize usage of water and energy needed in the production and usage of products. Also the use of renewable energy and secondary raw materials should be prioritized.

Keep products and materials in use for as long as possible

Efficient resource management is key to keeping materials in use as long as possible through reuse and recycling.

Regenerate natural capital

This principle is essential to guarantee the supply of natural goods and services on which human survival and well-being depends (Green Growth, 2020).

Companies should base their business models on three principles of action



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**To achieve
circularity
companies
should apply:**

- System thinking and resource efficiency to design out waste and pollution
- Production processes should be designed to use fewer resources by improving efficiency.
- Through material innovation, design product using bio-based or recycled materials.
- Products and systems should be designed to eliminate waste and pollution from the outset.
- Focus on using materials that can be easily reused, repaired, or recycled.
- Avoid harmful substances that can pollute the environment.
- Longer life of products and materials in use
- Encourage sharing, leasing, and refurbishing to extend the life of products.
- Design products to be durable and easy to repair.
- Develop efficient systems to recover materials at the end of their lifecycle.
- Convert used products into new ones with minimal energy input.
- Shift to renewable energy sources
- Circularity also includes usage of renewable energy.
- Systems should be designed to minimize energy use throughout entire life cycles of products.
- It includes reducing carbon and entire environmental footprints.
- Systems thinking and Collaboration
- Adopt a holistic approach to understanding how materials, processes, and products interact within a larger ecosystem.
- Collaborate across industries and sectors to close loops and maximize re-source use.
- Key of the success is collaboration with customers and implementation of innovative business models.
- As a result, develop new business models.
- Develop industrial symbiosis.

(WBCSD, 2018 [Linear Risk Report](#))

**As a result, circular solutions should
regenerate natural systems by using
renewable energy, supporting
ecosystems, and restoring resources
like soil and water**



Need some
tools to
explain these
actions?

Tools and Methods

Butterfly diagram

by Ellen McArthur Foundation (2015)

The management of the technical cycle envisages four circles which include

1. sharing of products as a form of a new business model and repair and maintenance to extend a life of a product;
2. reuse of products which includes designing durable products and behavioral change which includes using same product for multiple times;
3. refurbishment or re-manufacturing includes design of product that can be used as a unit or as part to develop new products of same sort; and
4. recycling as a least favorable option which is using materials incorporated in the product to produce same or different products of the same value.

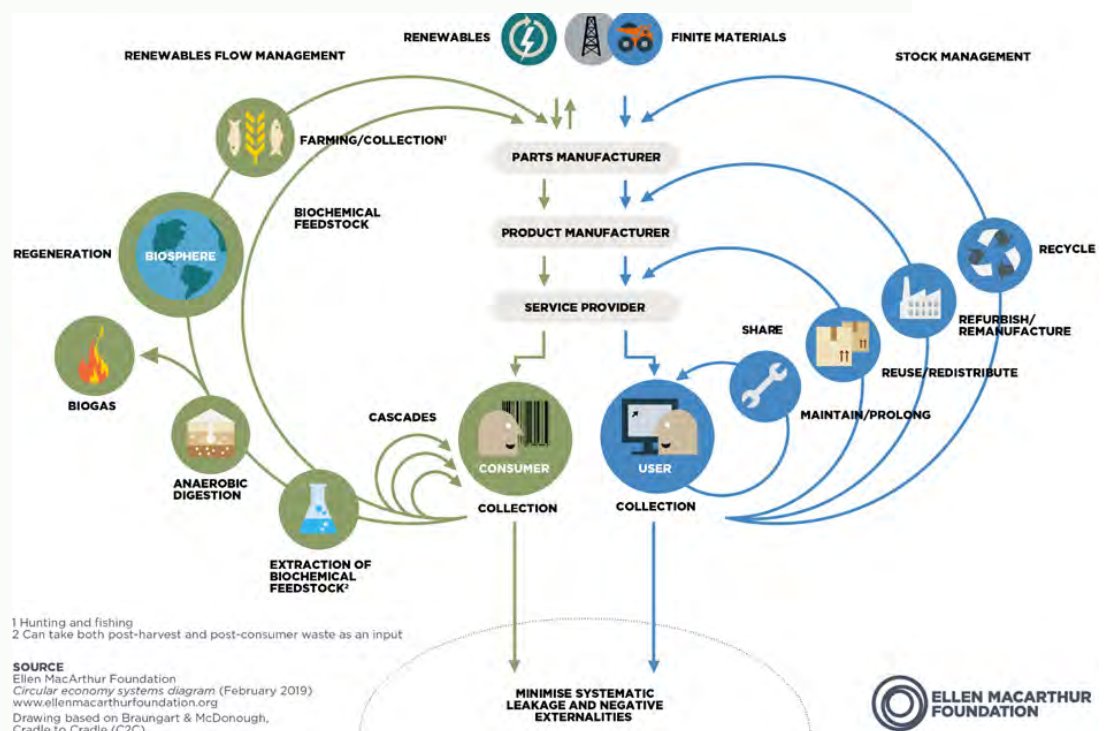


Figure 1: Ellen MacArthur Foundation *Circular Economy systems diagram*.

Case Study

CS1: Fairphone – Building a mobile phone that is socially and environmentally responsible and lasts longer

Overview:

Fairphone is a Dutch social enterprise creating smartphones with minimal environmental and social impact. Their phones avoid conflict minerals, ensure fair labor conditions, and are designed for longevity and repairability.

Key Features

- Modular Design: Fairphone 2 and 3+ are designed for easy repair and upgrades. Fairphone 2 received a 10/10 repairability score from iFixit.
- Circular Strategies:
 - Long-lasting design
 - Fair and recycled materials
 - Good working conditions across the supply chain
 - Reuse and responsible recycling

Sustainable Sourcing

Fairphone uses responsibly sourced materials such as:

- Fairtrade Gold, conflict-free Tin (DR Congo), Tungsten (East Africa), recycled Copper and Plastics, and eco-packaging.
- Focus on traceable supply chains for Cobalt, Lithium, and Rare Earths.

Prolonging Product Life

- Phones designed to last up to 5 years; batteries last ~3 years.
- Provides long-term software support (e.g., over 4 years for Fairphone 2).
- Offers a leasing model (Fairphone-as-a-Service), where phones remain company-owned and are returned for reuse/recycling.

Impact & Challenges

- Over 100,000 phones sold, 70+ employees from 20+ countries.
- Raised over \$40 million in funding.
- Fairphone admits 100% fairness is not yet possible, but it continues pushing boundaries with every product generation.



Exercise

E1: Exploring Circularity: Applying the Butterfly Diagram to Industry

The exercise aims at helping participants understand better what each of the circularity levels in the Butterfly diagram mean and to experience a difficulty in applying these circularity levels in practice in real industrial production.

Before starting, instructor should briefly explain each circularity level in the Butterfly Diagram and provide one illustrative example to ensure a shared understanding across teams. Then, divide participants into four teams and give each team one of the circles within the Diagram. Also give each of the team a company (preferably a large industry) to work on.

Teams should work at a conceptual level, focusing on inputs, transformation processes, outputs and circular logic, rather than technical or engineering details. Teams have 30 minutes to find a process within the company that uses the principle which is reflexing the type of circularity described in each circle. If a team is not able to find a process that suits the given circle, a team needs to suggest possible transformation of the processes in the industry to mimic more a circularity level of a given circle.

Each team should prepare a presentation covering: (1) the selected process or proposed transformation, (2) how it reflects the assigned circularity level, and (3) key challenges related to implementation. Teams may annotate or sketch directly on the Butterfly Diagram to support their explanation.

After 30 minutes each team presents their findings or suggestions for process modification to mimic a given circularity level. They need to speak about their success but also challenges in executing the given task. To increase interaction and horizontal learning, each team presentation should be followed by a short peer-feedback moment, where at least one other team is invited to comment, ask questions, or challenge assumptions. In addition, teams may be asked to briefly reflect on how their assigned circularity level connects to or depends on the levels presented by other teams. Presentation should be time-boxed (5-7 minutes per team, followed by 3 minutes of discussion) to maintain focus and energy.

The exercise should conclude with a facilitated plenary discussion comparing circularity levels in terms of feasibility, impact, and organisational complexity. Participants should be encouraged to reflect on trade-offs between different circular strategies and on why certain levels are more difficult to implement in real industrial context.

Where appropriate and if applicable, teams may also be invited to briefly assess their proposed solutions through a managerial lens, considering technical feasibility, economic viability, and organisational readiness.

objective

materials and steps

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1.2 Values Thinking on Circular Economy

Values in the context of the circular economy

When we talk about the necessity of a circular economy, we are talking about values.

There are three dimensions of the circular economy, and all dimensions have their own values. These dimensions are environmental dimension, economic dimension and social dimension.

In the early days of the circular economy, the circular economy was developed from an economic and environmental perspective. The social aspect of the circular economy was considered to a lesser extent.

However social dimension is very important because taking it into account makes transition just. Social dimension should be taken into account right from the start when moving from linear economy to a circular economy model and social dimension should be considered as a whole, not through other dimensions.

Including the social dimension also increases motivation. Taking social considerations into account legitimizes the transition to a circular economy. (Härri 2025)

What are values?

We can list values from different perspectives. When discussing circular economy and its values, we can start listing the dimensions: environmental dimension, economic dimension and social dimension.

Values are related to each other, but it is not possible to define which value is higher than another. The value system is also defined as multidimensional. The height of values is only one of its dimensions. (Hartman 2010, 48-49.)

- List things done and things to be done from economic, cultural and ecological points of view.
- In many cases two values are contradictory. For example, in most cases economic values and ecological values are contradictory.
- Choose which value you value more and justify your choice.

It is valuable to take care of environmental aspects and social issues when doing business.

Need some
tools to
explain these
actions?

Tools and Methods

Axiology

In axiology we try to define which things are good and how goodness of one thing is related to goodness of another. (Sroeder 2024.)

Further question to be asked is whether one thing has intrinsic or instrumental value. Intrinsic value is something that is valued by itself, instrumental value something that leads to something good. (Schroeder 2024.)

As a company representative, you can define your company's most important values and actions that can help achieve your goals. For example, you can set two equally important goals for your company: making a profit and minimizing environmental impact. You can then define the actions you will take to achieve your goals. Also explain how you will take into account the different dimensions of the circular economy.



Figure 1: Authors own album

**Need some
tools to
explain these
actions?**

Tools and Methods

Environmental Dimensions of Circularity

Virtue ethics is one area of normative ethics. Normative ethics is divided into deontology, consequentialism, and virtue ethics. Virtue ethics differs from the other two areas of normative ethics in that it focuses on virtues and moral character. (Hursthouse & Pettigrove 2023). Environmental virtues, humility and courage, are opposites of environmental vices arrogance and inattention (Cawall 2018, 662-667).

Environmental virtues can be divided into three categories:

1. Environmental responsive virtues: respect for nature, benevolence and reverence for life
2. Environmentally justified virtues: temperance and simplicity are virtues when they help to reduce our environmental burden.
3. Environmentally productive virtues are those virtues that maintain environmental values and goods: perseverance, courage and cooperativeness. (Cawall 2018, 662.)

As a company representative, you can name which environmental virtues support your company's core values. Then communicate to your employees and stakeholders how these virtues are realized in your company.

Case Study

CS3: Raseko's textile and fashion students' circular economy product project

Local shopping center challenged Raseko's textile and fashion students to come up with new uses for leftover banners from previous campaigns, giving the material a completely new life in the spirit of the circular economy.

Marketing material is waste material after one campaign, it is often durable, weather resistant, colorful and its plenty. Students studying to become design textile manufacturers accepted the challenge, resulting in the creation of wonderful products and artworks using textile techniques such as weaving, dyeing, sewing, composing, and combining.

Promotes Sustainability: By re-purposing leftover banners, the project reduces waste and promotes the principles of the circular economy.

Encourages Creativity: Students get the opportunity to think outside the box and come up with innovative ways to use the materials.

Hands-On Learning: The project provides practical experience for students, allowing them to apply their skills in real-world scenarios.

Community Engagement: It fosters a sense of community between the shopping center and the educational institution, highlighting the importance of collaboration.

