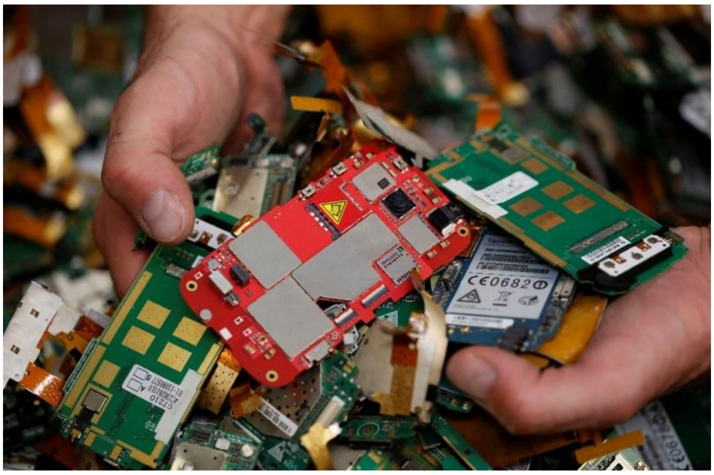

European ECOsystem for greeN Electronics

Eco-design from theory to practice

Beyond Functionality: Integrating Eco-design Principles for Responsible Small Electronics

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V1.1

4MOD/3DS

22.04.2024 (modified 30.04.2024)

Contents

INTRODUCTION (PROBLEM & OPPORTUNITY)

The recent UN Global E-waste Monitor paints a stark picture:

Electronic Waste Rising Five Times Faster than Documented E-waste Recycling

A record 62 million tones (Mt) of e-waste was produced in 2022, up 82% from 2010. On track to rise another 32%, to 82 million tones, in 2030. Billions of dollars worth of strategically-valuable resources squandered, dumped. Just 1% of rare earth element demand is met by e-waste recycling. This growing mountain of discarded electronics poses a significant threat to our environment and human health.

This white paper is a direct response to this critical challenge. Inspired by the UN report's call for action, we delve into a practical solution: the transformative power of **eco-design principles** applied to small electronic devices. We use the ubiquitous **Remote Control Unit (RCU)** as a compelling case study.

This whitepaper takes a deep dive into the practical application of eco-design principles. Using the Remote Control Unit (RCU) as a case study, it explores how seemingly minor changes throughout the product's lifecycle can lead to significant environmental benefits.

Importantly, the principles demonstrated here can be applied to a wide range of small electronic devices (or small equipment, one of the Global E-waste Monitor 2024 e-waste categories), multiplying the positive impact of our eco-design approach.

We embark on a journey exploring how eco-design can translate into tangible actions, employing Life Cycle Assessment (LCA) to understand the environmental impact of RCUs throughout their lifespan.By employing LCA, we gain invaluable insights into the environmental impact of RCUs at every stage of their existence, from resource extraction to end-of-life. This knowledge then informs multi-physics simulations, allowing us to optimize not only energy consumption and heat dissipation but also analyze aspects like structural integrity, material behavior under diverse conditions, and potential electromagnetic interference.

