Report on “Stakeholder engagement (incl. policy brief)”

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Abstract

The main aim of the CIRC-UITS project is demonstrating the improvement to the circularity of automotive and mass electronics sectors by recovering materials from wasted products, as well as supporting the reuse & remanufacturing of electronic components into new (high value) products in these sectors. To this aim, CIRC-UITS wants to demonstrate the improvement to the circularity of automotive and mass electronics sectors, by recovering materials from wasted products, as well as supporting the reuse & remanufacturing of electronic components into new (high value) products in these sectors. Through a set of success stories coming from the application of circular economy principles in four value chains (car braking systems, tyre sensors, in-mold electronics – IME and Waste from Electrical and Electronic Equipment – WEEE), CIRC-UITS demonstrated the benefits coming from Digital Circular Economy through 4 pilots.

Deliverable 6.3 “Stakeholder engagement (incl. Policy Brief)” outlines all the activities to liaise with the different stakeholder groups carried by CIRC-UITS consortium under the leadership of SAT.

After defining the different stakeholder groups a list of experts in the different sectors have been collected (chapter 2). For these identified stakeholders several dissemination activities have been organized as EU Green Week 2025 Partner events to maximise the visibility (chapter 3):

- Webinar “How can Digital Tools enable Circular Economy” targeting all professional stakeholders
- Open Day “Driving Circularity in Electronics and Automotive” at MADE Competence Center in Milan (IT) target all stakeholders (professional and the general public)
- Open Day “Innovative digital tools and serious games for sustainable product design” at OFFIC in Oldenburg (DE) targeting mainly the younger generations (scholars and students)

In addition several activities have been carried out with the Advisory Board (chapter 4 and deliverable 7.2) as well as clustering with other projects in this field (chapter 5).

Finally recommendations derived from experiences of the different stakeholders for European, national and regional policy makers have been summarized in a short Policy Brief (chapter 6).

Abbreviations

BOM	Bill of Materials
CE	Circular Economy
CRM	Critical Raw Materials
DIY	Do it yourself
ECU	Electronic Control Unit
ELV	End-of-Life Vehicle
EOL	End-of-Life
EPR	Extended Producer Responsibility
ESP	Electronic Stability Program
HMI	Human Machine Interface
IP	Intellectual Property
IPR	Intellectual Property Rights
KER	Key Exploitable Result
KPI	Key Performance Indicator
LCA	Life Cycle Assessment
LCC	Life Cycle Costing
OEM	Original Equipment Manufacturer
PCB	Printed Circuit Board
PCBA	Printed Circuit Board Assembly
SLCA	Social Life Cycle Assessment
TPMS	Tire Pressure Monitoring Sensor
WEEE	Waste from Electrical and Electronic Equipment

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1. Introduction

CIRC-UITS improved the circularity of the automotive and mass electronics sectors by recovering materials from waste products and reusing and remanufacturing electronic components into new high-value products. These sectors use many sensors, actuators, electronic control units and telecommunication systems to connect their products to the internet and enable real-time data exchange. However, this also creates environmental risks due to the dependence on semiconductors, which are scarce and hazardous materials. End-of-Life Vehicles (ELVs) and e-wastes are major sources of secondary raw materials that can be reused or recycled. The European Commission has published specific EU strategies for these sectors to make them more sustainable, circular and resilient. CIRC-UITS aligned with these strategies, as well as with the Sustainable Development Goals (SDGs) set by the United Nations (UN), the European Green Deal and the EU Circular Economy Action Plan, and the EU Industrial Strategy. CIRC-UITS addresses some of the priority areas of these plans, such as:

- CIRC-UITS used digital technologies to support the transition to circular practices, track and share data about critical and hazardous materials, calculate the environmental footprint of products, linked with the EU LCA platform, and reduced transaction costs and increased collection rates.
- CIRC-UITS increased resource efficiency and independence from imported materials, reduced the environmental impact of manufacturing processes, and identified the best EoL scenarios for reuse, refurbish, remanufacturing and recycling.
- CIRC-UITS improved and standardized information and data sharing among industrial leaders in the same or similar value chains, demonstrated the benefits of circular behaviours, and organized dissemination, communication and education actions.
- CIRC-UITS tested its achievements in four pilots: P1 – Brake systems' Electronic Control Units (ECU); P2 – Tyre pressure monitoring sensors (TPMS); P3 – In-Mold Electronics (IME); P4 – Obsolete PCBs.

CIRC-UITS focused on connecting actors who implement one or more Key Enabling Technologies (KETs) with the rest of the value chain to increase circularity. It also integrates I4.0-based technologies (e.g., simulation, Artificial Intelligence (AI), Augmented/Virtual Reality (AR/VR), Digital Twin (DT), cobot, Blockchain (BC), data spaces) into the project. The strong expertise of the partners in both automotive and mass electronics has been exploited to reach the objectives. The reference framework of CIRC-UITS covered different levels of its solution.

2. Identification of relevant stakeholders

Within this activity SAT with support of all CIRC-UITS partners carried out the following activities:

- Map relevant stakeholders interested to adopt and leverage impact of project results within EU Circular Economy Community (e.g. Business and Industry Association, Technology Cluster, Digital Innovation Hub, primary and secondary high schools)
- Create a stakeholder advisory group to be invited to project General Assembly for a preliminary assessment of activities of the project and provide input to ensure project alignment with market need. Dedicated workshops will be organized in alignment with WPs outcomes and need.

In the beginning SAT carried out internet and patent searches to identify potential stakeholders in the following business sectors:

- Automotive (tire sensors & car electronics)
- Mass electronics
- Flexible electronics
- Re-use of components, repair companies, recyclers
- Academia
- Multipliers (Business and Industry Associations, Technology Clusters, Digital Innovation Hubs, ...)

In parallel several partners suggested additional contacts. Out of those several hundred stakeholders a short list of 221 stakeholders have been created:

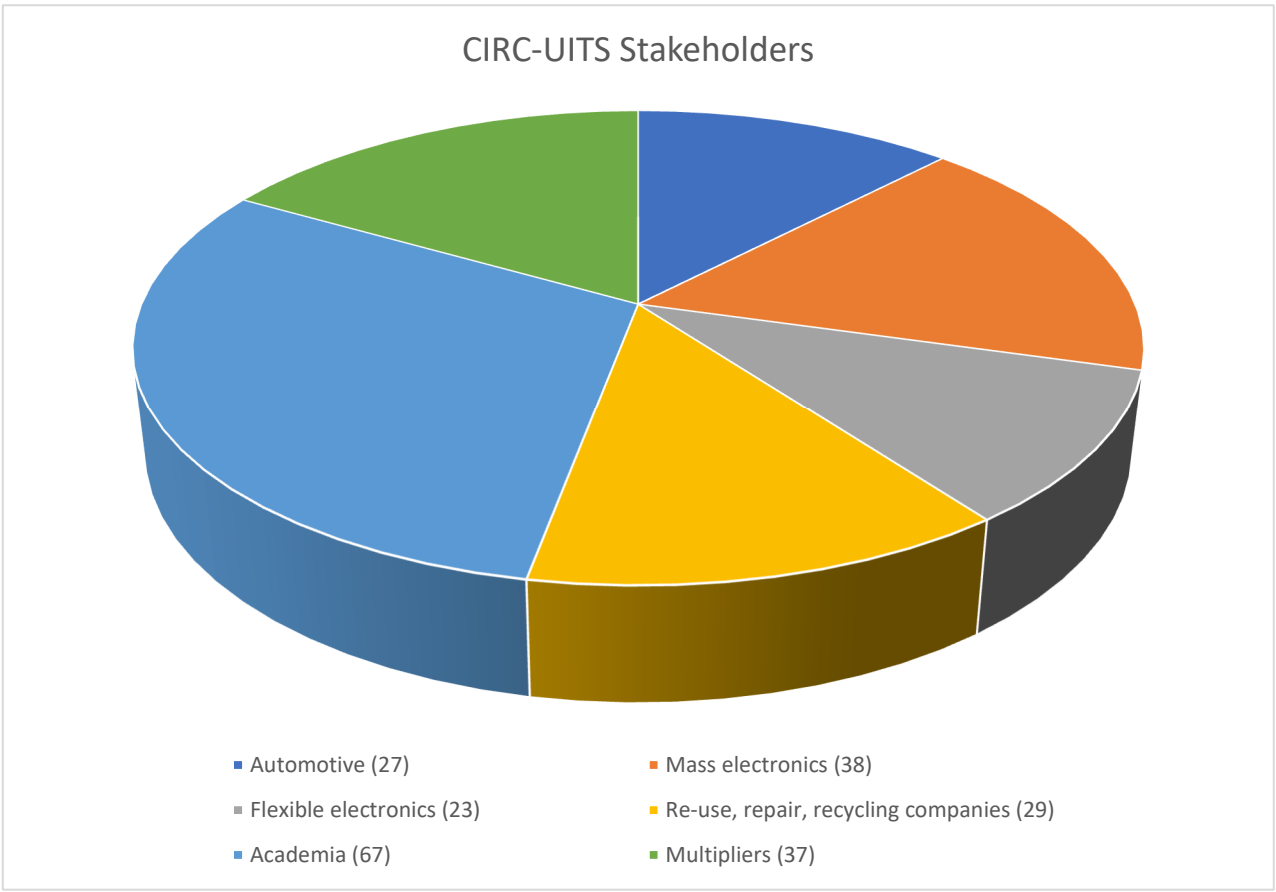

Figure 1. CIRC-UITS stakeholders

This identification of stakeholders strongly supported the creation of the stakeholder advisory group that has been invited to several project General Assemblies as well as 2 specific Advisory Board web meetings. More details on the Advisory Board and its activities can be found in the deliverable D7.2 Advisory Board Report.