CS2: FabPatch Oy Vaatelaastari (Clothing Patch)

FabPatch Oy is a company that offers products (fabric patches) for repairing clothing. Their products make it easy for consumers to repair clothes and keep them in use longer. FabPatch is an excellent example of how circular solutions can be socially inclusive, culturally transformative, and ethically responsible. By making sustainability effortless and accessible, it aligns with circular economy goals while reinforcing values of responsibility, resourcefulness, and empowerment in society.

Traditional societies valued mending clothing as a sign of resourcefulness. FabPatch helps revive and normalize repair culture in a modern, fast-paced world dominated by disposable fashion. As FabPatch is available in supermarkets, it seamlessly integrates sustainability into daily shopping habits, making circular fashion part of mainstream culture rather than a niche practice. In some cultures, repaired clothes are associated with financial hardship. FabPatch, through convenience and design, helps shift perceptions—promoting repair as a smart and stylish choice rather than a necessity.



Figure 1: Raseko



Figure2: FabPatch Website



Exercise

E2: Group work about circular economy and values (40 min)

Helps student to understand how values are related in a specific firm/company.

objective

Introduction: Sustainability in business means that firms take environmental issues seriously. Sustainability means that firms do more than is required by law. Sustainability can further be divided into three dimensions: economic, environmental and social. (Halonen et al. 2022, 217.)

Next, we focus on thinking about values in a specific firm/company.

1. In groups first, define your firm/community. You can also use well-known companies like Apple, Nike, Meta, Coca-Cola, and McDonald's.
2. Apply values and hopes defined in the previous exercise to a specific firm.
3. Write a slogan or express your values in the form of an image. Add your design to Miro.

materials and steps

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1.3 Systems Thinking in Circular Economy Implementation

There are no linear problems with only one solution, instead complex wicked problems.

A complex system
a set of several elements connected to each other by relations in a numerous nonlinear manner

Systems thinking is a holistic way of understanding complex problems. Rather than isolating individual parts, it considers the relationships, feedback loops, and broader context in which decisions are made. This approach recognizes that every element within a system influences and is influenced by others.

A system can be as small as a team or as large as a global economy — or as tangible as a human body or a city. In each case, interconnected parts interact in nonlinear ways, creating patterns of behavior that cannot be understood by looking at components in isolation.

Climate change, sustainability, and the transition to a circular economy (CE) are examples of such systemic challenges, where visible symptoms often stem from underlying causes.

Traditional linear approaches that focus on isolated fixes tend to overlook these underlying dynamics, focusing on single causes or quick fixes, rather than lasting change.

Within the circular economy, systems thinking provides a holistic approach to understanding and managing these complexities. It emphasizes the need to consider the entire lifecycle of products and materials – from design and production to consumption and disposal.

This perspective helps identify and address systemic barriers, uncover leverage points for change, and design interventions that promote long-term circularity (Hassan & Faggian, 2023; Jacovidou et al., 2020).

Simple vs. Complex systems

Instead of analyzing problems top-down, we should do a synthesis, have a bottom-up mentality with critical thinking involved where we are able to solve complex systems.

Methods and tools

Examples of methods and tools designed to understand and manage the complexities of circular systems are DSRP theory, Feedback Loops, Stock and Flow Diagrams and Life Cycle Assessment.

Unintended Consequences of Circular Strategies

Circular strategies aim to create sustainable systems by minimizing waste and maximizing resource efficiency. These strategies can sometimes lead to unintended consequences that may undermine their goals.

**Example:
common unintended effects and new sustainability challenges in closed-loop systems**



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should apply:**



This building block introduces **systems thinking** as a fundamental approach to implementing **circular economy (CE)**. It is explored how CE functions as an interconnected system, identifies key **feedback loops**, and analyzes the **unintended consequences** of circular interventions.

By the end of this building block, skills are gained for:

1. **Define** systems thinking and explain its relevance to CE.
2. **Analyze** CE as a system, identifying key elements, relationships, and boundaries.
3. **Apply** feedback loop concepts to understand how circular strategies influence economic, environmental, and social systems.
4. **Evaluate** the unintended consequences of CE implementation and propose solutions to mitigate them.
5. **Develop** a systems thinking approach to solving CE challenges.

The concept of the Circular Economy (CE) is gaining traction as a sustainable development model that aims to minimize waste and make the most of resources. Systems thinking, which involves understanding the interconnections and interdependencies within complex systems, is crucial for effectively implementing CE principles in organizational contexts. By considering the interdependencies within systems and addressing the systemic barriers to circularity, organizations can achieve the Sustainable Development Goals (SDGs) and contribute to a more resilient and resource-efficient economy.



**Define, analyze,
apply, evaluate
& develop**



Need some
tools to
explain these
actions?

Tools and Methods

Causal Loop Diagrams (CLDs)

CLDs are visual tools used to map out the relationships between different variables in a system (Acarolgu, L. 2017). They help in understanding the cause-and-effect relationships and identifying leverage points for intervention (Lemke, 2018)

Stock and Flow Diagrams

The stock and flow diagrams represent the quantities of resources (stocks) and their movements (flows) within a system. They are useful for modeling the dynamics of resource use and waste generation in a circular economy (Lemke, 2018).

Stocks represent accumulations that are generally measured in units, such as tons, Euros or people. Flows change the level of stocks and are measured by units per time, for example tons per year, people per month or Euros per day. They are defined as inflow and outflow.

Together they change the value of the stock. A good example is the bathtub, where the level of the water in the bathtub is dependent on the inflow and outflow of water as shown in the video lecture by John Sturman: [Stocks and Flows in The Climate Leader](#).

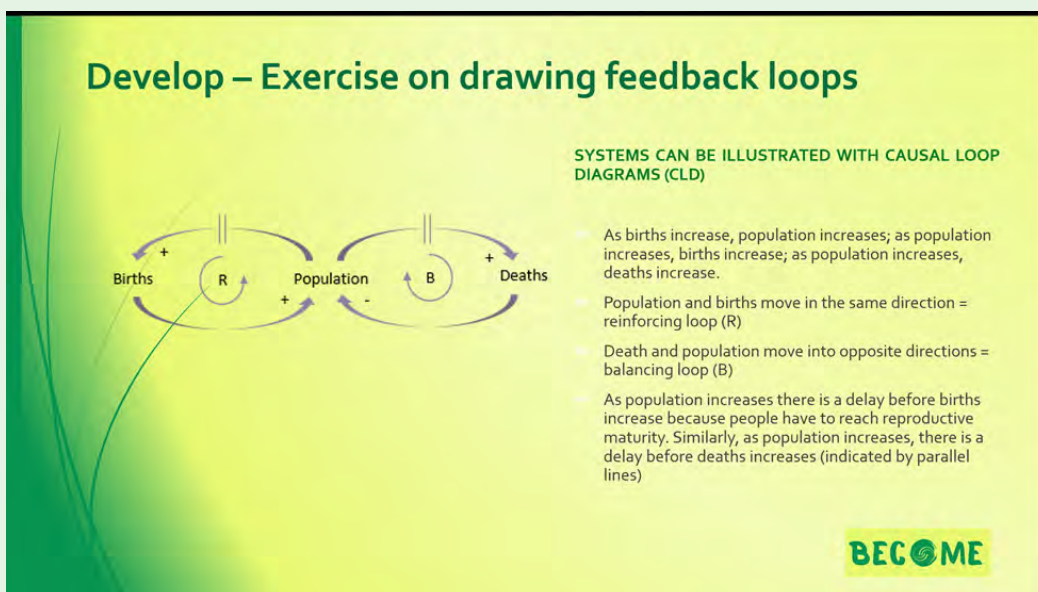


Figure 1: Authors teaching material

Case Study

CS4: Lounais-Suomen Jätehuolto Oy, local municipal waste company

There have been identified 9 key actions and strategies that help organizations transition from linear to circular business models. One of these key actions is Continuous Monitoring and Improvement. Organizations continuously monitor their progress and adjust as needed. This involves setting up metrics and indicators to measure circularity, such as the Material Circularity Indicator (MCI), and using feedback loops to identify areas for further improvement (Lemke, 2018).

LSJH has developed an internal Sustainability program, where the aim is to decrease the amount of collected mixed waste within the municipality and increase their actions to positively affect biodiversity. The sustainability program is focused on producing data for the coming sustainability reporting (CSRD reporting). It contains 9 data points that are continuously measured from three different sections. These 9 data points are presented in the report on LSJH's Sustainability Program. The report contains descriptions on how LSJH has incorporated the ISO standard certifications in their line of business and how they continuously improve the quality of their work.

Within the Sustainability program, LSJH has divided their objectives into three sections: Environment, People and Good Governance.

Each of these three sections contain three main strategic goals, as presented in Figure 1. For each goal, there are actions with targets for year 2030, as presented in Figure 2 for the environmental objectives, Figure 3 for the social and societal objectives and Figure 4 for the objectives of good governance.

The Sustainability program at LSJH is still work in progress. By monitoring the improvements and continuing with the progress they are making, LSJH is producing data for the coming sustainability reporting and reaching their aim to decrease the amount of collected mixed waste within the municipality and increase their actions to positively affect biodiversity.

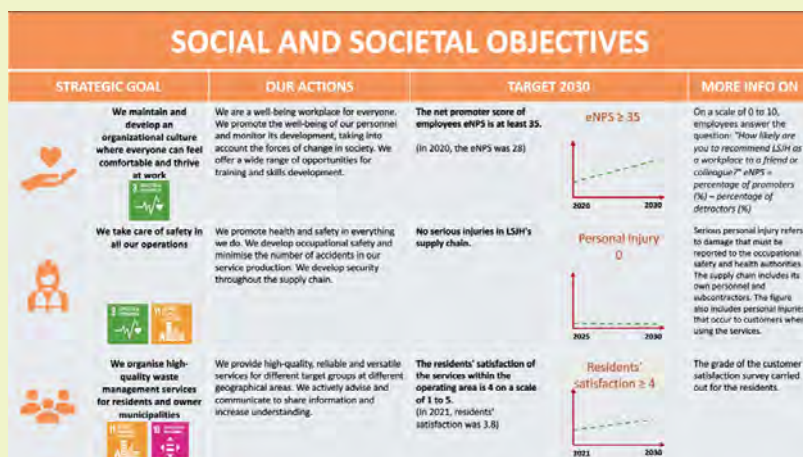


Figure 1: LSJH Sustainability program

Exercise

E3: Systems mapping exercise – Mapping a basic supply chain in linear and circular contexts.

Systems mapping is a powerful tool to develop a shared understanding of what a system looks like. It aids understanding what the root causes are, visualizes the complex problem with interconnections, recognizes patterns within the system, and aids with recognizing the leverage points within the complex system.

objective

Divide students into small groups and give them a simple business production process.

Give them 30 minutes to work together and develop a causal loop diagram. Students should start by defining the key components.

Next step is to map the relations between these key components as causal relations, i.e. draw by arrows how the components influence each other, starting from the caused component and drawing the arrow to the effected one. The effect of the relation can be increasing, positive (+) or decreasing, negative (-).

When the cause-and-effect ends where it starts, we have created a Feedback Loop. A feedback loop is a circular causal relationship. There are two kinds of feedback loops: reinforcing (positive, increasing) and balancing (negative, decreasing).

After 30 minutes ask each group to present the diagram that they have developed. Have other groups comment on the outcome and give suggestions on possible improvements of the diagram.

materials and steps

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1.4 Policy Frameworks for Advancing Circular Economy

CE policy framework provides strategic foundation for implementing circular practices at local, national, and international levels

As governments and industries transition from traditional linear systems — where resources are extracted, used, and discarded — a robust policy framework becomes essential to guide, enforce, and incentive this shift.

A circular economy policy framework includes legislation, regulations, incentives, and public-private partnerships that support circular business models, sustainable product design, extended producer responsibility (EPR), and resource efficiency. Policy tools may include bans on single-use plastics, tax incentives for remanufacturing, procurement guidelines favoring circular products, and regulations that promote material traceability and recycling.

Internationally, organizations like the European Union have taken a leading role, with the EU Circular Economy Action Plan setting comprehensive goals for reducing waste and promoting sustainable growth. National governments are increasingly embedding circular principles into environmental development policies.

Effective circular economy policies require cross-sectoral coordination and the integration of environmental, economic, and social objectives. They also need to be adaptable to technological innovations and local contexts. Importantly, policy frameworks must engage stakeholders—from businesses and communities to consumers and researchers—to ensure a just and inclusive transition.

