Circ Thread

Policy Brief #3

Recycling in the Context of the Digital Product Passport

dss+
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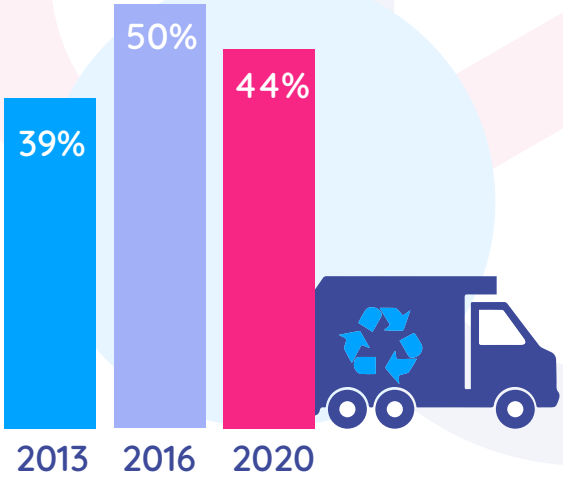
POLICY BRIEF #3: Recycling in the context of the DPP

1.1 Contents Overview

The rapid growth of the electronics industry has brought forth an escalating challenge with the mounting tide of electronic waste (e-waste). Further, EU e-waste collection rates leave significant room for improvement, with the collection rate using the EEE POM method having increased from 39% to 50% from 2013 to 2016, only to then drop from 2016 to 2020, to 44%[1]. Addressing these challenges is crucial not only for environmental preservation but also for securing critical raw materials (CRMs) vital for sustainable development. In Europe, the recycling of electronics faces multifaceted barriers, including the absence of detailed material information, complexities in identifying and sorting materials, and the lack of optimal policy frameworks.

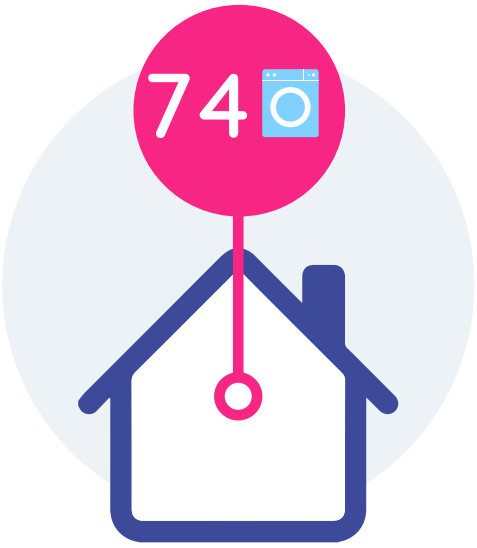


This paper critically examines the potential role of Digital Product Passports (DPPs) in improving electronics recycling in Europe. Analysing the existing state of e-waste recycling, the paper underscores the information-related hurdles inhibiting efficient recycling processes and CRM recovery. It delves into the inadequacies of current recycling practices, emphasises the significance of material transparency, and highlights the gaps within policy frameworks.

In proposing a comprehensive framework, the report outlines recommendations to maximise the potential for DPPs to address these challenges. The recommendations encompass standardised material declarations, enhanced material identification, disassembly guidelines, efficient feedback loops, consumer education, and realistic implementation strategies. The paper further underscores the importance of collaboration between policy makers, manufacturers, and recyclers to design a DPP framework that is both practical and effective.

DPPs hold the potential to bridge information gaps, help streamline recycling processes, and drive critical raw materials recovery. However, for this vision to materialise, stakeholders must align their efforts, harmonise standards, and ensure the proposed solutions resonate with the practical realities of electronics recycling. In doing so, DPPs can hopefully contribute to a more sustainable and circular electronics industry in Europe.

1 https://www.electronic-recycling.ie/custom/public/files/update-of-weee-collection-2021.pdf



1.2 State of e-waste recycling in Europe & information-related barriers

The electronics industry has experienced exponential growth over the years, with an ever-increasing number of electronic devices being produced and consumed worldwide. Today in Europe the average household owns an estimated 74 electrical and electronic devices (excl. lamps)[2]. This growth has also led to a significant rise in waste electrical and electronic equipment (WEEE), posing environmental and health hazards if not managed properly. The recycling of electronic products is crucial to mitigate these risks and recover valuable resources. Current recycling practices face limitations in terms of efficiency, transparency, and traceability as evident in the gap between WEEE annual treatment rates in the EU and the EU's WEEE Directive collection and treatment targets.