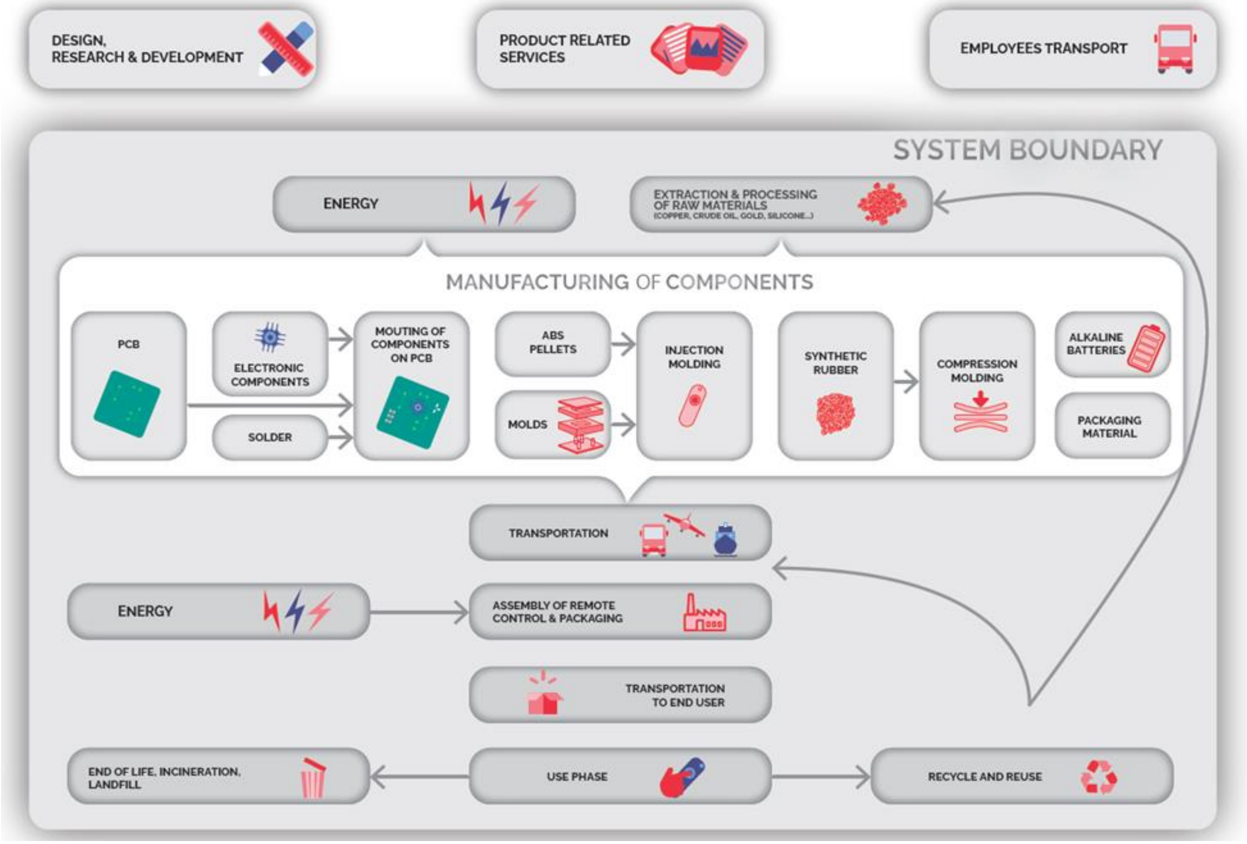
Furthermore, we will leverage the European ECOsystem for greeN Electronics (EECONE) 6R framework to guide the entire eco-design process and minimize the environmental footprint and associated e-waste generation of RCUs. By combining these strategies, we aim to unlock a future where even the simplest clicks contribute to a more sustainable environment.

THE CASE STUDY: RCU ECO-DESIGN

Our commitment to sustainable remote control design begins with a solid foundation: a comprehensive Life Cycle Assessment (LCA) conducted by 4MOD LCA expert, @Edmund Whitmore. This existing LCA serves as a crucial benchmark for future generations of remote control design.

WHY A BENCHMARK LCA MATTERS

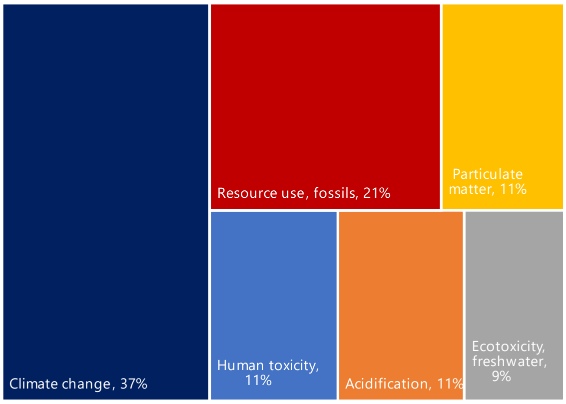
The existing LCA provides a detailed picture of the environmental impact associated with our current benchmark RCU model across its entire lifecycle. By analyzing each stage – from material selection and manufacturing to use and end-of-life management – the LCA identifies areas for improvement and establishes a baseline for measuring the effectiveness of future eco-design strategies.

