Utrecht University

CIRCULAR ECONOMY AND SOCIETY HUB

Università degli Studi di Messina
DIPARTIMENTO DI ECONOMIA

POLICY BRIEF on

Critical Raw Materials and their integration in Extended Producer Responsibility and Eco-design Policy

POLICY BRIEF on Critical Raw Materials and their integration in Extended Producer Responsibility and Eco-design Policy

This brief was based on Campbell-Johnston et al. 2022 Thermodynamic rarity of electrical and electronic waste: Assessment and policy implications for critical materials. Forthcoming

Contact:

Utrecht University
- Kieran Campbell-Johnston
  k.a.campbell-johnston@uu.nl
- Walter J.V. Vermeulen
  W.J.V.Vermeulen@uu.nl
- Ida Mae de Waal
  i.m.dewaal@uu.nl

University of Messina
- Erik Roos Lindgreen
  erik.rooslindgreen@unime.it
- Roberta Salomone
  roberta.salomone@unime.it
- Giovanni Mondello
  giovanni.mondello@unime.it
- Teresa Maria Gulotta
  teresamaria.gulotta@unime.it

Funding sources

This brief received funding under the European Union's Horizon 2020 research and innovation programme under Marie Sklodowska-Curie grant agreement No 765198.

Colophon

Cite as:
Campbell-Johnston, K., Roos Lindgreen, E., de Waal, I.M., Gulotta, T.M., Mondello, G., Salomone, R., Vermeulen, W.J.V. Policy Brief on Critical Raw Materials and their integration in Extended Producer Responsibility and Eco-design Policy.
(DOI: 10.5281/zenodo.6444189)

Downloadable at: www.uu.nl/en/link

Also watch our video
https://www.youtube.com/watch?v=brMxcEbu43c&ab_channel=FacultyofGeosciencesUtrechtUniversity

Editorial, graphic and language support:
Ton Markus, Margot Stoete UU Geosciences C&M
Photography: iStock

Key message

Critical raw materials are essential for the sustainability transitions, e.g. energy, digital and mobility of the European Union (EU).

- **Current electronics product design and waste policies fail to adequately integrate critical raw materials in the product design phase and recycling practices, resulting in many being lost in the waste stage.**
- **We propose changes to European Union product and waste policy, including specified waste monitoring and recovery strategies for critical raw materials (beyond mass-based targets), eco-design changes, and assessment of and financing for critical raw materials recovery.**
- **Legal implications and paths forward for these proposals are presented.**

POLICY BRIEF on Critical Raw Materials and their integration in Extended Producer Responsibility and Eco-design Policy

Content

Executive summary for policymakers

Challenges related to critical raw materials

Raw materials are at the heart of everything we make, use and dispose of. Many critical raw materials (CRMs) are essential in many sustainability transitions, such as energy, digital and mobility. These raw materials are present in electrical and electronic products, which is the focus of this policy brief. CRMs face supply risks in the immediate or short-term future due to their predominant location in a few countries, e.g. Palladium from Russia and Antimony from China, and in the long term due to decreasing geological reserves.

Waste management and recycling policy in the EU has historically played a role in preventing landfilling and pollution and providing secondary materials through recycling. However, the connection and integration between waste management policy, product design and CRMs are underdeveloped as these policies originate and operate in different departments with different remits and purposes. As the competition for and increased scarcity of raw materials rises, integrating CRMs coherently across policy domains is essential.

This policy brief aims to:

1. Outline the policy and practical issues present within current electrical and electronic waste policy in the EU, including current Waste from Electrical and Electronic Equipment (WEEE) targets; and
2. Propose improvements that affect waste policy, product policy and reporting requirements, including further considerations for the policy development process.

European context and policy brief focus

(W)EEE is currently governed under product and waste policies, in which CRMs are starting to be included. However, the potential to increase the knowledge of, monitoring of and recovery requirements for CRMs in (W)EEE within current policy instruments is not yet used to its full extent. For example, there is no EU central coordination of information on CRMs in EEE in either the Eco-design Directive or WEEE Directive and targets in the WEEE Directive are only based on promoting collection and recovery based on mass. To illustrate the presence, quantities and losses, CRMs were mapped in Italy. Using an indicator named Thermodynamic rarity the composition of electronic products and quantities of CRMs was estimated.

Issues identified

Three key issues pertaining to CRMs in the lifecycle of electronics products and their waste were identified:

1. Systematic **knowledge and information** of the material composition of electronic products, including the presence and quantities of CRMs, is lacking. This lack of systematic knowledge of the quantities and presence of CRMs has implications for organising appropriate recovery operations.
2. The unintended consequences of WEEE **targets based on mass collection and recycling**. This leads to a prioritisation of the recovery of mass bulk materials, at the expense of CRMs which may be present in low mass volumes, but which are of high value nevertheless;
3. Connected with points 2 and 3 is the difficult **access to and potential value retention options for CRMs** in WEEE. This requires further developing the secondary raw material market, assessing immediate and long-term risks of specific raw materials, and assessing and supporting CRMs technologies and recycling businesses.

Solutions

To combat these issues a new approach to waste management is needed. Waste management needs to evolve beyond recycling and dealing with pollution. Instead, it needs to become a **diagnostic tool** used to **design out waste** and recover materials with the **highest risk** (immediate geopolitical and long-term geological). Changes are needed for both product and waste laws in the EU to realise this.

Knowledge and information

- *Producers:* need to provide information on the presence and quantities of CRMs in their products. This would help improve treatment standards to promote CRM recovery;
- *Recyclers:* need to provide information on *which* materials they are and are not recovering to have a clear overview of gaps in recovery operations;
- Information from both recyclers and producers is collected in a **data system** recommended to be held by the EC, nominated third parties or through the promotion of product material passports. Policymakers use the information to inform long-term policy goals and research and development (R&D) innovation in recovery technologies.

Targets and conditions

- *Policymakers* should adjust extended producer responsibility (EPR) targets and/or conditions, including treatment standards, to promote the monitoring and recovery of CRMs where economically and environmentally feasible (connected to long-term ambitions). Incentives need to be given to support the recovery of CRMs, where it is currently not economically feasible;
- *Policymakers* should adjust Eco-design requirements to promote greater accessibility of CRMs in products. Where recovery of CRMs is currently not feasible at the waste stage given present technologies, CRMs substitutions should be promoted, or accessibility enhanced at the product design stage;

Access to and potential value retention options of CRM

- *Producers* should pay an (additional) contribution included in the EPR fee structure, usually paid to the producer responsibility organizations, which should then be used to finance innovative recycling technologies and/or upgrade existing recycling infrastructure;
- *Policymakers* should organise the systematic analysis of potential CRMs value retention options, including which technologies are available for which materials and what barriers (economic and legal) must be overcome. This analysis is related to immediate and long-term risks (geopolitical and geological) for CRMs.