Furthermore, in light of excessive resource use, and the urgency to secure critical raw materials (CRMs), particularly in the journey towards decarbonisation of the continent, there is a need to close the loop and increase recycling of electronics to secure supply of CRMs. As such, the current lack of detailed information on the end-of-life (EoL) activities, e.g. of tracking of CRM recycling rates to enable the devices' full potential recyclability, fails to take advantage of a huge source of value particularly in the face of CRMs role for decarbonisation.

When assessing the EU's Digital Product Passport (DPP) in the context of e-waste recycling, it is important to highlight a series of key information-related barriers in the e-recycling space upon which to consider how a DPP could potentially help fill these gaps:

Absence of CRM specific life-cycle information management system:

Firstly, in the realm of CRMs and e-waste, a significant policy gap in Europe's electronic waste recycling framework is the lack of explicit material declaration requirements in the EU's Eco-design and Waste Electrical and Electronic Equipment (WEEE) policies, including the Eco-design for Sustainable Products Regulation (ESPR). While these policies address various environmental aspects, they do not specifically mandate the declaration of material composition information in a standardised format, for example, by requiring a particular European or global standard to be followed like the upcoming IEC 82474-1 standard on universal material declarations.[3] The absence of clear material declaration

2 https://www.electronic-recycling.ie/custom/public/files/update-of-weee-collection-2021.pdf

3 https://www.iso.org/standard/85487.html

requirements hampers transparency and hinders the effective management of electronic waste. It limits the availability of accurate and comprehensive material data necessary for informed decision-making, recycling process optimization, and the development of a circular economy.

Findings produced as part of the CircThread project regarding efforts to conceptualise the architecture of a Circular CRM supply management system for components and materials across the life cycle of products have been synthesised in a CircThread project paper by Koppelaar et al, 2023[4]. The paper explains that there is an absence of an established CRM specific life cycle product/materials information management system[5]. Instead an information management practice is in place that lacks cohesion and sufficient details, with considerable gaps (e.g. lack of product specificity, lack of information on product/materials flow or quantities or on CRMs). Moreover, the research conducted found reverse logistics operators are often handling products without knowledge of their CRM composition – thereby there is a need to foster sorting of collected products and extraction of components containing high amounts of CRM in the reverse logistics chain, to enable their effective recycling. In addition to the low CRM recovery stemming from the lack of a business case in the current market, the low concentrations of metals located in products also add to the issue of economic profitability (e.g. neodymium magnets).

Difficulties for clear identification of substances: Recyclers have expressed challenges to easily identify certain substances, materials and components in WEEE, and requested better labelling/marking such as colour coding to demonstrate hazardous parts present, or batteries contained in products[6]. Moreover, the identification of key CRMs focused components (e.g., circuit boards; batteries; NdFeB magnets and fluorescent powders) is equally important as highlighted in the CEWASTE report published in 2021[7].

Multiplicity of materials and complexity of products: It is increasingly challenging to recycle products due to the complexity of their design and the variety of materials used. The varying types of components and many materials found in all WEEE can require a range of different and specialised processes. It is currently a challenge to create both general WEEE treatment lines combined with the specificity to categorise and

4 Koppelaar, Rembrandt H. E. M., Sreenivaasa Pamidi, Enik Hajósi, Lucia Herreras, Pascal Leroy, Ha-Young Jung, Amba Concheso, Radha Daniel, Fernando B. Francisco, Cristina Parrado, and et al. 2023. "A Digital Product Passport for Critical Raw Materials Reuse and Recycling" *Sustainability* 15, no. 2: 1405. https://doi.org/10.3390/su15021405

5 Koppelaar, Rembrandt H. E. M., Sreenivaasa Pamidi, Enik Hajósi, Lucia Herreras, Pascal Leroy, Ha-Young Jung, Amba Concheso, Radha Daniel, Fernando B. Francisco, Cristina Parrado, and et al. 2023. "A Digital Product Passport for Critical Raw Materials Reuse and Recycling" *Sustainability* 15, no. 2: 1405. https://doi.org/10.3390/su15021405