All identified stakeholders have been invited to our Webinar “How can Digital Tools enable Circular Economy?”, organized as one of the EU Green Week 2025 Partner Events, and received all our CIRC-UITS newsletters.

3. EU Green Week 2025 Partner events

3.1. Webinar "How can Digital Tools enable Circular Economy?"

SAT organised a CIRC-UITS project webinar " How can Digital Tools enable Circular Economy?" on June 3, 2025 under the umbrella of the EU Green Week 2025 as one of its official Partner events with the following agenda:

Figure 2. CIRC-UITS webinar on digital tools agenda

The webinar included presentations on innovative digital tools that support sustainability of design and manufacturing as well as advise circularity decision-making in the automotive and electronics value chains. The participants of this webinar had the opportunity to learn first-hand how the TXT digital information exchange platform and re-use market place works and how it enhances value chain transparency, how the SUPSI methodologies and tools support sustainability and circularity decision-making in manufacturing via Life Cycle Assessment and advisory, how the MARAS Recycling Simulation tool assesses recycling and EoL sustainability and circularity and how the OFFIS Digital Twin fosters advisory. All digital tools have been demoed live during the webinar to show how stakeholders can take full advantage of the potential and synergies of 2 major revolutions of our time: Circular Economy and Industry 4.0.

The event was open to the general public, with a particular focus on attracting industry representatives that benefit directly from the technological progress reported by the speakers, policymakers, researchers, and other stakeholders interested in circular practices.

In total 107 persons from 30 countries (Austria, Bangladesh, Belgium, Brazil, Cameroon, Canada, China, Czech Republic, Denmark, Ecuador, Finland, France, Germany, Greece, Hungary, India, Italy, Japan, Latvia, Malaysia, Norway, Poland, Portugal, Romania, Serbia, Spain, Sweden, Turkey, United Kingdom and Vietnam) signed up for the webinar, 67 actually participated and several more watched the recordings on the CIRC-UITS YouTube channel afterwards.

3.2. Open Day "Driving Circularity in Electronics and Automotive" @ MADE Competence Center, Milan, Italy

As part of the 2025 EU Green Week Partner Events, MADE – Competence Center Industria 4.0 hosted the Open Day "Driving Circularity in Electronics and Automotive" on 11 June 2025 at its Milan facility. The initiative was aligned with the European Commission's focus on Circular Economy: Reuse, Repair, Recycle for a better life, as defined by the official Partner Events Guidelines. The event was organised with the contribution of CIRC-UITS partners and aimed at sharing insights, tools and practical approaches to foster circularity in electronics and automotive.

A diverse group of stakeholders attended the event, including representatives from industry, research bodies, and technology providers. The setting favoured focused technical exchanges and in-depth discussions on specific challenges related to circular design, reuse and digitalisation. The event was attended by 20 participants, 85% of whom came from the private/industry sector, 10% from public institutions and 5% from academia. Attendees represented a wide range of organizations, including manufacturing, consulting, energy, and technology companies, with participants coming mainly from Italy.

Activities carried out

Figure 3 - Agenda

Opening remarks and introduction

The Open Day was opened by MADE, which presented its mission as a national Competence Center supporting the digital and sustainable transformation of manufacturing firms. MADE illustrated its 2,500 m² demonstration facility, hosting more than 100 Industry 4.0 technologies used for orientation, training and industrial experimentation. POLIMI then introduced the CIRC-UITS project, outlining objectives, pilots, and the importance of integrating digital tools to enhance the recovery, reuse and remanufacturing of electronic components in the automotive and mass electronics sectors. This introduction ensured a shared understanding of the project's scope and positioned the open day within the broader EU Green Week objectives.

Session 1 — Digital Tools for Circularity

Led by TXT, the first session introduced the CIRC-UITS Digital Toolbox, presenting its purpose, architecture, and the different modules designed to support circularity.

Through visual demonstrations and examples drawn from CIRC-UITS pilots, TXT showed how the Toolbox supports companies in overcoming key challenges such as data fragmentation, limited traceability and lack of decision-support tools for circularity.

Session 2 — Disassembly & Reuse in Electronics

The second session, delivered by POLIMI and ERION, focused on practical approaches for component disassembly, reuse and preparation for re-use.

POLIMI presented methodologies for disassembly — manual, semi-automated and robot-assisted — and illustrated how AI-based component detection and structured disassembly guidelines can support higher-value recovery. Examples included selective removal of electronic components and collaborative robotics tested in the POLIMI laboratory setting.

ERION provided insights into the operational realities of the WEEE sector, highlighting persistent challenges such as low collection rates, limited reuse practices, and the predominance of traditional shredding processes. The presentation drew on results from Pilot 4 (obsolete PCBs), including:

- identification and extraction of the PCB from washing machines;
- testing of recovered boards at BEKO;
- assessment of the feasibility of reuse pathways;
- initial on-site testing of the Marketplace and AI-assisted PCB sorting workflows.

These examples enabled participants to understand the complexity of implementing reuse-oriented processes in current industrial environments and demonstrated how CIRC-UITS tools can provide operational support.

Session 3 — Circular Economy Business Models

In the third session, POLIMI addressed the role of circular business models (CBMs) in enabling long-term value retention. The presentation covered:

- the distinction between linear and circular value creation mechanisms;
- the importance of product–service systems and servitisation for extending product lifetimes;
- opportunities for reuse, remanufacturing and component recirculation;

The session also explained how CIRC-UITS digital tools can reduce uncertainty, support performance-based business models, and enable new service-driven value propositions in both electronics and automotive sectors.

Panel discussion with industry representatives

The event included a short panel with representatives from CRF (online) and Italtel. Discussions centred on:

- the need for improved access to component data to enable reuse and high-quality recycling;
- integration challenges between OEMs, recyclers and refurbishers;
- opportunities for marketplaces in mitigating component shortages and supply-chain risks;
- the anticipated impact of new legislative developments, such as the ESPR and the Right to Repair Directive, on product design and circularity strategies.

The panel fostered a constructive dialogue and provided practical viewpoints from industrial operators.

Networking exchange

The Open Day concluded with an informal networking moment, allowing attendees to interact directly with presenters and explore potential collaborations.

Lessons learnt

From the organisation of the Open Day and the interactions during the sessions, some general observations emerged that may inform future dissemination and engagement activities:

- The format of focused technical presentations followed by open discussion proved effective for facilitating exchanges among participants.
- Demonstrating tools and use cases in a clear and practical way helped make the project results more accessible to non-specialist stakeholders.
- The combination of academic, industrial and service-oriented perspectives supported a balanced discussion on opportunities and challenges related to circularity.
- Sessions that included concrete examples from pilots or operational environments were perceived as particularly useful for clarifying the potential application of project outcomes.

- In-person events, even with a limited audience, can support more direct dialogue and allow for immediate feedback on presented concepts and tools.

The Open Day organised at MADE provided an effective platform to present CIRC-UITS results, demonstrate the potential of its digital tools, and discuss practical pathways for enhancing circularity in electronics and automotive. The focused interactions generated valuable insights and reinforced the relevance of coordinated, digitally supported approaches to enabling circular value chains. The outcomes of the event will contribute to ongoing dissemination, exploitation and policy-related activities within WP6.

Figure 4 - Photos of the event

3.3. Open Day “Innovative digital tools and serious games for sustainable product design” @ OFFIS, Oldenburg, Germany

3.3.1. Context and objectives

The Open Day “Innovative digital tools and serious games for sustainable product design” at the research institute OFFIS in Oldenburg was organised within the EU project CIRC-UITS. The event aimed to familiarise a broad audience with sustainable and circular product design and to showcase key project outputs – in particular innovative (digital) learning tools and serious games – in an accessible, hands-on way.

