Multi-partner project: Ecodesign to reduce electronic waste

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Abstract—**This paper presents the Chips JU project EECONE, a European initiative dedicated to reducing electronic waste. We outline the project's overarching goals and highlight ongoing work focused on integrating circularity principles into the design phase of electronics. Our research aims to develop methods and tools that enable designers to assess environmental impacts and embed circular economy strategies from the outset. We also examine the data and metrics essential for effective ecodesign and demonstrate early results from the EECONE ecodesign platform through real world case studies. These findings illustrate the potential of design stage interventions to drive environmental sustainability across the electronics value chain.**

I. INTRODUCTION

The rapid digital transformation and the growing reliance on electronic technologies have led to a surge in the production and use of electronic devices, driving global e-waste generation to unprecedented levels. By 2022, the world generated 62 billion kg of e-waste, yet only 22.3% was documented as formally collected and recycled in an environmentally sound manner [1]. This figure likely underestimates actual recycling rates due to incomplete documentation, but it highlights that sustainable end-of-life management remains far from systematic.

The Chips JU project EECONE, running from July 2023 to June 2026, structures its activities around the ambition of reducing electronic waste. To this end, the project is guided by the concept of 6R: Reduce, Reliability, Repair, Reuse, Refurbish, Recycle. Most of these strategies are well recognized within the framework of the circular economy [2]. However, their systematic integration into electronic design processes remains limited. Moreover, reliability has only recently been considered from an environmental sustainability perspective [3], [4]. Three main research directions structure EECONE: (i) management of existing electronic waste; (ii) development of a new generation of electronics with low environmental impact; (iii) design methods and tools for environmentally sustainable electronics. This paper focuses on the third direction, hereafter called ecodesign research direction, which introduces circular economy thinking as an enrichment of traditional ecodesign.

Design decisions made during the early stages of product development determine up to 80% of a product's environmental impact throughout its life cycle [5]. This is because choices regarding materials, architecture, modularity, and manufacturing processes are largely fixed once production begins. Addressing environmental sustainability at the design stage therefore offers greater potential for reducing resource consumption, improving circularity, and minimizing overall environmental impacts compared to downstream mitigation alone. Life Cycle Assessment (LCA) provides a robust framework for quantifying environmental impacts, but it remains insufficient alone to support ecodesign and circularity strategies: LCA typically evaluates designs post-hoc, requires specialized expertise, and does not inherently guide designers toward circular alternatives [6]. Achieving ecodesign goals requires methods and tools that embed environmental assessment and circularity principles directly within the design flow, making them accessible to electronics designers and engineers who may lack dedicated environmental expertise. Currently, environmental assessment in electronics design relies primarily on specialized LCA software (e.g., SimaPro, GaBi, openLCA) and commercial databases such as ecoinvent. While powerful, these tools present several barriers for routine use by design engineers: they require significant environmental expertise to operate correctly, they are often costly, and their workflows are disconnected from the electronic design automation tools that engineers use daily. As a result, environmental assessment is frequently performed post-design by LCA specialists, at a stage when design modifications are costly or impractical.

The objectives of the ecodesign research direction within EECONE are structured around three main dimensions: metrics and data, methods and tools, and guidelines. The first objective is to identify and, where necessary, define new and field-oriented ecodesign metrics, along with the data required for comprehensive environmental assessment. The second is to develop methods and tools that enable electronic designers and

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engineers to systematically integrate environmental criteria into their design flows. In this context, we introduce the concept of an ecodesign platform, intended as a catalog of methods and tools developed to facilitate the assessment of multiple environmental impacts, to account for different life cycle stages, and to embed circularity-by-design principles directly within the design process. Finally, the third objective is to derive guidelines for ecodesign, offering qualitative insights and consolidating knowledge from research and practical implementation to support broader adoption of ecodesign practices in the electronic domain.

To ensure the relevance and applicability of these developments across the electronics domain, the ecodesign axis considers three complementary design levels at which metrics and data, methods and tools, and guidelines are applied: the Integrated Circuit (IC) level, the Printed Circuit Board (PCB) level, and the system level. This multi-level approach ensures that ecodesign principles are consistently embedded across the electronic value chain. By addressing these three levels with a common framework of metrics and interoperable tools, designers working at different stages of the value chain can share data and environmental assessments, fostering interoperability between design tools and enabling holistic optimization across system boundaries.