6 European Electronics Recyclers Association (EERA (2022). Towards an EU WEEE Regulation: the position of the European Electronics Recyclers Association. https://static1.squarespace.com/static/6273d6aab17e87401893aefc/t/62c4b431fab29a4a04bb1c29/1657058354428/EERA+-+Towards+EU+WEEE+Regulations+-+Published+January+2022.pdf

7 CEWASTE Voluntary Certification Scheme for Waste Treatment. A contribution for future Critical Raw Materials Report, CEWASTE Project Final Report (2021). https://cewaste.eu/wp-content/uploads/2021/04/CEWASTE-Final-Public-Raport.pdf

sort the variety of materials in practice. Especially for most Critical Raw Materials due to their low content in weight per product. Producers have also raised the difficulty to attain information from suppliers about the exact material content of the EEE.

Furthermore, recyclers have indicated[8] that the intricacy of modern designs poses challenges when producers combine different types of EEE. For example, instances where refrigerators incorporate a TV screen in the door along with a computer component, or the expanding 'internet of things' phenomenon that links EEE to other products and user interactions. This connectivity could potentially involve personal data handling. Recyclers are compelled to factor in these composite products when strategising and managing treatment facilities.

Information on hazardous substances and components in WEEE (e.g. lithium batteries) is often missing from the recycler's side, preventing an easy flow of information that will support contamination reduction and risk management during treatment processes.

Additionally, recyclers have pointed out[9] that the existing WEEE streams used for collection focuses excessively on size similarities rather than the shared content within products. A more effective approach for prioritising the recovery of critical raw materials (CRM) would involve considering similar content across products. This would make it easier to recover materials from product groups that share comparable components and processing methods. This may not be easy to implement, given the constant evolution of the design and composition of EEE.

Furthermore, recyclers have described the depreciating value of materials in WEEE due to the lessening use of metals and growing use of lower cost materials such as plastics.[10] Aside from the significant limitations in adequate technologies for required processing of plastics, the wide variety of plastics in EEE adds to the significant limitations of the plastics processing technologies.

1.3 Addressing recycling information barriers through the DPP

In light of these challenges, the EU's Proposal of the Eco-design for Sustainable Products Regulation (ESPR) published in March 2022, puts forth the introduction of Digital Product Passports (DPP) as a key regulatory instrument targeting information-related barriers to product circularity by providing data on a product's origin, durability, composition, reuse, repair and dismantling possibilities, as well as end-of-life handling. The ESPR envisions DPPs as enablers for gathering of data on a product and its supply chain to share it across entire value chains so all actors, including consumers, have a better understanding of the materials and products they use and their embodied environmental impact.

8 European Electronics Recyclers Association (EERA (2022). Towards an EU WEEE Regulation: the position of the European Electronics Recyclers Association. https://static1.squarespace.com/static/6273d6aab17e87401893aefc/t/62c4b-431fab29a4a04bb1c29/1657058354428/EERA+-+Towards+EU+WEEE+Regulations+-+Published+January+2022.pdf

9 European Electronics Recyclers Association (EERA (2022). Towards an EU WEEE Regulation: the position of the European Electronics Recyclers Association. https://static1.squarespace.com/static/6273d6aab17e87401893aefc/t/62c4b-431fab29a4a04bb1c29/1657058354428/EERA+-+Towards+EU+WEEE+Regulations+-+Published+January+2022.pdf

10 European Electronics Recyclers Association (EERA (2022). Towards an EU WEEE Regulation: the position of the European Electronics Recyclers Association. https://static1.squarespace.com/static/6273d6aab17e87401893aefc/t/62c4b-431fab29a4a04bb1c29/1657058354428/EERA+-+Towards+EU+WEEE+Regulations+-+Published+January+2022.pdf

The following section explores how the EU's ESPR envisions that the DPP could help address some of the information-related challenges in the realm of electronics recycling.

