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Review of the MEErP - Methodology for Ecodesign of Energy-related Products

Task 1: Updating of the EcoReport tool

Task 2: More systematic inclusion of material efficiency aspects and of environmental footprint/ecological profile aspects in the design options and in the LLCC curve

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Contents

TABLE OF CONTENTS

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Abstract

The Methodology for Ecodesign of Energy-related Products (MEErP henceforth) consists of a techno-economic-environmental assessment of a specific product group. This assessment is the main analytical step in the potential implementation of the Ecodesign Directive on a specific product group.

Since 2013 the current MEErP methodology has been in used and considered fit for purpose. However, since 8 years have already elapsed in this very dynamic field, the need for an update is apparent.

The current report focuses on efforts carried out on the first part of the updating of the MEErP: the updating of the EcoReport Tool and on the systematic inclusion of material efficiency aspects in the design options and in the LLCC curve.

1 Introduction

Ecodesign and Energy Labelling legislation are key contributors in supporting the Commission's overarching priority to strengthen Europe's competitiveness and boost job creation and economic growth. Their effect can be felt in the Energy Union objectives, the transition to a Circular Economy, the internal market functioning and the environment. They also drive investment and innovation and save money for consumers.

The Methodology for Ecodesign of Energy-related Products (MEErP henceforth) consists of a techno-economic-environmental assessment of a specific product group. This assessment is the main analytical step in the potential implementation of the Ecodesign Directive on a specific product group.

Concerning the identification and the level of stringency of the (potential) Ecodesign requirements for a certain product group, the most important part of the analysis takes place within the techno-economic assessment, at the point when the life cycle cost curve is determined, and the Least Life Cycle Cost (LLCC henceforth) is defined. On the basis of the LLCC and related product environmental impact, Ecodesign requirements for a certain product can be set, aiming to gradually – and sustainably - push the market towards the LLCC. Once the requirements are defined, it is left to individual manufacturers to choose how, and with which technologies, to produce a compliant product (in line with the principle of technological neutrality). The LLCC is unique to each product category, and it provides the optimum level from a regulatory perspective because it minimises the total cost of ownership for the consumer and it pushes all manufacturers, at the same time, to make improvements to their products with existing technologies.

The MEErP is open, iterative, transparent, and utilises a tool (the EcoReport tool) that is free at the point of use, and is simple to use whilst being sufficiently complex/ complete in order to capture the main inputs and outputs at product specific level. The EcoReport is a streamlined life-cycle based tool that is openly available, with no presumption or requirement of prior purchase of a commercially-available Life Cycle Assessment package.

In 2013, the MEErP was evaluated and considered fit for purpose in the decision-making process of the Ecodesign and Energy Labelling legislative framework. A new update is now needed, in particular a) to update, when and where necessary, some of the data used in the analysis and b) to ensure that the MEErP is still fit for its purpose, in line with the policy developments of the last years. Within this framework, several areas of analysis (together with, in some cases, potential solutions/approaches) have been identified in the course of the last years, namely:

- Need for the update of the environmental impact data contained in the EcoReport tool, as well as an evaluation of the relevance of the various input categories/indicators with regard to material efficiency.
- Relevance for a more systematic inclusion of material efficiency aspects in the modelling of the MEErP. These aspects have been assessed in recent eco-design and energy labelling preparatory studies, although without having as reference a harmonised and systematic methodology. This could be attained, in particular, by systematically including two separate but equally important aspects in the construction of the LLCC curve:
    - Systematic inclusion (when relevant for the specific product group under analysis) of design options related to material efficiency aspects (such as a) increased reparability, b) increased durability, c) increased recyclability or d) aimed at promoting the reuse of secondary raw materials and/or components).
    - Systematic inclusion of lifetime in the MEErP modelling of the LLCC. In order to properly analyse and model circular economy requirements, product lifetime must be taken into account. In practical terms, following this approach would imply that an 'equivalent annual cost' (for a design option) should be calculated. With the use of the 'equivalent annual cost' it is possible to properly compare design options with different (expected) lifetimes, such as, for example, the base case (i.e. the average EU product), compared to a second product with increased durability (e.g. thanks to the higher quality of its components) and a third product with higher lifetime than the base case as a result of its improved design for reparability (see the previous point).

- Relevance of the development of the Product Environmental Footprint method (data and approach, e.g. for modelling impacts, normalising and weighting results) and related Product Environmental Footprint Category Rules to the MEErP and the EcoReport tool for assessing life cycle impacts both for developing the base case and the design options.
- Relevance for a more systematic inclusion of design options:
  - aimed at reducing the carbon and environmental footprint of the product.
  - (potentially linked to the previous point) compliant with generic ecodesign requirements based on the ecological profile of the product.
- Relevance of a more systematic inclusion of societal life cycle costs (direct environmental costs, externalities and other indirect costs) in the MEErP.
- Need for a more refined method for the evaluation of the economic impacts (e.g. impacts on employment) in Task 7 of the MEErP.

The current report focuses on efforts carried out regarding the updating of the first two tasks of the project, namely those focussing on the updating of the EcoReport Tool and on the systematic inclusion of material efficiency aspects in the design options and in the LLCC curve.