II. ECODESIGN METRICS AND DATA

Achieving the ultimate goal of reducing electronic waste requires that ecodesign extends beyond traditional environmental assessment, which typically focuses on quantifying impacts such as carbon footprint, energy consumption, and resource depletion, to explicitly integrate circularity strategies into the design process. Environmental evaluation alone, while essential, provides only a partial view towards reduction of environmental impacts if not complemented by design choices that guarantee reliability and enable repairability, reuse, refurbishment, and recycling. To operationalize such integration, quantitative metrics are needed to guide design decisions and ensure that circularity considerations are embedded from the earliest stages of electronic development.

Equally important is the availability of accurate, up-to-date, and transparent datasets to support environmental assessment. Without reliable data, designers cannot evaluate trade-offs between design options, compare environmental performance across alternatives, or make informed decisions that balance traditional engineering parameters (power, performance, area) with sustainability objectives.

A. Metrics: Quantifying environmental performance

In EECONE, a set of around 100 metrics has been collected to support both environmental assessment and the anticipation of circular economy strategies. The breadth of this collection reflects the multifaceted nature of ecodesign, spanning environmental impact indicators (e.g., carbon footprint, acidification potential), circularity metrics (e.g., recycled content, disassemblability index), reliability indicators (e.g., mean time between failures), optimization targets, environmental score, and absolute sustainability. For each metric, we specify: the circular economy strategy it supports among the 6R, its intended purpose (whether to monitor progress or enable comparison), and the design level to which it applies (IC, PCB, or system). A first list of metrics has been published by EECONE partners [7].

B. Environmental assessment databases: Limitations

The applicability of conventional LCA databases to contemporary electronics can be constrained by representativeness, methodological choices, and the pace of technological change. Among the most established databases for LCA, ecoinvent [8] serves as a key reference for environmental impact modelling. However, its coverage of processes specific to electronics remains limited, reflecting a broader challenge common to most existing Life Cycle Inventory (LCI) databases. This section examines these limitations for two key components: PCBs and ICs.

Available PCB datasets often reflect specific regions, manufacturing scales, or time periods. Since PCB production practices and geographies evolve, practitioners may observe discrepancies between historical models and primary data collected from current facilities (for example, energy demand or chemical use for different layer counts and process routes). To address this EECONE partners are enhancing generic inventories with recent, region and technology specific information. For instance, the PCF Tool for PCBs developed by AT&S (described in Section III) incorporates primary data from current manufacturing operations to improve representativeness while maintaining compatibility with established LCA workflows.

In modelling ICs, the sensitivity to proxy selection and foreground parameters is particularly acute. Approaches relying on readily observable attributes (e.g., package characteristics like weight) may not fully capture die-level drivers of impact, whereas alternatives (e.g., die area or process node-specific models) can better reflect fabrication realities when data are available. Electricity consumption and assumptions about the electricity mix are major contributors to overall impacts; results can therefore vary materially with site-specific conditions and technology choices. EECONE addresses these challenges by integrating state-of-the-art IC data from the imec.netzero initiative [9] into the ecodesign tools, and by adopting parameterisations aligned with current manufacturing practices, where transparency permits, which helps improve consistency and interpretability across studies [10], [11].

Electronics advance rapidly, from packaging architectures such as multi-die integration (combining multiple semiconductor dies in a single package) and three-dimensional stacking (vertically interconnecting dies to reduce footprint) to evolving wafer specifications and process nodes. Legacy models may lag behind these shifts, making some mass-based or package-level proxies, which estimate impacts based on component weight or package type less reliable over time. EECONE is developing iterative updates and modular inventories that reflect current design and manufacturing trends to maintain relevance.

For most IC and advanced packaging steps, LCI parameters remain proprietary. Limited public disclosure may therefore introduce variability across published LCAs of apparently similar devices. EECONE supports initiatives that enable secure sharing of anonymized, state-of-the-art process information, combined with clear metadata and versioning, to enhance comparability without compromising intellectual property.

Together, these limitations underscore the urgent need for more accurate, up-to-date, and transparent datasets tailored to electronics LCA—a central motivation for the data and tool development activities within EECONE.