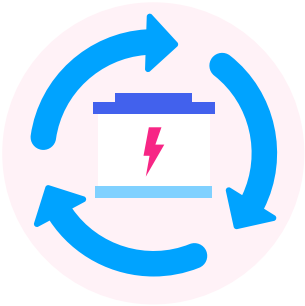
Information on material composition

Whilst experienced recyclers are well aware of the types and share of secondary raw materials arising from the processing of WEEE, there are gaps of their knowledge in what regards the content of hazardous substances and components (e.g. lithium ion batteries) and CRMs. A comprehensive understanding of the materials used in electronic devices is deemed as is deemed crucial for optimising resource recovery and effective processing. As such, an essential aspect of DPPs is comprehensive documentation of a product's material composition including CRM contents prepared by the manufacturer. This can include total materials content, hazardous substances and components, and a list of high CRM content components in the product.

Based on research conducted as part of CircThread[11] on the most useful information to provide on material composition, it is suggested that manufacturers should make available product and component CRM content data including:

- a flag based on percentages of CRM content for different CRMs for the DPP
- a linked product CRM information sheet
- a linked product component list identifying high CRM content components
- information on hazardous substances and components

The intended uses of information on material composition could include:



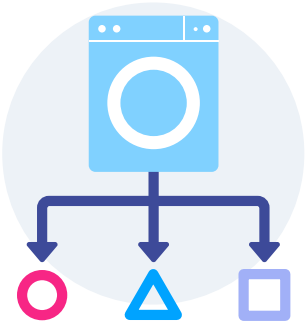
1. **Improved recycling method selection and maximisation of resource recovery**

By providing material composition data, the DPP is expected to improve product processing, in particular in what concerns depollution, risk management (e.g. lithium batteries) and recovery of targeted materials, such as CRMs.

Increased knowledge about products' material composition could help address the current challenge incurred by the vast types of materials, in particular plastics, and the lack of specific information to enable their identification (in addition to the absence of suitable technologies for their required processing). Moreover, increased visibility on a product's composition could help target the issue raised by recyclers regarding proper labelling/marking on products. Easy and clear identifications

11 Koppelaar, Rembrandt H. E. M., Sreenivaasa Pamidi, Enik Hajósi, Lucia Herreras, Pascal Leroy, Ha-Young Jung, Amba Concheso, Radha Daniel, Fernando B. Francisco, Cristina Parrado, and et al. 2023. "A Digital Product Passport for Critical Raw Materials Reuse and Recycling" *Sustainability* 15, no. 2: 1405. https://doi.org/10.3390/su15021405

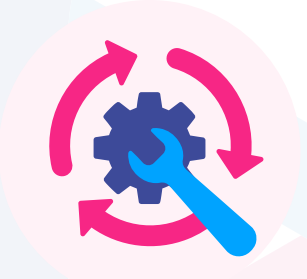
for certain substances, materials and components in EEE through colour coding, for example, would help to demonstrate any hazardous or significant parts present. This issue is particularly important for batteries given their proliferation in the growing and broad range of equipment, and end-of-life vehicles (ELVs). The uncertainty as to their location is highlighted by the European Electronics Recyclers Association (EERA) in their report on the experiences and best practices with batteries in WEEE.



2. Efficient Sorting and Separation

In addition to being beneficial for the processing stage, enhanced information on product composition could enable more efficient sorting for extraction/disassembly and pre-treatment before recycling. DPPs could enable identification of product components with high CRM content for extraction/disassembly. The DPP's CRM content flag per type of CRM could be used by collection companies for pre-treatment sorting, to separate products with high-CRM and low-CRM content in a relevant grouping of CRMs into different collection bays, for further reverse logistics purposes.[12] Providing collectors with a breakdown of CRM content in products could facilitate separate collections or pre-sorting of products and potential extraction of CRM containing components, so that the latter can be shipped to CRM specialised recyclers.

Moreover, pre-sorting based on information provided to collectors on products' content could not only be beneficial for CRM recovery but also to help address other issues listed by recyclers with EERA members. Their recommendation is for sorting (in a high-level manner) to start at the collection point / site, as bulk collection practices currently suppose a notable number of issues (e.g. fire hazards and other dangers arising from presence of hazardous substances such as lithium-containing WEEE). As such, recyclers mentioned that containers should be more adapted to the types of WEEE they hold given that the current treatment of everything as 'bulk' in most countries is counterproductive to maintaining material's quality.[13] As such, pre-sorting based on product composition information could improve the sanctity of the material delivered for recycling, thus enabling better processing and higher recycling rates.