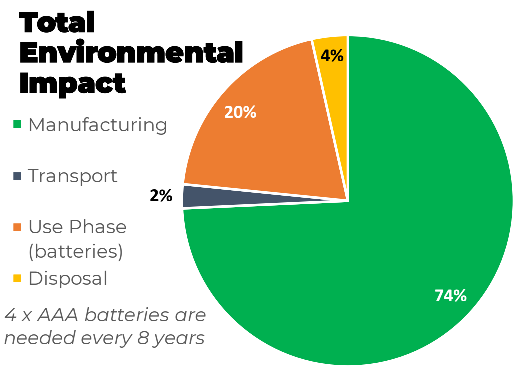


Our commitment to sustainable remote control design takes a bold leap forward with the EECONE Project. This groundbreaking project promises a wave of innovative solutions, revolutionizing the very foundation of small electronics manufacturing – from the materials we use to the processes we employ.

Total Environmental Impact

The majority (74 %) of the environmental impact is from the manufacturing phase. For the weighted impact categories, the impact category Climate Change (37 %) contributes the largest proportion to the weighted score.





A UNIQUE APPROACH TO SUSTAINABLE REMOTE CONTROLS: LEVERAGING THE POWER OF EECONE

Within the EECONE Project, we are pioneering a **unique approach** that leverages the project's innovative solutions and rigorous analysis tools.

This unique approach hinges on three pillars:

1.CUTTING-EDGE R&D FUELED BY EECONE INNOVATIONS:

The EECONE Project's exploration of novel materials (substrates, inks, etc.) and manufacturing processes fuels our R&D efforts.

TRANSFORMATIVE SUBSTRATES:

- **Biodegradable materials:** Derived from renewable resources like plant-based polymers, these substrates offer a sustainable end-of-life solution and reduce dependence on fossil fuels.
- **Recycled content:** EECONE explores incorporating recycled plastics or metals into the substrate, promoting a circular economy and minimizing virgin material usage.

NEXT-GENERATION INKS:

- **Conductive inks:** These inks eliminate the need for traditional Copper based PCB, simplifying manufacturing and potentially reducing quantity of metals needed.
- **Bio-based inks:** Derived from sustainable sources, these inks can minimize the environmental impact of the printing process.

PIONEERING MANUFACTURING PROCESSES:

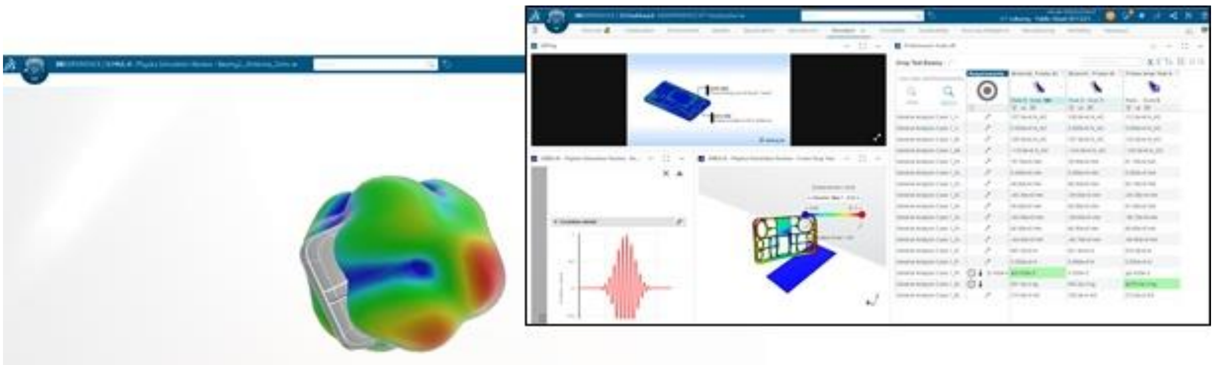
- **Additive manufacturing (Screen printing):** This technology allows for precise and resource-efficient production, minimizing waste and opening doors for customized designs.
- **Energy-efficient processes:** EECONE might explore ways to reduce the energy consumption associated with traditional manufacturing methods, contributing to a smaller carbon footprint.