Core topics included circular economy, sustainable product design, critical raw materials and right-to-repair. The event addressed both the knowledge dimension (understanding product life cycles and circular strategies) and the action dimension (discussing concrete levers in design, use, policy and infrastructure).

Figure 5. CIRC-UITS event invitation flyer; Impressions from the workshop

3.3.2. Format and structure of the event

The Open Day was designed as an on-site event with a varied and interactive programme. Throughout the event, visitors could join short talks and facilitated play sessions to experience two serious games developed in CIRC-UITS and one game already in use by OFFIS:

1. **CEBM Card Game** – a card-based learning format on circular business models.
2. **CE Estimation Game** – a physical, room-scale estimation and discussion format on circular flows.
3. **Game Based Approach to learn about Critical Materials**

All formats were offered at separate stations in the OFFIS building. Participants could flexibly join and take part in one or other activities in small, moderated groups. Over the full duration of the event, a total of around **24 participants** took part in the serious game formats by BeSu.Solutions and OFFIS; many of them engaged in more than two games in sequence.

The event primarily targeted upper-secondary school pupils (approx. ages 14–17) and interested members of the public, while also addressing teachers, university students, regional actors and practitioners from administration and industry. The activities were delivered in German and tailored to the OFFIS/Oldenburg pilot context, as the schools in the near vicinity were invited. The serious games were explicitly chosen to be low-threshold and entertaining, while still conveying substantive knowledge and prompting reflection.

3.3.3. Serious Game 1: CEBM Card Game

The **CEBM Card Game** is a facilitated, card-based learning format that makes the functioning of circular economy business models (CEBMs) tangible. Players adopt different core roles inside a fictional venture and co-develop a circular business model for concrete products (e.g. smartphones).

Using product, role, task, hint and strategy cards (covering 11 R-strategies), players are prompted to make decisions on design, operations, partnerships, revenue models and reverse logistics. Outcomes are documented on adapted canvases (Circular Business Model Canvas and Partnership Canvas).

Problem addressed
For many learners, “circular business model” remains an abstract term; reports and frameworks often rely on jargon and do not reveal the concrete decision points in everyday practice (what to design, who to partner with, how to earn revenue, what to measure). The CEBM Card Game addresses this gap by translating theory into a cooperative modelling situation in which options are explicit, assumptions are made visible and consequences are discussed openly.

Learning objectives in the context of the Open Day

- Understand the building blocks of circular business models and how they differ from linear models.
- Apply circular strategies (repair, reuse, sharing, remanufacturing, etc.) to specific products.
- Link design and operational decisions to basic unit economics (e.g. cost structure, revenue logic) and environmental outcomes.
- Practise teamwork, negotiation and evidence-based argumentation, including a critical stance towards greenwashing (claim–metric–evidence).

Observations and added value for stakeholder engagement
The game sessions showed that especially younger participants quickly engaged in discussions about usage models (ownership vs. access), repairability, take-back schemes and the role of partners in a circular system. The structure of short iterations (design → exchange in the “circle” → revision → pitch) fostered a visible shift in perspective: instead of only demanding “more sustainable products”, participants started thinking in terms of business models, partner networks and reverse flows.

For the CIRC-UITS project, the Open Day provided an opportunity to test the material with heterogeneous, real-world groups and to collect feedback on comprehensibility, game pace and suitability for school and outreach settings. The enthusiasm and commitment of the young people confirmed that serious games can serve as an effective entry point into complex circular-economy topics, even for audiences without prior expertise.

3.3.4. Serious Game 2: CE Estimation Game

The **CE Estimation Game** is an analogue, physical group format that makes material flows and circularity spatially and socially tangible. Ropes on the floor mark different circular loops (e.g. repair and maintenance, product/component/material reuse, energy recovery, “black hole”). Small sandbags each represent a 10% share of a product stock.

Participants work in teams to estimate what share of a product fleet (e.g. washing machines, smartphones, PV modules) ends up in which loop. Different stakeholder roles (User, Manufacturer, Recycler, Politician) structure the discussion. The group’s estimates are then compared with reference distributions, which are revealed using additional sandbags. This is followed by a moderated Fishbowl discussion, in which challenges and levers are explored from the perspective of each stakeholder group.

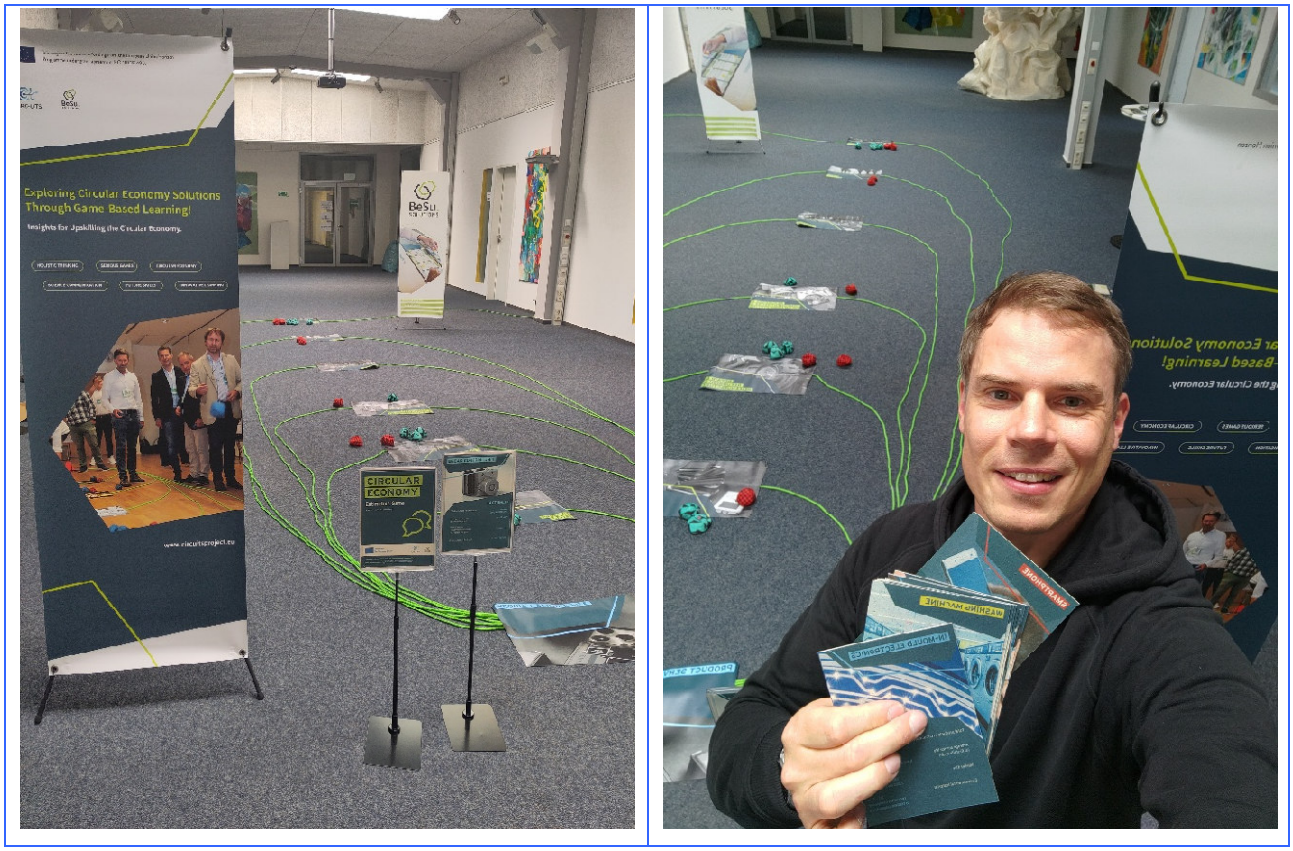

Figure 6. CIRC-UITS game setup of the CE estimation game

Problem addressed

Circular economy is often communicated through abstract percentages and schematic loop diagrams. Without a physical and social experience, it remains unclear “where (waste-)products really go” and how design, behaviour, policy and infrastructure shape outcomes. The CE Estimation Game creates a shared picture in the room, enabling participants to connect perceptions, data and levers for action, and to jointly interrogate common assumptions.

Learning objectives in the context of the Open Day

- Name and distinguish key circular loops and the levels of product, component and material.
- Compare and reflect personal mental models against reference flow distributions.

- Understand differing roles and responsibilities of users, manufacturers, recyclers and policymakers.
- Identify concrete intervention points (e.g. repairability requirements, take-back systems, design for disassembly, financial incentives).