1 How should critical raw materials be integrated within EU policies?

A new approach and understanding for product and waste policy is needed, one that focuses on the conservation of the most critical resources. This brief takes a system perspective on critical raw materials (CRMs) in European Union (EU) product and waste policy. It presents the case of electrical and electronic products to explore this topic as they contain significant quantities of CRMs [1].

This policy brief aims to:

1. Outline the issues present within current electrical and electronic waste policy in the EU, including current WEEE targets; and
2. Propose improvements that affect waste policy, product policy and reporting requirements, including further considerations for the policy development process.

This policy brief is structured as follows. First, the current EU policies and laws that are important for (waste) electrical and electronic products (W)EEE are described. Second, the case study of CRM losses is presented, together with the key issues that this research observed in the policy design for CRMs and (W)EEE. Third, the policy implications of the research are presented. Finally, the legal implications of this research are reviewed.

2 What are critical raw materials, and why are they important?

Materials are at the heart of everything we make, use and waste. Those “raw materials that are most important economically and have a high supply risk” are called CRMs by the European Commission (EC) [2]. CRMs are important in a variety of technologies that are essential for a climate neutral and sustainable future, e.g. Li-ion batteries, fuel cells, photovoltaic panels and wind energy [3]. These materials are present in varying quantities within most electrical or electronic products, e.g. phones, monitors and laptops [4].

Safeguarding the availability of raw materials for future generations is a key aspect of intergenerational equity in a sustainable and just world. This is an immense challenge as some materials are projected to be exhausted in the next 150 years, given present consumption patterns [5]. Similarly, many CRMs have a higher supply risk, with many mined in a small number of countries, e.g. Russia and China. Currently, the recycling rates of CRMs, globally and in the European Union (EU), are moderate or negligible and have a low impact on the input demands (see Figure 1) [1,2,6].

Since 2011, the EC has outlined a list of CRMs, which was updated in 2014, 2017 and 2020. Presently, there exist potential value retention options for CRMs from extractive industries and landfills [7], in addition to several best practices for a circular economy within Member States (MSs) [4].

End-of-life recycling input rate (EOL-RIR) [%]

- > 50%
- 25-50%
- 10-25%
- 1-10%
- < 1%

H																He 1%
Li 0%	Be 0%											B* 0.6%	C	N	O	F* 1%	Ne
Na	Mg 13%											Al 12%	Si 0%	P* 17%	S 5%	Cl	Ar
K* 0%	Ca	Sc 0%	Ti 19%	V 44%	Cr 21%	MN 12%	Fe 24%	Co 35%	Ni 34%	Cu 55%	Zn 31%	Ga 0%	Ge 2%	As	Se 0%	Br	Kr
Rb	Sr	Y 31%	Zr	Nb 0%	Mo 30%	Tc	Ru 11%	Rh 9%	Rd 9%	Ag 55%	Cd	In 0%	Sn 32%	Sb 28%	Te 1%	I	Xe
Cs	Ba 1%	La-Lu[1]	Hf 1%	Ta 1%	W 42%	Re 50%	Os	Ir 14%	Pt 11%	Au 20%	Hg	Tl	Pb 75%	Bi 1%	Po	At	Rn
Fr	Ra	Ac-Lr[2]	Rf	Db	Sg	Bh	Hs	Mt	Ds	Rg	Cn	Uut	Fl	Uup	Lv	Uus	Uuo

[1] Group of Lanthide	La 1%	Ce 1%	Pr 10%	Nd 1%	Pm	Sm 1%	Eu 38%	Gd 1%	Tb 22%	Dy 0%	Ho 1%	Er 0%	Tm 1%	Yb 1%	Lu 1%
[2] Group of Actinide	Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr

Aggre-gates	Bento-nites	Cooking Coal	Diatomite	Feldspar	Gypsum	Kaolin Clay	Limestone	Magnesite	Natural Cork	Natural Graphite	Natural Rubber	Natural Teak Wood	Perlite	Sapele Wood	Silica Sand	Talc
7%	50%	0%	0%	10%	1%	0%	58%	2%	8%	3%	1%	0%	42%	15%	0%	5%

* F = Fluorspar, P = Phosphate rock, K = Potash, Si = Silicon metal, B = Borates

Figure 1 *End-of-life (EoI) recycling input rate, , i.e. the degree to which EoL recycling meets current input demands* [7]

Table 1 *List of elements analysed and related information*

Element name	2020 EU CRM [2]	Main global producers [2]	Indicative exhaustion period (years after 2015) [5]	EoL recycling input rate (EU)[7]
Aluminium (Al)	No		10,500	12%
Antimony (Sb)	Yes	China (74%)	150	28%
Bismuth (Bi)	Yes	China (85%)	150	1%
Chromium (Cr)	No		350	21%
Cobalt (Co)	Yes	DRC (86%)	1100	35%
Copper (Cu)	No		100	55%
Dysprosium (Dy) (2)	Yes	China (86%)	1200 (4)	0%
Gold (Au)	No		150	20%
Indium (In)	Yes	China (48%), Korea rep. (21%)	250	0%
Iron (Fe)	No		1100	24%
Lithium (Li)	Yes	Chile (44%), China (39%)	1600	0%
Magnesium (Mg)	Yes	China (89%)	40,000	13%
Molybdenum (Mo)	No		200	30%
Neodymium (Nd) (2)	Yes	China (86%)	1200 (4)	1%
Nickel (Ni)	No		450	34%
Palladium (Pd) (1)	Yes	Russia (40%)	5300 (3)	9%
Platinum (Pt) (1)	Yes	South Africa (84%)	5300 (3)	11%
Silver (Ag)	No		150	55%
Terbium (Tb) (2)	Yes	China (86%)	1200 (4)	22%
Tin (Sn)	No		700	32%
Tungsten (W)	Yes	China (69%)	600	42%
Zinc (Zn)	No		400	31%

(1) Platinum Group Metals are: ruthenium, rhodium, palladium, osmium, iridium, and platinum; (2) REE are scandium, yttrium, lanthanum, cerium, praseodymium, neodymium, samarium, europium, gadolinium, terbium, dysprosium, holmium, erbium, thulium, ytterbium, lutetium, and promethium; (3) Rare Earth Metal exhaustion rate are given collectively based on [5]; and (4) Platinum Group Metal exhaustion rate is given collectively for all metals. Sources from which the chosen elements were selected are [5,6].