2.DATA-DRIVEN DESIGN WITH EECONE'S LCA EXPERTISE:

Life Cycle Assessment (LCA) is a critical foundation of our design philosophy. By conducting in-depth LCAs on remote controls, we gain a comprehensive understanding of their environmental impact throughout their entire lifespan. This valuable process, facilitated by the extensive tools and expertise of the EECONE Project, empowers us to make informed design decisions. The data gleaned from LCAs allows us to pinpoint areas for improvement and measure the effectiveness of our eco-design strategies in minimizing the environmental footprint of our remote controls.

3.RIGOROUS SIMULATION TESTING: OPTIMIZING PERFORMANCE SUSTAINABLY:

We don't compromise on functionality. Through comprehensive multi-physics simulations, we ensure our eco-friendly designs meet the highest standards for performance and durability. These simulations, facilitated by the advanced tools within EECONE, minimize the need for physical prototypes, further reducing our environmental footprint.



A 3-YEAR JOURNEY TOWARDS AN ECO-FRIENDLY REMOTE CONTROL

A cornerstone of our commitment to creating truly sustainable remote controls is validating the effectiveness of our multifaceted eco-design approach. To achieve this, we will employ a rigorous testing methodology:

DEFINING THE COMPARISON LANDSCAPE: COMMON FEATURES ACROSS RCU GENERATIONS

To ensure a fair and comprehensive comparison, we have identified a **predefined list of key features** that will be evaluated for each RCU generation.

Antenna

State of the Art	EECONE Innovation
Is implemented on a conventional rigid designed substrate	To be implemented on semi-flexible/semi-rigid substrate
Silver ink	Graphene or copper ink
	Recycled copper ink

(Antenna + PCB) Manufacturing

State of the Art	EECONE Innovation
Subtractive methods (with hazardous chemicals, waste and bio-incompatibility)	Printing-based additive manufacturing (Eco-Design)

Power source

State of the Art	EECONE Innovation
Primary batteries (E-Waste)	Use rechargeable batteries
	Use solar-powered technology
	Use radio frequency energy harvesting
	Use ambient light harvesting (sunlight + lamp lighting)
	Recycling models, no primary batteries
	Use batteries with bio-derived components to enhance the batteries' recyclability

Binding Agent

State of the Art	EECONE Innovation
No issue with the binding agent because materials are not carbon-based	Use a binding agent that doesn't hinder electrical conductivity (if carbon-based materials are used such as graphene on the PCB)

Casing

State of the Art	EECONE Innovation
The 70% M-ABS plastic used for housing.	Use of 100% chemically or mechanically recycled plastics. Refurbishment at end of life.
The M-ABS plastic in use is oil-based	Use ABS plastic that is bio-based

Casing manufacturing

State of the Art	EECONE Innovation
Both electric plastic injection press and hydraulic plastic injection press are used	Use an electric plastic injection press instead of an hydraulic one since it consumes less energy

Design Freedom

State of the Art	EECONE Innovation
RCU designed for performance	Open design opportunities with flexible materials
	RCU designed to be easily recycled and refurbished
	Optimized design for reduced Bill of Materials (BOM)