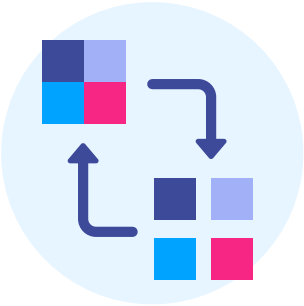
3. Streamlining Refurbishment and Reuse

Considering the existing structure of the recycling and repair/ preparing for re-use sector, re-use is probably the 'after EEE life' sector that can be most benefited from the DPP in the short term. While the recycling industry may need an adaptation of their

12 Koppelaar, Rembrandt H. E. M., Sreenivaasa Pamidi, Enik Hajósi, Lucia Herreras, Pascal Leroy, Ha-Young Jung, Amba Concheso, Radha Daniel, Fernando B. Francisco, Cristina Parrado, and et al. 2023. "A Digital Product Passport for Critical Raw Materials Reuse and Recycling" *Sustainability* 15, no. 2: 1405. https://doi.org/10.3390/su15021405

13 Koppelaar, Rembrandt H. E. M., Sreenivaasa Pamidi, Enik Hajósi, Lucia Herreras, Pascal Leroy, Ha-Young Jung, Amba Concheso, Radha Daniel, Fernando B. Francisco, Cristina Parrado, and et al. 2023. "A Digital Product Passport for Critical Raw Materials Reuse and Recycling" *Sustainability* 15, no. 2: 1405. https://doi.org/10.3390/su15021405

processes, which are mostly based on treatment in bulk of appliances, the re-use sector processes devices on a per-unit basis. However, by prolonging the life of the used EEE or WEEE, refurbishers/preparing for re-use companies may require training and access to use the DPP, as they may become a relevant player in the data entry and use to/of the DPP. DPPs could help promote refurbishment and reuse by documenting information about product condition, repairability, and available spare parts. This could facilitate the identification of products suitable for refurbishment, extending their lifecycle and reducing electronic waste generation. The feasibility of this is being trialled within WP6.3 of the CircThread project. The company SIMAVI are creating a website that assesses damaged EEE based on extensive product data collected from recyclers and refurbishers (using age, damage, energy consumption) to recommend if a product should be just repackaged or repaired or dismantled for recycling.

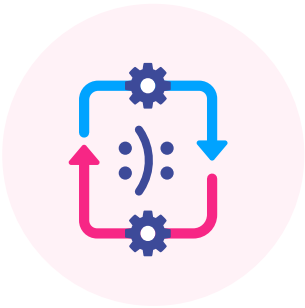


4. Disassembly information

Providing specific information on disassembly in the DPP that can assist recyclers and refurbishers/preparing for re-use companies in their operations and could also aid in improving efficiency of processing. Such information could include for instance:

- A disassembly map of a product from the manufacturer to improve component extraction for reuse/recycling;
- Fastener Types and Locations: Information about the types and locations of fasteners used in the product for quick identification and removal during disassembly.
- Connector Types and Interfaces: types of connectors and interfaces employed in the product to aid comprehension on how different components are connected and how to disconnect them without causing damage.
- Component Identification: Identification of various components within the product e.g. labelling or categorising components, such as circuit boards, batteries, displays, sensors, or other key parts.
- Adhesive Usage and Removal Techniques: Specification on location and types of adhesives employed to enable recyclers to employ appropriate methods for their detachment, minimising damage to the components.
- Fragile or Delicate Components: identification components that are fragile or require special care during disassembly to enable recyclers to handle sensitive parts with caution to avoid breakage or damage.
- infectious, radioactive

5. Provide feedback to manufacturers



DPPs could also influence product design decisions to facilitate material recovery. Enabling recyclers to provide feedback to manufacturers about the ease of disassembly, and the presence of design features that prevent recyclability, DPPs could aid manufacturers to design products with increased recyclability.

In particular, key feedback information loops of use would include[14]:

- feedback loop of CRM recycling performance of products and components into secondary raw materials from recyclers to manufacturers, for purposes of improving product design to enhance recovery and recycling;
- provision of a disassembly map of the product and specific CRM containing components by the manufacturer, with feedback back from the pre-treatment operator to the manufacturer on disassembly issues based on a disassembly log.