2 Task 1 – "Updating of the Ecoreport Tool"

This document illustrates the progresses on the update of the Ecoreport tool (ERT), as per Task 1 of the project ""Review of the MEErP - Methodology for Ecodesign of Energy-related Products" (MEErP)"[1]. The purpose is to present the updating and review of the current version of the tool. Taken actions and implementations are described, including screenshots from the new version of the tool.

As general objective of Task 1, it is important to keep the same format of the ERT[2] (excel file), its logic and simplified approach, whereas aiming at enhancing transparency (especially for the background data and modelling options) and consistency in the different sections of the tool.

The state of play of the Task 1 and its various subtasks is presented hereinafter.

2.1 Impact categories (Subtask 1.a)

Objectives

Update of the impact categories in the ERT.

Status Ecoreport tool

The results of the environmental assessment of the ERT are currently displayed as a set environmental inputs and outputs, as in the spreadsheet "Results". In particular, these include:

- a list of inputs as "Materials" (e.g. bulk plastics, Ferro, electronics, etc.),

- a list of inputs and outputs as "Other Resources & Waste" (e.g. Total Energy – GER, water, Waste non-hazardous etc.),

- a list of "emissions to air" (grouped as e.g. Greenhouse gases, acidification emissions, etc.),

- a list of "emission to water" (heavy metals and eutrophication).

This list of inputs and outputs is generally not in line with usual impact assessment in life cycle approaches, since it combines inventory flows (as raw materials, water and waste) and more complex impact assessment categories (as combination of emissions multiplied by corresponding characterisation factors for the contribution to a certain impact category). This structure of environmental assessment was firstly introduced in the MEEuP in 2005, and partially revised in 2011. However, since 2011 it has been not updated, and it does not reflect the large progresses in the last decade by the scientific community to harmonize impact assessment methods for life cycle approaches. Worth of note are the developments by the UN LCA initiative3 and by the EU Environmental Footprint method4. Moreover, environmental impacts in current ERT are based on impact factors developed ad-hoc within the MEErP, and these are not included in other common software for Life Cycle Assessment (LCA). This makes particularly difficult the procedure to calculate these impacts when updating the database of the ERT (as within the current project) and also for any new dataset introduced, for example, by consultants during preparatory studies. Moreover, except for a few examples (as GWP, GER and water) the impact categories in the ERT have been not widely commented in the LCA literature and therefore they are difficult to interpret. Based on the experience of previous preparatory studies, very few of these categories have been used to develop product requirements in the last decades.

Rationale and Action

Based on this analysis, it was decided to align ERT with impact categories used in the Product Environmental Footprint (PEF). This choice allows to use robust indicators aligned to prominent literature; it facilitates continuous updates of characterisation factors in future (following scientific progress); granting alignment with developments in PEF and other EU policies; and overall allow an easier interpretation (following also relevant publications for the various categories). Moreover, this choice is relevant also for the process of updating datasets (as described later), to grant alignment between inventory and Impact assessment.

[1] Administrative Arrangement N ° JRC 35847-2020 // GROW SI2.831466
[2] Version 3.06 VHK for European Commission 2011, modified by IZM for european commission 2014
[3] https://www.lifecycleinitiative.org/activities/phase-i/life-cycle-impact-assessment-programme/
[4] COMMISSION RECOMMENDATION of 9 April 2013 (2013/179/EU).

Implementation

In the new version, ERT is currently being revised to include new impact categories (as in Figure 1. A specific new spreadsheet is dedicated to the impact category selection. The spreadsheet has been revised to be flexible to expand/modify this list in a simple way, in case new relevant impact categories would be identified in future.

Detail on the impact assessment methods is provided in the Technical reports developed for the PEF method[5]. Guidance on the interpretation of the different impact categories will be provided at later stage (as part of subtask 1.c).

Figure 1: 1.a) Current impact categories in the ERP (as in the "RESULTS" spreadsheet); and 1.b) "NEW IMP_CAT" spreadsheet with list of Impact categories aligned with PEF.

Fig. 1.a: Impact categories in the current ERT

	Other Resources & Waste	
11	Total Energy (GER)	MJ
12	of which, electricity (in primary MJ)	MJ
13	Water (process)	ltr
14	Water (cooling)	ltr
15	Waste, non-haz./ landfill	g
16	Waste, hazardous/ incinerated	g
	Emissions (Air)	
17	Greenhouse Gases in GWP100	kg CO2 eq.
18	Acidification, emissions	g SO2 eq.
19	Volatile Organic Compounds (VOC)	g
20	Persistent Organic Pollutants (POP)	ng i-Teq
21	Heavy Metals	mg Ni eq.
22	PAHs	mg Ni eq.
23	Particulate Matter (PM, dust)	g
	Emissions (Water)	
24	Heavy Metals	mg Hg/20
25	Eutrophication	g PO4