Ink

State of the Art	EECONE Innovation
Silver-based, high environmental impact, high cost	Use carbon allotropes instead of silver for ink formulation
	Replace silver with copper
	Replace silver with recycled copper
	Reduction of conductive traces thickness

Manufacturing

State of the Art	EECONE Innovation
High volumes of water are used	Use limited water volumes
Non-renewable energies are used (especially coal in China)	Use renewable energies during the manufacturing phase
Plastic injection molding represents 55% of the RCU's casing environmental impacts	Optimize casing's design to reduce energy required for injection molding

Packaging of the RCU

State of the Art	EECONE Innovation
Non-recycled materials	Use recycled materials for the packaging
Single use plastics currently used in some packaging	Do not use any single use plastics

PCB

State of the Art	EECONE Innovation
The design is not optimized to be modular	Have a modular design
FR4 is the substrate used in the PCB, traditionally made of Fiberglass reinforced with epoxy resin.	Use PET or Bio-based flexible substrates (PLA, PVA, cellulose)
	Reduce the total weight of material used in the PCB
No recycled metals used in the manufacturing process	Manufacture the PCB with recycled metals

User Experience

State of the Art	EECONE Innovation
Regular RCU (transmit signals wirelessly to control electronic devices via a mechanical input)	Include LEDs for use in low-light conditions
	Allow the control through motion option
	Allow the voice control option
	Be able to control multiple devices at the same time
	Allow customization of settings to suit individual preferences

Beyond the State of the Art

State-of-the-art technology refers to technology that is currently the best available. This can be a somewhat subjective term, as what is considered state-of-the-art in one field or industry may not be in another. Generally speaking, state-of-the-art technology is the most advanced technology available in a given field or industry. Here the State of the Art is as of march 19th 2024.

By establishing this common set of features, we guarantee a like-for-like comparison that accurately reflects the environmental impact reduction achieved through our approach.

DESIGNING FOR SUSTAINABILITY: OPTIMIZED RCUS WITH EECONE 6R PRINCIPLES

Next, we will leverage the power of the EECONE project and our multifaceted approach to design two optimized versions of the RCU. These optimized RCUs will be specifically designed with the EECONE 6R principles in mind.

LCA COMPARISON AND ENVIRONMENTAL IMPACT ASSESSMENT:

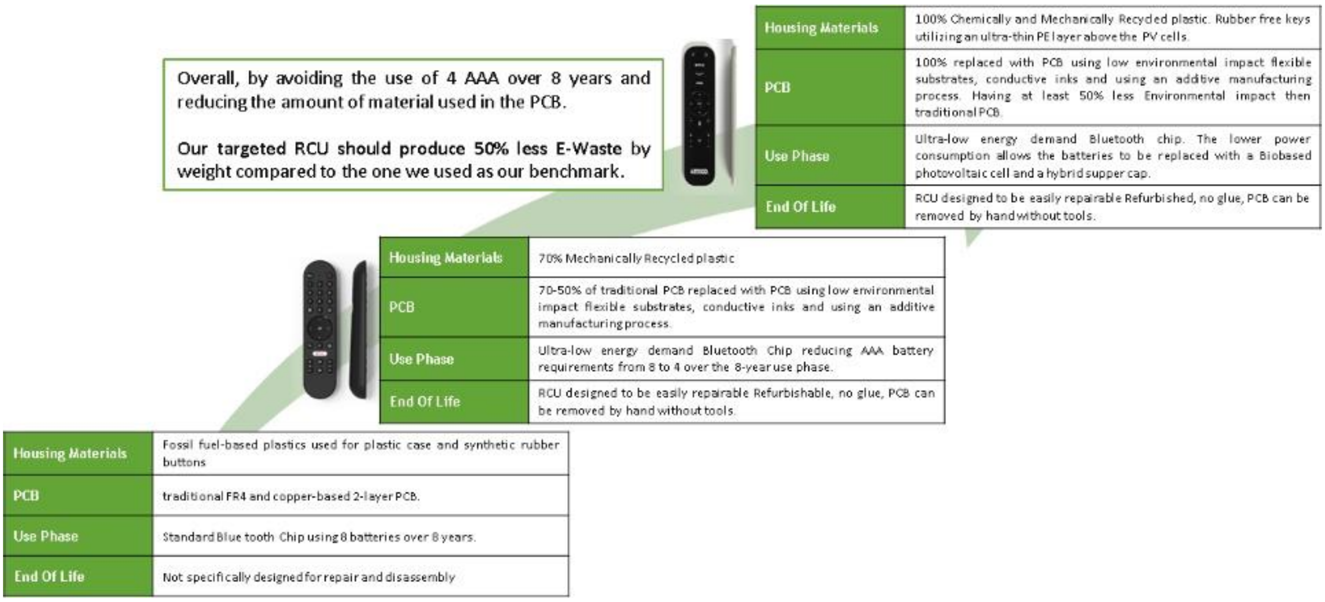
Following the design and development of the optimized RCUs, we will conduct a comparative LCA for each. By comparing the results of these LCAs to the baseline established with the standard RCU, and considering all the pre-defined features, we can quantitatively assess the environmental impact reduction achieved through our multifaceted approach and the application of EECONE 6R principles.