A critical issue in governing such feedback loops is to ensure there is no information leakage, as recycling performance information can be sensitive for recyclers when widely available for competitive purposes within the recycling market. Therefore data masking or restrictions so that only manufacturers would have access would be needed for such feedback to be feasible.

Further aspects for consideration in the setup of DPPs for recycling include:

Dynamic data

A DPP should allow data to be updated by manufacturers to prevent a gap in the relevance of the information being provided for recycling operations (given the time gap between when a product is put on market and when it reaches end of life/recycling operations), so that it is up to date when it is utilised by recyclers versus when the data would have been originally generated for a DPP.

Consumer guidance

Recyclers have often stated the lack of consumer awareness regarding end-of-life disposal guidance is a critical issue for achieving adequate collection targets as well as receiving products that are able to be processed/refurbished/re-used. As such, there is an opportunity for

14 Koppelaar, Rembrandt H. E. M., Sreenivaasa Pamidi, Enik Hajósi, Lucia Herreras, Pascal Leroy, Ha-Young Jung, Amba Concheso, Radha Daniel, Fernando B. Francisco, Cristina Parrado, and et al. 2023. "A Digital Product Passport for Critical Raw Materials Reuse and Recycling" *Sustainability* 15, no. 2: 1405. https://doi.org/10.3390/su15021405

the DPP to provide consumers with information on where and how to recycle/repair/donate their electronic products, including drop-off locations and recycling/repair/donation programs. This information can help consumers make informed disposal decisions for recycling or extending a product life and contribute to the reduction of electronic waste that ends up in landfills. Especially if the information is provided in well-designed user interfaces, up to date, and readily available with as little effort as possible to retrieve it for consumers.

Standardisation requirements:

Establishing a standardised format for product passport data is crucial to ensure compatibility and interoperability across various stakeholders, including manufacturers, recyclers, and regulatory bodies. A key issue is to determine the definition of data points that are included in the DPP. For instance, a standardised definition of the 'recyclability of a product' is needed before this can be claimed in the DPP. Moreover, there is a need for a standardised Bill of Materials and of the associated material declarations when determining how to showcase product and component content data.

Some of the existing standards that could provide a basis for creating guidance on material identification, classification, and reporting include:

- ISO/IEC 82474-1, Material Declaration; Part 1: General requirements is a dual logo International Standard currently under development by IEC TC 111 and ISO TC 207/SC 1, by the joint working group 16 (JWG 16).

  The main intended use of the standard is to provide data up and down the supply chain that allows organizations to:

  - assess products against material and substance requirements,

  - assess substances used in manufacturing and other product life cycle stages,

  - use information in their activities related to environmentally conscious design and

  - obtain information about material efficiency and product circularity of their products.

  The foreseen publication date is July 2024.

- IEC 62474:2018+AMD1:2020, Material declaration for products of and for the electrotechnical industry

- IEC TS 62474-1:2022, Material declaration for products of and for the electrotechnical industry - Part 1: Guidance on the implementation of IEC 62474

- IPC-175x family Materials Declaration Data Exchange Standards, establishes a standard reporting format for data exchange between supply chain participants. This series of standards is XML-schema based, which allows for more efficient and effective communication of data.

Further standards are available through the CircThread standardization toolkit.

While several existing EU standards can be employed, there is room for the development of specific standards tailored to DPPs and material composition reporting. These standards could address the following aspects:

- **Standardised Format:** A standardised format for material composition information within DPPs.
- **Reporting Requirements:** Clear reporting requirements could be established, specifying the necessary details to be included in the material composition information. This could cover aspects such as quantitative composition, hazardous substance concentrations, and location of materials within the product.
- **Material Classification:** standardised classification system for materials used in electronic products. This would facilitate consistent categorisation and identification of materials, simplifying the reporting process and enabling better data exchange between stakeholders.
- **Material Traceability:** Standards could address the traceability of materials used in electronic products throughout their lifecycle. This would involve capturing information about the origin, sourcing, second life, and processing of materials, promoting transparency and responsible sourcing practices.
- **Harmonisation with International Standards:** Efforts could be made to harmonise EU standards with relevant international standards, ensuring compatibility and facilitating global data exchange. This would enable seamless integration of material composition information in DPPs across different regions.

