Sustainable electronics: Towards the creation of a European ecosystem and e-waste reduction
Agenda

- EECONE: European Ecosystem for Green Electronics
- Eco-designed Remote Control Unit: From theory to practice
- Global vision: The paths towards eco-innovation
EECONE: European Ecosystem for Green Electronics
The impact of electronics on the environment

- Many different environmental impacts and benefits arising from electronics
- Double role of electronics in the race towards environmental sustainability
  - Significant environmental impact arising from production and usage
  - Reduce or avoid GHG emissions

Azote for Stockholm Resilience Centre, based on analysis in Richardson et al 2023

Freitag et al., Patterns, 2021

ICT 2020: 2.1-3.9% of global CO2 emissions
Focus on e-waste

- Many different environmental impacts arising from electronics
- **E-waste**: One of the fastest growing waste streams in EU
  - 5 times faster than e-waste recycling
- Obstacle to EU efforts to reduce its environmental footprint
- Potentially harmful materials polluting the environment
- Many rare materials

- Circular Economy Action Plan priority: E-waste prevention
  - Right to repair
  - Reusability improvement
  - Recycling rewards
- ESPR: Sustainable product design to reduce waste
- WEEE Directive

The Global E-waste Monitor 2020

H. Roy et al., 2022
Electronic waste reduction: How to

► EECONE mission: Electronic waste reduction

► Objective 1: Define environmentally sustainable ECS
  ► Tools and methods to design ECS for circularity
  ► At least 80% of 6R metrics implemented in tools

► Objective 2: Make environmentally sustainable ECS
  ► Techniques to boost circularity and decrease e-waste in new generation of electronics
  ► At least 25% e-waste reduction

► Objective 3: Showcase environmentally sustainable ECS
  ► Demonstrate solutions along the value chain
  ► 10 use cases with dedicated KPIs

► Objective 4: Build consciousness
  ► Ecosystem creation
  ► At least 100 publications, over 10 recommendations to improve standards and regulations
Strategy: The 6R concept

- **Reduce**: Reduction of materials by optimizing the use of resources
- **Repair**: Techniques for repairability facing the barriers
- **Reuse**: Capacity to use parts of a broken product as spare parts for another
- **Refurbish**: Second life, use of a product for another mission
- **Recycle**: Critical pillar of the European e-waste reduction strategy
- **Reliability**: Guarantee and maximisation of the lifetime
Consortium

- 49 partners from 16 Countries

- Interdisciplinarity to link electronic industry with environmental and material sciences
Work plan

- Management of existing electronic waste
  - Focus on Reuse and Recycle

- Tools and techniques for environmentally sustainable ECS by design
  - Eco-design for 6R at IC, PCB and System levels

- New generation of electronics
  - Technologies for environmental sustainable ECS

- Ecosystem building
  - SWOT of the 6R approach
  - Survey and feedbacks on standards and regulations
  - Education content
Management of existing electronic waste

- **Objective:** Improve circularity
  - Reuse, waste valorisation, recycling

- **Step 1:** Study the raw materials supply
- **Step 2:** Cross with critical and strategic material list
- **Step 3:** Create the mapping and define a list of EECONE most impacting raw materials

**Gain a view of the raw materials flows and production scraps on a European scale**

**Identify impacting materials**

**Develop new recycling technologies and raw materials circular loops**

Recycling quiz: [https://www.eecone.com/eecone/survey/?id=90](https://www.eecone.com/eecone/survey/?id=90)

European Commission, 2023
Design of environmentally sustainable ECS

- Objective: **Tools, metrics and guidelines** to enhance future electronics design based on the 6R

Platform Element example: xR design flow for IC

- From traditional design flow to eco-design flow for circularity
Platform Element example: xR design flow for IC (2/2)

- Current status: Eco-reliable design flow

- Eco-reliability: Maximization of the reliability while minimizing the environmental impacts

\[ E_{\text{coreliability}} = \frac{\text{Operating time}}{\text{System Earth equivalent Time}} \]