Observations and added value for stakeholder engagement
The physical set-up in the room, the clear visual structure and the simple sandbag estimation mechanic lowered the entry barrier for participants without prior knowledge or technical background. In mixed groups (e.g. school pupils, interested citizens, technically trained participants), lively debates emerged when personal estimates were contrasted with the reference distributions. For CIRC-UITS, the format proved valuable to observe how different stakeholder groups react to empirically grounded flow assumptions and to identify needs for additional information (e.g. on collection systems, product lifetimes or existing policy targets).

3.3.5. Serious Game 3: Game Based Approach to learn about Critical Materials

The **Game Based Approach to learn about Critical Materials** is a learning format on a card board that makes the understanding of Critical Raw Materials in the EU visible. Players adopt a company role and need to bargain for raw minerals needed for specific products (e.g. Printed Circuit Boards). The market is often disturbed by so-called events, where the market is changing due to environmental conflicts or political situations.

The team players are prompted to make decisions on buying or selling materials, invest in strategies on remanufacturing and repair, including its own warehouse. The board game was supported by the OFFIS CRM Dashboard, as the Material could be connected to the recent criticality assessment.

Problem addressed
For many learners, critical materials, remains an abstract term and official reports and frameworks are often not entering a class room. The CRM Board Game addresses this gap by translating theory into a cooperative modelling situation in which options are explicit, assumptions are made visible and consequences are discussed openly.

Learning objectives in the context of the Open Day

- Understand the meaning of critical raw materials.
- Apply circular strategies (repair, reuse, sharing, remanufacturing, etc.) to products and receive rewards for it.
- Practise teamwork, negotiation and evidence-based argumentation and taking risks to invest in new strategies.

Figure 7. OFFIS' criticality assessment tool explained to public

Observations and added value for stakeholder engagement

The game sessions showed that especially younger participants quickly engaged in discussions about investing in specific raw materials and the importance of setting up a circular system. Participants started thinking in terms of business models, partner networks and (own) reverse flows. Students with a gaming background were already familiar with the term "strategic resources" and for them it was easier to adapt to the story line.

3.3.6. Contribution to the CIRC-UITS project and outlook

The Open Day made a direct contribution to the **stakeholder engagement and dissemination strategy** of CIRC-UITS by:

- Demonstrating and testing project outputs (serious games) with real target groups in a pilot context.
- Collecting qualitative feedback on clarity, attractiveness and applicability in schools, universities and community formats.
- Raising awareness among young people and regional stakeholders for circular product design, resource conservation, critical raw materials and right-to-repair.
- Building and strengthening contacts with teachers and other multipliers relevant for follow-up activities (e.g. project weeks, teaching materials, further workshops).

The experiences gathered during the Open Day feed into the further refinement of the materials (fine-tuning rule sets, canvas layouts, facilitation guides, timing). On this basis, the project team plans to **repeat similar events in the future**, including formats delivered **directly in schools**, in order to reach even more young people and to inspire them to engage with circular economy and resource conservation.

The partners are convinced that the future of the environment and society depends strongly on the education and engagement of young people. Accordingly, further events and activities within CIRC-UITS and related EU projects are planned to continue using serious games and interactive tools as a bridge between research, education and public engagement.

4. Advisory Board

As mentioned already before, the identification of stakeholders in task 6.4 strongly supported the creation of the stakeholder advisory group that has been invited to several project General Assemblies as well as 2 specific Advisory Board web meetings. More details on the Advisory Board and its activities can be found in the deliverable D7.2 Advisory Board Report.

5. Interaction with the standardisation community

Under the leadership of DIN the CIRC-UITS partners initiated and chaired the following 2 CWAs (CEN Workshop Agreement) from the European Committee for Standardization (CEN):

- **CWA 18311:2025 - Enabling Circular Economy Practices: Repair and Recycling of PCBAs** (chaired by Paolo Rosa from POLIMI)
- **CWA 18313:2025 - Use-case for the application of EN 45554 in the automotive industry** (chaired by Lisa Dawel, OFFIS)

More details on the standardization activities within the CIRC-UITS project can be found in the deliverable D5.4 Report on standardization activities (v2).

6. Clustering activities

6.1. Overview

Clustering activities have been implemented by the CIRC-UITS consortium during the whole duration of the project. These activities have been mainly focused on the interaction with other EU projects and communities focusing on similar topics covered by CIRC-UITS.

6.2. Clustering with other EU projects

This activity saw **the interaction of CIRC-UITS with 13 European projects** (e.g. Horizon Europe, H2020, Interreg and national funded ones). The interaction with other projects has been implemented under the form of periodic confcalls in order to discuss about common topics. In few cases (e.g. TREASURE, FREE4LIB and ECOTRON) the interaction taken the form of co-organized dissemination & communication events.

Clustering with H2020 TREASURE project

TREASURE project developed a scenario analysis and simulation tool to assess the positive and negative implications of circular economy practices and principles in car manufacturing to facilitate the adoption of CRM recovery and circular economy in this sector. CIRC-UITS interacted with TREASURE in order to 1) exploit the results obtained during the TREASURE project in terms of semi-automated PCB disassembly in order to develop a new (component-oriented) functional disassembly process, 2) exploit the results obtained during the TREASURE project in terms of green IME eco-design practices in order to develop innovative repair/reuse procedures for green IME, 3) exploit the results obtained during the TREASURE project in terms of sustainability & circularity assessment methods in order to develop innovative advisory services to be embedded in the CIRC-UITS digital toolbox, 4) exploit the results obtained during the TREASURE project in terms of digital tools supporting circularity approaches in order to develop innovative (AI-based) digital twins supporting the eco-design of products and decision-making processes, 5) identify innovative Circular Business Models in the automotive and mass electronics sector and 6) exploit synergies during the organization of a 3-days Spring School in April 2024.

TREASURE & CIRC-UITS 3-days Spring School in Paris

During this 3-day event, TREASURE and CIRC-UITS partners had the chance to exchange their perspectives on common topics covered by the two EU projects.

On Day 1, TREASURE and CIRC-UITS project partners presented their work to an audience of about 60 people (constituted by industrial companies, EU institutions and EU industry associations) in terms of A) circular web platforms, B) web-based services for sustainability & circularity assessment C) innovative disassembly procedures for car electronics. In addition, some external stakeholders (e.g. VALEO and FORVIA) shared their perspective on circular economy and recycling of car electronics.

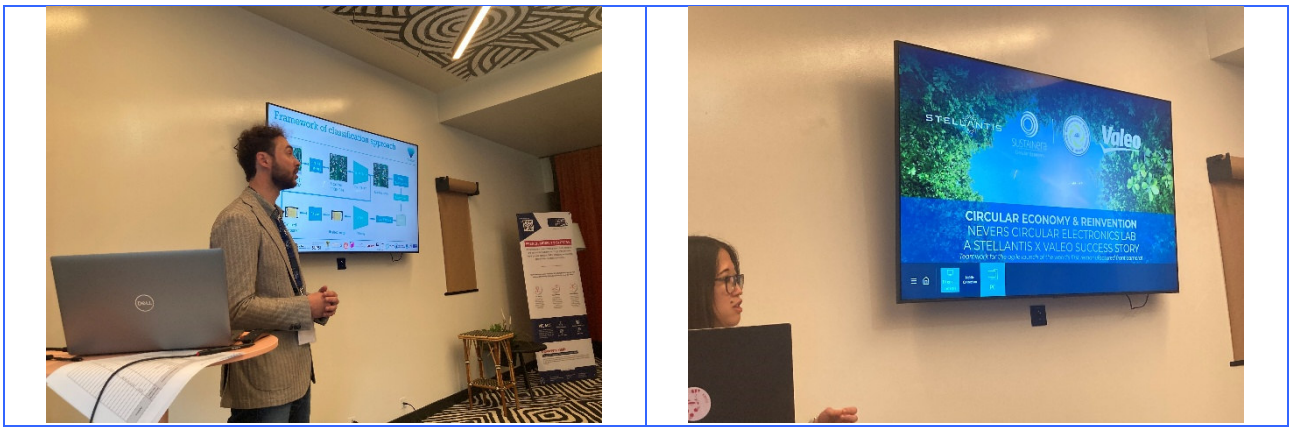

Figure 8. TREASURE & CIRC-UITS Spring School presentations

On Day 2, TREASURE and CIRC-UITS partners (a group of about 40 people) had the chance to visit THE REMAKERS industrial plant in Flins (Paris) dedicated to car remanufacturing services. This historic RENAULT plant has been retrofitted to manage EoL cars. The plant is now the 1st EU circular economy plant for mobility. The visit of THE REMAKERS site was really in phase with the CIRC-UITS objectives and a great opportunities to prove that circular economy is feasible and can be profitable at industrial level. The visit shown also how RENAULT is dealing with car electronics as well with specific tools and processes dedicated to disassembly and repair of entertainment electronic equipment's.