III. ECODESIGN TOOLS: INTEGRATING ENVIRONMENTAL ASSESSMENT AND R STRATEGIES IN EARLY DESIGN

The EECONE ecodesign research direction aims to develop accurate, transparent, and up-to-date tools that support environmental assessment and the integration of the 6R principles from the early design phase of electronics. These tools are organized in a structured catalog (Figure 1), where each tool is described through an identity card summarizing its scope, target product granularity (IC, PCB, system), and alignment with the 6R. This structure enhances accessibility and interoperability for designers and sustainability experts. The following section presents selected tools from the catalog.

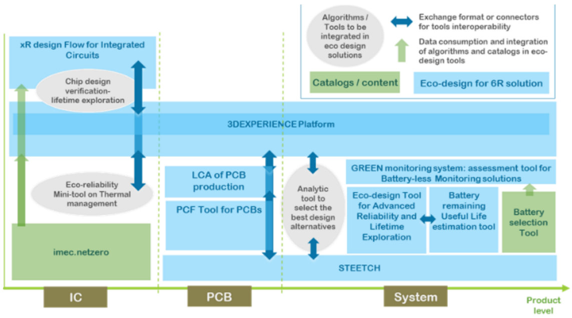


Figure 1: Ecodesign tools catalog. Each tool is shown together with its type (algorithm, catalog/content or ecodesign solution) and the electronic design level it addresses (IC, PCB, system).

A. *Ecodesign Tool for Advanced Reliability and Lifetime Exploration*

The Ecodesign Tool for Advanced Reliability and Lifetime Exploration supports sustainable design and life cycle management of electronic devices. It integrates two main subsystems: the Monitoring Data Quality System and the Remaining Useful Life (RUL) Prediction System. The former the reliability of input data by detecting data drift, while the latter estimates device degradation and lifetime using simulations and artificial intelligence. Together, they enable early detection of problems, informed maintenance decisions, and design optimization aimed at improving reliability and reducing electronic waste.

The Monitoring Data Quality System is a data quality control tool that focuses on monitoring and detecting alterations in time series. It identifies data and target drift using statistical methods such as Chi-square, Kolmogorov–Smirnov, and the Population Stability Index (PSI), comparing data distributions over different time periods [12]. Additionally, change detection algorithms, including Page-Hinkley and ADWIN [13], are employed to detect gradual or abrupt deviations in data quality. The system generates visual and statistical reports, ensuring that data feeding subsequent analyses and predictive models remain valid and trustworthy.

The RUL Prediction System estimates degradation and remaining service life, using temperature sensors as main example. It employs the SPICE electrical circuit simulator [14] to model aging effects such as sensitivity loss, offset drift, and increased electrical noise. A coupled thermal model captures seasonal and daily temperature variations to emulate realistic operating conditions. The data generated is used to train an LSTM (Long Short-Term Memory) neural network [15], which learns temporal degradation patterns and predicts future measurement error. This subsystem supports engineers in assessing sensor degradation, scheduling preventive maintenance, and optimizing design for enhanced reliability and service life.

B. *PCF Tool for PCBs*

The PCF Tool for PCBs is a tool developed by AT&S that enables the calculation of Product Carbon Footprints (PCF) of PCBs in accordance with the ISO 14067. It is based on the concept of incorporating all major design aspects that significantly impact the PCF, such as:

- Base materials used in PCB build-up: copper-clad laminates, pre-impregnated fibre sheets, and copper foils.
- Manufacturing technologies: Different technologies result in different specific manufacturing process steps. Therefore, the technology must be represented in the tool to enable accurate inventory analysis.
- Number of layers: In the tool, this is directly reflected through the manufacturing process steps (multiple layers mean the process steps are repeated accordingly).
- Size: PCBs are manufactured on panels of specified dimensions. Thus, panel utilization and the overall size of the PCB are significant influencing factors.
- Surface finishing: Various coatings for the copper pads on the top and bottom sides of the PCB are available, each with a different impact on the PCF depending on the material chosen.

The Impact Assessment is calculated using modified and adapted emission factors from the ecoinvent database for energy, chemicals, and materials involved. For energy, depending on the scenario, either location-based or AT&S-specific market-based factors can be applied. Special chemicals used in production are modelled based on their ingredients, and for base materials, a methodology was developed to model specific impacts based on material specifications (e.g., thickness, glass and resin content, copper thickness, and country of origin).

The advantage of the bottom-up methodology used in the tool is its ability to generate detailed assessments that show the distribution of emissions across materials, waste, and processes. This detailed view forms the basis for applying and evaluating ecodesign measures.