Ultimately, policy serves as a critical enabler for circular transformation, aligning incentives, reducing systemic barriers, and driving systemic change towards a regenerative and low-carbon future.

Extended Producer Responsibility (EPR)

Holds producers accountable for the entire lifecycle of their products, especially for take-back, recycling, and final disposal. It encourages eco-design, durability, and easier recyclability of products.

Eco-Design and Sustainable Product Policies

Aims to minimize environmental impacts across a product's life cycle. These include regulations on energy efficiency, durability, reparability, modularity, and recyclability.

Waste Prevention and Resource Efficiency

Reducing waste generation at the source and improving resource use throughout value chains. It includes targets and incentives for waste reduction, reuse, and high-quality recycling.

Green Public Procurement: drives circular innovation through sustainable public buying and financial levers.



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**To achieve
circularity
companies
should apply:**

To become more circular from a policy-driven standpoint, companies must align internal strategies with external regulations and societal goals. They should:

- **Align with Regulatory Requirements:**

Comply with policies such as the EU Ecodesign Regulation, Packaging Waste Directive, and Extended Producer Responsibility schemes by redesigning products for durability, repairability, and recyclability.

- **Leverage Financial Incentives:**

Utilize available subsidies, tax breaks, and green financing linked to circular business models under frameworks like the EU Taxonomy and Sustainable Finance Disclosure Regulation.

- **Embed Circular Metrics into Corporate Policy and KPIs:**

Track resource productivity, waste diversion rates, reuse/remanufacturing ratios and carbon impacts and tie circular economy performance to executive and departmental KPIs

- **Enhance Transparency and Reporting:**

Adopt robust sustainability reporting practices in line with the Corporate Sustainability Reporting Directive and the European Sustainability Reporting Standards, particularly ESRS E5 on circular economy.

- **Invest in Innovation and Partnerships through Policy:**

Earmark R&D budget for circular projects and formalize collaborations with startups, universities and recyclers. Pilot reverse logistics, product as a service and material passport schemes.

- **Engage in Public-Private Initiatives:**

Join voluntary partnerships or innovation programs that promote circular supply chains, resource sharing and industrial symbiosis.

- **Track Regulatory Trends:**

Use tools like policy mapping to anticipate policy shifts and adapt strategies for compliance and competitiveness.



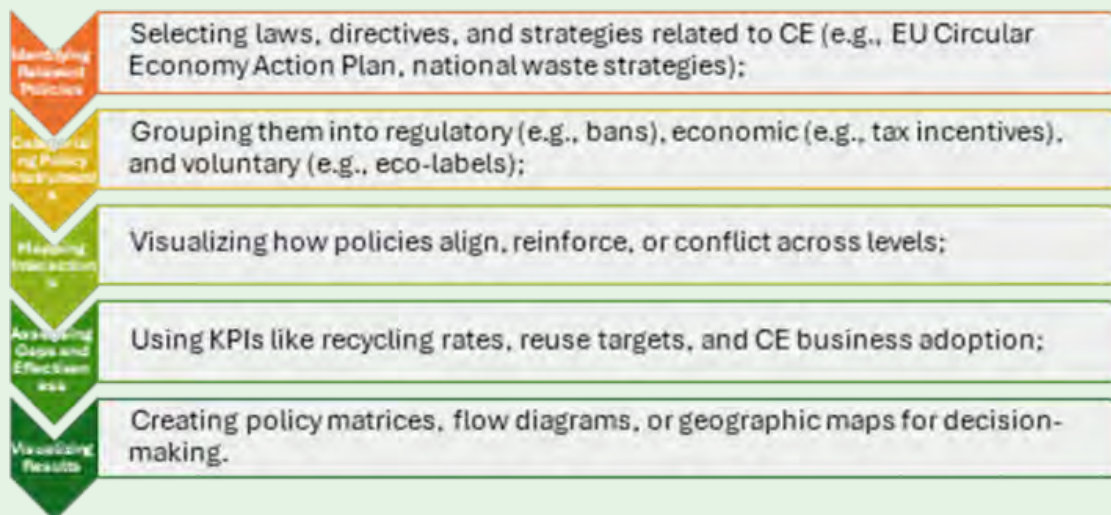
Need some
tools to
explain these
actions?

Tools and Methods

Policy Mapping

Policy mapping is a structured method used to identify, categorize, and analyze policies related to the circular economy (CE) at different governance levels—global, regional, national, and local. It helps stakeholders understand the regulatory landscape, assess policy coherence, and detect gaps or overlaps in implementation.

How It Works:



Benefits:

- Enhances regulatory transparency and intelligence
- Supports strategic planning and policy alignment
- Improves strategic decision-making
- Identifies best practices and weak points for reform

Limitations:

- Requires up-to-date, comparable policy data
- Does not directly assess real-world impact without integration with other tools (e.g., MFA, LCA)

Case Study

Policy Mapping in the European Plastics Sector

This case study illustrates the application of a policy mapping framework to assess circular economy (CE) policy implementation across Germany, France, the Netherlands, Spain, and Poland. By comparing policy measures in these countries, it highlights best practices, enforcement challenges, and gaps in CE implementation.

Step 1: Identifying Relevant Policies.

Key national adaptations of EU directives were analyzed. For example, Germany's Verpackungsgesetz enforces strict Extended Producer Responsibility (EPR), while France's Anti-Waste Law bans plastic packaging for fresh produce. In contrast, Poland shows delayed implementation with continued landfill dependency.

Step 2: Categorizing Policy Instruments.

Policies were grouped into regulatory (e.g., bans), economic (e.g., tax incentives), and voluntary measures (e.g., industry agreements).

Step 3: Mapping Interactions.

A comparative matrix revealed the extent of implementation.

Step 4: Findings.

Germany, France, and the Netherlands demonstrate strong enforcement and robust financial support for circular economy (CE) policies. In contrast, Spain and Poland lag behind, with weaker regulatory frameworks and limited economic incentives.

The correlation is clear: countries with strict enforcement and targeted financial measures achieve better CE outcomes. To strengthen coherence and accelerate progress across the EU, policies should be harmonized, economic incentives enhanced, monitoring systems reinforced, and public-private partnerships expanded.

Overview:

Europe generates over 29 million tonnes of plastic waste annually, with recycling rates stagnating around 32%. To address this, the EU introduced several CE policies, including the Single-Use Plastics Directive (SUPD) and Packaging Waste Directive.

Country	Bans on Single-Use Plastics	EPR Implementation	Recycling Targets	Economic Incentives	Enforcement Strength
Germany	✓ Strict bans	✓ Advanced	✓ 63% by 2025	✓ Tax incentives	High
France	✓ Strong bans	✓ EPR expansion	✓ 55% by 2025	✓ Eco-labeling	Medium
Netherlands	✓ Moderate bans	✓ Strong EPR	✓ 60% by 2025	✓ Subsidies	High
Spain	✓ Partial bans	✓ EPR, but weak enforcement	✓ 50% by 2025	✓ Limited incentives	Low
Poland	✗ Weak bans	✗ Limited EPR	✗ Below 40%	✗ Few incentives	Very Low



Exercise

Mapping Circular Economy Policies in Practice

Objective:

To develop participants' ability to identify and compare circular economy (CE) policy instruments across different governance levels and evaluate their effectiveness.

Target Group:

Students, sustainability officers, policy decision makers.

objective

Instructions: The exercise is based on the Circular economy principles with focus on Construction and Building Value Chain (e.g. construction industry, building materials, build environment). Each group will work on one of the principles listed below:

- o Ecodesign and sustainable production
- o Extended producer responsibility (EPR)
- o Recycling and waste management
- o Material recovery and reuse

materials and steps

Exercise

Mapping Circular Economy Policies in Practice

materials and steps

Materials: Handouts with list of policy instrument/regulations for reference and a QR codes for more detailed information and policy mapping template.

Step 1: Brainstorm Current Policies & Initiatives

Each group lists existing policies, regulations, or programs relevant to selected CE principle.

Step 2: Policy mapping

Using the template trainees will analyze how each policy addresses their specific CE principle:

- Sort policies/regulations
- Discuss overlaps and unclear classifications
- Identify Gaps and Barriers/Challenges
- Spot Leverage Points & Opportunities
- Define actions

Step 3: Presentation of each group

Please provide a concise 5-minute summary of key recommendations, highlighting urgent policy needs, collaboration opportunities, and suggested next steps.

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Strategies and Governance for Circular Business Models

2.1 Innovative Business Models for Circular Economy

2.2 Comparative Cost Analysis

2.3 Financial Strategies for Circular Economy Ventures

2.4 Circular Maturity Tool

2.1 Innovative Business Models for Circular Economy

From ownership models to service-based solutions

Circular economy prioritizes different business models in the following order to allow the highest possible value of goods to be maximized and prolonged.

The circular economy goes beyond just managing waste: it is more about keeping the value of materials high and making them last longer in their intended use. It also seeks to design unnecessary material use out of the economy. This requires new business models and a more decisive transition from ownership models to service-based solutions.

To speed up development of new business models, companies should be supported by regulators creating circular policies that are binding and target-oriented, extending beyond waste to possibly include targets on resource use or material footprint (EEA, 2023).

Innovation in business models to trigger circular economy should follow one of the four fundamental Principles of circular economy defined by Ellen MacArthur Foundation (2015):

The power of the inner circle: refers to the idea that the tighter the circle, the more valuable the strategy.

The power of circling longer: refers to maximizing the number of consecutive cycles and/or the time in each cycle for products.

The power of cascaded use refers to diversifying reuse across the value chain.

The power of pure inputs: lies in the fact that uncontaminated material streams increase collection and redistribution efficiency while maintaining quality, particularly of technical materials, which

Product-as-a-service

Keeps the product ownership and responsibility of managing the materials through the entire product lifecycle with the manufacturer or leaser; the highest likelihood of achieving circular material flows and maintaining high value.

Product life & use extension

Focuses on creating a second use phase and/or prolonging the useful life of a good; this model creates new or extends the valuable life of products offered at broad, accessible price ranges.

Resource recovery

Leverages waste as an asset to ultimately create new revenue streams or material supply for new products.

Examples of Circular Economy Business Models



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**To achieve
circularity
companies
should apply:**



- Understand your value chain
- Identify points which are unsustainable or uncircular and represent negative environmental impacts
- Research for alternative suppliers, resources or business models
- Innovate to make changes in your technological processes towards circularity
- Become more efficient, less resource and energy intensive or switch from hazardous to bio-based materials
- Implement close circle business models by providing return options to your customers
- Repair, refurbish or remanufacture products if applicable
- Explore using recycled materials or change resources you use with those that can be recycled.
- Implement some of the business models that discourage ownership such as Product as a Service or Second-hand Marketplaces to promote repeated usage of your product
- Educate your customers and clients about how they can become more circular and more sustainable by introducing improvements in their business models or behavior.



**Define, analyze,
apply, evaluate
& develop**

Need some
tools to
explain these
actions?

Tools and Methods

Circular Business Models

Decoupling economic growth from its environmental impacts is a strategy that aims to increase economic activity without a simultaneous increase in material resource use (UNEP, 2011; OECD, 2001). Relying solely on technological and efficiency improvements within the existing system will not be sufficient to reduce material use and the related environmental impacts to a level that respects the planetary boundaries (EEA, 2023).

Shifting consumption to alternative, more sustainable and less material-intensive options is a way to reduce the environmental effects of consumption. Circular business models offer opportunities for producers and consumers to reduce overall consumption in terms of material or product use (Rethink strategy). Collaborative consumption models allow consumers to participate in sharing or renting, providing temporary access to a product instead of permanent ownership. As multiple people have access to the product or service, the purchase costs and possible maintenance costs are shared.

Many examples already exist, such as public transport and libraries, but to increase consumers' commitment to sharing, businesses need to implement easy-to-use sharing platforms and make them widely available. Digitalization has further promoted the adoption of collaborative consumption models by the emergence of a broad range of applications, such as sharing platforms and second-hand marketplaces (EEA, 2023).



Figure 1: Circular business models, authors own depiction

Case Study

Free-Floating System

Users can pick up and drop off vehicles anywhere within a designated city zone. No need for fixed rental stations, making it more flexible than traditional rental services.