Figure 9. TREASURE & CIRC-UITS Spring School visit @ THE REMAKERS plant

In addition, they have been involved in a training activity on circular economy.

Figure 10. TREASURE & CIRC-UITS Spring School serious game @ THE REMAKERS plant

On Day 3, TREASURE and CIRC-UITS partners have been involved in a roundtable with sister projects where they had the chance to discuss about complementary topics. The event was held at the French Automobile Manufacturers Committee (CCFA in French) and had the objective of gathering around the table projects with potential synergies to explore either potential follow-up activities or new ways of collaboration among ongoing projects. During this event, also FREE4LIB and ECOTRON have been presented.

Figure 11. TREASURE & CIRC-UITS Spring School presentations @ CCFA headquarter

Clustering with HE ALICIA project

The ALICIA project will design a circular manufacturing ecosystem (CME) so that production resources will be traded and reused to their maximum utility in between factories in Europe. The CME approach will be tested in two real industrial environments. The innovations behind ALICIA include a machine-readable ontology for mapping factory owner requirements and an AI-matchmaking engine for combining incumbent factory assets with second-hand assets coming from the ALICIA online marketplace. CIRC-UITS interacted with ALICIA in order to develop DT and AI-based tools supporting products' eco-design strategies.

Clustering with HE AUTO-TWIN project

AUTO-TWIN project will introduce a new method for creating digital twins. It aims to address the limitations of current system engineering models via a breakthrough method for automated process-aware discovery towards autonomous digital twins generation. CIRC-UITS interacted with AUTO-TWIN in order to develop DT and AI-based tools supporting products' eco-design strategies.

Clustering with HE DACAPO project

DACAPO project will design human-centric digital tools and services for improving the adoption of circular economy strategies along both manufacturing value chains and products lifecycles (design and engineering, manufacturing, use phase and End of Life). These tools and services, focused on the creation of new digital assets, AI-based systems and the application of process and product Digital Twins, will greatly improve sustainability. The overall goal of this project is the creation of new methods supporting circular economy business models across three production environments (aeronautics, electronics and logistic applications). CIRC-UITS interacted with DACAPO in order to 1) develop DT and AI-based tools supporting products' eco-design strategies, 2) identify innovative Circular Business Models in the electronics sector and 3) organize a special session & booth at ECOMONDO 2024 and 2025.

Figure 12. POLIMI's booths @ ECOMONDO 2024 and 2025

Clustering with HE FREE4LIB project

FREE4LIB project will develop technologies to achieve six new sustainable and efficient processes to recycle end-of-life LIBs. The project will also deliver three processes aimed at reuse of metals and polymers and electrode synthesis for remanufacturing new LIB battery packs based on the design for recycling. The use of Battery Passports will overcome the current lack of access to open data in the LIB value chain. CIRC-UITS interacted with FREE4LIB in order to 1) define the main data structure of a potential DPP for PCBAs and 2) organize a special session & booth at ECOMONDO 2024 and 2025.

Clustering with HE ECOTRON project

ECOTRON project will develop adaptable organic and eco-friendly printed electronics solutions that allow for improved and expanded recycling while impacting the environment less during production. The project will present use cases in packaging, healthcare, consumer goods and wearables to demonstrate the novel electronics' increased durability and lifetime, and decreased environmental impact. CIRC-UITS interacted with ECOTRON in order to 1) develop new materials and repair/reuse procedures for making IME more sustainable and circular and 2) organize a special session & booth at ECOMONDO 2024 and 2025.

Clustering with HE HyPELignum project

HyPELignum project will propose and demonstrate a holistic approach, from the sourcing of raw materials to the end of life, to manufacture net-zero carbon electronics. The project will aim to show how wood and wood-waste derived materials can be core (substrate, ink components) for the additive manufacturing of electronics. The project will also develop an energy-efficient microchip for sensing systems as well as look at new ways to recycle wood and recover electronic materials. CIRC-UITS interacted with HyPELignum in order to 1) develop new materials and repair/reuse procedures for making IME more sustainable and circular and 2) identify innovative Circular Business Models for green IME.

Clustering with HE UNICORN project

UNICORN project will increase the circularity-driven functional integration of electronics in automotive. It will do so by embedding eco-design principles and ensuring net beneficial effect on climate change mitigation. Specifically, the project will design and develop innovative green and circular technologies for automotive electronics. These include lightweight, low impact and bio-based materials, as well as the implementation for material circularity. UNICORN will establish a vision and roadmap to ensure functional electronics support EU mobility climate targets. CIRC-UITS interacted with UNICORN in order to develop new materials and repair/reuse procedures for making IME more sustainable and circular.

Clustering with H2020 CircThread project

CircThread project focused on data and information management to support the circular economy. More specifically, the project will support decision-making processes by promoting access to existing data. It will design a methodology for sharing information about the different stages of the products' life cycle, focusing on environmental, social, economic and circular aspects. The overall goal is to create data linkages between product chain, value chain, asset chain and life cycle chains. CIRC-UITS interacted with CircThread in order to 1) develop sustainability & circularity assessment methods and 2) co-organize an industrial seminar with Swiss (Ticinese) companies.

Figure 13. CIRC-UITS & CIRCTHREAD event poster

Clustering with Interreg REUSE2030 project

REUSE2030 project will analyze current waste streams and circular practices in the mechanical sector. This leads to a new digital circular inventory, which empowers mechanical companies to autonomously choose sustainable practices. The inventory is complemented by a newly developed zero carbon toolkit. Both tools are tested in companies and inform a new strategy with circular solutions to reduce the mechanical sector's waste streams. CIRC-UITS interacted with REUSE2030 in order to develop AI tools supporting disassembly of electronic components.

Clustering with HE Circular TwAIn project

Circular TwAIn will develop a novel AI platform for circularity with the aim to increase the performance, resilience, and sustainability of direct manufacturing and process industries. CIRC-UITS interacted with Circular TwAIn in order to develop AI-based tools supporting products' eco-design strategies.

Clustering with HE CIRPASS-2 project

CIRPASS-2 project will demonstrate functioning DPPs in real settings and at scale in four target value chains: textiles, electrical and electronic equipment, tires and construction materials. The project will also create a wide community of DPP stakeholders to facilitate the deployment of DPPs in different product sectors, across Europe and beyond. CIRC-UITS interacted with CIRPASS-2 in order to define the main data structure of a potential DPP for PCBAs.

Clustering with Austrian (FFG-funded) DPP4Electronics project

DPP4Electronics project will 1) investigate the compliance issues associated with the implementation of a DPP and its impacts on the business models of electronics supply chains, 2) conceptualize a robust and flexible data infrastructure for generating, managing and maintaining DPPs that takes account of a company's digital and technical capabilities, 3) align existing data exchange practices to proposed norms and standards for interoperability to enable a seamless flow of distributed data between systems at the syntactic and semantic level, and 4) suggest an appropriate governance, model and policies for data access and exchange that ensure sovereignty, security, transparency, nuanced usage control and compliance in trusted data spaces. CIRC-UITS interacted with DPP4Electronics in order to define the main data structure of a potential DPP for PCBAs.

6.3. Clustering with other international organizations and working groups

This activity saw the interaction of CIRC-UITS with the EU Green Electronics WG and the involvement of CIRC-UITS in the IAM-I community. Both these actions are focusing on the development of green electronics and CIRC-UITS has been involved because of its interest in green IME eco-design activities.

Clustering with the EU Green Electronics WG

The interaction with the EU Green Electronics WG has been mainly implemented under the form of recurrent confcalls in order to discuss about common topics.

Clustering with the IAM-I Community

The interaction with IAM-I taken the form of both recurrent confcalls with specific IAM-I WGs and a workshop on green IME organized at the VDMA headquarter in Frankfurt.