Increasing the monitoring and recycling of CRMs is important for two reasons: 1) preserving materials for future generations (intergenerational equity principle) and 2) reducing future demand bottlenecks for key green technologies, especially concerning CRMs such as Cobalt, Indium and Lithium [8]. However, many CRMs are currently unrecoverable, owing to a combination of different economic/technological barriers in different stages of the product's lifetime, such as their design, low post-user product collection rates, and/or the small quantities of CRMs within the product's themselves [9] (See Table 1 and Figure 2).

Waste management and recycling policy have historically played a role in preventing landfilling, pollution reduction and providing secondary materials through recycling. More recently, it has fallen under the EU's Circular Economy ambitions [10]. However, the connection and integration between waste management policy, product design and CRMs are underdeveloped as these policies operate in different departments with different remits and purposes. As the competition for and increased scarcity of these raw materials rises, integrating them in and across policy is essential.

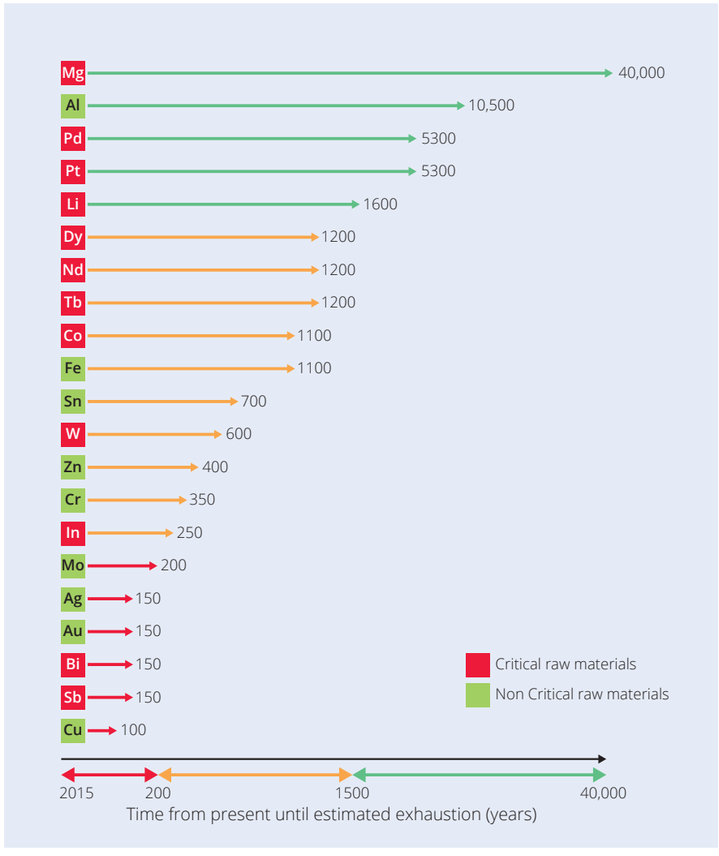
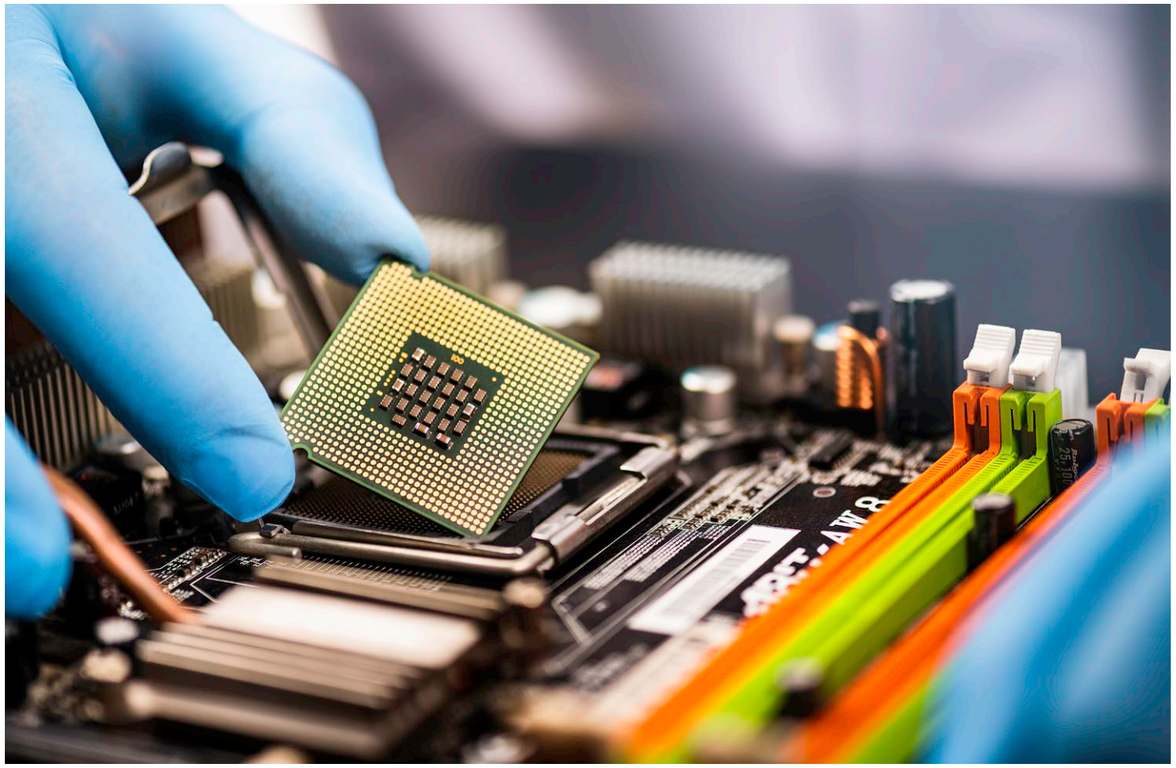


Figure 2 *Time from the present until exhaustion of specific element. Based on [5].*



3 Current policy approaches to (waste) electrical and electronic products and CRMs

Electronic waste consists of all electrical and electronic equipment (EEE) items that have been discarded or are intended or required to be discarded. In 2016, the EU generated 16.6 kg of WEEE per capita. Around 40% of the weight of all WEEE is recycled in the EU [11].