C. Sandionigi, SusTech 2024, To appear
New generation of electronics

- **Objective:** Reduction of electronic waste > 25%
  - Introduction of new materials
  - Improved manufacturing technologies to reduce the material usage
  - Modular designs
  - Novel techniques to increase the lifetime of electronics

- **Activity example:** New IPs to increase lifetime of IC
  - Monitoring of Remaining Useful Lifetime, auto-diagnostic, auto-reparability

What changes with 6R design flow and lifetime extension IPs?

- Knowledge of environmental impacts
- Optimized number of active and spare cores
- Choice of reliability techniques driven by impacts
- Information for reuse
Ecosystem building

- Have a clear view of ecosystem demands and offers
  - Surveys
    - Map requested needs and available expertise
    - Regularly on eecone.com
  - Standards and regulations
    - State of the art and recommendations

- EECONE contribution for the ecosystem
  - Dissemination
    - Networking events, webinars, publications
  - Education
    - Summer school and MOOC
Showcase environmentally sustainable ECS

<table>
<thead>
<tr>
<th>Team</th>
<th>Title</th>
<th>WP-2</th>
<th>WP-3</th>
<th>WP-4</th>
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<tr>
<td>UC-01</td>
<td>BOSCH, HTV, IZH, AT&amp;S, ORBIX, DTI &amp; IFAG</td>
<td>Reducing eWaste from Electrical Control Units for Automotive Industry</td>
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<td>VITESCO, SOITEC, SPHEREA, INS-Gr, AT&amp;S, DASSAULT SYSTEM, PREMO &amp; IFAG</td>
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Eco-designed Remote Control Unit: From theory to practice
Rethinking remote controls with Eco-design principles

- While our primary focus is on Remote Control Units, the underlying principles we're developing here have the potential to be applied to a wide range of SMALL ELECTRONIC DEVICES.

Dissemination...
Eco-Challenges in Remote Control Design

- Our quest for sustainable remote control design starts with a deep dive. 4MOD LCA expert conducted a comprehensive Life Cycle Assessment (LCA) of our benchmark RCU model.
- This LCA will serve as a crucial starting point, revealing the environmental challenges associated with its entire lifecycle – from material selection and manufacturing to use and end-of-life management.
The Foundation for Our Eco-Design Approach

- Our study will use a recent LCA (July 2023, SimaPro version 9.5) as a starting point to explore new possibilities for more environmentally conscious remote control design. Our LCA is making 2 significant assumptions:
  - The RCU will have a lifetime of **8 YEARS**
  - The specific use case of 250 key presses, 120 seconds of voice commands and 8 hours connect to set-up-box
A multifaceted eco-design approach

- Our multifaceted approach leverages the full spectrum of eco-design available tools to create the most environmentally responsible remote controls possible.

Life Cycle Assessment

Research & Development

Multi-Physics Simulation
To validate the effectiveness of our multifaceted eco-design approach, we will compare a standard RCU to two optimized versions designed with EECONE 6R principles in mind.

Overall, by avoiding the use of 4 AAA over 8 years and reducing the amount of material used in the PCB.

Our targeted RCU should produce 50% less E-Waste by weight compared to the one we used as our benchmark.
Ensuring Consistency and Measurable Progress

- To ensure a consistent and replicable approach for evaluating the sustainability of each RCU generation, we have identified a defined set of features and criteria for each of the RCU.
- By comparing these features across different RCU generations, we can accurately measure progress towards our eco-design goals.

Non-exhaustive list

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<th>GEN0</th>
<th>GENX</th>
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<tr>
<td>37%</td>
<td>73%</td>
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EECONE KPIs
Defining a Common Scenario for Sustainable RCU Design

- To ensure consistent and comparable evaluation of our remote controls across generations, we’re developing a common scenario.
- This standardized scenario will replicate a typical usage pattern and environmental context. By applying this scenario to each RCU generation, we can objectively measure progress towards our sustainability goals and identify areas for further improvement.
- This approach ensures a level playing field for comparison and provides a reliable benchmark to track the evolution of our eco-friendly RCU designs.