Pricing Model

Rentals can be charged per minute, per hour, or per day. Monthly subscription plans are available for users who need frequent access to cars. Pricing includes fuel, insurance, and parking within the service area.

Mobile App Integration

The Share Now app allows users to find, reserve, unlock, and start vehicles without a physical key. Payments are handled directly through the app.

Parking & Refueling Benefits

Users do not need to worry about refueling (for non-electric cars) since the company provides free refueling stations. Parking is allowed in most legal public spaces within the designated service area.

Share Now operates in several major European cities, including Berlin, Hamburg, Munich, Cologne, Paris, Rome, Milan, Turin, Madrid, Vienna, Amsterdam.

Sharing platforms can serve up to 20 users per vehicle reducing drastically number of vehicles on city streets, decreasing pollution and resource consumption.

Product as a Service are Car-sharing platforms

Share Now is a free-floating car-sharing service that allows users to rent vehicles by the minute, hour, or day. The company was formed in 2019 through the merger of Car2Go (owned by Daimler) and DriveNow (owned by BMW). It operates in multiple European cities, offering a convenient and flexible alternative to car ownership. Share Now offers a diverse fleet of vehicles, ranging from compact city cars to premium models. Many vehicles are electric, supporting ecofriendly mobility.



Figure 1: Unsplash



Exercise

Circular Economy Case Study Discussions

Analyze real-world examples of circular economy practices.

objective

Provide students with a case study of a company or initiative implementing circular economy practices (e.g., Patagonia's clothing recycling program, IKEA's furniture take-back system).

Have students break into small groups and discuss the following questions:

- What circular practices does the company use?
- How do these practices benefit the environment?
- How do these practices benefit the business?
- Can the practices be improved? If so, how?

After analyzing cases of their own companies or suggested well known examples, students should spend next 15 minutes discussing what trade-offs are included in the suggested circular solutions. What are the downsides of the models in question? After 15 minutes, each group presents their findings.

materials and steps

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2.2 Comparative Cost Analysis

CCA is widely applied in business, economics and policy-making

CCA supports economic competitiveness, helping businesses identify circular alternatives that are not only sustainable but also financially superior

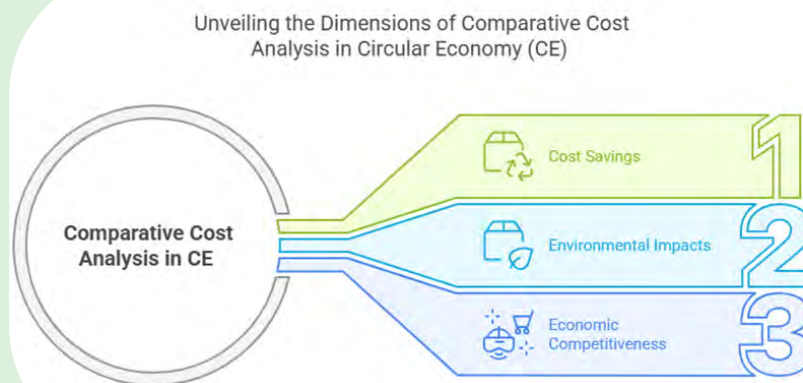
Comparative Cost Analysis (CCA) is a method used to evaluate the relative costs of different options or projects to identify the most cost-effective solution. CCA typically includes both direct costs (e.g., materials, labor) and indirect costs (e.g., overhead, administration), and is useful across various sectors such as healthcare, education, and infrastructure.

Life Cycle Costing (LCC) complements CCA by examining the total cost of ownership throughout a product's lifecycle, including purchase, operation, maintenance, and disposal (Sherif & Kolarik, 1981; Woodward, 1997). This approach allows stakeholders to understand long-term cost implications rather than focusing solely on upfront expenses.

In the **circular economy context**, CCA plays a vital role by comparing the financial viability of circular strategies like recycling, remanufacturing, and reusing materials with traditional, linear approaches. LCC enhances this analysis by revealing cost benefits associated with sustainable choices—for instance, reduced material costs or longer product life.

CCA also integrates **environmental impact assessments**, considering benefits such as reduced carbon emissions and resource conservation, which may result in regulatory compliance and cost savings. For example, remanufactured gearboxes have proven to be both more cost-efficient and environmentally friendly than new ones.

The Dimensions of Comparative Cost Analysis in CE



CCA is crucial financial tool used to evaluate the economic feasibility of different business models



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**To achieve
circularity
companies
should apply:**

Life Cycle Costing (LCC) can be used in:

- Profitability analysis
- Investment decision-making
- Design and product development
- Repairability analysis
- Warranty definition
- Sales strategy development

(Valkjärvi, 2023)

Life Cycle Costing takes into account the expected lifespan, investment costs, operating costs, maintenance and repair costs, as well as downtime and depreciation. The same expected lifespan was chosen across different sectors—life cycle costs were examined over a 50-year period. Additionally, the assumed lifespans of equipment, vehicles, and other acquisitions were considered, and the costs of new acquisitions were added to the investment costs based on these lifespans. (Valkjärvi, 2023)



**Need some
tools to
explain these
actions?**

Tools and Methods

Life Cycle Costing

LCC-oriented environmental accounting tools are identified as useful in environmental decision-making. 'Traditional' LCC is a type of investment calculus used to rank different investment alternatives. The main difference between traditional investment calculus and LCC is that the LCC approach has an expanded life cycle perspective, and thus considers not only investment costs, but also operating costs during the product's estimated lifetime (Gluch & Baumann, 2004).

Life Cycle Costing (LCC) is a crucial tool for evaluating the long-term financial viability of both linear and circular business models. By comparing costs across various lifecycle stages, LCC helps businesses understand the economic impact of their choices. Transitioning from a linear to a circular economy, particularly through remanufacturing, offers both environmental benefits and cost savings, as shown by case studies like remanufactured gearboxes.

Effective LCC application depends on best practices such as clear assumptions, sensitivity analysis, and standard methodologies. Adopting circular practices not only supports sustainability but also enhances economic competitiveness, contributing to job creation and resource conservation. Therefore, businesses are encouraged to integrate LCC into decision-making to achieve sustainable, profitable outcomes.

Case Study

Rester Oy – a mechanical textile recycling company

Rester is a leading global forerunner in building textile recovery value chains. Located in Southwest Finland, the company offers textile recycling solutions which can be used to process end-of-life textiles and by-products of manufacturing into recycled fibers and high-quality raw materials.

During the process, the textiles are opened mechanically back into fibers. Rester recovered fiber can be used by a great diversity of sectors to replace virgin raw material. Founded in 2019, the company began its fiber opening operations in November 2021 (Rester, 2025).

Rester's operations impact LCC in the following ways:

By offering recycled fibers as an alternative to virgin textiles, companies using Rester's materials can lower procurement costs while reducing dependency on resource-intensive virgin fibers (e.g., cotton, polyester).

Recycled fibers can contribute to designing products for longevity, reducing replacement and disposal costs. Companies using Rester's services can reduce landfill or incineration costs by diverting textile waste into reusable fiber streams.

Mechanical fiber opening requires less energy than producing virgin materials, translating into lower operational expenses over the lifecycle of a textile product.



Figure1. Rester Oy's Impact on Textile Industry



Figure2. During the process, the textiles are opened mechanically back into fibers.(Rester, 2025)

Exercise

Comparative Cost Analysis and Financial strategies

To understand the fundamentals of comparative cost analysis and financial strategies.

Materials: Mobile phones (for virtual game), Paper and pens.

Steps:

1. Introduction (10-15 mins)

The teacher will begin by demonstrating how the game platform works. Following this brief introduction, students will be divided into smaller groups of 4-5 members.

2. Activity (45-60 mins)

Each group will select a leader who will access the game via QR-code (seppo.io)

The game consists of a board with 7 tasks, which each group must complete in chronological order from 1 to 7.

3. Feedback Session (10-15 mins)

After the gaming session, each group will evaluate the experiment and share their thoughts on paper. Finally, the entire class will come together to discuss their best practices and propose improvements.



objective

materials and steps

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2.3 Financial Strategies for Circular Economy Ventures

CE presents both significant financial risks and opportunities

Shift to circular economy can lead to new revenue streams, cost savings and enhanced resilience against source scarcity and regulatory changes

The transition to a circular economy presents both significant financial risks and opportunities for businesses and investors.

Circular economy emphasizes resource efficiency, waste reduction, and the continual use of resources which can lead to new revenue streams, cost savings and enhanced resilience against source scarcity and regulatory changes.

However, it also involves financial risks such as the need for substantial upfront investments, potential market uncertainties, and the challenge of redesigning products and processes. Understanding these risks and opportunities is crucial for stakeholders aiming to leverage the circular economy for sustainable growth and long-term value creation

CCA (Coalition Circular Accounting) highlights the importance on understanding the differences between traditional and circular business finance. It's crucial for companies aiming to adopt sustainable practices. Traditional business finance operates on a linear model, focusing on resource extraction, production, consumption, and disposal, often leading to significant waste and environmental impact. In contrast, circular business finance emphasizes a closed-loop system where resources are reused, recycled, and regenerated, minimizing waste and promoting sustainability.

This shift not only reduces environmental impact but also fosters innovation, resilience, and long-term value creation.

Traditional business finance

Focuses on maximizing short-term profits through a linear model of resource extraction, production, consumption, and disposal, often leading to significant waste and environmental impact. Success is measured mainly by financial returns, with investments prioritizing efficiency and scale.

Circular business finance

Emphasizes a closed-loop system where resources are reused, recycled, and regenerated, minimizing waste and promoting sustainability. It supports long-term value creation through service-based models and measures success using both financial and environmental metrics.

This shift fosters innovation, resilience and long-term value creation



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explain these
actions?

Tools and Methods

Innovative funding approaches

Traditional funding approaches typically involve established financial institutions such as banks, which provide loans based on creditworthiness and collateral. These methods often require significant documentation and can be less flexible. In contrast, innovative funding approaches include venture capital, crowdfunding, and impact investing (Herve & Schwienbacher, 2018). These methods are more adaptable, often focusing on the potential for growth, sustainability, innovation, long-term value creation and social impact rather than just financial returns.

Venture capital (VC) firms invest in early-stage companies with high growth potential. These investments are typically high-risk but can yield significant returns.

Impact investing focuses on generating positive social and environmental impacts alongside financial returns. Investors are looking for companies that address global challenges such as climate change and social inequality.

Green bonds are fixed-income securities issued to finance environmentally friendly projects. These bonds support initiatives in renewable energy, energy efficiency, and pollution prevention.

Crowdfunding can help validate business ideas and build a community of supporters. This method is particularly useful for CE startups, as it provides access to capital without the need for traditional loans or equity investments.

Other forms of alternative finance include peer-to-peer lending, revenue-based financing, and angel investors. These methods offer flexibility and can be tailored to the specific needs of CE startups.

Case Study

Case Study 1:

Japan was the first country to issue a government-formulated, non-mandatory guidance on disclosure and engagement for the circular economy. Its main goal is to attract investment by encouraging companies to show how their circular initiatives and technologies can deliver returns.

The guidance builds on existing financial frameworks and promotes collaboration with other governments and institutions to embed circular economy principles into business strategies, investment decisions, and company–investor dialogues.

For companies, it provides a framework to integrate circular economy thinking into values, business models, and governance. It recommends identifying circular economy as a key material issue in integrated and annual reports, and developing KPIs to measure progress. This integration should span all management levels—from boards to executives—using the “Plan-Do-Check-Act” (PDCA) cycle to track performance against circular targets.

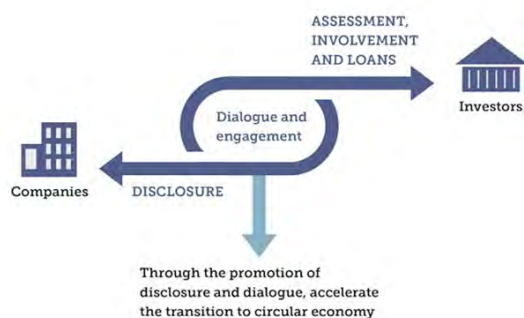


Figure 1: Ellen MacArthur Foundation. Interaction between companies and investors through the guidance



Exercise

Comparative Cost Analysis and Financial strategies

To understand the fundamentals of comparative cost analysis and financial strategies.

Materials: Mobile phones (for virtual game), Paper and pens.