Fig. 1.b: list of new impact categories proposed for the revised ERT

	A	B	C	D	E
1		Impact categories		Selection	
2	IC 1	Climate change, total	kg CO2 eq	☑	
3	IC 2	Ozone depletion	kg CFC-11 eq	☑	
4	IC 3	Human toxicity, cancei	CTUh	☑	
5	IC 4	Human toxicity, non-c	CTUh	☑	
6	IC 5	Particulate matter	disease incidence	☑	
7	IC 6	Ionising radiation, hun	kBq U235 eq	☑	
8	IC 7	Photochemical ozone	kg NMVOC eq	☑	
9	IC 8	Acidification	mol H+ eq	☑	
10	IC 9	Eutrophication, terrest	mol N eq	☑	
11	IC 10	Eutrophication, freshw	kg P eq	☑	
12	IC 11	Eutrophication, marin	kg N eq	☑	
13	IC 12	Ecotoxicity, freshwate	CTUe	☑	
14	IC 13	Land use	UoM	☑	
15	IC 14	Water use	m3 world eq	☑	
16	IC 15	Resource use, mineral	kg Sb eq	☑	
17	IC 16	Resource use, fossils	MJ	☑	

[5] https://eplca.jrc.ec.europa.eu/EFtransition.html

2.2 End of Life modelling (recycled content and recyclability at end of life) - (Subtasks 1.d & 1.g)

Objectives

Revising the current approach to end-of-life in the ERT, with the aim to grant consistency of modelling for different materials and allowing the implementation of different assumptions about the recyclability of materials and/or use of secondary raw materials.

Status Ecoreport tool:

ERT reports predefined End of Life (EoL) mass fraction to: re-use, recycling, recovery, incineration and landfill to calculate credits (see Figure 2). These mass fractions can be modified by the user for some materials (e.g. plastics and electronics), whereas these are fixed for metals.

Additional recyclability aspects can be taken into account by modifying recyclability assumptions (e.g. best, average worst cases) as a reduction/increased up to 10% on all impacts of the recycled mass: best/>avg/avg (base case)/<avg/worst (per materials category) with credit on recycled mass +10%/+5%/0/-5%/-10% (also for metals).

The possibility to calculate the recyclability benefit rate (RBR) was added in the latest version of the ERT to compare different EoL scenarios. However, this RBR is currently applied to plastics only.

Moreover, the database of ERT is currently missing sufficient data about recycled materials. Content of recycled materials is also partially embodied into inventory datasets for certain materials (e.g. metals). Downcycling factors (to account for changes in quality of recycled materials) are also foreseen as inputs to the RBR calculation, however little detail have been provided so far for their calculation.

Overall, the current EoL modelling in the ERT is affected by low transparency (in assumptions and datasets), and high risk of inconsistencies (e.g. about different modelling assumptions for different materials).

Figure 2: Assumptions in the Ecoreport tool for End of Life.

	Per fraction (post-consumer)	1	2	3	4	5	6	7a	7b	7c	8	9	
		Bulk Plastics	TecPlastics	Ferro	Non-ferro	Coating	Electronics	Misc., excluding refrigant & Hg	refrigerant	Hg (mercury), in mg/unit	Extra	Auxiliaries	TOTAL (CARG avg.)
263	EoL mass fraction to re-use, in %						1%			1%		5%	1.0%
264	EoL mass fraction to (materials) recycling, in %	29%	29%		94%		50%	64%	30%	39%	60%	30%	40.2%
265	EoL mass fraction to (heat) recovery, in %	15%	15%		0%		0%	1%	0%	0%	0%	10%	12.1%
266	EoL mass fraction to non-recov. incineration, in %	22%	22%		0%		30%	5%	5%	5%	10%	10%	18.7%
267	EoL mass fraction to landfill/missing/fugitive, in %	33%	33%		5%		19%	29%	64%	55%	29%	45%	28.0%
268	TOTAL	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	######
269	EoL recyclability****, (click& select: 'best', '>avg', 'avg' (basecase); '< avg'.; 'worst')	avg	avg	avg	avg	avg	avg	avg	avg	avg	avg	avg	avg

Rationale and Action

The EoL modelling is updated according to the PEF method by using the Circular Footprint Formula (CFF). This choice will grant internal consistency within the ERT (in line with updated datasets to be implemented), and potential consistency with external studies (e.g. results of PEF). Recyclability and recycled content will be modelled taking into account the CFF formula, as these parameters will be inputs for this formula. Default values for recycled content/recyclability will be provided. Guidance on how the user could better estimate these values for the case-study product and how potentially setting requirements on such aspects will be investigated in Task 2.

Implementation

The CFF (Figure 3) is implemented in the ERT as following.

Figure 3: The Circular Footprint Formula implemented in the PEF method.

Material

$$(1-R_1)E_V + R_1 \times \left(AE_{recycled} + (1-A)E_V \times \frac{Q_{Sin}}{Q_p}\right) + (1-A)R_2 \times \left(E_{recyclingEoL} - E_V^* \times \frac{Q_{Sout}}{Q_P}\right)$$

The terms in use in the formula are:

R1 (recycled content): default value from the PEF method[6]. Possibility for the user to change according to his/her knowledge

R2 (recyclability[7]): default value from PEF method[8]. Possibility for the user to change according to his/her knowledge

A (allocation factor)[9]: default value provided by the ERT and based on the PEF method. The user shall include this value only if the material is included by the user as a new material, namely it is not part of the ERT database. The value needs to be compliant with the rules of the PEF method. In case no detailed information is available for the user, default 0.5 value shall be used.