Currently, (W)EEE is governed and directed under two main policies within the EU, regarding the product stage, e.g. eco-design, and the waste stage, e.g. extended producer responsibility (EPR). Also, some best practices and standards that are relevant for WEEE.

Product stage

Directive 2009/125/EC on eco-design (Ecodesign Directive) establishes a framework for the setting of eco-design requirements for energy-related products. For several product groups, implementing measures set product specific ecodesign requirements. The Directive aims to reduce the environmental impact of products across their whole life cycle, which includes raw materials use.

The Ecodesign Directive offers a basis for addressing aspects relevant with regard to the circular design of products. Especially concerning the use of materials in products, the parameters that must be identified in the preparation for the implementing measures (Annex I & Annex II) do cover the life cycle of 'raw material selection and use', for which several environmental aspects must be assessed, such as the possibilities for reuse, recycling and recovery of materials. To evaluate the potential for improving these aspects, several parameters must be used, including parameters such as the ease for reuse and recycling of materials. Although there is a mention in the parameters of 'easy access to valuable and other recyclable components and materials',[a] CRMs are not explicitly mentioned. However, as CRMs are (valuable) materials, CRMs can and should be included in the assessment for implementing measures, according to the Ecodesign Directive. Ecodesign requirements have been updated in the 2022 Sustainable Products Initiative, where CRMs are considered as a category for future product specific requirements. The Methodology for Ecodesign of Energy-related Products (MEErP) considers CRMs. This means that preparatory studies for eco-design requirements will consider if CRM substitutions or design modifications should be made.

While CRMs can and should be assessed for the implementing measures, there are only a few that directly mention CRMs. A requirement for producers to provide information on CRMs exists in Regulation (EU) 2019/424 on servers and data storage products[b] and in Regulation (EU) 2019/1784 on welding equipment[c]. Also, Regulation 2019/424 and Regulation 2019/2021 on electronic displays require that CRMs are one of the aspects being assessed in the review of these regulations in 2022.[d] In Regulation (EU) 1253/2014 on ventilation units there is an indirect focus on CRMs: a requirement of more detailed instructions for manual disassembly of permanent magnet motors and the electric parts that contain significant amount of CRMs.[e]

---

a Annex I 1.3 (f) Ecodesign Directive.

b Article 3 jo Annex II 3.3 Regulation 2019/424 on servers and data storage products.

c Article 3 jo Annex II 3 (h) Regulation 2019/1784 on welding equipment. This information requirement for manufacturers inter alia includes a list of CRMs present in a certain amount and an indication of the component(s) in which these critical raw materials are present.

d Article 8 (d) Regulation 2019/424; Article 8 (g) Regulation 2019/2021. Also, Regulation 2019/1781 on electric motors and variable speed drivers requires that the 'reuse of rare earth' has to be taken into account with the 2023 review.

e Annex IV (3) and Annex V (3) Regulation (EU) 1253/2014.

Further influencing EEE is Directive 2011/65/EU which restricts the use of hazardous substances in EEE, such as cadmium, mercury and lead. In addition, the Regulation (EC) No 1907/2006 (REACH), sets a general framework for the registration and assessment of substances, including some CRMs that are registered (Beryllium, Antimony and Cobalt) or also classified as hazardous (Beryllium). However, these CRMs are only covered because of their potential negative effects on human health and the environment, not because of their scarcity.

Waste stage

The Waste Framework Directive (Directive (EU) 2018/850) provides the general framework of waste management requirements and waste-related definitions. This Directive also outlines the general minimum requirements for extended producer responsibility schemes. Regarding CRMs, the Waste Framework Directive requires that MSs take measures to prevent the generation of waste of products containing CRMs[f] and include in their waste management plans any special arrangements for waste containing significant amounts of CRMs.[g] Also, the WFD contains a requirement for the European Chemicals Agency (ECHA) to establish a database on hazardous substances. In this 'substances of concern in products' (SCIP) database, producers or importers of articles need to submit information waste operators and consumers can access. However, this requirement is only relevant for CRMs that qualify as hazardous substances, such as antimony.

Directive 2012/96/EU on WEEE (WEEE Directive) focuses on WEEE. The WEEE Directive builds on the principles of extended producer responsibility as specified in the WFD: the financial and/or organizational responsibility for the waste stage of energy-related products is transferred to the producers. Concerning the collection of WEEE, producers, either individually or collectively, must:

- Collect: 65% of the average weight of EEE placed on the market in the three preceding years, or 85% of WEEE generated on the territory of that Member State.
- Recover and recycle: targets specified in Table 2.

In addition, the WEEE Directive requires MSs to ensure that all separately collected WEEE undergoes proper treatment, which includes the selective treatment of certain components. As a minimum, some components have to be removed from the separately collected WEEE. However, there is an absence of binding standards for WEEE treatment,[25] the WEEE Directive does not contain any provisions on (the recovery of) CRMs, and the presence of CRMs in WEEE is not mentioned. Furthermore, the WEEE Directive requires MSs to ensure that producers provide information to treatment facilities about preparation for re-use and treatment of WEEE, including information on the different components and materials, either by manuals or electronic media.[13]

In short, CRMs are starting to be included in the discussion related to the policies governing the product and waste stage of WEEE. Even though there are possibilities in legislation to increase the knowledge, monitoring of and recovery requirements for CRMs in WEEE, these have, however, not been used to their full extent.

Therefore, the question can be asked if current policies promote the effective monitoring and recovery of CRMs? What kind of issues does this result in, and how can CRMs be better integrated into current Extended Producer Responsibility (EPR) and Ecodesign policy?

f Article 9 (1) sub c WFD.

g Article 23 (3) sub b WFD. See also, with regard to CRMs, recitals 36 and 37 of Directive 2018/851.

Table 2 *WEEE product category targets from the 2012 WEEE Directive recast*

		Recovery [1] %	Recycling/preparing for reuse % [2]
1	Temperature exchange equipment	85	80
2	Screens, monitors, and equipment containing screens having a surface greater than 100 cm	80	70
3	Lamps	n.a	80
4	Large equipment (any external dimension more than 50 cm)	85	80
5	Small equipment (no external dimension more than 50 cm)	75	55
6	Small IT and telecommunication equipment (no external dimension more than 50 cm)	75	55

1 Which refers to operations for preparing for reuse, recycling and also incineration with energy recovery.

2 'recycling' means any recovery operation by which waste materials are reprocessed into products, materials or substances whether for the original or other purposes.