ECO-DESIGNED RCU DEMONSTRATOR (Storyboard)

- Introduction & Objectives
- Specifications
- RCU Design Part 1 - MCAD Import
- RCU Design Part 2 - ECAD Import
- RCU Design Part 3 - MCAD/ECAD review
- RCU Simulation - Drop Test
- RCU Simulation - Vibration Test
- RCU Simulation - Key Test Strength
- RCU Simulation - Electrostatic Discharge
- RCU Simulation - Antenna
- RCU LCA (Goal & Scope)
- RCU LCA (Inventory Analysis)
- RCU LCA (Impact Assessment Part 1)
- RCU LCA (Impact Assessment Part 2)
- RCU LCA Interpretation (report + review)
- RCU End of Life
DEMO STEP 0: Intro

Contributors/Contributions

Eco-Design platform
- 3DS application
- CEA metrics/guidelines
DEMO STEP 1: LCA/Define Scope & Target

Scope & Target Definition
- 3701 as reference
- REGO improved target = 50%

BOM + 3D directly linked To LCA
DEMO STEP 2: Inventory Analysis

- Direct link to ecoinvent LCI database
- Assign Human Activities To BOM
- Assign activities to Lifecycle phase(s)
DEMO STEP 3.1: Impact Assessment (Global/Metrics)

- Objective
- Top Human Activity Impact
- BOM distribution

EF3.0 global score
16 metrics score
DEMO STEP 3.2: Impact Assessment (Reveal in 3D)

You can reveal in 3D various types of Analytics as illustrated here.

BOM elements without Human Activities highlighted in 3D
DEMO STEP 3.3: Impact Assessment (comparative LCA)

RCUs comparative LCA
For all EF3.0 metrics
DEMO STEP 4: Interpretation

LCA Reports automatically generated thanks to the Impact Assessment results
In our pursuit of the most eco-friendly remote control design, we're introducing a novel concept: a weighted circularity rating system. It considers a holistic range of parameters crucial for sustainable design:

- **Environmental impact**: Minimizing the lifecycle footprint of the remote control.
- **E-waste reduction**: Prioritizing designs that generate less electronic waste.
- **Performance**: Ensuring the remote control functions effectively and reliably.
- **Cost**: Balancing affordability with sustainable practices.
- **User experience**: Creating a remote control that is intuitive and enjoyable to use.

<table>
<thead>
<tr>
<th>RCU</th>
<th>Circularity Rating</th>
<th>E-Waste Reduction Score (Recycling, Reliability, Reduce)</th>
<th>LCA Score</th>
<th>Performance Score</th>
<th>Cost Score</th>
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Global vision: The paths towards eco-innovation
Technology and sustainability: A maze of concepts

- Wide and wild use of various terms to link technology and sustainability
- Risk of collapse of the concepts

**Sustainability:**
Ability of meeting the needs of the present without compromising the ability of future generations to meet their own needs

Bruntland report, 1987
Two paths towards eco-innovation

Eco-innovation:
A powerful instrument to protect the environment with a positive impact on the economy and society
... without neglecting social impacts

- S-LCA: A framework to better understand and address social impacts

ISO 14075

Guidelines for SOCIAL LIFE CYCLE ASSESSMENT OF PRODUCTS AND ORGANIZATIONS 2020
The EECONE project receives grants from the EU Horizon Europe research and innovation program, KDT Joint Undertaking, and National Funding Authorities from involved countries under grant agreement no. GAP-101112065.

Recycling quiz: [https://www.eecone.com/eecone/survey/?id=90](https://www.eecone.com/eecone/survey/?id=90)