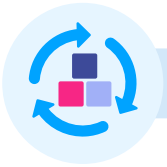
1.4 Challenges for DPP implementation related to recycling practical realities

In addition to the potential useful contributions of a DPP to recycling as listed above, it is important to note that as background for this paper, discussions were held with stakeholders from the electronics recycling industry who raised concerns regarding current developments around the DPP, which they stated do not reflect the realities of recyclers' everyday operations. This, they underlined, would impede the DPP's usefulness in its practical implementation. The following examples of key challenges were mentioned, which are critical for policy-makers to take into account in their development of the DPP in order to avoid it becoming a legislative instrument that lacks true impact or utility:

Day-to-day operational limitations:

- **Resource constraints:** Recyclers lack space and time and/or personnel to scan each product that is processed, given the fast pace and systematic design of operations. CircThread is currently investigating available technologies that would allow reading the DPP of WEEE collected in bulk. These technologies exist but may require modifications in the WEEE reception lines of the recycling facilities and may not be compatible with the DPP intended for consumers.

- **Safety concerns:** The hazardous risks of having mobile phones on the operational floor of a treatment site for personnel to scan the QR codes are high for health and safety reasons (e.g. not paying attention to moving conveyors, other personnel, fork-lift trucks etc). Mobile phones are usually banned in these processing areas. It would therefore not be feasible for most recyclers to use mobiles for accessing of DPP data. A potential solution could be automated scanning devices for reading DPPs with relevant information terminals and information management systems. Further, mobile phones do not necessarily need to be the reading device. Technologies for reading DPPs in bulk are in development, and the legislative push for implementing the DPP in the near future in a wide variety of products could help boost the development of technologies fit for purpose upgrading the existing ones.
- **Poor material quality**: at times consumers bring in partially dismantled equipment (where they have tried to make a repair or the product is damaged), which in addition to inadequate controls at collection sites when WEEE is received, often means that products are crushed or broken prior to arriving at a recycling facility. The age of the product is another factor - with many old appliances received that are rusty and damaged with no manufacturing or rating label or identification marks. This leads to poor quality, which impedes any kind of identification and proper recycling. CircThread is currently assessing the technologies available for a DPP that would stand in good condition in time and after use and disposal. However, it is reasonable to estimate that a share of DPPs would be defective or damaged, in all cases due to several reasons.
- Metal clash issues that would require solutions for the reading of DPPs.



Regarding CRM recovery:

- **Recovery challenges:** secondary raw materials and CRM identification is already quite efficiently managed by recyclers, who have tailored their processing methods to be highly efficient in identifying certain CRMs from certain components such as printed circuit boards, hard-drives, copper-rich components etc, and already can identify where hazardous components and substances may be found such as batteries, capacitors, oil, gases, mercury switches etc. Instead, CRM recovery challenges are more related to volume and accessibility. Unless recyclers have a particular output partner willing to pay for further processing and separation, CRM recovery is generally not carried out at the initial treatment facility but at downstream post-shredder facilities or at smelting plants. The main barrier to CRM recovery is the low concentration of CRM in the WEEE collected, the low quantities of CRM present in products, and the lack of prevalent market demand making it economically appealing to go through the efforts of CRM recovery at an e-waste facility, which is thus the policy area that should be tackled to trigger higher CRM recovery.
- **New technologies:** recyclers pointed out that the development of other new technologies that improve recycling should be explored. One example is A.I. scanning tools being developed that

are able to locate battery-containing products from a batch of products allowing for separation for separate treatment (helping avoid hazards). This proves more useful than having to individually scan QR codes on products to achieve a similar purpose, which recyclers consider is impractical given the hourly volumes needing to be processed and the state of input WEEE etc. Learnings from companies developing such AI scanning (currently in testing status), show that a good performance requires a long learning process, given the high variety of EEE in the market and the constant evolution of the types of products.

Provision of feedback to manufacturers:

- **Competition challenges:** This would be feedback to manufacturers from recyclers on challenges they've experienced along the recycling process in order to potentially better inform design choices. Stakeholders have voiced that intellectual property rights are a high concern in the industry, where the competitive nature of the industry stimulates some reluctance to share detailed information about operations, volumes of CRMs recovered and downstream routes with external parties. As such, providing feedback on recycling challenges that may be linked to proprietary recycling methodologies and routes is deemed to not be very realistic.
- Similarly to secondary raw materials in WEEE, technologies that can accurately identify the CRM content of fractions sent for recovery are key to characterise and quantify the value of the waste in the trade negotiations between recyclers and CRM recovery operators.