Ev (virgin material dataset): EF3.0 dataset automatically taken from the ERT

$E_{recycled}$: EF3.0 dataset of recycling processes of the recycled material.

$E_{recycling\ EoL}$: set equal to $E_{recycled}$.

Ev*: will be set by default equal to Ev[10]

Qs/Qp: Q parameters are set equal to 1.

Moreover, the contribution to the CFF related to the "energy recovery" and disposal in landfill will be not implemented in the ERT, to keep the EoL modelling easy and lean, and also considering their minor contribution to the life cycle impact of Energy related Products.

The simplified version of the CFF implemented in the ERT is:

$$(1-R_1)E_V + R_1 \times \left(AE_{recycled} + (1-A)E_V\right) + (1-A)R_2 \times \left(E_{recycled} - E_V\right)$$

Default data are assigned to the various parameters (i.e. values of the recycled content R1, recyclability R2 and allocation factor A) as referring to the PEF guidance documents[11]. Figure 3 is showing how the CFF is implemented in a new spreadsheet of the ERT. Furthermore, in the spreadsheet "Inputs" it is possible for the user to adjust or change these values according to his/her knowledge (see Figure 5). Guidance for the users on how to interact with these spreadsheets will be provided as in sub-task 1.c.

Figure 4: "NEW CFF_calc" spreadsheet. The CFF is implemented in this spreadsheet. Default R1, R2 and A are taken from the sheet "NEW_PEF_DB", while if the user inserted the values this is automatically updated and reported in columns E and F. Values shown in the table are illustrative.

[6] Default values of R1 for CFF are illustrated in https://eplca.jrc.ec.europa.eu/permalink/Annex_C_V2.1_May2020.xlsx

[7] In the PEF method R1 is referred as "Recycling output rate", i.e. the proportion of the material in the product that will be recycled in a subsequent system. It takes into account the inefficiencies in the collection and recycling processes.

[8] Default values of R2 for CFF are illustrated in https://eplca.jrc.ec.europa.eu/permalink/Annex_C_V2.1_May2020.xlsx

[9] The "A" factor in the CFF allows to allocate impacts and/or benefits between the use of recycled materials as input (i.e. recycled content) and recycling at the end-of-life (i.e. recyclability).

[10] Under investigation if the user will be allowed to change the factor for some materials.

[11] https://eplca.jrc.ec.europa.eu/permalink/Annex_C_V2.1_May2020.xlsx

The simplified version of the CFF

$$(1-R_1)E_V + R_1 \times \left(AE_{recycled} + (1-A)E_V\right) + (1-A)R_2 \times \left(E_{recycled} - E_V\right)$$

Component	Category	Virgin Material	Recycled material	Mass of materials	R1	R2	A	Climate change, total	Ozone depletion	Human toxicity, cancer	Human toxicity, non-canc
								kg CO2 eq	kg CFC-11 eq	CTUh	CTUh
COMP1	01-Plastics	8-PET granulates, amorph	51-Polyethylene terephth	50	0%	0%	0.5	0.31	0.49	0.60	0
COMP2	02-Metals	18-Steel sheet cold rolling	52-Secondary steel slab	50	30%	90%	0.2	0.56	0.72	0.36	0
COMP3	01-Plastics	1-LDPE granulates	49-Plastic granulate seco	50	0%	0%	0.5	0.56	0.26	0.18	0
COMP4	02-Metals	196-New_NON FERRO	197-New_NON FERRO	50	30%	90%	0.2	0.83	0.40	0.40	0
COMP5	03-Electronics	34-Capacitor SMD	62-End of life of Capacito	50	0%	50%	0.5	0.79	0.59	0.02	0
COMP6	03-Electronics	192-New_ELECTR	193-New_ELECTR	50	0%	50%	0.5	0.34	0.85	0.54	0
COMP7	04-Others	40-Corrugated board	66-EoL of beverage cartc	50	10%	30%	0.5	0.45	0.77	0.29	0

Figure 5: Example of introducing new inputs for the Bill of materials ("Inputs" spreadsheet). From column I to Q there is the section for the CFF implementation. Default values are provided. User can modify the values, if relevant.

Nr	Product name Products		Date	Author		CFF implementation								
Pos nr	Bill of Materials Description of componer	Weight in g	Category Click &select	Virgin Material lect Category first !	Recycled Material	Default R1? Yes/No	R1, recycled content default	custom please insert	Default R2? Yes/No	R2, recyclability default	custom please insert	Default A? Yes/No	A coefficient default	custom please insert
1	COMP1	50.0	01-Plastics	8-PET granulate:	51-Polyethylene terephthalate (I	Yes	0%		Yes	0%		Yes	0.5	
2	COMP2	50.0	02-Metals	18-Steel sheet cc	52-Secondary steel slab	Yes	30%		Yes	90%		Yes	0.2	
3	COMP3	50.0	01-Plastics	1-LDPE granulat	49-Plastic granulate secondary (I	Yes	0%		Yes	0%		Yes	0.5	
4	COMP4	50.0	02-Metals	196-New_NON F	197-New_NON FERRO	Yes	30%		Yes	90%		Yes	0.2	
5	COMP5	50.0	03-Electronic:	34-Capacitor SM	62-End of life of Capacitor SMD;	Yes	0%		Yes	50%		Yes	0.5	
6	COMP6	50.0	03-Electronic:	192-New_ELECT	193-New_ELECTR	Yes	0%		Yes	50%		Yes	0.5	
7	COMP7	50.0	04-Others	40-Corrugated b	66-EoL of beverage carton	No	n.a.	10%	No	n.a.	30%	Yes	0.5	