Steps:

1. Introduction (10-15 mins)

The teacher will begin by demonstrating how the game platform works. Following this brief introduction, students will be divided into smaller groups of 4-5 members.

2. Activity (45-60 mins)

Each group will select a leader who will access the game via QR-code or mobile phone [here](#).

The game consists of a board with 7 tasks, which each group must complete in chronological order from 1 to 7.

3. Feedback Session (10-15 mins)

After the gaming session, each group will evaluate the experiment and share their thoughts on paper. Finally, the entire class will come together to discuss their best practices and propose improvements.



objective

materials and steps

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2.4 Circular Maturity Tool

Only 7,2% of companies worldwide operate in a circular manner

The latest insights on global circularity are provided by the Circularity Gap Report Initiative. It shows the circularity of the global economy and that only 7.2% of companies worldwide operate in a circular manner.

We are in transition, “we do not live in an area of change, but change of an area”, words from Jan Rotmans, professor of transitions and sustainability at Erasmus University Rotterdam. He describes the transformation process as an S-curve and regarding the transition to circularity we are at the bottom of the S curve, conducting (small-scale) initiatives and experiments.

PhD candidate Arjen Wierikx from Utrecht University of Applied Sciences in collaboration with Eindhoven University and Route Circulair has developed the Circular Maturity Tool (CMT) on a scientific basis. The CMT gains insight for companies into where they stand in the field of circular economy and with which advice they can take the next steps. Development of a Circular Maturity Framework, A.A.C.M. (Arjen) Wierikx, A.A. (Alex) Alblasb, N. (Néomie) Raassensb, and P. (Pascal) Ravesteijn, 2025.

CMT is based upon the theory of the linear and circular Value Hill (Hinfelaar et al., 2016), based upon the Butterfly model, (Ellen MacArthur Foundation, 2019) and R-ladder (Ellen MacArthur Foundation & A. Lansink, 1978).

Circular Maturity Tool
is based upon the theory of the linear and circular Value Hill, Butterfly model and R-ladder

Circular Maturity Tool

Assessment tool that focuses on getting acquainted with different dimensions of circularity within an organization and making the circular performance of organizations measurable.

10 themes

Strategy, Finance, Products & Service, Innovation & Technology, Environmental, Value Chain Collaboration, Leadership & Culture, Skills, Communication, Internal operations

Knowledge Hub

Offers you relevant literature, exercises/workshops. You can have an internal conversation; do we recognize it? What would we want to change?

knowing how CMT works, and understanding the current status of the company

**To achieve
circularity
companies
should apply:**

When organizations work towards a circular society, their own way of working will change. To make the transition, organizations have to change their business operations, have to deal with performance, and the way they collaborate. The Circular Maturity Tool is considered to be a critical tool to assess and guide companies in their transition.

The CMT gives organizations insight into ten themes about the various dimensions of circularity within the organization. It makes the circular performance of the organization measurable and can therefore provide input for drawing up an action plan to improve circular performance.

How does the CMT work?

Everyone is invited to take the assessment. The CMT collects all results in a database that also makes it possible to show data per industry or per country.

Link to Circular Maturity Tool: [here](#)

Preparation before performing the assessment, ask yourself as a company:

- Do I use materials from the biological cycle or from the technical cycle? Which biobased materials can I use?
- What is my motivation to learn more about the circular economy? Is it useful or necessary for me?
- Which R-strategies can I use in my organization? Refuse? Re-use? Repair?



Need some
tools to
explain these
actions?

Tools and Methods

Overall maturity levels on circularity for the organization

Results of **Level 01 I explore**; there is an ambition within your company to start doing business in a circular way, but it is not entirely clear where to start. A few circular activities are being developed without a substantiated plan.

Results on **Level 02 I do**; Your company already has a circular strategy, but it is still unclear how to put it into practice. Multiple circular activities are being developed, but they are not yet leading to the desired results. A circular step-by-step plan and new collaborations are necessary.

Results on **Level 03 I know and measure what I do**; There is a tangible and quantifiable circular step-by-step plan that is being implemented. You monitor the progress of this, and you adjust it where necessary.

Results on **Level 04 I anticipate**; In addition to executing the circular objectives, your company actively seeks and responds to new opportunities in the market. There is a budget and space available for discovering new circular applications outside your current playing field.

Results on **Level 05 I look beyond the boundaries of the company walls to others in the chain** in all the circular activities and I actively involve external parties in achieving joint circular objectives.

After completing the assessment, a diagram “circular wheel”, is shown indicating the level at which the company or organization is performing, on ten themes. It offers a clear snapshot of the organization’s current circular status.

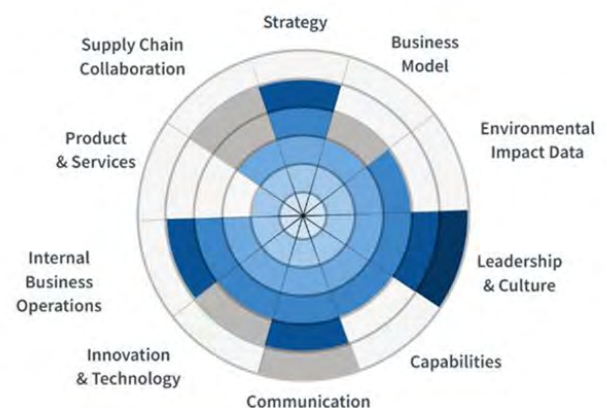


Figure 1: Circular wheel (Route Circulair 2.0, 2021)

Case Study

Case Study 1: Construction company's circular ambition

A SME (small and medium-sized enterprises) construction company wants to become more circular. The company has between 10-50 FTE (full-time equivalent) employees. They completed the CMT to map out where the company currently stands and where their circular opportunities and challenges lie. Employees indicated a wide range of scores on the CMT, from level 2 to 3.

Their challenge is; How to make the transition to a circular business model? Missing is; Where to start to work towards the next circular maturity level? Where do we want to go? What should we do? And how do we get our partners in the chain moving? In short, what are the logical next steps to start with?

Step 1. The internal challenge; Sustainability manager starts with internal discussions, with the management and various departments, mapping out; ambition, opportunities and challenges for everyone. Then they work out the circular strategy with clear quantified KPIs. For example; X% of the quotes offer a circular option or a biobased option, X% of our orders have an MKI < 0.4 (environmental cost indicator), X% of the orders have a detachability index $< 0.X$.

Step 2. The external challenge – getting chain partners on board; The construction company goes public with their circular ambition, looking for support. They draw up a potential partner list with entrepreneurs from the region to work with. And they have registered with a circular network in the region to find new partners to collaborate with who also have the ambition to make a circular impact.



Figure 1: Unsplash



Exercise

Business Model Canvas

Organize a session with colleagues to discuss which aspects want to be improved, combined with the question of who do you need to contact, work together with, for this ambition?

Conduct a conversation using the Business Model Canvas (A. Osterwalder, 2005) as a starting point.

Fill in your current Business Model Canvas, [here](#)

Ask yourselves two questions:

1. What is the social impact that my organization wants to make?
2. What role should my organization adopt for this?

Discuss what you can change in your value proposition in order to become more circular.

What effect this will have on your customers or on your relations with your customers?

What does it mean for the partnerships your company or organization has?

Finally, what are the effects on costs and revenues?

objective

materials and steps

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Collaboration and Resource Management in Value Chain

3.1 Driving
Organizational
Change in Circular
Transformation

3.2 Partnership and
Collaboration in
Circular Economy

3.3 Optimization on
Resource Flows in
Circular Economy

3.4 Environmental
Impact Analysis via Life
Cycle Assessment
(LCA)

3.1 Driving Organizational Change for Circular Transformation

It is crucial that the change is being supported

Success in transformation **demands thorough change in the ways and behavior of major stakeholders of the organizations.**

Circular economy often represents disruptive transformation of the production and consumption patterns. To achieve circular economy, an organization needs to change its processes and procedures starting within, with restructuring of its business and technological models, what also include significant social changes for the involved employees.

These changes can evoke resistance among key staff and other stakeholders involved. To avoid the resistance and secure buy-in of employees and other stakeholders in driving change, organizations must understand causes of potential resistance before it happens to prevent disruptions and engage employees as drivers of the change instead of obstacles (Circularity Gap Report, 2024).

For the successful introduction of the circular change in company's business model, it is also crucial that this change is supported by the second most important group of stakeholders, i.e. customers /clients. Given the strong influence of marketing on purchasing decisions, there is a need to consider communication change but also legislative changes to stimulate a shift away from consumption culture. As buyers, individuals have an important role to play and should be informed about the consequences of consumption choices through awareness raising actions. EU citizens should be supported by responsible marketing to engage with the circular vision and embrace new practices. They should moderate consumption through avoiding wasteful models such as fast fashion and support sharing-economy approaches to meeting their needs (EEA, 2023).

Stakeholder engagement

Important but rather difficult task to perform successfully. Challenges lie in the fact that stakeholders are very varied group of people and organizations, with different interests and different ways of communication.

To open fruitful discussions, the organization needs to well understand to whom it is speaking and to prepare the approach appropriately. Generally, stakeholders have rather low confidence in companies. Therefore, they are reluctant to get engage in serious discussions or any kind of partnerships with companies.

It takes patience and time to get to that level of understanding and cooperation, but such understanding, cooperation and trust are crucial in developing and preserving company's reputation and get support in driving necessary changes for circular transformation (Carissimmi, 2023).

Support is essential in driving necessary changes for circular transformation



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**To achieve
circularity
companies
should apply:**



- To succeed on a circularity journey, a company needs to work on its strategy for organizational change. The most important is to win buy-in of the top management who need to be the change leaders.
- Further company needs support from policy makers. If needed advocacy efforts need to be put into working on policy development to enable circular change.
- Change needs to be project based. Action plan with targets, metrics, reporting and impact assessment needs to be in place.
- Company must win support from internal and external stakeholders.
- To better understand its stakeholders, a company can use tools for stakeholder mapping.
- To better understand its stakeholders, a company can use tools for stakeholder management.
- It also should understand the challenges in stakeholders' engagement.

**Need some
tools to
explain these
actions?**

Communication & Collaboration

Tools and Methods

Communication

Open and transparent communication is crucial in building trust and reputation in the circular economy. Organizations need to effectively communicate their circular initiatives, progress, and impact to stakeholders, demonstrating transparency and accountability. Clear and concise messaging about the benefits, challenges, and outcomes of circular initiatives help stakeholders understand the organizations commitment to sustainability. Transparent reporting on key metrics, environmental performance, and social impact reinforces the organizations credibility and builds trust with stakeholders. Transparent reporting will help sharing sustainability goals, progress, and impact through sustainability reports. Other communication channels such as social media and public statements should also be used to state company's dedication towards circularity.

Collaboration

Multi-stakeholder partnerships represent tools for collaboration with governments, NGOs, and academia to drive circular innovations. In the circular economy, trust is a valuable currency that organisations must earn through active collaboration with stakeholders. By actively involving stakeholders in the co-creation of circular strategies, businesses demonstrate their commitment to shared goals and collective well-being. Collaborative partnerships with customers, suppliers, regulators, NGOs, and local communities enable organizations to foster trust, mitigate risks, and leverage diverse expertise. This collaboration not only enhances the quality and effectiveness of circular initiatives but also generates a sense of shared responsibility and accountability, contributing to the establishment of a trusted reputation.

Case Study

Philips – Circular Economy Transformation in Manufacturing

Philips, a global leader in electronics and healthcare technology, has been integrating circular economy principles into its business. The company aims to achieve 100% circularity by 2025, focusing on product lifecycle extension, material recovery, and new business models.

Key Circular Strategies:

1. Product-as-a-Service (PaaS) – Instead of selling medical equipment, Philips offers "Lighting-as-a-Service" and "Healthcare-as-a-Service", where customers pay for usage rather than ownership.
2. Design for Circularity – Products are modular, upgradeable, and repairable to extend their lifecycle.
3. Reverse Logistics & Take-Back Programs – Old medical devices and lighting equipment are refurbished or re-manufactured.
4. Material Recovery & Recycling – Reuse of critical materials like rare earth metals and plastics.

Results & Impact: 30% increase in refurbished product sales; millions of devices recovered and reused; cost savings & brand differentiation in sustainable markets.