BENEFITS OF VALIDATION:

This rigorous validation process provides several key benefits:

- **Quantified Sustainability:** We can demonstrate the effectiveness of our eco-design approach with concrete data, showcasing the environmental benefits achieved through reduced resource consumption, lower energy use, and responsible end-of-life practices.
- **Continuous Improvement:** The insights gleaned from the comparative LCA will guide future design iterations, allowing us to refine our approach and continuously improve the environmental footprint of our remote controls.
- **Transparency and Credibility:** By openly sharing the results of this validation process, we demonstrate our commitment to transparency and build trust with consumers and stakeholders who share our vision for a sustainable future in electronics.

By employing this comprehensive validation approach, we not only ensure the effectiveness of our sustainable design strategies but also establish a foundation for continuous improvement and leadership within the field of eco-friendly electronics.



A HOLISTIC APPROACH EMBODIED IN THE CIRCULARITY RATING:

RCU	CIRCULARITY	E-Waste	Environnemental Impact	Performance	Cost	User Experience
RCU 00	C+	D	C	C	A	B
RCU 01	B-	C	C	B	B	B
RCU 02	A-	A	A	B	B	A

Our weighted circularity rating system considers a holistic range of parameters crucial for truly sustainable design:

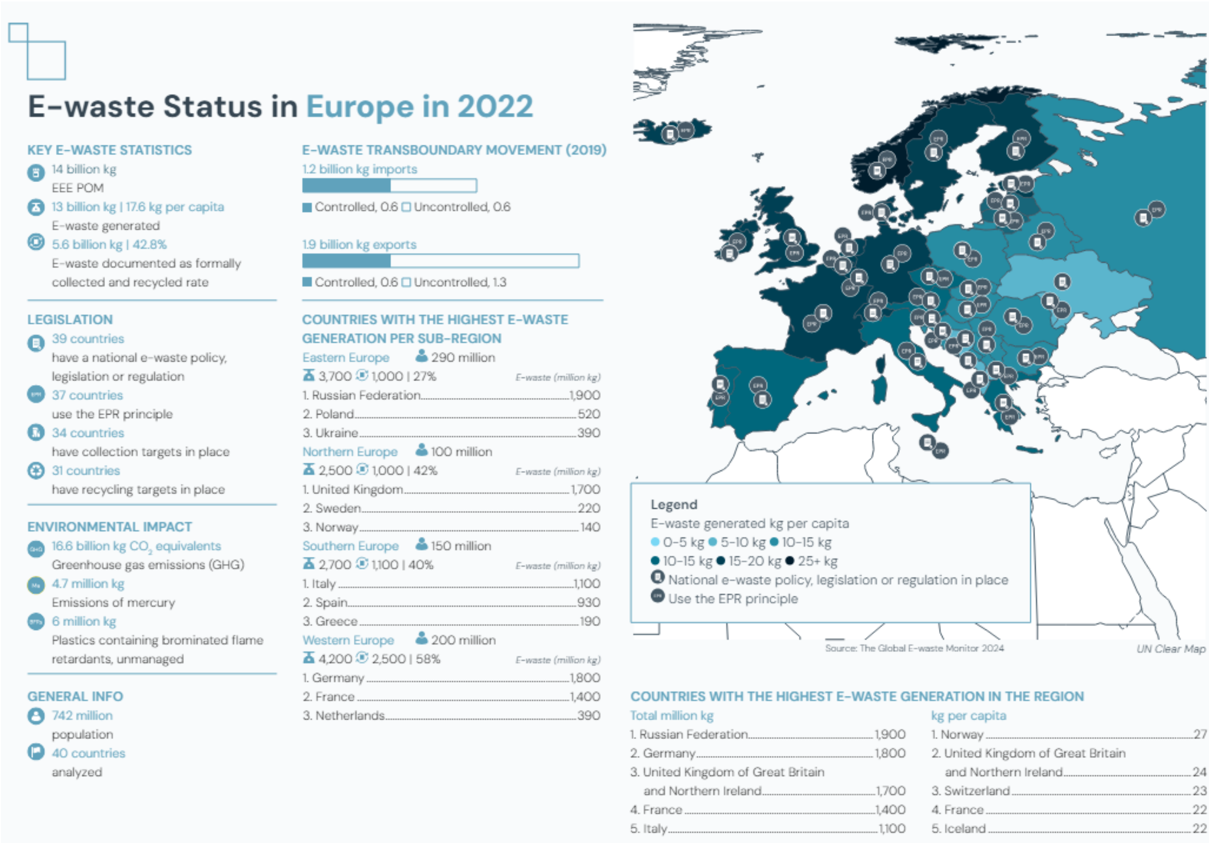
- **Environmental Impact:** We minimize the lifecycle footprint of the remote control, focusing on aspects like material selection, energy efficiency, and manufacturing processes.
- **E-waste Reduction:** This factor prioritizes designs that generate less electronic waste. We explore strategies like increased durability, easier repairability, and use of recycled content.
- **Performance:** Ensuring the remote control functions effectively and reliably remains paramount. However, we optimize performance within the context of reduced environmental impact.