4 Case study: Critical raw materials presence, quantities and losses within electronics

To estimate the quantities and flows of CRMs, a case study was conducted using the case of Italy, using national data and data from an electronic waste recycler to estimate the presence, quantities and losses of CRMs. National-level estimated data was complemented by using a 'point-in-time' sampling approach, where 680 products were sampled and categorized by the product, brand and model at the company. The product categories 'Screens and Monitors' and 'Small equipment and small IT and telecommunications' were examined (Categories 2, 5 & 6 Annex 4 WEEE Directive 2012). The recovery targets for these products categories are reported in Table 2.

There is limited available data and datasets on the presence and quantities of CRMs within (W)EEE [7]. Estimating the product's material composition was done through using the ProSUM database held by the United Nations University [12]. 22 elements were selected to be examined, including 12 CRMs (Table 1).

Since WEEE EPR targets are based on mass (collection and recycling), the mass of the collected materials is compared to their rarity. Rarity is calculated[h i] as the total exergy requirement needed to extract and refine each specific material from the Earth's crust into a useful commodity. In essence, this indicator weights those elements that are currently (and in the future) more difficult to extract and refine. As the demand for materials and energy grows and mine grades decline these costs are likely to increase. The relative mass and relative rarity of each material at the national level and within the company is presented in Figure 3 and 4 (page 20).

This study identified three issues:

1. Systematic **knowledge and information** of the material composition of electronic products, including the presence and quantities of CRMs is lacking. The presence and quantities of CRMs were estimated using the best available dataset [12]. This lack of systematic knowledge of the quantities and presence of CRMs has implications for organising appropriate recovery operations, e.g. sorting and processing. The differences between materials related to their mass and their rarity at different operational levels are shown in Figures 3 and 4;

2. The unintended consequences of WEEE **targets based on mass collection and recycling**. This leads to a prioritization of the recovery of mass bulk materials at the expense of CRMs. In this study, bulk metals (Copper, Aluminium and Iron) accounted for 86% of the total mass, while the CRMs accounted for roughly 5% [6]. Using the rarity indicator (Figure 3 and 4) allows us to see the difference in weighing between a materials mass and rarity, where the latter has greater significance from a long-term conservation perspective. For example, Indium forms less than 0.1% of the mass but more than 6% of the rarity of the product category R3 (Figure 4). This analysis indicates the issue of short term mass-based goals in the context of longer term resource supply and depletion threats;

h Exergy is defined as the maximum amount of work that may be theoretically performed by bringing a resource into equilibrium with its surrounding environment through a reversible process.

i For a more detailed explanation of the methodology see [15,16]. For the full analysis of this study see Campbell-Johnston et al. forthcoming.

3 Connected with points 2 and 3: The difficult **access to and potential value retention options for CRMs** in WEEE. This requires the further development of the secondary raw material market, assessing immediate and long-term risks of specific raw materials, and assessing and supporting CRMs technologies and recycling businesses. See CEWASTE (2021) for examples of potential targets, e.g. gold, silver and pallidum from printed circuit boards (PCBs) and Cobalt and Lithium from batteries (see box).

Products with significant concentrations of CRMs:

- Printed circuit boards from IT equipment, hard disc drives and optical disc drives.
- Waste batteries from WEEE and EoL vehicles.
- Neodymium iron boron magnets (NdFeB-magnets) from hard disc drives and electrical engines of EoL vehicles (ELVs).
- Fluorescent powders from cathode ray tubes (CRTs; in TVs and monitors) and fluorescent lamps.

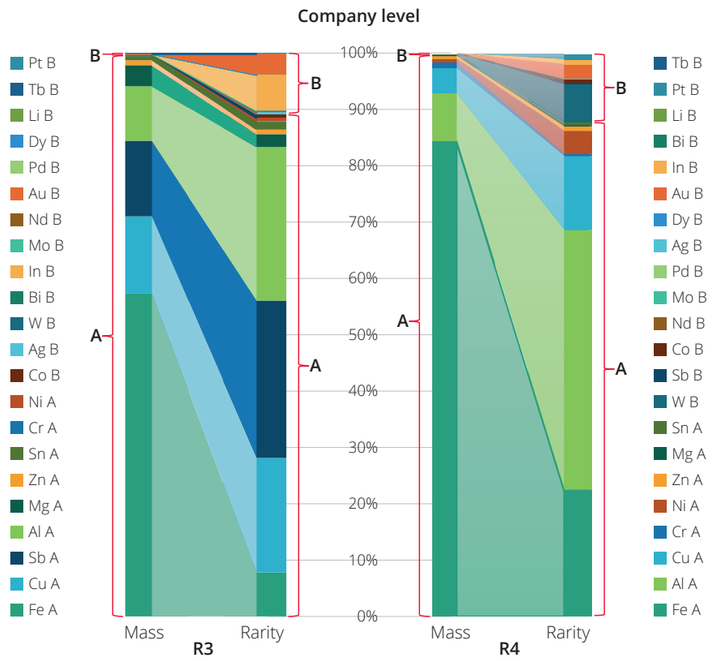


Figure 3 *The mass of materials vs. their rarity at the national level. A = all those elements with a mass share above 0.1% of the total weight in the sample. B = all those elements with a mass share below 0.1% of the total weight in the sample*

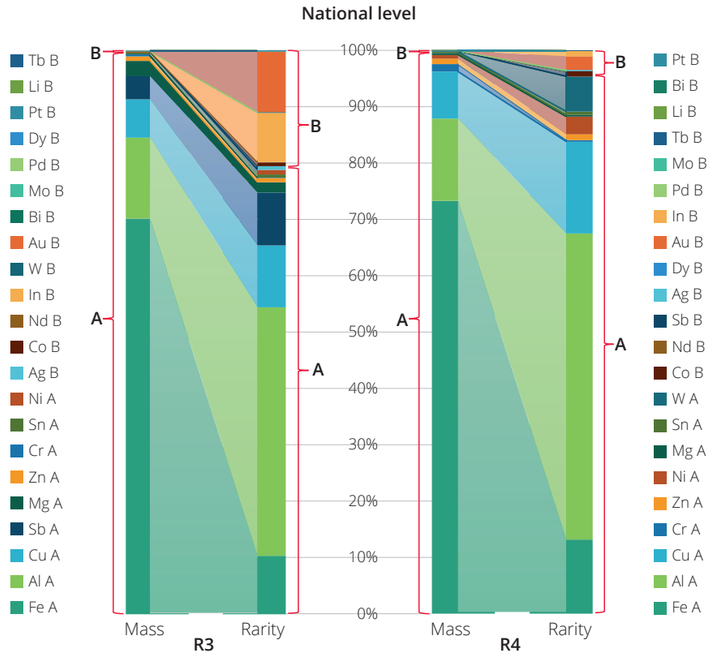


Figure 4 *The mass of materials vs. their rarity at the company sampled. A = all those elements with a mass share above 0.1% of the total weight in the sample. B = all those elements with a mass share below 0.1% of the total weight in the sample*

5 Integrated policy approach to CRM within EPR and eco-design

A new approach to waste management is needed to facilitate a circular economy. Waste management must evolve from preventing pollution and landfilling and providing secondary materials via recycling to being a **diagnostic tool that informs issues related to product design change.** This means prioritizing what needs to be recovered and conserved in the waste stage and, using the information of what can and cannot be recovered to inform product design practices [9]. We illustrate this in the case of CRMs, showing how EPR policy can be better integrated with eco-design policy.

