Enhancing WEEE management using the Circular Digital Thread

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Lack of suitable digital infrastructure currently hinders the exploitation of Circular Economy business models to its maximum potential through the integration of the different stakeholders involved in a product life cycle and efficient information sharing as enabler of CE strategies including repair and reuse, refurbishment, remanufacturing and recycling. In present systems product life cycle information is stored in separate silos, and cannot be holistically used for effective decision making. The CE provides a regenerative growth model based on material recovery routes, to ensure materials can stay in the economic loop for as long as possible thus benefitting the sustainability of the economy and the environment and reducing waste generation.

The WEEE value chain, being one of the waste fractions with the highest growth rate, presents large opportunities for the application of the Circular Digital Thread, including a relevant role in prevention, collection and processing by bringing together the most relevant stakeholders involved in the value chain and integrating concepts such as cloud platforms and digital product passports[1].

In this context, The EU funded CircThread project (H2020 2021-2025) will seek to capture, link and share both data and Circular Economy-related information in a collaborative way achieving a Circular Product Chain of Custody. The goal of the platform is to set standard information linkages between the physical and the digital dimension of products, including relevant sets of information such as product status logs, material content, critical raw materials and chemical substances information, product and component lifespan data, environmental and social impact indicators, as well as end-of-use alternatives for citizens to support informed decision-making.

To enable this information link, CircThread will explore existing tools such as manufacturing and component suppliers Bill of Materials (BOM), the Product Environmental Footprint (PEF), Life Cycle Sustainability Assessment (LCSA) and Eco-design as the norm for product assessment and decision-making support. Additionally, Circularity Strategies will take a central role, linking to information relative to product maintenance and lifespan extension, furthered by refurbishment repair and re-use, re-manufacturing, and finally recycling for secondary raw materials use.

To this end, the project will integrate such concepts into seven different use cases (UCs):

1- Product status tracking and tracing as a chain of custody.
2- Product manufacturing information acquisition.
3- In-transit and after-market spare parts recovery.
4- Product End-of-Use recommendation service.
5- Lifespan extension via repair and circular design.
6- Critical raw materials and chemicals evaluation.
7- Consumer purchasing and use decisions.

In the use cases, economic, environmental, circularity and social information exchanges at different life cycle stage between different actors across the product's value chain will be addressed to mainstream decision possibilities. (See Table 1). The CircThread project will implement these cases for home appliances and home energy products in Slovenia, Spain, and Italy. In particular, two of these Use Cases (UC 3 and UC 4) are directly related to WEEE management, targeting an enhanced decision-making process for End-of-Use (EoU) products to support the implementation of the optimum combination of End-of-Life (EoL) management strategies.

[1] Sipka (2021). Towards circular e-waste management: How can digitalization help? EPC. Brussels, Belgium.

UC 3 – In transit and after-market spare parts recovery

UC 3 will try to set effective information exchanges via the Digital Thread from products damaged in-transit and during the useful service life, to assess the availability of spare parts and their quality for re-use in repaired, refurbished and remanufactured products. To this end, it will build on the expertise of manufacturers, logistic operators and repair and collection companies, to make it possible to check the number and the quality of recoverable parts from used appliances, turning them into spare parts with potential for a second life. This will reduce the number of discarded parts that end-up as WEEE, while at the same time optimizing the collection/recovery process and allowing for new business models.

UC 4 – Product end-of-use recommendations

UC 4 provides take-back collectors/waste-management companies with product and component information to evaluate from a materials perspective, the best pathway among the different circularity routes (incl. re-use, remanufacturing and recycling), resulting in a series of End-of-use Circularity Recommendations. To this end, collection companies and producer responsibility organizations will be linked to the platform, building a digital process for them to feed them with circular economy recommendations, informed by economic, social, environmental and logistic evaluations, per product. This will support the creation of a reuse/repair value chain that will contribute to the development of the Circular Economy concept via enhanced recycling/recovery rates and increased number of WEEE correctly disposed of.

Table 1. Circular Digital Thread benefits to CE.

Product stage	CE added value
Purchase	Extended lifespan and increased product longevity from the design stage. Better informed purchase decisions for consumers. Transition to new CE business models.
Use	Tracing spare parts and recovering them from used products boosts circular re-use. Real-time monitoring of the use of the appliance supports predictive maintenance plans to extend the lifespan and better design for OEMs.
Collection	Tracking and tracing of EoU appliances helps tackling the issue of WEEE leakage, cutting down scavenging and illegal trade.
Reuse	Product status log supports decision-making for re-used products and components keeping materials in circulation.
Recycling	Enhanced WEEE recycling performance. Overcoming challenges related to safety and process efficiency in dismantling and recycling.

In terms of information flows within the WEEE value chain, the application of the Circular Digital Thread will allow the exchange of data about the the potential reusable/remanufactured components for each appliance, the requirements to be fulfilled by such components in order to be potentially reusable/remanufactured, the content in potentially hazardous substances to enable safer process operations, and detailed information regarding the materials contained in each equipment, in particular critical raw materials.

The approach is to enable on-site evaluations as part of the sorting and logistics process performed by municipal collection points, retailers, and recycling companies. The service will initially be developed to work with products with a scannable QR code linked to CircThread, integrating information such as specific BOM data, condition of the appliances, and lifespan information. It will also be developed in order to work with legacy end-of-use products where only manual identification is possible, with information approximated based on an operator appliance type selection. This will provide streamlined economic and environmental assessments for the alternative EoU routes. This will also support management challenges arising from limited material information along the product life cycle, for example from products sold more than a decade ago. Banned legacy hazardous wastes and Substances of Very High Concern (SVHC) can end up in recycling streams from electronic wastes when not adequately screened and regulated. To this end three solutions will be explored:

i) visual identification of the product based on a product classification structure as well as machine learning classification using cameras on the conveying system,
ii) automated matching of the identified product relative to the closest related product materials data available from relevant databases,
iii) enhancement of material data from product disassembly using spectroscopic techniques.

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