C. *STEETCH*

STEETCH is an ecodesign tool for electronic systems co-developed by CEA-Leti, INP-Gre/UGA/CNRS, SCHAEFFLER and DTI. STEETCH is an open access web application which supports electronic designers in integrating environmental considerations early on within their design process. Environmental assessment of electronic systems is complex and usually requires the use of expensive databases. For that reason, it is often performed by LCA experts, post-design, once it is no longer possible to modify the system. On the one hand, STEETCH will allow electronic experts to easily assess the environmental impacts of their designs, compare them and confront them with cost and performance data, thus guiding their choices. This simplified environmental assessment will be based on an open access LCA database. On the second hand, STEETCH will embed a Knowledge Base, gathering design guidelines, tips and educational content intended to empower designers to make informed and relevant ecodesign choices for their systems. This tool will be adapted for Power Electronic Systems (and PCB electronics in general), and Printed Electronics.

D. *3DEXPERIENCE Platform*

The 3DEXPERIENCE Platform, developed by Dassault Systèmes, provides a cross-level (IC, PCB, system) backbone enabling integration of metrics, tools, and guidelines. It is a collaborative environment that spans the entire product lifecycle, from design and engineering to manufacturing and operations, and includes dedicated applications for sustainability assessment. A key requirement for ecodesign is to combine trusted background data with the flexibility to adapt inventories to product and site-specific realities. In this context, the platform introduces 'Human Activities' to provide an abstraction of processes across the product lifecycle (e.g., manufacturing or transportation operation). Stored in a central database (3DSpace), these activities include metadata such as version, geolocation, lifecycle phase, and impact formulas. Moreover, they are organized according to the International Standard Industrial Classification (ISIC) [16], which ensures alignment with recognized taxonomies, transparent documentation, and adaptability to regional contexts. This abstraction layer enables to model consistent processes while maintaining traceability.

The platform enables also environmental data management through four complementary mechanisms:

- Native access to ecoinvent database: Through the 'Business Value Definition' application, users can directly access multiple versions of ecoinvent to assign activities across all lifecycle phases to Product Lifecycle Management (PLM) entities, with full version traceability.
- Ingestion of external databases via EKL: The 'Enterprise Knowledge Language' (EKL) allows the integration of external or proprietary datasets into the platform, improving representativeness (e.g., regionalized LCIs or experimental data) while keeping data governance within the PLM backbone.
- Creation of custom processes 'Human Activities: With the 'Business Activities Definition' application, users can define specific 'Human Activities' (complete with formulas, lifecycle phases, and geolocation) which are then stored and reused in LCA studies, ensuring consistency across projects.
- Collaboration: Collaboration is organized through 'Collaborative Spaces'. The database is common across the platform, so 'Human Activities' created in one collaborative space are visible to others. However, to protect intellectual property (IP), sensitive content such as formulas remains hidden outside the originating collaborative space: only the activity name is visible. This principle ensures both interoperability and confidentiality.

Overall, the 3DEXPERIENCE Platform approach combines standard reference data (ecoinvent), extensibility (via EKL and Human Activities), and IP-aware collaboration. This balance makes it possible to overcome the limitations of static or "black-box" databases and to support transparent, adaptable, and secure ecodesign workflows in electronics.

A major advantage of the EECONE approach is the seamless integration of specific, up-to-date IC data from imec.netzero initiative [9] into the 3DEXPERIENCE Platform. This enables design teams to evaluate the environmental impact of their products with a much higher degree of accuracy, especially for electronic components. As a result, designers can make informed decisions about materials, manufacturing processes, and product features, with immediate feedback on sustainability outcomes. This synergy supports continuous improvement and helps organisations meet increasingly stringent environmental requirements.

In alignment with EECONE activities, Dassault Systèmes explored workflow automation to operationalize circular economy principles within industrial organizations. Building on industrial deployments of Iterop for large-scale process digitalization [17], this work extends its capabilities to sustainability and ecodesign process management. The goal is to embed ecodesign and circularity criteria directly into enterprise workflows—spanning design, procurement, repair, and end-of-life management—thus transforming sustainability from a reporting activity into an actionable, traceable framework. Using Iterop, environmental checkpoints can be implemented as decision gates referencing EECONE circularity metrics (e.g., recycled content, disassemblability, repair potential) or LCA results from the 3DEXPERIENCE Platform.