Based on the above case study, we recommend changes to the responsibilities of actors within the WEEE and Eco-design Directives, plus new coordination responsibilities for the European Commission (EC).

Knowledge and information

- *Producers*: need to provide information on the presence and quantities of CRMs in their products. This would help improve treatment standards to promote CRM recovery;
- *Recyclers:* need to provide information on *which* materials they are and are not recovering to have a clear overview of gaps in recovery operations;
- Information from both recyclers and producers is collected in a data system recommended to be held by the EC, nominated third parties or through the promotion of product material passports. The information is used to inform long-term policy goals and R&D innovation in recovery technologies.

Targets and conditions

- *Policymakers* should adjust EPR targets and/or conditions, including treatment standards, to promote the monitoring and recovery of CRMs[j] where economically and environmentally feasible (connected to long-term ambitions). Incentives need to be given to support the recovery of CRMs, where it is currently not economically feasible [6,13];
- *Policymakers* should adjust Eco-design requirements to promote greater accessibility of CRMs in products. Where recovery of CRMs is currently not feasible at the waste stage given present technologies, CRM substitutions should be promoted, or accessibility enhanced at the product stage.

Access to and potential value retention options of CRMs

- *Producers* should pay an (additional) contribution included in the EPR fee structure, usually paid to the producer responsibility organizations, which should then be used to finance innovative recycling technologies, and/or upgrade existing recycling infrastructure [14];
- *Policymakers* should organise the systematic analysis of potential CRM value retention options, including which technologies are available for which materials and what barriers (economic and legal) must be overcome. This analysis is related to immediate and long-term risks (geopolitical and geological) for CRMs.

Deciding *which* CRMs should be included in the EPR 'targets and conditions' and which eco-design aspects need to be adjusted will require a large amount of knowledge and dynamic and continuous coordination between EPR and eco-design policy. Following recent developments with regard to the battery sector, we would recommend that the EC plays a central role on coordinating these activities (see Figure 5).

j We propose the rarity method as presented above provides a useful support tool for deciding on priority recovery CRM.

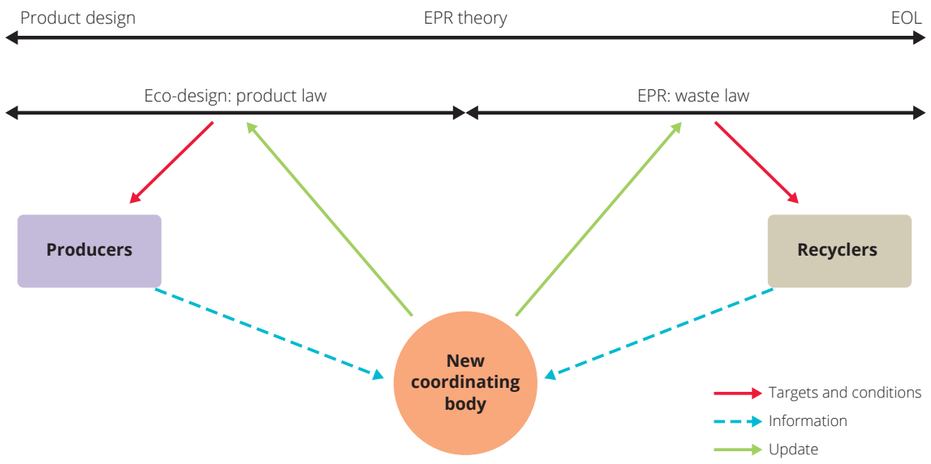


Figure 5 Integrating CRMs in EU product and waste law (a simplified systems perspective)

Process:

1 The issue related to CRMs and conservation of scarce materials must be integrated as a key feature in policy design processes (we recommend the rarity indicator as a useful tool to enable this[k]);
2 Producers provide information on the presence and quantities of CRMs in products. Recyclers provide information which materials are currently being recovered with present technologies;
3 Based on step one, the new coordinating body (EC) decides *which* materials are to be prioritised in monitoring targets or the recycling standards, which cannot, and which materials require further immediate and long-term research and development efforts;
4 Eco-design targets for specific materials are updated accordingly (removing or substituting materials that cannot be recovered OR mandating greater accessibility). WEEE targets and conditions are updated to prioritize specific CRMs. This is done periodically by EC.
5 The immediate and long-term risks of specific raw materials are periodically reviewed. Information from point 2 needs to continuously updated to provide accurate information for target and conditions setting decision-making processes.

k Campbell-Johnston et al., 2022 Forthcoming.

6 Legal implications

In section 5 three solutions have been suggested:

1. **Providing knowledge and information on CRMs;**
2. **Targets and conditions; and**
3. **The development of potential value retention options for CRMs**.

This section briefly examines some of the possible legal implications of these suggested solutions without claiming that these are the only possible legal implications or solutions for the identified issues.

Knowledge and information on CRMs

Currently, some of the implementing measures based on the Ecodesign Directive contain requirements on providing information on CRMs. Providing information on CRMs is also included in voluntary standard EN 45558. These existing instruments could be used to increase the available data on CRMs in (W)EEE. For the proposed solution regarding a new EU central coordinated database a connection could be made with existing information databases and initiatives for components and materials in (W)EEE.