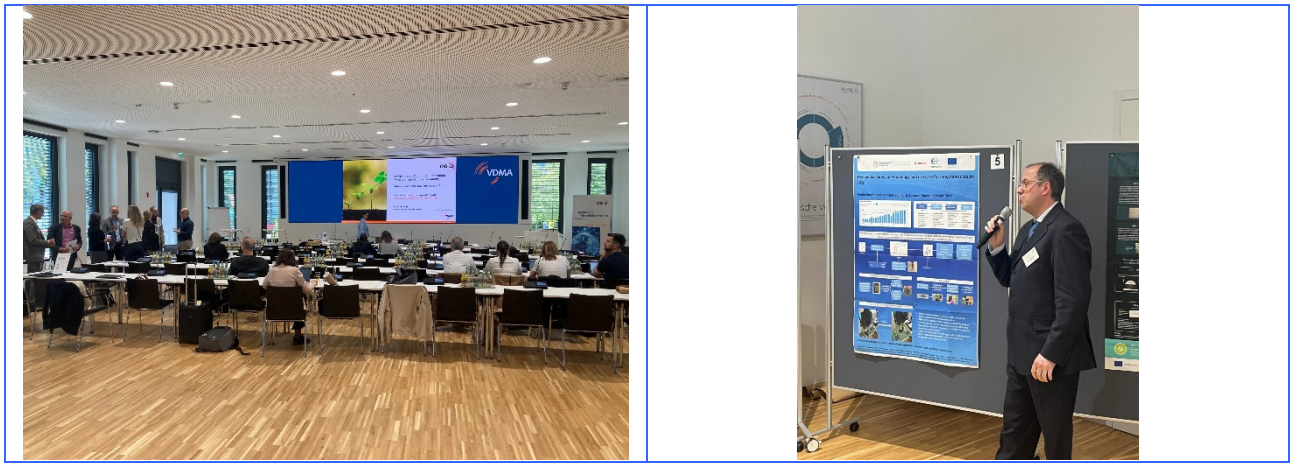

Figure 14. CIRC-UITS presentation @ VDMA headquarter

6.4. Results and impacts

Clustering activities have been a vital activity for CIRC-UITS in order to be aware about incoming actions implemented by other EU projects, working groups and international organizations managing some of the aspects covered by CIRC-UITS. Thanks to these actions, CIRC-UITS results have been shared with other EU projects, by enlarging our audience and improving the visibility of CIRC-UITS both on the web and within specific events. Considering what reported in the previous section, the main focus of these actions have been sustainability & circularity assessment methods, digital tools supporting eco-design strategies & decision-making processes, the development of DPPs, the definition of eco-design practices for IME and the identification of innovative Circular Business Models.

6.5. Lessons learned and recommendations

Clustering activities (together with standardization actions) allowed to identify some relevant recommendations to be considered for future EU projects development:

- In terms of sustainability & circularity assessment methods and digital tools supporting eco-design strategies & decision-making processes, there are plenty of solutions already in the market. However (mainly because of a lack of significant data), the usage of these tools is limited to the calculation of LCA-related KPIs. There is still the need to expand the availability of datasets containing relevant data in order to make real the digitalization of products' lifecycle and the creation of digital circular economies.
- In terms of DPPs development, there is still a lot of work to do. Mainly because of the same lack of data discussed in the previous point, DPPs are currently limited to few products (e.g. EV batteries

and textile). However, CIRC-UITS pointed out (also thanks to its standardization actions) about the urgent need of a DPP for PCBs. Only through a similar tool the electronics value chain could be able to share all the information needed to reuse, reman and recycle obsolete PCBs (and their components).

- In terms of eco-design of IME, good advances have been done during the last years under the sustainability and circularity perspectives. However, there is still a lot of work to do in order to transform these initial (lab-scaled) results into industrially relevant benefits.
- In terms of Circular Business Models, companies must be still supported in order to better comprehend the benefits coming from the adoption of circular practices. A good way to demonstrate them which kind of benefits they could achieve is the direct involvement in demonstration actions, mainly focusing on the re-design of some of their products and the comparison of them with existing ones. This was one of the actions where CIRC-UITS got very high success, demonstrated by a set of quantitative results available under the form of prototypes.

7. Policy recommendations

7.1. General Policy Brief

Electrical and Electronic Equipment as well as automotive vehicles and, consequently, the amounts of waste from these products are particularly significant in a Circular Economy (CE) context: both from the consumers perspective which consider important their reparability as well as from manufacturers/recycling companies' point of view for the possibility to recycle the valuable and critical materials such as rare earth elements contained in these devices.

Moreover, embracing the logic of "recycling" and "re-use" becomes economically advantageous both for manufacturers and end-users. Suffice it to say that taxation on waste (i.e.: landfill taxes) over the years has never stopped growing, and the prospect is to move more and more in the direction of contributory differentiation based on the "polluter pays " principle.

Therefore, in this context it is important that the concept of circularity begins a pillar both for manufactures and end-users for all the industrial sectors including the electrical and electronic as well as the automotive sector.

The aim of this Policy Brief is to provide Policy Recommendations for policy makers/EU political institutions to overcome legislative barriers towards circularity in the Electrical & Electronics and the automotive sectors.

According to a quick analysis the main legislative barriers against circularity in the Electrical & Electronics and the automotive sectors include:

a. lack of legislative requirements and application guidelines in term of Circular Economy understanding and awareness (some Member States have a proper legislative framework towards Circular Economy but they need guidance to apply the proper one);

b. lack of discrimination among products categories (differentiate regulations according to the specificity of individual products could bring to market fragmentation);

c. lack of global consensus on regulatory framework (lack of product standardisation between countries make difficult to work in a coordinated way and open the competition between Member States for national laws. The development of an international standard regarding WEEE (Waste from Electrical and Electronic Equipment) and ELV (End-of-Life Vehicles) management would promote the harmonisation of the WEEE and ELV treatment across all the countries);

d. lack of a clear regulatory framework for the processes which are needed to prepare the products and their components for re-use.

After discussion within the CIRC-UITS consortium as well as with additional stakeholders a few policy recommendations have been identified. The list of specific recommendations for the Electrical & Electronics and the automotive sector below is mainly based on the countermeasures proposed by the consulted experts on how to overcome the legislative barriers. In particular, the following recommendations are worth mentioning:

- Legislators shall provide financial, informational and regulatory incentives to stimulate the repair, re-use and remanufacturing of products as well as the uptake of Circular Economy Business Models (e.g. pay-per-use). For example, offer a tax reduction (e.g. VAT, labor taxes for employees dealing with re-use and recycling operations) or even exemption for re-used products and components as well as recycled materials.
- The EU and Member States shall develop guidelines and/or public campaigns targeting the main actors to increase awareness, understanding and compliance with the regulatory framework.

- The European Commission, along with the Member States, shall engage the final users in awareness-raising programs, improving accurate identification of re-usable products and components, recyclable materials and their proper disposal into separate collection systems.
- The European Commission, together with policy makers, shall differentiate the regulations according to the product specifics, preserve the requirements of Circular Economy at EU-wide level, to avoid market fragmentation resulting from different national laws and discrimination among product categories.
- Policy makers shall consider the real needs of all stakeholders while updating the framework below:
    - Establish specific collection targets for products that are rich in critical materials (e.g. in the information technology and telecommunication sector).
    - Include specific re-use and recycling targets for products containing a high percentage of critical raw materials in the legislation (e.g. at least a to be defined percentage of Neodymium must be recycled in order to allow Europe to become self-sufficient on the supply side) to make the re-use and recovery mandatory for producers and the EPR (Extended Producer Responsibility) schemes acting on their behalf.
    - Limit values in REACH Directive, the CMRT or the SVHC list,
    - ELV and WEEE Directive to better address competencies and responsibilities of stakeholders. Most Member States obligate producers to meet collection targets, even though they do not even possess full access to all the ELV and WEEE at their End-of-Life.
    - Strong restriction in the Waste Shipment Regulation regarding the shipment of waste within the EU (cross-border movement), without distinction between proper treated waste and untreated waste, can hamper the export of waste needed for the recovery of CRM in bigger recycling facilities in other member states.
    - In addition a stronger restriction on export of End-of-Life products outside the EU will be appreciated. It is of utmost importance to keep “European” End-of-Life products within Europe to enable economy of scale for innovative re-use and recycling operations and by that support Europe´s resilience and Clean Industrial Deal.
- The cooperation of the whole value chain with national and local authorities across Europe is fundamental to achieve optimal re-use and recycling results for the benefit of European economy and citizens.
- Public authorities should express recommendations, via procurement policies, to promote the re-use of products as well as the use of products with a higher content of re-used components and recycled materials.
- European Commission and Member States shall promote European (at least, better international) standards to establish trust of consumers and all other market players.
- European Commission should propose a new ecolabel for products containing re-used components and recycled material (similar to energy label), maybe incorporating also information of repairability and re-usability.