- **Cost:** We strive for a balance between affordability for consumers and sustainable practices. This ensures that eco-friendly remote controls are accessible to a wider audience.
- **User Experience:** Creating a remote control that is intuitive and enjoyable to use is still important. However, we strive to achieve this without compromising on sustainability principles.

BENEFITS OF THE CIRCULARITY RATING SYSTEM:

- **Standardization for Sustainability:** This system can become a benchmark for the entire electronics industry, fostering a shift towards a more sustainable future. By establishing a common language for circularity, we can encourage collaboration and innovation across the sector.
- **Transparency and Consumer Empowerment:** The weighted circularity rating provides consumers with clear and transparent information about the environmental impact of a product. This empowers them to make informed choices and prioritize sustainable options.
- **Continuous Improvement:** The rating system itself can evolve over time as new technologies and design strategies emerge. This ensures that the bar for sustainability is constantly being raised, leading to progressively more eco-friendly electronics.

THE POWER OF A RIPPLE EFFECT:

The success story of the RCU case study, combined with the introduction of the circularity rating system, creates a powerful starting point for positive change. By replicating and expanding this approach across the vast landscape of small electronics, we can create a ripple effect of positive environmental change. Furthermore, the potential for the circularity rating system to become an industry standard can have a far-reaching impact on the sustainability of the entire electronics sector.



BEYOND THE REMOTE: EXPANDING ECO-DESIGN IMPACT

The principles presented above, centered around R&D innovation, data-driven design with LCA, and rigorous simulation testing, can be effectively adapted to optimize the sustainability of a wide range of products.