IV. CASE STUDIES

EECONE encompasses ten use cases covering various application domains and design challenges. The target domains are: automotive, consumer electronics, health, ICT, aeronautics, agriculture. The use cases serve to demonstrate and validate the results obtained in the three research directions of the project.

In this section, we discuss the validation results obtained for selected use cases employing the ecodesign tools described in the previous section. For each case study, we provide initial findings and early results, together with the planned developments and expected outcomes for the remainder of the project.

A. *Green-Soil Probe*

The use case Green-Soil Probe addresses the environmental challenges associated with IoT devices used in agriculture to monitor field conditions. These devices measure soil temperature and moisture near plant roots, providing useful information for optimizing irrigation, fertilization, pest management, and more. Many of their components contain hazardous materials, with lithium batteries being a prime example. The focus of the use case is the reduction of electronic waste through multiple strategies: adopting organic substrates, modular design for component reuse, and even replacing conventional primary lithium batteries with more sustainable alternatives.

The Eco-Design Tool for Advanced Reliability and Lifetime Exploration supports the use case's sustainability goals through its two components. First, Data Quality Monitoring enables continuous validation of sensor data integrity. By detecting data drift and quality degradation in sensor measurements, the system can identify when the sensors are no longer providing reliable data. This capability is critical for determining the optimal replacement time. It also ensures that data-driven decisions remain accurate. Additionally, the RUL Prediction feature anticipates device aging and sensor degradation patterns, making it possible to design better calibration methods and maintenance schedules by predicting how sensor measurements drift. The initial results of the system using synthetic data are encouraging. The LSTM-based model achieved small final errors (mean squared error (MSE): 0.000019, root mean squared error (RMSE): 0.0043, mean absolute error (MAE): 0.0020), demonstrating the model's ability to predict data with high accuracy. Even when predicting up to six steps ahead, the error (RMSE: 0.005050, MAE: 0.002579) naturally increases but remains low. Since the model generalizes well and remains reliable for short-term and multi-step predictions, it leads to a longer sensor life and more reliable operation of the entire system.

Moreover, within the Green-Soil Proble use Case, a close collaboration between CSEM, TST, and Dassault Systèmes has been established to evaluate the environmental impacts of lithium-ion electrode manufacturing. The study focuses on comparing two process routes, the conventional solvent-based approach (PVDF: Polyvinylidenefluoride / NMP: N-methyl-2-pyrrolidone) and an alternative water-based process using biopolymers as binders, both representative of current industrial and emerging low-impact practices. Using CSEM's detailed bill of materials, process flow parameters, and operational data, the partners jointly modeled the electrode line within the 3DEXPERIENCE platform, linking process operations (mixing, coating, drying, calendering) to corresponding ecoinvent life-cycle inventories. This work has resulted in the development of two environmental assessment models:

- a comprehensive LCI-based model relying on ecoinvent datasets and process-level time mapping (via DELMIA) to capture the energy and material intensity of each operation, and
- a fixed-factor model using Electricity Maps emission data to estimate impacts based on real-world grid mixes and fuel intensities, offering a rapid cross-check and sensitivity evaluation.

The combination of these two approaches is unique within EECONE, providing both detailed traceability and practical comparability across data sources. Early results indicate a potential decrease in overall energy demand and greenhouse-gas emissions for the aqueous, NMP-free route, primarily due to the removal of solvent recovery and lower drying energy requirements. These trends are being verified through CSEM and TST pilot data to ensure industrial representativeness and alignment with recent literature benchmarks on green electrode manufacturing. Beyond the environmental quantification, this joint study demonstrates the feasibility of coupling process-level modelling, optimization and LCA workflows in a shared digital environment, supporting the future integration of such methods into circular-design and eco-innovation practices across the industry.

B. Power Electronic Products

The ecodesign tool STEETCH will be used to support the design of Schaeffler's High Voltage Box, an On-Board Charger Combined with a DC-DC converter. This product currently being under development, STEETCH will be used to compare the environmental impacts of different design options, and evaluate specific ecodesign strategies aiming at fostering circularity. This use case will also help identify future development requirements for STEETCH. For example, Schaeffler and INP-Grenoble are investigating ecodesign guidelines based on modular design for the DC-DC converter, comparing LCA results of modular design and reference design. The LCA comparison has been conducted on LCA for Experts (LfE) tool with Sphera database. Throughout this work, LCA of the modular design was conducted with two different tools and databases: sphera and ecoinvent. Figure 2 shows the contribution of each part of the product on the Climate Change (kg CO_2 eq.) indicator with each database. Significant deviations among the results are observed when derived from two different LCA tools and databases. These differences call for precaution while trying to compare LCA results that are not produced under same conditions (tool and database especially).