- Manufacturers shall analyse the impacts of their products, according to the LCA-based method, for a decision-making guide for CE. From the policy standpoint, LCA studies should be required as an element of public procurement practices or invitations to EU project tenders.
- Technology developers shall provide technical and technological recommendations regarding standardization, normalization and obsolescence of products and regarding instruction manuals that enable and facilitate maintenance and repair, technical data sheets, availability of spare parts, languages of documentation, etc.
- Probe the potential of circular products and services in the industry through collaboration between the European Commission and manufacturers on the identification of suitable classes of products for product-service systems.
- Raise the circularity readiness level in the industry through European Commission's analysis of specific challenges preventing Small Medium Enterprises from engaging in circular practices; authorities shall launch awareness campaigns to support Circular Economy regulatory compliance.
- Simulate resource-efficient and circular design, sourcing and manufacturing. The European Commission shall consider an extended life-circle perspective and potential environmental trade-offs to avoid unintended consequences of the incorporation of circularity into eco-design policies. The European Commission shall investigate the use or adaptation of the existing tools to increase product circularity through eco-design.
- European Commission and Member States should provide incentives for scaling up of already existing re-use and recycling processes on lab or pilot scale in order to bring them to the market.
- European Commission and Member States should provide incentives for actual re-use of products and components as well as recycling of products containing a high percentage of critical raw materials if the politically influenced low market price does not allow profitable re-use or recycling.

7.2. Specific policy recommendations from individual partners

AUMOVIO:

In 2019, the Automotive global economy consumed more than 100 billion tons of resources—primarily virgin metal ores, fossil fuels, biomass and minerals—and only 8.6% of this was cycled back into use. (*The Circularity Gap Report 2021, Circle Economy*)

Most of the automotive industry are designing products focusing on a **linear life cycle** and **economical constraints** of the markets, focus on design to cost product.

The idea is to start not only to produce components with a **low carbon footprint,** but also change the **design philosophy** to enter the **circular economy**, allowing first, the **repairability,** using obviously **eco-friendly materials**, and provide an **easy dismantling** at the end of the component's life.

AUMOVIO, Tire Information System

The Tire Pressure Monitoring Sensor is currently a sensor placed on the tire, measuring temperature, pressure and much more allowing additional services to the customers.

Taking the example of the Tire Pressure Monitoring Sensor, the design is completely sealed and impossible to open without specific tool and lead to destroying the product. This type of design is applied to most of the product within a car.

The current design of product at the end of life does not allow repair, reuse, recycling (mixed material), disassembly in a safe way for product itself and for operator. The battery can be extracted leading to trash the rest of components.

The circular economy opens opportunities for the next generation of eco-design products by allowing repair, reuse/ replacement of defect component, limiting trash volume, creating new jobs and globally generating value for a global and local eco-system.

CHALLENGES AND KNOWLADGE GAP

The current design focusing on economical perspective within a linear economy does not allow sustainable design.

Only the perspective of performing circular economy and offering services (based on new business models) from economical perspective give the chance of sustainable design.

The first step must be an eco-design, and tools able to measure the product, manufacturing process performances across different criteria like carbon equivalent, dismantlability and repairability and much more…..

As explained above, the tools to evaluate the performance of the design must address the disassembly complexity and repairability/recyclability efforts for getting a cost break down structure and identify levers to optimize them in the circular loop.

By developing the circular economy, the carbon footprint and recycling raw material criteria are in evolution with new ones, as reuse parts and material volume are increasing quantitively.

Policy Recommendation

The Policy should reinforce the ELV regulation, including the tools for evaluation and the score targeted according the recycling and information needed already started on:

Basis for a future Digital Passport for PCB and Automotive product :

- **CWA 18311:2025 - Enabling Circular Economy Practices: Repair and Recycling of PCBAs**

Circular economy performances, set up KPI within the ELV**:**

- ISO 5910 Circular Economy - **Guidance on the transition of business models and value network**
- ISO 59020 **Circular economy — Measuring and assessing circularity performance**
- ISO/TR 59032 - **Circular economy — Review of existing value networks**
- **CWA 18313:2025 - Use-case for the application of EN 45554 in the automotive industry**
- **IPC 7712 – 7731 → How to repair.**

Erion Compliance Organization – Leader Pilot #4

Building on the evidence gathered in CIRC-UITS Pilot #4, several concrete challenges emerged when attempting to scale up business models based on extraction, repair and re-use of components from WEEE and automotive-related products. In particular, treatment plants willing to integrate preparation for re-use, component extraction and repair into their existing activities are facing a market that is not yet ready to absorb these circular streams: demand from producers for re-used, tested and requalified parts remains weak and uncertain, so that the additional capital and operational expenditures required to set up such systems cannot be justified under current economic conditions.

From a producer's perspective, the preferred option would be to re-acquire only fully functioning components, meaning that testing, requalification and, where relevant, repair operations should be performed within authorised treatment facilities, also in order to streamline the declaration of "end-of-waste" status and to simplify the movement of components whose legal status would otherwise oscillate between "waste" and "product" along the value chain. The absence of a clear and harmonised framework for the legal status of extracted components and the stringent, product-level safety and certification obligations make it extremely difficult for producers to reintroduce repaired components into new products, even when their technical performance is equivalent to new parts.

Moreover, innovation activities concerning the end-of-life phase of products must now focus on the continuous improvement of collection and sorting systems in order to increase collection rates and the quality of separately collected fractions. The efforts of appliance manufacturers in eco-sustainable design must be accompanied by the correct collection and treatment of end-of-life equipment, in order to recover and recycle the materials that make up the equipment and reintroduce them into production cycles, considering that an appliance is 96% recyclable.

Finally, Pilot #4 has shown that the overall cost of repaired components, driven by testing, quality assurance and logistics, is frequently higher than the cost of new ones, making these circular options non-competitive in the absence of appropriate incentives or regulatory support.

<u>Policy Recommendation</u>

- Member States shall simplify and accelerate permitting procedures for treatment plants that want to integrate preparation for re-use, component extraction and repair activities into their existing operations. However, in the field of WEEE, it is important to guarantee a real sales market for preparation for reuse. It would be necessary to assess whether there is actually consumer demand for such products, especially considering the relatively low prices of new electrical and electronic equipment available in physical stores or on e-commerce sites. With regard to WEEE, the effectiveness of reuse operations depends on a number of specific factors that cannot be overlooked. In particular, WEEE must be of good quality, preferably high-end and not too old; the number of hours of work required by operators on WEEE must not be too high, to avoid the costs of preparing it for reuse automatically taking the product off the market; spare parts must be available, easily accessible and affordable.
- The European Commission shall develop a clear, harmonised regulatory framework for the legal status of extracted components, by defining EU-wide "end-of-waste" criteria and practical guidelines on when a component removed from a WEEE stream can cease to be waste and be placed back on the market as a product or spare part. This framework shall also clarify the allocation of responsibilities between producers, treatment operators and distributors. Accelerate the definition of 'End of Waste' (EoW) criteria: currently, the criteria for considering a

substance no longer as waste but as a secondary raw material that can be used in other production sectors have only been established for a few types of materials. It is therefore essential to accelerate the definition of new regulations to expand the opportunities for the recovery of secondary raw materials. Moreover, a genuine Single Market for circularity must be created, overcoming inconsistent applications and interpretations among Member States, through the extension of end-of-waste criteria at EU level.

- Product safety and product compliance legislation shall be adapted to enable the safe re-introduction of certified repaired, remanufactured and re-used components into new products without requiring a full and costly re-certification process of the entire product.
- Policy makers shall address the lack of cost-competitiveness of repaired components versus new ones by introducing fiscal and EPR-related incentives. Examples include: eco-modulation of EPR fees in favour of products containing a minimum share of certified re-used or remanufactured components, reduced VAT rates for products and spare parts incorporating such components, and targeted support schemes for industrial-scale repair and remanufacturing operations.
- The European Commission and Member States shall facilitate structured cooperation and data sharing between producers and authorised treatment and repair operators. This includes ensuring access to essential technical documentation, test protocols and repair instructions (for example via the Digital Product Passport or sectoral implementing acts) so that components can be safely extracted, tested, requalified and reintroduced on the market, while respecting intellectual property and cybersecurity requirements.

MARAS:

Faced challenges

- Policy is based on simplistic (Excel) approaches, which are not helpful not to say harmful for industry, especially as recycling and thus the effect of design for recycling is not correctly and sufficiently covered by physics of recycling possibilities and limits.
- Policy should be supported by a rigorous basis, at least based on process simulation calculations that defines actual achievable target based on nature law's possibilities and limits of recycling and design for recycling. This provides a rigorous basis to challenge and support policy and define targets which are ambitious but at the same time feasible from an industrial and physics point of view.
- The large body of simplistic policy does not help EC industry, recycling rates are selected from average databases with no link to design. As each product and/or part has its own characteristic recycling and CE fingerprint, this is not reflecting the reality of design related to recycling. There is no link to the complex affect of interlinkages of materials and compounds in design for e.g. functional specifications and no basis in thermodynamics of material separation and energy recovery. This is making the work of the EU industry difficult, having to comply with unrealistic and unfeasible targets.