There are implementing measures that already contain information requirements for producers to provide information on CRMs. These can be seen as promising initiatives.[17] However, including such information requirements on CRMs in other Ecodesign implementing measures would be a possibility to increase the available information on CRMs. Moreover, the current standard EN 45558 defines and details how information on CRMs could be collected and communicated by manufacturers.[18] Although relevant for this solution, standards are only voluntary – despite the fact that in some MSs, such as the Netherlands, standards have been made mandatory.[19] However, following article 8 (5) WEEE Directive the EC has the possibility to adopt implementing acts laying down minimum quality standards for proper treatment based on standards such as these.[20] To stimulate the collection and communication of information on CRMs in a standardized way it is recommended to consider making these standards legally binding.[21]

Next to information requirements in implementing measures or mandatory standards to collect all necessary information on CRMs, another opportunity could be to link with already existing information databases or initiatives. For example, the information obligations that already exist under the WEEE Directive and the data facilities that have been set up for this purpose, such as the i4R platform.[l] This information obligation requires MSs to ensure that producers provide information for treatment facilities about re-use and treatment of EEE and covers *inter alia* the different EEE components and materials. The i4R platform allows the exchange of this information between producers and recyclers. Also, the Raw Materials Information System (RMIS) could be instrumental in this regard, which is a web-based platform for non-fuel, non-agricultural materials from primary and secondary sources, including CRMs.[22] Or, it might be relevant to look into the possibilities to connect with the existing information requirements regarding the ECHA database, even though only few CRMs currently fall under the scope of the REACH Regulation. Other examples can also be mentioned, including in the proposal for the Regulation concerning batteries and waste batteries for a European Electronic Exchange System for certain categories of batteries, in which information on battery composition (incl. CRMs) is to be stored, and the proposal for the Digital Product Passport in the proposal for Ecodesign for Sustainable Products Regulation.[23] Looking at all these databases and initiatives, we would recommend to make the EC responsible for establishing the information system, comparable to the proposed set up for the batteries

l Article 15 WEEE Directive. To meet the obligation of article 15 WEEE Directive, i4R has been created. This is a single central online platform, where recyclers can access recycling information at product category level. See: https://i4r-platform.eu/about/.

sector and in line with the product passport registry as proposed in the Ecodesign for Sustainable Products Regulation.

Targets and requirements

The WEEE Directive contains the targets and requirements for the recycling and recovery of WEEE. Currently, the WEEE Directive sets mass-based targets for recycling and recovery. Concerning these targets, it is recognized that the WEEE Directive only sets minimum requirements on recycling targets for WEEE and that it is already possible for MSs to set more stringent targets for WEEE in their national legislation.[24] However, it is recommended to set additional targets to recover CRMs from WEEE at the EU level, to put greater emphasis on CRMs in WEEE.

The WEEE Directive requires MSs to ensure that all separately collected WEEE undergoes proper treatment, including selective treatment of certain components. As a minimum, some components have to be removed from the separately collected WEEE and undergo selective treatment. Some of these components also contain a high amount of CRMs (i.e. PCBs, batteries and cathode ray tubes).[m] While MSs would still be responsible for the proper treatment, it could be considered to include other components containing (high amounts of) CRMs in this list. Also, according to article 8 (4) WEEE Directive, the EC can adopt a delegated act to amend Annex VII (which states the selective treatment for materials and components of WEEE) and introduce other treatment technologies, which would include technologies favourable to CRMs. However, even if all CRM containing components were to be required to undergo proper treatment, it has been stated that the absence of binding standards for WEEE treatment is hampering the recycling market of WEEE. A proposed solution for this would be to make standards for WEEE, such as the EN 50625, mandatory.[25] This could also stimulate the recycling of CRMs in WEEE, provided that all relevant aspects of CRMs are being included in these standards. The EC has recently identified CRMs recycling as a standardisation urgency, and has the intention to develop standards to support the recycling of CRMs.[26] MSs may set up such minimum quality standards, but as already discussed, the EC could also adopt implementing acts laying down these minimum quality standards.

With regard to ecodesign requirements for recycling and recovery of WEEE, the WEEE Directive states that these should be laid down in implementing measures based on the Ecodesign Directive.[27] As already stated, the Ecodesign Directive makes it possible to address the whole life cycle of products, which also includes the use and presence of (critical) raw materials; CRMs are also already being mentioned in a few implementing measures. In its Energy Labelling and Ecodesign Working Plan 2022-2024, the EC stated the intention to further assess product-specific requirements on CRMs. However, to increase the focus on CRMs in implementing measures, explicitly including CRMs as a parameter and/or environmental aspect in the Ecodesign Directive – comparable to how this is being done with regard to hazardous substances – might be a possibility. Also, CRMs are currently included in the MEErP, but it can be questioned if this has resulted in CRMs being fully considered in the preparatory studies for the implementing measures. Therefore, it might be necessary to consider revising the CRM approach in the MEErP to enhance ecodesign requirements on CRMs.

A different way to improve the recovery of CRMs would be to set more ecodesign requirements on the design of EEE. An example could be the introduction of requirements on the amount of CRMs that products or components are allowed to contain, or requirements on the dismantling or ease of recovery of CRMs.[n] Such requirements could tackle technological issues related to the way CRMs are used in EEE. To increase a synergy between ecodesign requirements and the WEEE Directive, a link could be made with possible new components containing CRMs that need special treatment based on the WEEE Directive.[28]

Access to and development of potential value retention options of CRMs

The intention for this solution is that part of the fee that producers pay in the EPR fee structure goes into either financing CRMs recovery techniques or stimulating R&D with regard to CRMs. A possible way in which this could be realized is by using the instrument of modulated fees.[13]

What is needed to support this is a periodic technological assessment of available and potential CRM recovery options, e.g. recycling technologies and proper organization of collection and sorting. Technologies that are available and/or viable should be supported with the fee to either make it commercially viable and/or enable further research on what is possible with regards to CRMs recycling. Where such technology or the recovery of the CRMs isn't either (a) currently viable or (b) viable in the near future, the fee paid by the producer should be raised in order to penalize design practices that do not support the circular flow of CRMs.

Currently, there is a legal basis for modulated fees in EU law in the case of a collective fulfilment of extended producer responsibility obligations. Article 8a (4) sub b WFD states that MSs need to ensure that the fees are modulated 'where possible', notably by taking into account *inter alia* durability, re-usability, recyclability and the presence of hazardous substances. While the provision in the WFD leaves room to take into account (the recyclability of) CRMs as well, it could be considered to explicitly include CRMs in Article 8a (4) sub b WFD as such an aspect, comparable to the way hazardous substances are now explicitly mentioned as in this regard. However, it is important to note that while there is a basis in EU law, it has to be applied by MSs. The same applies with regard to requiring producers to contribute to the costs of the PROs in general. This also has to be provided at the MS level, not the EU level.