When new datasets are inserted in the database by the user (description in chapter **Error! Reference source not found.**), default values of R1, R2 and A are provided by the ERT (based on values in Table 1). However, the user will have the possibility to change these values if he/she has better information. Detailed guidance on how to insert values for new datasets will be provided (as part of subtask 1.c).

Table 1: Exemplary values of R1, R2 and A given by default for new datasets included by the user (values to be referred to the last version in use for PEF[12]). Values shown in the table are temporary.

Categories	**R1** **(default values)**	**R2** **(default values)**	**A** **(default values)**
Metals	30%	90%	0,2
Plastics	0%	0%	0,5
Electronics	0%	50%	0,5
Others (including Miscellaneous, Auxiliaries)	Set as not available 'n.a.' to be inserted by the user	Set as not available 'n.a'. to be inserted by the user	0,5

[12] https://eplca.jrc.ec.europa.eu/permalink/Annex_C_V2.1_May2020.xlsx

2.3 Datasets (Subtask 1.a & 1.b)

Objectives

Update the underlying datasets of ERT and include additional datasets on new materials also considering the possibility to provide regular updates in future. The datasets and their relationship to the bills of materials, energy sources etc., should be of an appropriate degree of complexity and refinement, and generally representative for the "average" EU context. The quality (e.g. time, technological and geographical representativeness) of the datasets to be used should be transparently indicated. Data format compatibility between the datasets and the impact categories shall be taken into account.

Status Ecoreport tool

Already when the ERT was developed, authors identified some difficulties and limitation in using life cycle inventory data for the ERT database. In particular authors stated that "*there is a wide discrepancy between emission data for one material or process between the various database sources. Several initiatives are underway to deal with this (e.g. SETAC/UNEP Life Cycle Initiative, European Platform on LCA by DG JRC-IES), but no homogenous average EU database exists. [...] Documentation regarding the origin of emission data and their validity (for which region? for which process? why are they different from the rest?) is often not clear from the tool alone and would require extensive additional research to explain the differences [...]. Public availability of data is limited* " (VHK, 2005) [13]. Some of these problems have been tackled by using a combination of different data from various sources, and modelled by ERT'sauthors to fit for the purpose. However, the majority of datasets are now outdated (mainly referring to data from early 2000s). Moreover, few details are available on the exact reference[14] for the various datasets and further elaborations performed[15]. Those aspects (i.e. lack of detail on the data references and modelling) make not possible to update the database following the same approach as in the original ERT.

In addition, based on outcomes of previous preparatory studies, the database is lacking of several relevant datasets (especially those related to electronics). Finally, the current format of datasets in ERT is not aligned to prominent literature on inventory data for LCA, which makes particularly difficult any updates.

Rationale and Action

It is proposed to update the database in the ERT by replacing all the previous datasets with **EF 3.0 datasets[16]** developed for the PEF studies. These datasets cover virgin and recycled materials (as e.g. to be used in the CFF). This approach guarantees consistency and robustness across data (since all data have been developed according to same rules), and representativeness (all data are representative of current situation at the EU level). This choice is also aligned to the strategy proposed for the update of impact assessment

[13] VHK (2005). Methodology Study Eco-design of Energy-using Products (MEEUP) - Methodology Report - Final Report.

[14] It is generally stated that "Sources for emission data are amongst others: APME (plastics), AKZO (aramid fibres), IISI, Eurofer (St), IPAI, Aluminium Institute (Al), ETH-1996 (preliminary data on Cu pending Eurocopper input), The Nickel Institute (Ni), IPPC BREF on VOCs (Cu filaments, pre-coat, powder coat), The European Dioxin Inventory (secondary metals, solids combustion), Frauenhofer Institute and SemaTech 2002 (ICs), IPPC BREFs on Paper, Glass (misc.), NTM (transport), ANEC, Öko-institut GEMIS 4.2 (Fossil fuel heat), EPER 2001, Eurelectric (electricity), IPPC BREF on Waste Incineration (disposal), Ecolabel-studies (dishwasher detergents, paper/cardboard, CRT), USGS and US DoE EER (mining), US EPA (some Hg emissions), SAVE studies (Heating & hot water appliances), Lithuanian Cleaner Production programme (plating) and individual manufacturer's environmental reports, like AT&S (PWBs). We are especially grateful for the personal contributions/reviews by AMD (ICs), Sharp Corp. Japan (LCD Factory) and Philips (CRT). Data were checked against public VHK studies in the past (downloads from www.vhk.nl), LCI-databases such as EcoInvent in SIMAPRO 6 and a host of other literature. The largest part of the emission data refers to 2000-2005. For the electronics sector, primarily more recent (2003-2004) information was used, because of the sector-dynamics in pollution abatement" (VHK, 2005). Same statement is reported in 2011 MEErP reports (https://ec.europa.eu/docsroom/documents/26526).