LCA of Power Electronic products highlighted that populated and unpopulated PCBs are one of the main contributors on the Climate Change indicator. With the objective to understand better these impacts and to identify the main contributors in PCB production, the PCF tool for PCBs developed by AT&S has been used in the use case. Figure 3 shows the distribution of emissions of a DCDC-converter's PCB. Results highlight that copper, press and photo processes are the three main contributors in the manufacturing of PCB based on an average Austrian energy mix and general Austrian production conditions.

Further investigation will be conducted on a new design of PCB with copper reduction with the aim of decreasing the environmental footprint of PCBs.

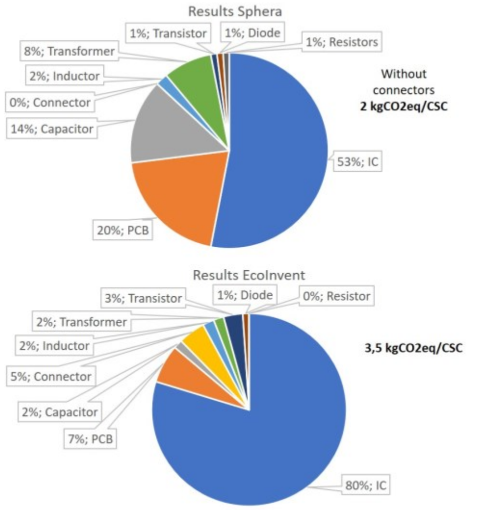


Figure 2: Comparison of the CO2 emission impact category for an elementary conversion bloc, at the manufacture stage, from two different LCA tools and databases.

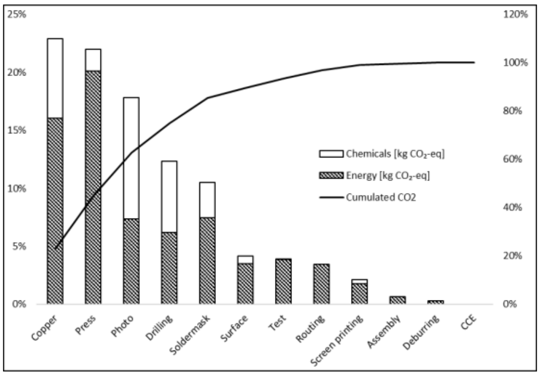


Figure 3: Distribution of emissions as share from total production emissions of the PCB, part of a DCDC Converter, between different process steps. An average Austrian energy mix and general Austrian production conditions were applied.

C. Remote-Control Unit

Another use case of EECONE demonstrates the application of a modular ecodesign catalog to the development of a Remote-Control Unit (RCU). The catalog-based approach supports systematic environmental assessment by enhancing existing datasets like ecoinvent with more up-to-date metrics and representations of electronic manufacturing processes. The RCU use case workflow is orchestrated in the 3DEXPERIENCE Platform, which ensures consistent system boundaries and collaborative data management. In the 'Business Value Definition' application, the 3D product structure is explored part by part: for each component, users define parameters such as material composition and mass, and attach 'Human Activities' representing lifecycle processes such as manufacturing or transport. At this stage, additional datasets can also be integrated by overloading parameters or creating specific activities. For example, data from imec.netzero for ICs and from WEEECycling — a key actor in the French recycling landscape and member of the consortium — on silver-based conductive inks were directly integrated through the application. This approach maintains coherence with the 3D representation of the product while enabling transparent versioning and real-time stakeholder engagement throughout the life cycle assessment process.

The assessment results are then evaluated in the "Sustainability Assessment" application using the Environmental Footprint (EF) methodology, as defined by the European Commission's Joint Research Centre (JRC) in the Product Environmental Footprint (PEF) and Organization Environmental Footprint (OEF) guidelines (European Commission, 2021). Designers can visualize impact indicators at both part and system level, compare variants, and trace how material or process choices affect overall performance and environmental impact.