Figure 1. Philips - Accelerating the adoption of circularity



Exercise

Sustainability Roleplay

Understand different perspectives on circular economy practices

objective

Step 1: Divide participants in teams (5 to 6 participants per team). Students are to play one of the roles of the different stakeholders in a circular economy case explained in the scenario. Each of the students shall play a role of a consumer, a manufacturer, a policymaker, an environmental NGO, a supplier, a CEO of Madison).

Scenario:

Madison is a textile brand that wants to become a first circular textile company in Europe. They own a chain of stores in all EU countries, while their production is in Vietnam. Their sustainability strategy has developed a transition plan to circular model by 2030. In order to achieve this goal they need to make their stores completely sustainable, climate positive, their transport has to be low carbon options of transportation using renewables whenever possible and offsetting the rest. They also want to implement a take-back program for used products, collect used clothes and reuse the materials to produce new clothes.

Step 2: Have debate the potential benefits and challenges from their assigned roles. Each of the stakeholders needs to present arguments why they support or disagree with the business model that Madison has presented.

Step 3: Students should answer the following questions:

1. Are you as a stakeholder supporting Madison in pursuing the presented business model?
2. What benefits do you see for the company and for the society / environment in this business plan?
3. Do you find this idea to be feasible?
4. Is the idea sustainable and circular from your point of view?
5. Does it represent a risk or an opportunity for Madison?

Step 4: Each team should present their findings to the group and then entire group should debate on feasibility and sustainability as well as obstacles and risks of the proposed Madison business model. This exercise will help students see how circular economy practices require cooperation across multiple sectors and perspectives. They will also become more aware of the challenges that circular models face in the implementation phase.

materials and steps

Exercise

Sustainability Roleplay

Have debate the potential benefits and challenges from their assigned roles. Each of the stakeholders needs to present arguments why they support or disagree with the business model that Madison has presented.

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materials and steps



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3.2 Partnerships and Collaborations in Circular Economy

Collaboration is the key

Collaborations with the chosen partners should be established in a way ensuring their future success.

The circular economy isn't just about new products or smart designs above all, it's about collaboration. True circularity can't happen in isolation. Whether you're a manufacturer, designer, policymaker, or logistics partner: real impact only happens when all parties join forces.

In this module, we dive into the practical side of partnerships and collaboration in the circular economy. How do you find the right partners? How do you work together with stakeholders who may have different interests? And how do you build trust and create shared value?

This module gives you concrete strategies, insights, and motivation to seize circular opportunities within your sector, with your own network.

This module introduces nine steps which businesses may follow to set-up collaborations in a circular economy (Kleine Jäger e.a, Circle Economy, 2020). After understanding the local market and its material flows, businesses should prepare internally for the collaboration. They should create and align on a circular economy vision, assess internal resources and gaps, and form a team. Based on the identified gaps, the required partners can be identified, contacted, and evaluated.

The collaboration set-up steps will zoom in on the following topics: collaboration as an enabler in the circular economy, the circularity network and types of collaboration, the 14 roles in a circular economy, and nine partner characteristics in a circular economy.

Will you be my partner?

A company can't do it on its own so collaboration is key to transition to a resilient, circular economy. Whereas the need for collaboration in the circular economy is largely understood, in practice, it often poses challenges.

Trust, vision, pragmatism makes circular partnerships works.

Chain cooperation is necessary the strategic alignment and collaboration among businesses in a supply chain, like suppliers, manufacturers, and distributors, to work together toward shared circular economy goals.

Recognize the need to collaborate



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explain these
actions?

Tools and Methods

The Collaboration Set-up Steps



Figure 1. The Collaboration Set-up Steps - author's own depiction

Case Study

Case Study 1: Hemp Fiber: Insulation sourced from the Netherlands

Heijmans is taking a new step towards circular and climate-conscious construction. After a valuable pilot in Heerenveen in 2024, where 6.5 hectares of fibre hemp were cultivated, the company is expanding cultivation to 23.5 hectares in 2025. For this, they collaborate with Greeninclusive, a tenant and a farmer.

Key features:

Hemp cultivation is an example of how Heijmans collaborates with partners to integrate sustainable innovations from the chain into its projects

Outcomes:

Creating an innovative ecosystem in which Heijmans, together with partners, takes steps that contribute to a livable future for people, animals, and nature.



Figure 2. Heijmans hemp fiber - author's own depiction



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Exercise

Mapping Existing Collaborations

Map out which collaborations already exist at your company, employer, internship or research location.

objective

Name a CE topic within your branch where there is a need for collaboration. Use the Collaboration set up steps to map out the potential collaboration up to and including step 8.

materials and steps

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3.3 Optimization of Resource Flows in Circular Economy

Material Flow Analysis makes the use of materials visible

Global demand for raw material continues to rise - **reaching over 92 billion tonnes in 2017 and projected to nearly double by 2060**

The circular economy (CE) aims to move away from the traditional linear model of "take, make, dispose" and toward a more sustainable system where resources are reused, recycled, or regenerated. As global demand for raw materials continues to rise - reaching over 92 billion tonnes in 2017 and projected to nearly double by 2060 - the urgency of implementing more efficient and circular systems becomes critical.

Material Flow Analysis (MFA) supports this transition by making material use visible. It is a powerful tool used to understand how materials move through our economy. It provides a systematic assessment of the flows and stocks of materials within a defined system - whether it's a city, a country, or a specific industrial sector.

In the context of the circular economy, MFA helps identify inefficiencies, resource losses, and opportunities for closing material loops. By mapping these flows, MFA helps policymakers, businesses, and researchers design strategies to reduce resource consumption, minimize waste, and improve environmental performance. For example, MFA can reveal how much valuable metal is lost in electronic waste or where construction materials could be better recycled.

Ultimately, Material Flow Analysis provides the data-driven foundation needed to build more resilient and resource-efficient systems. It is a key instrument in turning circular economy principles into actionable, measurable outcomes.

Material Flow Analysis (MFA)

Material Flow Analysis (MFA), quantifies the inputs, outputs, and stocks of materials, helping identify inefficiencies and opportunities for resource recovery.

Life Cycle Assessment (LCA)

Evaluates environmental impacts across a product's lifecycle. The integration of digital technologies: blockchain, AI, and IoT has revolutionized tracking and monitoring, enabling transparency of material flows.

Industrial symbiosis

Enhances circularity by promoting resource efficiency across sectors. These tools and approaches empower businesses and policymakers to transition from linear models to circular systems.

The exchange of waste or by-products between companies



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**To achieve
circularity
companies
should apply:**

To become more circular using MFA a company must map, understand, and optimize its material flows. MFA helps identify inefficiencies and opportunities for keeping materials in use longer

Key Elements:

1. Mapping Material Flows

Define system boundaries (e.g., factory, product lifecycle) and quantify all inputs, outputs, and stocks of materials. This creates a clear picture of how resources move through the company.

2. Identifying Waste and Inefficiencies

Analyze where material is lost (e.g., waste, emissions) and where inputs are used inefficiently. This helps target areas for reduction and reuse.

3. Closing the Loop

Use MFA data to support internal recycling, by-product reuse, and design for disassembly. Collaborate with other businesses to repurpose waste materials.

4. Scenario Analysis

Simulate the impact of strategies like material substitution, recycling, or redesign. This supports informed decisions for circular improvements.

5. Monitoring Progress

Track changes in flows over time and set key performance indicators (e.g., recycling rate, material productivity). Transparent reporting builds trust and accountability.

6. Supporting Circular Business Models

Use insights from MFA to design take-back systems, modular products, or service-based models that keep materials circulating.

By integrating MFA into business planning, companies can shift from linear to circular systems, improving resource efficiency, reducing waste and supporting sustainability goals



Need some
tools to
explain these
actions?

Tools and Methods

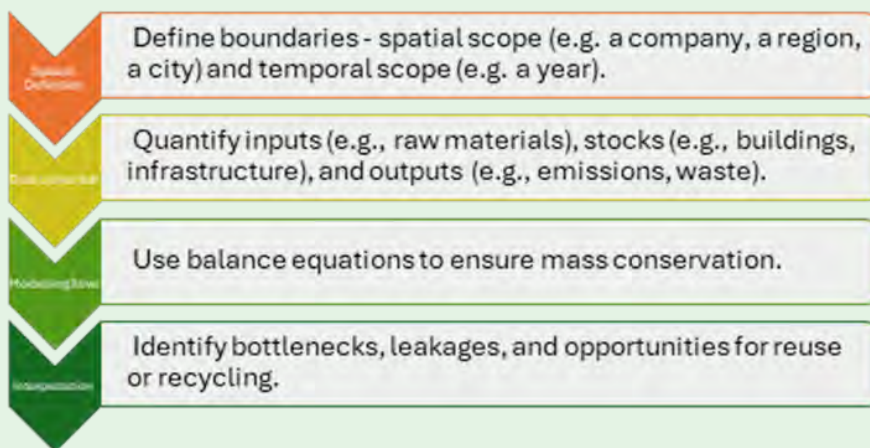
Material Flow Analysis

Overview:

Material Flow Analysis (MFA) is a quantitative method used to track the flow of materials into, through, and out of a defined system. It enables decision-makers to identify resource inefficiencies, detect waste hotspots, and support strategic planning for resource optimization and circularity.

How It Works:

MFA involves four core steps:



Application:

- Urban planning (e.g., tracking construction waste in cities)
- Industry (e.g., mapping critical raw material use in mining and electronics)
- National policy (e.g., EU-wide circularity gap analyses)

Benefits:

- Provides a holistic view of material usage
- Enables evidence-based circular economy strategies
- Supports reporting and policy compliance

Limitations:

- Requires robust and often scarce data
- Static snapshots may not reflect dynamic systems unless coupled with time-series or scenario tools

Case Study

Key features:

The MFA covered material flows from procurement to post-construction waste. Key materials included concrete, steel, timber, glass, insulation, and water. Data was sourced from supplier records, BIM models, and waste logs, analyzed using STAN software and GIS tools. The study quantified inputs, outputs, and inefficiencies, identifying that concrete and timber had the highest waste rates (8.75% and 16.7% respectively).

Outcomes:

The project achieved a 12% reduction in material inputs, a 25% drop in construction waste. Additionally, carbon emissions from materials decreased by 18%. The case demonstrates how MFA can guide data-driven resource efficiency and sustainability in the construction industry.

Conclusion:

Applying MFA in the construction project enabled the identification of inefficiencies. MFA proved to be an effective tool for improving sustainability, reducing costs, and enhancing project planning in the construction sector.

Case Study 1: Resource Optimization in Construction Industry (Using MFA)

Overview:

The construction industry is one of the largest consumers of natural resources and a significant contributor to waste and carbon emissions. Efficient resource use is crucial for sustainability, cost reduction, and regulatory compliance. Material Flow Analysis (MFA) offers a systematic approach to quantify material inputs, stocks, and outputs within construction systems, enabling improved resource management and optimization.

MATERIAL FLOW ANALYSIS

Material	Input (tons)	Productive Use	Waste (tons)	Efficiency %
 Concrete	8,000	7,300	700	91,25 %
 Steel	1,200	1,140	60	95
 Timber	600	500		83,3 %
 Glass	200	100		95
 Water	2,000 m ³	1,650		82,5 %
 Water	2,000	1,650		82,5



Figure1. Material Flow Analysis — author's own depiction



Exercise

Applying Material Flow Analysis in an Industrial Context

To demonstrate the use of Material Flow Analysis (MFA) in identifying resource inefficiencies in the construction sector. This exercise targets sustainability officers, engineers, and facility managers in the building industry.

objective

Step 1: Watch the video

Step 2: Quick MFA Analysis

Conduct a quick Material Flow Analysis (MFA) by briefly answering the following three questions:

- What are the three main materials used in this industry?
- At which stage of the life cycle do most material losses occur?
- What digital tools could support material flow management in this industry?
- How can these losses/waste be reduced? (1–2 ideas)

Step 3: Circular Idea

What new business or service could help extend the lifespan of materials? (e.g., exchange platform, modular design, buy-back scheme)

Step 4: Presentation and Group Discussion

Present the outcomes of your group work by answering the following two questions:

- What surprised you the most?
- What was your circular idea?

materials and steps



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3.4 Environmental Impact Analysis via Life Cycle Assessment (LCA)

LCA is widely used in sustainability strategies, product development, and policy-making

Redesign products to use fewer raw materials or more recycled content

Environmental Impact Analysis via Life Cycle Assessment (LCA) is a systematic method for evaluating the environmental aspects and potential impacts associated with a product, process, or service throughout its entire life cycle.