Proposal for policy brief

- The Metal Wheel explains this is detail and should be included in any policy brief: Metallrad – Wikipedia
- Lead policy brief detail below (Reuter was involved in this – figures help)

- SOCRATES Press Release on the importance of lead metallurgy – European Training Network for the sustainable, zero-waste valorisation of critical-metal-containing industrial process residues
- (PDF) Lead Metallurgy is Fundamental to the Circular Economy Policy Brief SOCRATES EU MSCA-ETN

Policy Brief: Lead Metallurgy and Its Role in the Circular Economy (see links)

Lead metallurgy plays a critical role in advancing the circular economy by enabling the efficient recycling of valuable materials. The policy brief authored by experts such as Prof. Markus Reuter emphasizes the following key points:

1. **Fundamental Role in Recycling**: Lead metallurgy is essential for recovering not only lead but also other critical and precious metals, such as silver, gold, and rare earth elements, from complex waste streams.
2. **Environmental Benefits**: By supporting high recycling rates, lead metallurgy reduces the need for primary resource extraction, minimizing environmental degradation and energy consumption.
3. **Industrial Synergies**: Lead smelters act as hubs for processing diverse waste materials, including batteries, electronic waste, and industrial residues, contributing to a sustainable materials management system.
4. **Policy Recommendations**:
   - Avoid restrictions on lead metallurgy, as it could disrupt the recycling of other valuable materials.
   - Promote research and innovation to enhance metallurgical processes and reduce environmental impacts.
   - Foster collaboration between industries, policymakers, and academia to ensure a balanced approach to sustainability.

This brief underscore the importance of maintaining and improving lead metallurgy infrastructure to support a resilient and sustainable circular economy.

- In 2013 a policy brief on the Sustainable Design of Electronics was presented to the Dutch government, including above addressed issues:
https://www.nvmp.nl/uploads/pdf/nieuws/2013/2013%2008%2030%20NVMP%20Manifesto%20DfR.pdf

- An issue is the lacking training and harmonization in thinking, therefore simulation-based approaches should be the heart of the system (see e.g. point 4 above) and given links and work in CIRC-UITS showing that rigorous simulation modelling can provide the basis for recycling and CE targets. The close cooperation with the OEMs/designers demonstrate how this can work in practice by linking physics based recycling process technology knowledge, recycling and CE KPI calculation as a unique fingerprint of targets to be defined, with the basis of simulation modelling which allows to calculate this without having to perform costly and large scale experiments. Also the link to LCA community (as realised in the project together with SUPSI) shows this is all possible.
- Synergies between different players should be emphasized, see figure below from the Handbook of Recycling | ScienceDirect that explains the physics detail that should underly the brief.

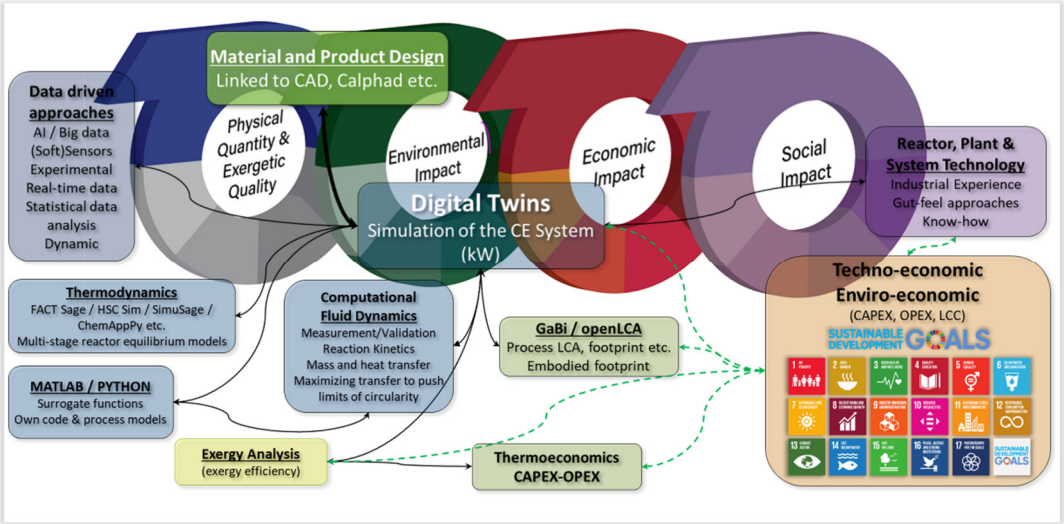

Figure 15. A picture from the Handbook of Recycling

- Visualize the recommendations, see the policy brief, in which we integrated the Metal Wheel as follows, that makes it so much more accessible (this policy brief was used by the metals industry to show the criticality of processing industry)

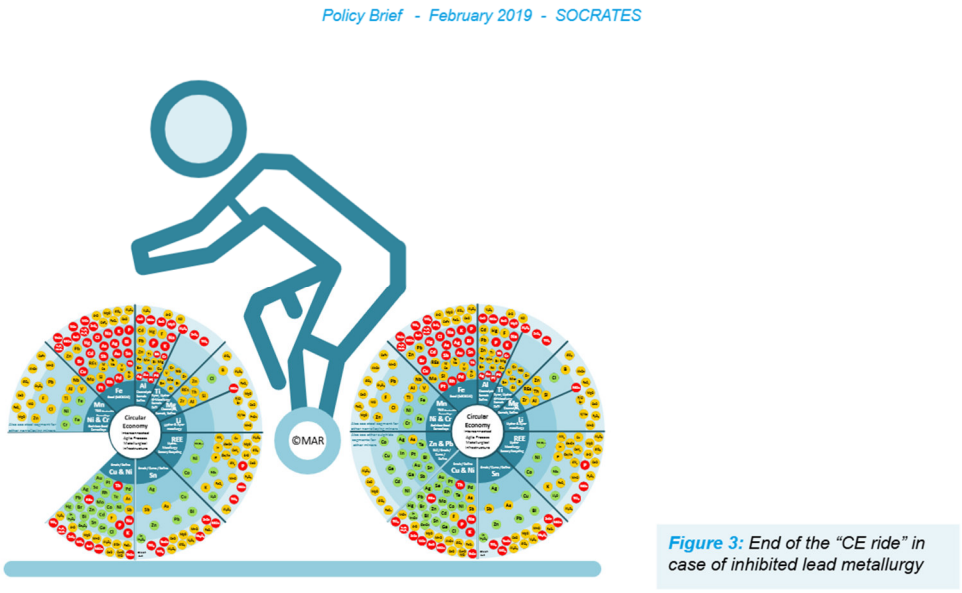

Figure 16. "End of the CE ride"

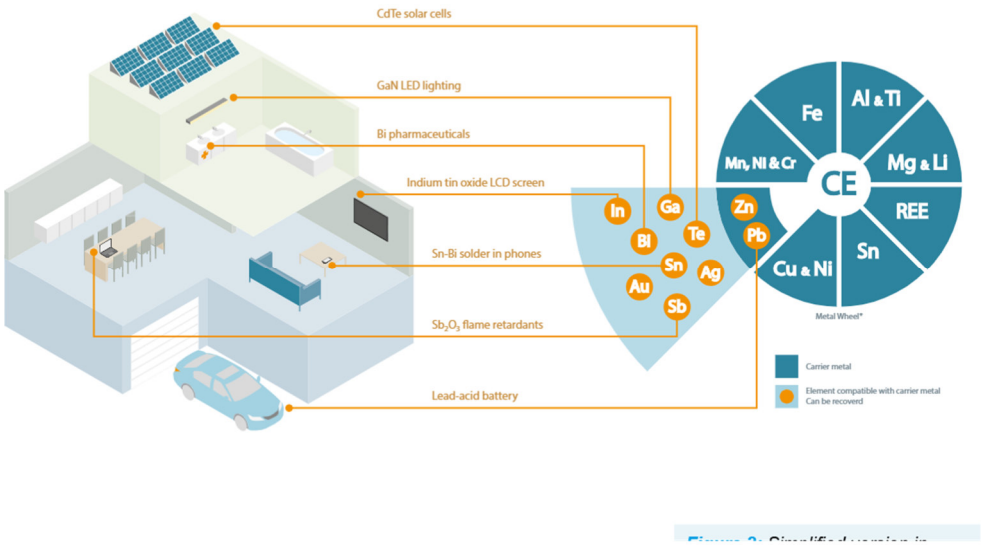

Figure 17. Policy briefs from SOCRATES project

- In summary MARAS would recommend the WHY, HOW WHAT approach and then the recommendations as summarized by the 4 points above in the box expanded with the further recommendation as provided in this document.

POLIMI	ALPHA
The representative of QAT Responsible for business issues **Status:** Approved **Name:** Paolo Rosa (POLIMI) **Date:** 01/12/2025	The representative of QAT Responsible for business issues **Status:** Approved **Name:** Claudio Travi (ALPHA) **Date:** 18/12/2025