Interreg
Baltic Sea Region

Co-funded by
the European Union

CIRCULAR ECONOMY
Circular spaces

Circular makerspaces:
training program

FOREWORD

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

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

Circular Spaces Project Team

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

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

How to make use of this program?

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

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

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

Circular design-oriented training structure

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

Circular behaviour-oriented training structure

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

Introduction to circular economy training structure

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

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

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

Activity icon

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

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

Circular Economy and Sustainability

Developed by
Technical University of Applied Sciences Wildau

Topic 1

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

Expected training outcomes

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

Notes for target groups

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

Makers
Acquiring knowledge on circularity principles.

Makerspaces
Transitioning towards an ecologically and circularity-focused approach.

Suppliers
Grasping the circular strategy through real case studies.

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

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

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

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

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

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

Circular economy

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

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

Two key circular economy groups include:

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

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

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

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

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

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

Benefits of Circular Model:

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

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

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

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

Linear Economy

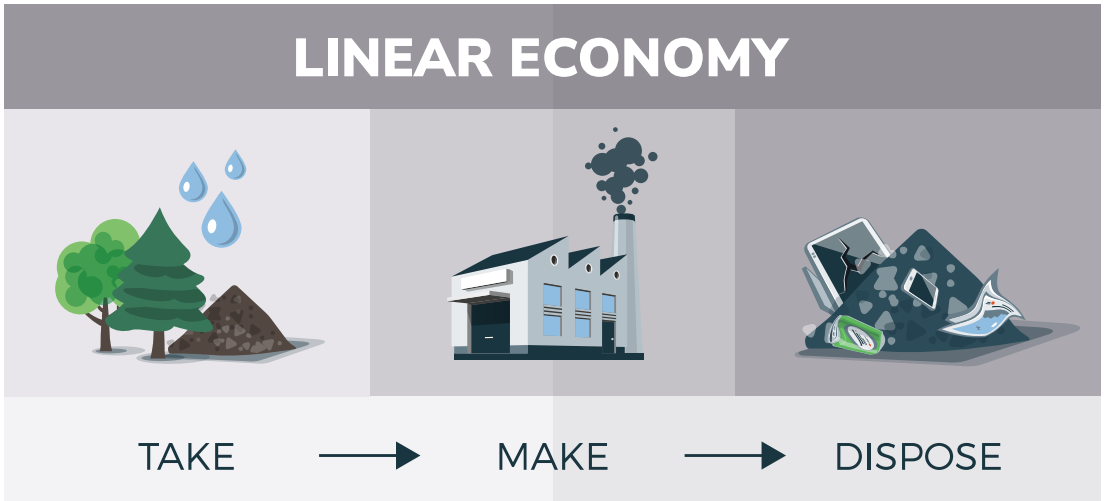
Linear economy features operation type that is linear, resembling a river, where natural resources are transformed into products through a series of value-adding steps. Linear economy is based on values driven by the "bigger-better-faster-safer" syndrome, influenced by fashion, emotion, and the pursuit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

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

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

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

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



Linear vs. Circular economy

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

Plan obsolescence

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

Factors driving premature obsolescence:

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

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

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

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

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

Mitigating Premature Obsolescence:

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

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

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

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

Right to repair

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

Factors Inhibiting Repairability:

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

EU Directive – Right to Repair

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

Circular Raw Materials

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

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

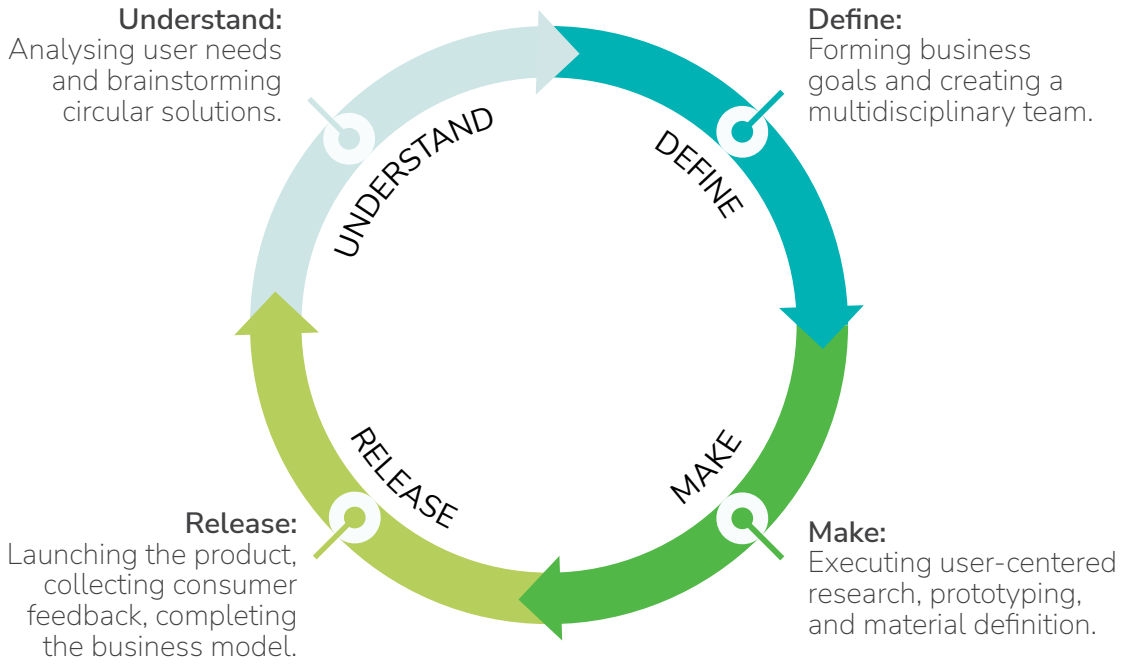
Understanding CRMs within specific sectors (e.g., automotive, renewable energy) is crucial for a comprehensive view. Highlighting critical raw materials in specific sectors, emphasizing the diverse raw material needs across industries. Advocate for complementary sector-specific assessments to capture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

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

Circular Design

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

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



Understand:
Analysing user needs and brainstorming circular solutions.

Define:
Forming business goals and creating a multidisciplinary team.

Make:
Executing user-centered research, prototyping, and material definition.

Release:
Launching the product, collecting consumer feedback, completing the business model.

Case Study: Local Roots - Transforming Agriculture with Circular Design

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

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

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

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

Circularity vs Sustainability

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

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

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

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

Case Studies

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

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

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

Used references and additional resources

- https://www.nature.com/articles/531435a#citeas
- https://www.europarl.europa.eu/news/en/headlines/economy/20151201STO05603/circular-economy-definition-importance-and-benefits
- https://www.ellenmacarthurfoundation.org/towards-the-circular-economy-vol-1-an-economic-and-business-rationale-for-an
- Empowering Sustainable Consumption by Giving Back to Consumers the 'Right to Repair' Ricardo J Hernandez 1,2,* , Constanza Miranda 1 and Julian Goñi DILAB School of Engineering, Pontificia Universidad Católica de Chile,
- Journal of Cleaner Production Business model innovation for circular economy and sustainability: Technical University of Denmark Marina P.P. Pieroni, Tim C. McAloone, Daniela C.A. Pigosso
- https://www.sciencedirect.com/science/article/abs/pii/S2452223621000912c
- https://repair.eu/
- https://www.researchgate.net/publication/321998000
- https://www.designorate.com/the-future-circular-economy-circular-design/
- https://www.builtinla.com/2017/12/13/agtech-local-roots-shipping-containers
- https://www.sciencedirect.com/science/article/abs/pii/S2452223621000912
- https://reflowproject.eu/blog/how-to-bring-circularity-into-the-event-industry/
- https://reflowproject.eu/blog/the-development-of-circular-isolation-gowns-a-case-study/
- https://stateofgreen.com/en/solutions/the-danish-deposit-return-system-for-recycling-drink-cans-and-bottles/
- https://maakleerplek.be/leuvenriverupcycling/
- https://www.ellenmacarthurfoundation.org/circular-examples/creating-a-reverse-logistics-ecosystem
- https://www.cleanup.org.au/sodastreamsustainability