From raw material extraction to production, use, and disposal, LCA provides a comprehensive view of environmental burdens and helps identify opportunities for improvement. It is a key tool in promoting sustainability and circular economy practices, enabling organizations to make informed decisions based on data-driven insights. (Syke 2023)

LCA is structured around four main phases:

1. Goal and Scope Definition
2. Life Cycle Inventory (LCI)
3. Life Cycle Impact Assessment (LCIA)
4. Interpretation.

These phases ensure that environmental impacts such as greenhouse gas emissions, resource depletion, water use, and pollution are systematically assessed and interpreted.

One of the most widely used applications of LCA is carbon footprint calculation, which quantifies the climate impact of a product or service in terms of CO₂ equivalents. (Syke 2023)

Goal and Scope Definition:

This phase sets the foundation by defining what is being assessed, the system boundaries, and the intended use of the results.

Life Cycle Inventory (LCI):

Involves collecting data on all inputs (e.g., raw materials, energy) and outputs (e.g., emissions, waste) throughout the product's life cycle.

Life Cycle Impact Assessment (LCIA):

Translates inventory data into environmental impacts, such as climate change, eutrophication, and resource depletion.

Interpretation

Synthesizes findings to support decision-making and identify improvement opportunities. (ISO 14040:2006).

These concepts ensure a holistic and standardized approach to evaluating environmental impacts.

To achieve circularity companies should apply:

Life Cycle Assessment (LCA) offers companies a structured approach to identifying environmental hotspots and opportunities for circularity. By analyzing the full life cycle of products—from raw material extraction to end-of-life—companies can pinpoint where resources are wasted, emissions are highest, and improvements are most impactful. This insight enables the transition from linear to circular models, where materials are reused, emissions minimized, and value retained longer.

To become more circular using LCA insights, companies can:

- Redesign products to use fewer raw materials or more recycled content.
- Optimize production processes to reduce energy and water consumption.
- Extend product lifespans through maintenance, repair, and modular design.
- Implement take-back schemes and recycling systems for end-of-life products.
- Choose suppliers with lower environmental footprints.
- Use LCA data to support eco-labeling, green marketing, and regulatory compliance.

By integrating LCA into product development and strategic planning, companies not only reduce their environmental impact but also gain competitive advantage, improve brand reputation, and align with sustainability goals (Ellen MacArthur Foundation(2022)).

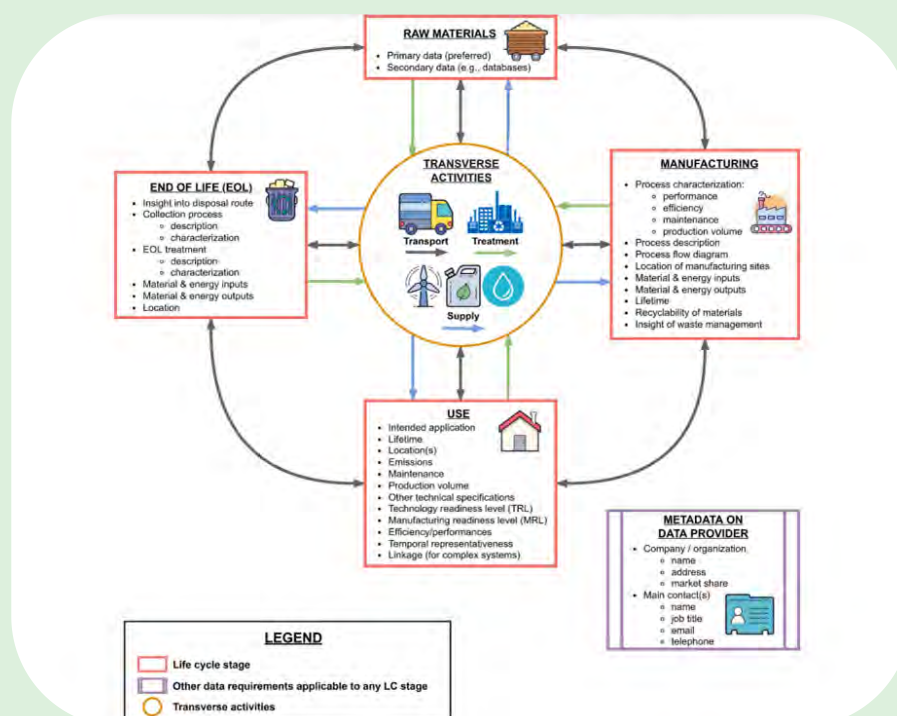


Figure 2. Data requirements in the LCI phase along the different life cycle stages. Bullet points are meant to be used as examples and not to be understood as an exhaustive list. (Saavedra-Rubio)

Need some
tools to
explain these
actions?

Tools and Methods

Carbon Footprint Calculation

Carbon footprint calculation is a focused application of LCA that quantifies the total greenhouse gas (GHG) emissions associated with a product, service, or organization, expressed in carbon dioxide equivalents (CO₂e). It is one of the most widely used indicators in environmental impact analysis and a key metric in climate change mitigation. (ISO. (2018))

The calculation typically follows these steps:

Define the scope – Determine which emissions are included

(Scope 1: direct, Scope 2: indirect from energy, Scope 3: other indirect).

Collect data – Gather information on energy use, transportation, materials, and waste.

Convert to CO₂e – Use emission factors to translate activity data into GHG emissions.

Analyze and report – Identify major emission sources and opportunities for reduction.

Carbon footprinting is often used in corporate sustainability strategies, product labeling, and environmental declarations. It supports compliance with climate-related regulations and helps organizations set science-based targets. (ISO 14040:2006)

Tools like the GHG Protocol and various online calculators (e.g., CoolClimate, Carbon Trust) provide frameworks and databases for accurate calculations. When integrated with LCA, carbon footprinting offers a powerful way to assess and reduce climate impacts across the value chain.



Case Study

Case Study: Comparing the Global Warming Potential of Different Ownership and End-of-Life Scenarios for Textiles

Overview of the business case:

A study by LUT University explored how different ownership models and end-of-life strategies for textiles affect their global warming potential (GWP). The research compared traditional linear models (e.g., single ownership and landfilling) with circular approaches such as reuse, resale, and recycling. The goal was to identify which scenarios offer the greatest climate benefits and support circular economy transitions in the textile sector.

Key features:

The study used Life Cycle Assessment (LCA) to evaluate emissions across the textile life cycle. Scenarios included product-as-a-service, resale, mechanical recycling, and landfill disposal.

Outcomes:

Results showed that circular models—especially reuse and product-as-a-service—significantly reduced GWP compared to landfilling. The findings support the adoption of circular business models in the textile industry to mitigate climate impacts.

Source:

LUT University. Comparing the global warming potential of different ownership and end-of-life scenarios for textiles. Retrieved from <https://research.lut.fi/converis/portal/detail/Publication/13895187>



Figure 1: Unsplash



Exercise

T-Shirt Life Cycle Process Diagram

The objective is to visualize and analyze the environmental impacts of a T-shirt's life cycle. This exercise is suitable for students in sustainability, environmental engineering, or circular economy courses. It enhances systems thinking and understanding of life cycle stages and their environmental consequences.

objective

Students are asked to draw or interpret a process flow diagram of a T-shirt's life cycle. The diagram should include the following stages:

- Raw Material Extraction (e.g., cotton farming)
- Textile Manufacturing (e.g., spinning, dyeing)
- Garment Production (e.g., cutting, sewing)
- Distribution (e.g., transport to stores)
- Use Phase (e.g., washing, drying)
- End-of-Life (e.g., landfill, recycling)

For each stage, students should identify key inputs (e.g., water, energy, chemicals) and outputs (e.g., emissions, waste). They should also mark where the LCA starts and ends, and reflect on which stages have the highest environmental impact.

materials and steps

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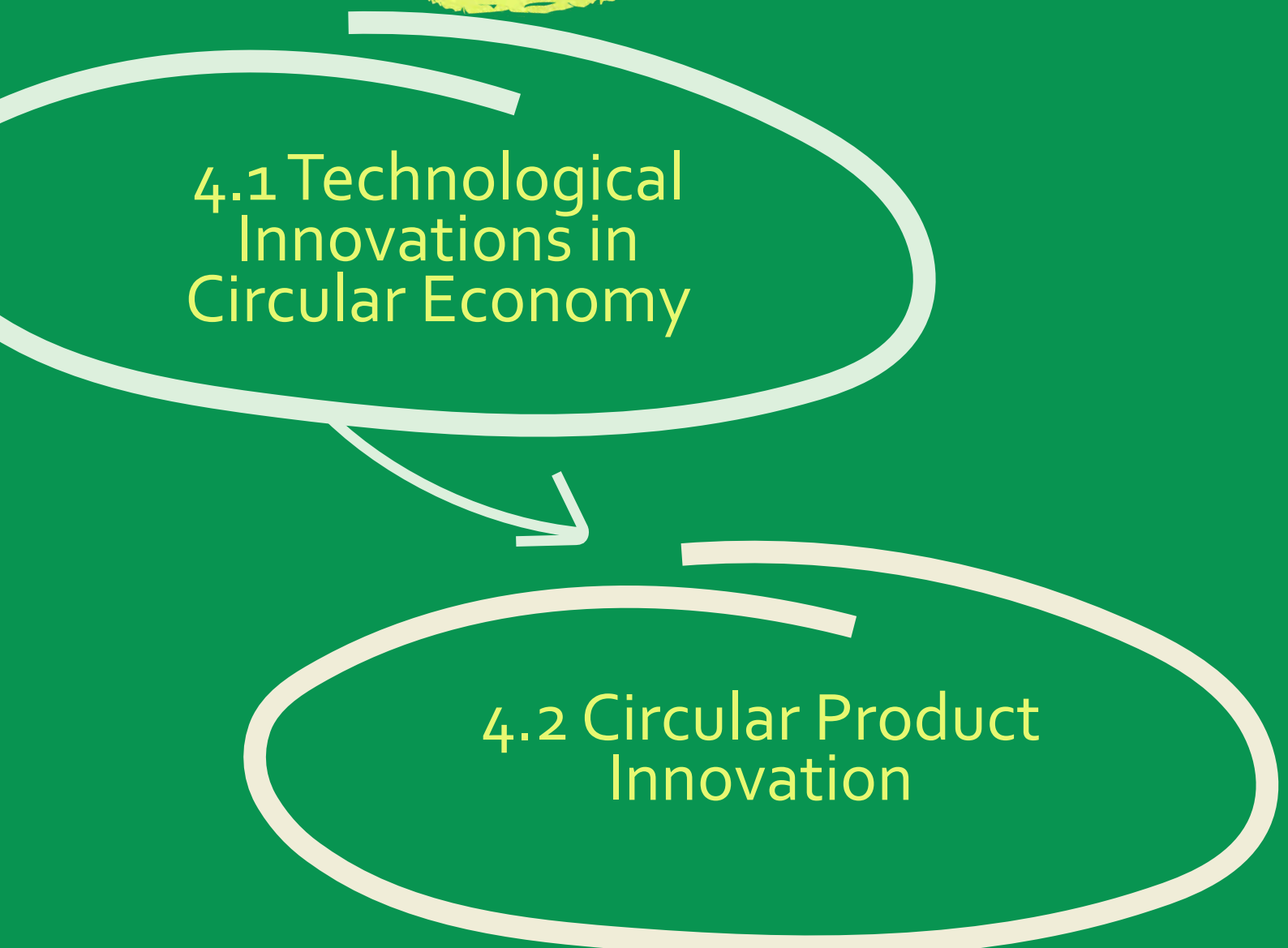
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Module
04

Technological Innovation and Circular Design



4.1 Technological
Innovations in
Circular Economy

The diagram consists of two light blue ovals. The top oval contains the text '4.1 Technological Innovations in Circular Economy'. A white arrow points from the bottom of this oval to the top of the bottom oval. The bottom oval contains the text '4.2 Circular Product Innovation'.

4.2 Circular Product
Innovation



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4.1 Technological Innovations in Circular Economy

How emerging technologies can enhance sustainability?