In short, we would propose fee modulation by taking into account the presence of CRMs as the way forward. While this means that MSs need to press ahead, the current development of guidelines on fee modulation by the EC hopefully guides and supports MSs to do so.[29]

m See box on page 12.

n See for example Regulation 1253/2014 that contains a requirement on providing detailed instruction for disassembly.

References

1. Blengini GA, Mathieux F, Mancini L, et al. *Recovery of Critical and Other Raw Materials from Mining Waste and Landfills*.; 2019. doi:10.2760/600775
2. European Commission. COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS Critical Raw Material Resilience: Charting a Path towards greater Security and Sustainabilty. *COM(2020), 474 Final*. 2020:61-70. doi:10.1016/b978-0-12-823886-8.00023-3
3. Bobba S, Carrara S, Huisman J, Mathieux F, Pavel C. *Critical Raw Materials for Strategic Technologies and Sectors in the EU – a Foresight Study*.; 2020. doi:10.2873/58081
4. European Commission. *European Commission, Report on Critical Raw Materials and the Circular Economy, 2018*.; 2018. doi:10.2873/331561
5. Henckens MLCM. Scarce mineral resources: Extraction, consumption and limits of sustainability. *Resour Conserv Recycl*. 2021;169(February):105511. doi:10.1016/j.resconrec.2021.105511
6. Horta Arduin R, Mathieux F, Huisman J, et al. Novel indicators to better monitor the collection and recovery of (critical) raw materials in WEEE: Focus on screens. *Resour Conserv Recycl*. 2020;157(March):104772. doi:10.1016/j.resconrec.2020.104772
7. Mathieux F, Ardente F, Bobba S, et al. *Critical Raw Materials and the Circular Economy. Background Report*.; 2017. doi:10.2760/378123
8. Valero A, Valero A, Calvo G, Ortego A. Material bottlenecks in the future development of green technologies. *Renew Sustain Energy Rev*. 2018;93(May):178-200. doi:10.1016/j.rser.2018.05.041
9. Ciacci L, Reck BK, Nassar NT, Graedel TE. Lost by Design. *Environ Sci Technol*. 2015;49(16):9443-9451. doi:10.1021/es505515z
10. European Commission. *The European Green New Deal*. Brussels: https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en; 2020.
11. European Commission. Circular economy action plan. *Eur Comm*. 2020;(March):28. doi:10.2775/855540
12. Huisman J, Leroy P, Tertre F, et al. *ProSUM Project Urban Mine and Mining Wastes – Final Report*.; 2017. http://prosumproject.eu/sites/default/files/DIGITAL_Final_Report.pdf.
13. WEEE Forum 2018.
13. CEWASTE. *A Contribution to Future Critical Raw Materials Recycling*.; 2021.
14. Vermeulen WJV, Backes CW, Munck MCJ de, et al. *WHITE PAPER on Pathways for Extended Producer Responsibility on the Road to a Circular Economy*.; 2021. doi:10.13140/RG.2.2.11527.93602
15. Ortego A, Valero A, Valero A, Restrepo E. Vehicles and Critical Raw Materials: A Sustainability Assessment Using Thermodynamic Rarity. *J Ind Ecol*. 2018;22(5):1005-1015. doi:10.1111/jiec.12737
16. Ortego A, Valero A, Valero A, Iglesias M. Downcycling in automobile recycling process: A thermodynamic assessment. *Resour Conserv Recycl*. 2018;136:24-32. doi:10.1016/j.resconrec.2018.04.006
17. Horta Arduin R, Mathieux F, Huisman J, et al. Novel indicators to better monitor the collection and recovery of (critical) raw materials in WEEE: Focus on screens. *Resour Conserv Recycl*. 2020;157(March):104772. doi:10.1016/j.resconrec.2020.104772
18. Talens Peiro L, Polverini D, Ardente F et al. Advances towards circular economy policies in the EU: The new Ecodesign regulation of enterprise servers. *Resour Conserv Recycl*. 2020;154:104426. doi:10.1016/j.resconrec.2019.104426
19. WEEE Forum. Compliant WEEE recycling: Why making EN 50625 standards legally binding is part of the solution.; 2018. Article 11 Regeling AEEA.
20. EU-WIDE UNIFORM CONDITIONS FOR THE PROPER QUALITY TREATMENT OF WEEE: A call for Implementing Acts to lay down minimum quality WEEE treatment standards in strict accordance with the European standards, 2019; WEEE Forum. Compliant WEEE recycling: Why making EN 50625 standards legally binding is part of the solution.; 2018.
21. This requires that these standards are sufficient for what is required for CRM Recycling. See about this e.g.: SCCREEN report 'Upgrading regulations and standards to enable recycling of CRM from WEEE', 2019.
22. Endnote: Mathieux F, Ardente F, Bobba S, et al. *Critical Raw Materials and the Circular Economy*. Background Report.; 2017.. doi:10.2760/378123
23. Proposal for a Regulation of the European Parliament and of the Council concerning batteries and waste batteries, repealing Directive 2006/66/EC and amending Regulation (EU) No 2019/1020, COM(2020) 798 final. Proposal for a Regulation establishing a framework for setting ecodesign requirements for sustainable products and repealing Directive 2009/125/EC, COM(2022) 142 final.
24. Mathieux F, Ardente F, Bobba S, et al. *Critical Raw Materials and the Circular Economy*. Background Report.; 2017. doi:10.2760/378123
25. WEEE Forum. Compliant WEEE recycling: Why making EN 50625 standards legally binding is part of the solution.; 2018.
26. See about this more extensively: SCCREEN report 'Upgrading regulations and standards to enable recycling of CRM from WEEE', 2019.
27. Article 4 WEEE Directive. Recital 11 Directive 2012/19/EU. See also: EEB, 'Delivering Resource-Efficient Products – How Ecodesign can drive a circular economy in Europe', 2015.
28. Bundgaard, A. M., Remmen, A., & Zacho, K. O. (red.) (2015). Ecodesign Directive version 2.0: From Energy Efficiency to Resource Efficiency. Miljøstyrelsen. For the sake of completeness, it is also noted that ecodesign requirements have to meet the criteria in Article 15 of the Ecodesign Directive.
29 Recital 27 WFD 2018/851; Hogg et al., Study to Support Preparation of the Commission's Guidance for Extended Producer Responsibility Schemes, 2020. See also: F. Laubinger, Modulated fees for Extended Producer Responsibility schemes (EPR), OECD Environment Working Papers No. 184.