Here are some specific examples of small electronic devices that could significantly benefit from these eco-design strategies:

Wireless headphones and earphones: Similar to RCUs, these devices rely on electronic components and batteries. By employing innovative materials with lower environmental footprints and exploring design elements that facilitate easier disassembly and repair, we can significantly reduce the environmental impact of these popular electronics.

Wearable fitness trackers and smartwatches: The ever-growing market for wearable technology presents both opportunities and challenges from a sustainability perspective. Applying our eco-design approach can lead to the development of wearables with extended lifespans, reduced material usage through miniaturization, and increased reliance on recycled content.

Portable gaming consoles and handheld electronics: The portability and frequent upgrades associated with these devices can contribute to e-waste concerns. By implementing eco-design principles, we can create more durable and energy-efficient handheld electronics, potentially extending their lifespan and reducing the need for frequent replacements.

The potential benefits of implementing eco-design across the entire spectrum of small electronics are truly multiplied. Consider these possibilities:

Reduced Environmental Impact: By applying these strategies across a vast array of devices, the cumulative reduction in material usage, energy consumption, and e-waste generation can be substantial.

Conservation of Resources: The focus on efficient material use and extended lifespans through eco-design can help conserve precious resources and minimize our reliance on virgin materials.

A More Sustainable Future: Widespread adoption of eco-design principles for small electronics can pave the way for a more sustainable future for the electronics industry, minimizing its environmental footprint and fostering responsible production practices.

CONCLUSION: A SUSTAINABLE FUTURE FOR ELECTRONICS

The potential for a more sustainable future for electronics is within our reach. This proposal outlines a multifaceted approach, centered on eco-design principles, that demonstrably reduces the environmental impact of small electronics. The successful application of these principles to remote controls, leveraging innovations from the EECONE project, serves as a powerful case study.

KEY TAKEAWAYS AND A VISION FOR SUSTAINABILITY:

- **Reduced Environmental Impact:** By adopting eco-design principles, we can significantly lessen the environmental footprint of small electronics across their lifecycle. This includes minimizing material usage, optimizing energy efficiency, and prioritizing sustainable materials.
- **Circular Economy Champion:** Eco-design naturally aligns with the principles of a circular economy. Promoting design for durability, repairability, and recyclability can minimize e-waste and foster responsible resource use.
- **Consumer Empowerment:** A transparent and holistic approach to eco-design, like the proposed circularity rating system, empowers consumers to make informed choices. This drives demand for sustainable electronics, pushing for further innovation and responsible production practices.
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PROPOSAL: EMBRACING ECO-DESIGN FOR A GREENER FUTURE

This proposal urges the entire electronics industry to embrace eco-design principles and implement them across product lines.

CALL TO ACTION:

- **Standardize Sustainable Practices:** Collaborative efforts to establish common eco-design standards and metrics can accelerate progress and create a level playing field for sustainable electronics.
- **Invest in Green Innovation:** Increased investment in R&D focused on sustainable materials, manufacturing processes, and innovative design solutions is crucial for the future of eco-friendly electronics.
- **Educate Consumers and Stakeholders:** Raising awareness about the importance of eco-design and empowering consumers with the knowledge to make sustainable choices is essential for driving change throughout the electronics ecosystem.
- By adopting these recommendations, we can create a future where:
- **Eco-design becomes the industry standard:** Sustainable practices are seamlessly integrated into the design and development of all electronics.
- **Transparency empowers consumers:** Consumers are empowered with clear and transparent information about a product's environmental impact.
- **Collaboration fosters innovation:** Collaborative efforts within the industry accelerate the development of even more sustainable solutions.

Let's embark on this journey together. By embracing eco-design principles and fostering a collaborative spirit, we can create a future where electronics are not just essential tools, but also responsible partners in a sustainable world. This proposal lays the groundwork for a greener future – let's turn it into a reality.