Students are encouraged to **critically assess how technologies can be integrated into circular strategies.**

This document outlines a comprehensive educational module focused on the role of digitalization in advancing the Circular Economy (CE). It explores how emerging technologies—such as artificial intelligence (AI), the Internet of Things (IoT), blockchain, and 3D printing—can enhance sustainability by improving resource efficiency, enabling traceability, and supporting innovative business models.

The module is structured around four key themes: the enabling role of technology in CE, innovations in material science and manufacturing, smart circular supply chains and reverse logistics, and scaling tech-enabled circular business models.

The course also addresses real-world challenges to tech adoption, including high implementation costs, infrastructure limitations, and regulatory barriers.

To support learning, the module includes exercises, group discussions, and creative projects that promote hands-on engagement and critical thinking. Learners are tasked with designing their own circular solutions using the technologies discussed, fostering innovation and practical application.

Overall, the module aims to equip students with the knowledge and skills needed to drive digital transformation in the circular economy.

Artificial Intelligence (AI)

Enhances circular systems through predictive maintenance, smart inventory management, and AI-driven waste sorting. It enables data-driven decision-making and supports innovative business models like Product-as-a-Service.

Internet of things (IoT)

Provide real-time monitoring of resources and equipment, improving efficiency and reducing waste. They also support traceability in supply chains, essential for recycling and reuse.

Blockchain

Ensures transparency and traceability across product lifecycle. It verifies material origins and processing, which is crucial for responsible sourcing and circular supply chains.

Additive Manufacturing (3D Printing)

This technology reduces material waste by producing items on-demand and with high precision. It supports customization, minimizes overproduction, and enables the use of sustainable materials.

Four main Technological Innovations in the Circular Economy



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**To achieve
circularity
companies
should apply:**

How Companies Can Become More Circular Through Technology

Leverage AI for Efficiency and Waste Reduction

- Use predictive maintenance to extend equipment life.
- Implement AI-driven waste sorting and smart inventory systems.

Adopt IoT for Real-Time Monitoring

- Track resource use and product conditions to optimize operations.
- Enable transparency and traceability in supply chains.

Utilize Blockchain for Supply Chain Transparency

- Ensure secure, verifiable tracking of materials and products.
- Support recycling and reuse through verified material histories.

Implement Additive Manufacturing (3D Printing)

- Produce on-demand, customized items with minimal waste.
- Use sustainable or recycled materials in production.

Explore Bio-Based and Biodegradable Materials

- Replace fossil-based inputs with renewable, eco-friendly alternatives.
- Reduce environmental impact and support closed-loop systems.

Integrate Digital Twins and Simulation Tools

- Simulate product lifecycle to optimize design and resource use.
- Monitor performance and predict maintenance needs.

Develop Circular Business Models

- Shift to Product-as-a-Service (PaaS) or leasing models.
- Encourage reuse, refurbishment, and extended product lifespans.

Enhance Reverse Logistics and Remanufacturing

- Use automation and robotics to streamline returns and repairs.
- Restore used products to like-new condition efficiently.



Need some
tools to
explain these
actions?

Additive Manufacturing (3D Printing) in the Circular Economy

Tools and Methods

Additive manufacturing, commonly known as 3D printing, is a transformative technology that supports circular economy principles by significantly reducing material waste and enabling sustainable production. Unlike traditional subtractive manufacturing—which cuts away material from a larger block—3D printing builds objects layer by layer, using only the material required. This precision minimizes scrap and optimizes resource use.

One of its key advantages is **on-demand production**, which reduces the need for large inventories and prevents overproduction. It also allows for **high customization**, enabling the creation of tailored products without excess material or energy use. Additionally, 3D printing supports the use of **recycled and biodegradable materials**, further reducing environmental impact.

In circular systems, 3D printing facilitates **product repair and refurbishment** by enabling the production of replacement parts locally and efficiently. It also supports **modular design**, making products easier to disassemble, upgrade, and recycle.

By integrating 3D printing into their operations, companies can lower their carbon footprint, reduce costs, and extend product lifecycle—key goals of a circular economy. This innovation not only enhances sustainability but also opens up new business models and market opportunities.

Exercise

Exploring Technology for Circular Solutions

Understand how emerging technologies can support the transition to a circular economy.

Instructions:

Choose one technology from the list below:

- Artificial Intelligence (AI)
- Internet of Things (IoT)
- Blockchain
- 3D Printing (Additive Manufacturing)

Research how your chosen technology contributes to circular practices. Focus on:

- Reducing waste
- Extending product life
- Improving resource efficiency
- Enabling reuse or recycling

Create a short presentation or infographic (max 3 slides or 1 page) that includes:

- A brief explanation of the technology
- One real-world example of its use in a circular business model
- Key benefits and potential challenges

Present your findings in small groups and discuss:

- Which technology seems most impactful?
- What barriers might companies face in adopting it?

Outcome:

Students will gain insight into how digital tools can drive sustainability and innovation in business.

objective

materials and steps

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4.2 Design Strategies for Circular Products

Circularity can be pursued through various strategies

Unlike downstream innovation, which focuses on end-of-use, upstream innovation focuses on rethinking products and services at the design stage

Circular product innovation is about designing products and systems that fit within a circular economy, where value is retained as long as possible and waste is minimized. Traditional approaches often focus on downstream solutions such as recycling and waste treatment, but these address symptoms rather than root causes. By adopting an upstream mindset, designers and businesses can rethink materials and business models to prevent waste from arising in the first place (EMF, 2020).

Design plays a decisive role: around 80% of environmental impacts are determined during the design stage. Choices about product materials, and assembly methods influence how long products last, how easily they can be repaired or upgraded, and whether their materials can be recovered at end-of-life.

The Circular Design Strategies Wheel helps to make these strategies actionable. The wheel provides both a framework for analysis and a brainstorming tool for ideation. This allows companies to explore trade-offs, combine strategies, and identify pathways that maximize circularity in practice.

Circular product innovation requires more than incremental changes: it calls for a mindset shift that embeds circularity into product function, design, and business models. By taking a life cycle perspective, choosing materials that fit the right cycle, applying circular design strategies, and using tools such as the Circular Design Strategies Wheel, organizations can translate the principles of the circular economy into practical solutions.

Product function

Rethinking how needs are met (e.g. moving from selling CDs to streaming services).

Product design

Redesigning the physical product to extend its life, improve reparability, reduce complexity and enable reuse. This may involve changes to materials, form, size and component construction.

Business model

Innovating on a system level, for instance by rethinking ownership of products, value chain collaboration and reverse logistics.

Rethinking product function, redesigning the product itself and innovating business models



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**To achieve
circularity
companies
should apply:**



Start with function, not form — Rethinking the user's need (e.g., "washing hair") rather than the product itself (e.g., "shampoo bottle"). This opens space for radical alternatives (PBL, 2018) (e.g. shampoo bars or refill systems), going beyond material changes or waste treatment.

Embed circularity in design — Apply design strategies such as design for disassembly, repairability and standardization to extend lifespans, enable reuse, repair and refurbishment, and simplify recovery.

Combine strategies across the life cycle — Circularity requires interventions at every stage, from resource extraction and design to use and end-of-life. Each stage presents opportunities to preserve resources, energy, and labor. Applying a mix of strategies across the product's life cycle strengthens circularity and maximizes overall value retention.

Balance trade-offs — No single strategy guarantees better outcomes in every situation. Strategies such as material substitutions, reductions or durability improvements may shift impacts elsewhere. Each design choice should therefore be assessed in terms of environmental, social, and economic trade-offs.

**Need some
tools to
explain these
actions?**

Tools and Methods

The Circular Design Strategies Wheel

The Circular Design Strategies Wheel is a practical tool that translates circular principles into actionable product design strategies. It presents eight main strategies, each broken down into sub-strategies, and organizes them across the product lifecycle: pre-use (redesign, resources & manufacturing), in-use (long-use, re-use, extended-use), and post-use (end-of-life).

The wheel serves both as a thinking framework and a hands-on brainstorming tool. It helps designers and businesses explore options, compare trade-offs, and combine strategies to identify circular opportunities. By making abstract principles tangible, the tool supports more systematic and creative approaches to circular product innovation.

For physical use, the wheel is supported by brainstorm cards. These cards describe the sub-strategies in more detail and act as inspiration during brainstorming. In a workshop setting, participants can use the canvas and cards together to generate ideas, capture them on post-its, and translate them into design concepts. It encourages practical, actionable thinking and collaborative discussion. The combination of canvas and cards enables individuals or teams to systematically explore design opportunities for (re)designing circular products, making circular design more accessible. Both formats are also available in PDF for easy use in digital or physical sessions.

Case Study

Case Study 1: Textiles & Outdoor Clothing

Outdoor clothing brands, such as Patagonia and The North Face, exemplify circular product innovation by integrating durability, repair, and reuse into their designs. The physical garments are designed to last longer (Design for Longevity) through high-quality, durable materials that withstand wear and environmental exposure. Customers are encouraged to return old garments for resale or recycling (Design for Reuse, Design for Recovery & Recycling), extending the life of textiles and reducing landfill waste.

Brands also provide repair services, making it easy for users to replace zippers, buttons, or seams (Design for Repair & Disassembly), supported by standardized parts and modular garment features (Design for Standardization & Compatibility). Material choices prioritize recycled or bio-based fibers (Design for Material Substitution), while multifunctional clothing designs, such as jackets that convert into vests, optimize use for multiple purposes (Design for Smarter Functionality). Resource-efficient production techniques, such as minimizing water and energy in dyeing or fabric finishing, further reduce environmental impact (Design for Resource Efficiency).

By embedding circular strategies across product design, use, and end-of-life treatment, these companies demonstrate how fashion can shift from a linear consumption model to a more sustainable, resource-efficient system.

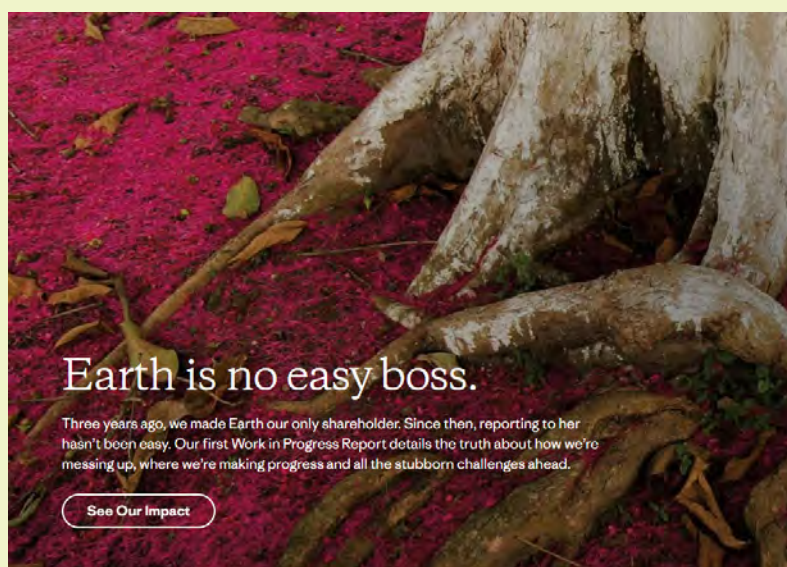


Figure 1: Patagonia website



Exercise

The Circular Design Strategies Wheel

Materials:

- Circular design strategies wheel canvas, printed on A2-paper.
- Brainstorm cards circular design strategies, printed.
- Post-its and pens

Exercises:

1. Choose a product-service system
2. Describe which functions the product-service system fulfills
3. What other elements are needed to provide the function (e.g. detergent and water/energy usage for washing clothes)?
4. Explore ideas for circular product design, using the circular design strategies wheel canvas (see figure...) and brainstorm cards (see figure...)
 - a. Go through the cards and use the circular product design strategies as inspiration for your product. Can you come up with any ideas to make your product-service system more circular?
 - b. Write the ideas on post-its
5. Select ideas for long-term and short-term options and describe how to implement them.

objective

materials and steps

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Boosting Circular Economy Expertise through Learning Communities

BECOME (Boosting Circular Economy Expertise through Learning Communities); Erasmus+ Alliances for Innovation, Project number: 101140141; ERASMUS-EDU-2023-PI-ALL-INNO-EDU-ENTERP

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