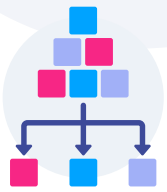
General points from recyclers:

- **Practical policy solutions:** Policy-makers should ensure that legislative decisions are grounded in the every-day practicalities of the recycling business. Stakeholders urge policy-makers to engage with and visit electronics recyclers to better understand how operations are run and therefore how the DPP might potentially be used and which barriers could be faced.
- **Identification of CRM:** According to the recyclers interviewed, there is some potential for the DPP to prove useful for recyclers in the realm of B2B/commercial equipment, where more detailed information around the location of CRMs in these product types could potentially be beneficial (for instance, for medical equipment, although this product category is not covered by the ESPR). CRM volumes are known to be higher and thus theoretically more attractive for recyclers of this equipment to innovate and invest in specialist treatment technologies.

1.5 Recommendations for DPP in the context of improved electronic recycling

The challenges associated with electronics waste recycling in Europe, especially concerning the intricate nature of identifying and sorting materials, low-quality recyclable materials, policy gaps, and barriers to critical raw materials (CRM) recovery, underscore the pressing need for effective solutions. The integration of the DPP presents a promising avenue to address these challenges and enhance the sustainability of electronics recycling practices. Building upon the insights gained from the assessment of the state of e-waste recycling in Europe and the information-related barriers, the following recommendations are proposed:

- **Inclusivity and Realistic Implementation:** While considering the potential benefits of DPPs, policymakers should collaborate closely with electronics recyclers to ensure that the proposed regulations align with the practical realities of the recycling industry. Recycler insights are invaluable in designing a DPP that is feasible and effective.



- **DPP system should enable pre-sorting in the reverse logistics chain for CRM content,** before the product reaches the recyclers site.

- **Focus on Value-Centric Recovery:** Rather than solely concentrating on CRM recovery, policymakers should also emphasise the value proposition of recycling. Creating a market demand for secondary raw materials, including CRMs, will incentivise recyclers to invest in innovative technologies for efficient recovery.

- **Comprehensive Material Composition Information:** DPPs should mandate provision of detailed material composition data for electronic products, including the content of CRM. This data could encompass both the product level and high CRM content components, facilitating efficient recycling processes and CRM recovery.

- **Standardised Material Declaration Requirements:** Policymakers must establish clear and standardised material declaration requirements in this regard, allowing manufacturers to provide consistent and detailed material composition information in a specified format.

- **Enhanced Labelling and Marking**: The DPP should encourage the use of better labelling and marking techniques for hazardous parts, components, and substances in electronic products. This will aid recyclers in easily identifying and handling potentially harmful materials.

- **Effective information points**: Policymakers should explore whether the integration of disassembly information in DPPs would be impactful/beneficial e.g. fastener types, connector interfaces, fragile components, adhesive usage, and more.

- **Feedback Loop for Continuous Improvement:** DPPs should facilitate a feedback loop between recyclers and manufacturers. Recyclers can provide insights on disassembly challenges, material identification issues and design features that hinder recyclability. This input will enable manufacturers to enhance product designs for better recyclability.

- **Dynamic Data Updates:** Manufacturers should be encouraged to regularly update the data within the DPP to ensure its relevance and usefulness for recyclers. This will prevent a gap between the information provided and the actual recycling operations.

- **Consumer Education and Guidance:** DPPs should incorporate consumer-friendly information on electronic product recycling that empowers consumers to make informed decisions about disposal options and reduce improper disposal.

- **Standardisation and Harmonization:** Regulatory bodies should establish standardised formats for DPP data, material classification, reporting requirements, and material traceability. These standards should align with existing international standards to enable seamless data exchange and interoperability.

In conclusion, the adoption of DPPs holds significant promise in addressing the challenges faced by electronics recycling in Europe by leveraging the power of information transparency, traceability, and collaborative feedback loops. However, for DPPs to truly be impactful, policymakers, manufacturers, and recyclers must work in unison to develop a well-structured framework that reflects the practicalities of the recycling industry while fostering sustainable electronics recycling practices and critical raw materials recovery.

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