[15] Both MEEuP (VHK, 2005) and MEErP (VHK, 2011) guidance documents provide a description of each entry line in for data in the database. However, this information is no sufficient to fully reproduce the dataset as currently displayed.

[16] Datasets in use to develop PEF studies according to available Product category rules, and based on the format "EF reference package 3.0" (https://eplca.jrc.ec.europa.eu/LCDN/developerEF.xhtml). In the ERT database, only a portion of the EF dataset is displayed, in particular, the series of the 16 impact category values (according to the impact categories as in the PEF- see subtask 1.a in section 1.1).

methods (i.e. alignment with PEF impact categories). It also guarantees potential interoperability with LCA software.

This updated of the ERT is combined with an extension of the database to include additional datasets on plastics, metals and electronics[17].

Implementation

A new spreadsheet in the ERT has been developed to contain the relevant parts (mainly Life Cycle Impact Assessment results by impact category) of the selected EF 3.0 datasets ("NEW_PEF_DB" as in Figure 7).

The new spreadsheet "New datasets" (see Figure 7) has been developed for users that want to insert additional datasets, currently not included in the database. This spreadsheet replaces the former spreadsheet "Extra materials". For each material both datasets on virgin and the correspondent recycled material need to be included. These new datasets added by the users will be automatically stored in the "NEW_PEF_DB", including also all the relevant parameters to calculate the CFF.

Figure 6: "NEW_PEF_DB" spreadsheet. Values in the table need to be defined (tbd). For each material both datasets on virgin and the correspondent recycled material need to be included

Category in ERT	id	Datasets	Virgin/ Recycled	Unit of measure	Climate change, total	Ozone depletion	Human toxicity, cancer	Human toxicity, non-cancer
					kg CO2 eq	kg CFC-11 eq	CTUh	CTUh
01-Plastics	1	LDPE granulates	V	kg	tbd	tbd	tbd	tbd
01-Plastics	2	HDPE granulates	V	kg	tbd	tbd	tbd	tbd
01-Plastics	3	LLDPE granulates	V	kg	tbd	tbd	tbd	tbd
01-Plastics	4	Polypropylene (PP) fibers	V	kg	tbd	tbd	tbd	tbd
01-Plastics	5	EPS Beads	V	kg	tbd	tbd	tbd	tbd
01-Plastics	6	Polystyrene production, high impact	V	kg	tbd	tbd	tbd	tbd
01-Plastics	7	PVC granulates, low density	V	kg	tbd	tbd	tbd	tbd
01-Plastics	8	PET granulates, amorphous	V	kg	tbd	tbd	tbd	tbd
01-Plastics	9	Acrylonitrile Butadiene Styrene (ABS)	V	kg	tbd	tbd	tbd	tbd
RECYCLED MATER	49	Plastic granulate secondary (low metal	R	kg	tbd	tbd	tbd	tbd
01-Plastics	11	Polycarbonate (PC) granulate	V	kg	tbd	tbd	tbd	tbd

Figure 7: "New Datasets" spreadsheet. Values shown in the table are still to be defined (based on final data to be implemented).

Category	nr	Dataset Name	Virgin/ Recycled?	Unit of measure	Climate change, total	Ozone depletion	Human toxicity, cancer	Human toxicity, non-ca
Please select the category	unit				kg CO2 eq	kg CFC-11 eq	CTUh	CTUh
01-Plastics	188	**New_PLAST1**	**V**	kg	tbd	tbd	tbd	tb
	189		**R**		tbd	tbd	tbd	tb
01-Plastics	190	**New_PLAST2**	**V**	kg	tbd	tbd	tbd	tb
	191		**R**		tbd	tbd	tbd	tb
03-Electronics	192	**New_ELECTR**	**V**	item	tbd	tbd	tbd	tb
	193		**R**		tbd	tbd	tbd	tb
02-Metals	194	**New_FERRO**	**V**	kg	tbd	tbd	tbd	tb
	195		**R**		tbd	tbd	tbd	tb

[17] The extension of the database is currently also open to new data needs identified in the discussions with stakeholders.

2.4 Further improvements of the modelling (Manufacturing, Packaging, Distribution, Use phase, Maintenance & Repair)

Objective

Increase transparency and granularity level of the assessment in order to put emphasis on life cycle stages which can be more relevant for a specific product group.

Status Ecoreport tool

In the current ERT, the manufacturing/assembly processes are modelled based on predefined assumptions, being not possible to be modified by the users. For example, it is not possible to link these phases to the use of additional materials[18] or energy sources.

It is not clear if/ how packaging is currently modelled in the ERT.

Distribution is based on the volume of the package. It is not possible to distinguish different transport means and/or insert the transport distances.