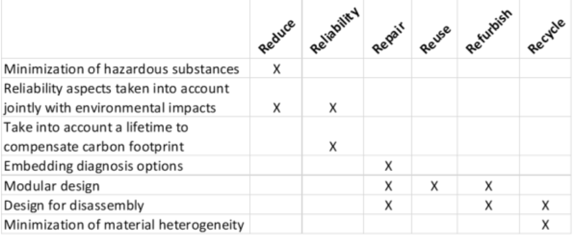
Life cycle modelling of three RCU variants (Baseline, Intermediate, and Mirage Solar) revealed substantial reductions in carbon footprint: from 1.5 kg CO_2 eq. (Baseline) to 0.60 kg CO_2 eq for the Mirage Solar RCU due to integration of the following technologies: i) replacing FR4 based PCB with Flexible printed PCB using Copper based conductive ink, ii) replacing ABS plastic with 70% mechanically recycled plastic, iii) replacing AAA batteries with organic photovoltaic cell and hybrid super capacitor, iv) designing for refurbishment and reuse. The Intermediate RCU design used Silver conductive ink, the results from the LCA analysis in the 3DExperience platform indicated that the use of silver has a significant environmental impact. Consequently, silver was switch to copper ink for the final design.

The RCU use case validates the EECONE catalog-based methodology, demonstrating modular data interoperability and the value of integrating primary, up-to-date datasets for electronics environmental impact assessment. The approach is being extended to additional use cases, with ongoing efforts to expand catalog tagging, refine classification logic, and operationalise eco-design feedback loops in product development workflows. The RCU use cases thus serves as a foundational model for advancing robust, scalable sustainability practices in the European electronics sector.

V. ECODESIGN GUIDELINES

Ecodesign guidelines aim to support decision making in the early stages of the design process. It is expected to help designer considering alternative design choice to minimize electronic product environmental footprint. Design guidelines are complementary to environmental impact indicators and specific ecodesign metrics. More qualitative rather than quantitative, guidelines outline design considerations such as: modular design [18], design for disassembly and/or design for circularity (to ease repair, refurbish, etc...). With the adoption of such guidelines, the cumulative reduction in e-waste and associated emissions could be substantial. Research indicates that increasing the useful lifespan of electronic devices by 50–100% could mitigate up to half of the total GHG emissions from the ICT sector [19], while reducing e-waste

As part of EECONE, the partners have identified approximately twenty guidelines derived from their experience in developing methods and tools for ecodesign, as well as from their application to use cases. Each guideline has been linked to one or more R strategy, ensuring that the full spectrum of the 6R is represented. Table 1 briefly introduces a set of ecodesign guidelines as an illustration.

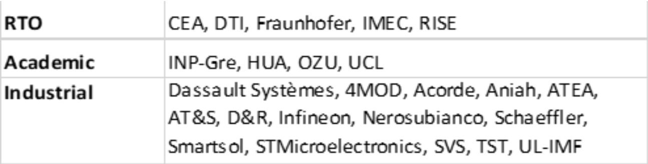


	Reduce	Reliability	Repair	Reuse	Refurbish	Recycle
Minimization of hazardous substances	X					
Reliability aspects taken into account jointly with environmental impacts	X	X				
Take into account a lifetime to compensate carbon footprint		X				
Embedding diagnosis options			X			
Modular design			X	X	X	
Design for disassembly			X		X	X
Minimization of material heterogeneity						X

Table 1: Examples of ecodesign guidelines.

VI. THE CONSORTIUM

EECONE brings together a multidisciplinary consortium of 48 partners from across Europe composed of Research and Technology Organizations (RTOs), academic institutions, and industrial partners. This composition ensures strong synergies among fundamental research, applied technology development, and industrial exploitation. Within this consortium, 24 partners, listed in Table 2, collaborate specifically on the research direction presented in this paper. The research direction on ecodesign is jointly led by Dassault Systèmes and CEA.



RTO	CEA, DTI, Fraunhofer, IMEC, RISE
Academic	INP-Gre, HUA, OZU, UCL
Industrial	Dassault Systèmes, 4MOD, Acorde, Aniah, ATEA, AT&S, D&R, Infineon, Nerosubianco, Schaeffler, Smartsol, STMicroelectronics, SVS, TST, UL-IMF

Table 2: Partners involved in the ecodesign research direction.

VII. CONCLUSION

All the tools proposed in the ecodesign axis of EECONE are currently under active development and are being validated through representative use cases covering different levels of the electronic design flow. In parallel, the complete list of collected metrics and the guidelines will be made available through a public repository to foster transparency and broader adoption within the research and industrial communities.

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