The impact of Maintenance and Repair is based on the assumption that spare parts are 1% of the materials included in the Bill of Materials. The percentage is fixed and it is not possible to be adjusted, not to be adapted to specific repair scenarios[19].

Rationale and Action

Compared to the current ERT, inputs for Packaging, Distribution and Maintenance&Repair are modelled separately and consistently, and then presented in the results separately. For example, it will be possible to add energy and materials consumed during manufacturing/assembly or repair processes (to be selected from the general database) to better model the impacts of these stage (and being to be distinguished by the Raw materials production stage). For the Use phase the same format of the current ERT is kept, but allowing the possibility to select data from the general database (among those as in Task 1.a and 1.b) or even additional datasets introduced by the user.

Implementation

Manufacturing/Assembly (Figure 8): User can insert manufacturing and assembly processes. Alternatively, it is possible to include energy and materials consumption during manufacturing (e.g. materials ending in scraps; ancillary materials, etc.). The impact of these materials will be calculated according to the CFF.

Packaging (Figure 9): user can insert, if relevant, energy and materials consumption used for packaging. The impact of these materials will be calculated according to the CFF.

Distribution (Figure 10): User shall select the transport mean and type the distance. This input box covers all the distribution phases occurring over the life cycle.

Use phase (Figure 13): Current ERT format is kept (with few modifications to facilitate the access to data in the database). Maintenance and repair is assessed separately

Maintenance & Repair (Figure 11): In the revised ERT, the user will have the opportunity of choose accounting for impacts of this stage in a simplified way (e.g. as a set percentage of the impacts of the materials used in the BOM, potentially adjustable compared to the current version). Alternatively, if relevant and more refined data are available, the user could include a detail of energy and materials consumed during this stage.

Figure 12 presents a possible way on how results for the different stages will be presented.

Figure 8: Manufacturing and Assembly phase Input box

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[18] Consumption of special materials during the manufacturing could be partially taken into account, by adding those materials to the "Bill of Materials" lines. However, it would be not possible to see the difference of these materials compared to materials in use in the product.

[19] As above for the manufacturing, it is not possible to compute for additional components necessary for the repair. These could be introduced in the initial "Bill of Materials", but it would be not possible to differentiate them from the materials in use in the product.

Pos	MANUFACTURING / ASSEMBLY				ENERGY				MATERIALS			
	Process description	Datasets	Amount	Unit of	Category	Datasets	Amount	Unit of	Category	Datasets	Amount	Unit of
nr	please insert	Click and select	please insert	measure	click and select	click and select	please insert	measure	click and select	click and select	please insert	measure
201	Aluminium Extrusion	111-Forging of steel parts	20.0	kg								
202	Heating				08-Thermal energy	76-Thermal energy from natu	55	MJ	04-Others	200-New_Other	2	kg
203	Electricity consumption				07-Electricity	80-Electricity grid mix (EU mix)		MJ				
204	Process1								02-Metals	19-Cast iron		kg
205												
206												
207												
208												
209												
210												

Figure 9: Packaging Input box

Pos	PACKAGING	Material/Energy	Category	Dataset	Amount	Unit of measure
nr	Description	Click and select	Click and select	click and select		automatic
218	Box	Material	04-Others	40-Corrugated board		kg
219						
220						
221						
222						
223						
224						
225						

Figure 10: Distribution input box

Pos	DISTRIBUTION				
nr		Description		Amount	unit
226	**Transport mean 1**	e.g. tranport to the regional storage	85-Articulated lorry transport, Euro 5, Total weight 28-32 t (without fuel)		**kgkm**
227	**Distance 1**				**km**
228	**Transport mean 2**	e.g. raw material transport	93-Freight train, electricity traction		**kgkm**
229	**Distance 2**				**km**
230	**Transport mean 3**	e.g. maintenance&repair	90-Barge		**kgkm**
231	**Distance 3**				**km**

Figure 11: Maintenance and repair input box

Pos	MAINTENANCE and REPAIR	Energy/Materials	Category	Dataset	Amount	Unit of measure
nr	Description	Click and select	Click and select	click and select		automatic
271	Electricity consumption	Energy	07-Electricity	80-Electricity grid mix (EU mix)		**MJ**
272	Other materials	Material	04-Others	200-New_Other		**kg**
273	Steel	Material	02-Metals	18-Steel sheet cold rolling - thickness 2.5mm		**kg**
274						
275						
276						
277						
278						
279						

Figure 12: RESULTS, Resources use and emissions are reported by phase.

	Life Cycle phases --> Resources Use and Emissions		RAW MATERIALS	MANUFACTURING	DISTRIBUTION	PACKAGING	USE	MAINTENANCE & REPAIR	TOTAL
	Materials	**unit**							
1	Plastics	g							0
2	Metals	g							0
3	Electronics	g							0
4	Others	g							0
5	**Total weight**	g	0	0		0	0	0	0
	PEF Impact categories	**unit**							
6	Climate change, total	kg CO2 eq							0
7	Ozone depletion	kg CFC-11 eq							0
8	Human toxicity, cancer	CTUh							0
9	Human toxicity, non-cancer	CTUh							0
10	Particulate matter	disease incidence							0
11	Ionising radiation, human health	kBq U235 eq							0
12	Photochemical ozone formation, human	kg NMVOC eq							0
13	Acidification	mol H+ eq							0
14	Eutrophication, terrestrial	mol N eq							0
15	Eutrophication, freshwater	kg P eq							0
16	Eutrophication, marine	kg N eq							0
17	Ecotoxicity, freshwater	CTUe							0
18	Land use	UoM							0
19	Water use	m3 world eq							0
20	Resource use, minerals and metals	kg Sb eq							0
21	Resource use, fossils	MJ							0

Figure 13: Use phase (direct impact), input box. This is implemented also for indirect impact as in current ERT.

Pos nr	USE PHASE direct ErP impact Description		unit	Subtotals
251	**ErP Product (service) Life in years**	**0**	years	
	Electricity			
252	**Electricity mix (Click & select)**	80-Electricity grid mix (EU mix)		
253	**On-mode: Consumption per hour, cycle, setting, etc**	0	kWh	0
254	**On-mode: No. of hours, cycles, settings, etc. / year**	0	#	
255	**Standby-mode: Consumption per hour**	0	kWh	0
256	**Standby-mode: No. of hours / year**	0	#	
257	**Off-mode: Consumption per hour**	0	kWh	0
258	**Off-mode: No. of hours / year**	0	#	
259	**TOTAL over ErP Product Life**	**0.00**	**MWh (=000 kWh)**	
	Heat			
260	**Avg. Heat Power Output**	0	kW	
261	**No. of hours / year**	0	hrs.	
262	**Type and efficiency (Click & select)**		< >	86-not applicable
263	**TOTAL over ErP Product Life**	**0.00**	**GJ**	
	Consumables (excl. spare parts)			**material**
264	**Water**	0	kg/year	**44-Tap water; technology mix; at user; per kg wate**
265	**Auxiliary material 1 (Click & select)**	0	kg/ year	
266	**Auxiliary material 2 (Click & select)**	0	kg/ year	
267	**Auxiliary material 3 (Click & select)**	0	kg/ year	
268	**Refrigerant refill (Click & select type, even if there i**	0	kg/ year	

2.5 Material efficiency (Subtask 1.d)

Objective

Making the EcoReport tool an effective instrument for the identification of environmental hotspots linked to material efficiency aspects.

Status Ecoreport tool

Only a partial focus was dedicated to the modelling of material efficiency aspects in the original ERT (up to the 2011 version). For this reason, a dedicated study was conducted in 2013 to amend the methodology and the tool (Bio IS, 2013[20]). The study produced additional guidance on how material efficiency aspects could be

[20] https://op.europa.eu/en/publication-detail/-/publication/7c3d958d-42cc-4af7-985c-2a3347b66fa8

modelled in the ERT and relevant implementing measures could be derived. In this case, the ERT was partially revised (introducing e.g. the above mentioned Recyclability benefit rate for plastics). However, tackling material efficiency aspects systematically would have required a substantial revision of the ERT, which was not in the scope of the study.

Rationale and Action

Material efficiency aspects are modelled consistently in various parts of the revised ERT.

Durability is modelled through lifetime estimation as part of Task 2. The results will link back to the ERT. In the proposed modelling, an initial lifetime is estimated based in the specific characteristics of the product. This would be expected until the occurrence of the first limiting event. In the terminology of standard EN 45552 this is called reliability. Then, lifetime extensions due to reparability and upgradability are estimated. Finally, all is put together and a final value for durability (or total lifetime) is estimated. Detailed calculations are laid out in the description of task 2 and are based on a discrete steps scoring system that allows to link design options to expected durability. The specific values for the scoring levels will be calculated using a Weibull longevity model that is described in detail in Task 2. Afterward, impacts are normalised on a per year basis using the estimated durability.

On top of its contribution to durability, reparability can be also modelled as a separate section of the ERT, allowing the user to tailor the model according to the energy and material inputs needed in this stage.

Other critical aspects of material efficiency, namely recyclability and recycled content are modelled as parameters of the newly introduced CFF.

Implementation

Recycled content and Recyclability are modelled through the CFF. Default parameters are defined in the database for each materials, based on average values in use in the PEF (see section 1.2 for details), and displayed when materials are introduced in the BoM. Still, if relevant and if more specific information is available for the product in study, the user has the possibility to modify these entry values. Guidance on both how to better estimate input data for recyclability and how to potentially setting requirements on such aspects will be part of the analysis in Task2 and will be based on a discrete steps scoring system very similar to the one used to model durability.

2.6 Modelling of annual sales (Subtask 1.f)

Objective

Implementation of a finer modelling of annual sales, including the possibility to calculate or insert a dynamic stock model in the tool.

Status Ecoreport tool

In the current version of the EcoReport tool the sales figures are constant from year to year.

Rationale and Action

The purpose of modelling sales is twofold: 1) to estimate the economic impact of Ecodesign requirements (which, in turn, also involve that the effect that such requirements will have on sales is modelled); and 2) to estimate the total stock of the products under analysis in order to be able to estimate the overall environmental impact associated with its production and use.

If we model the products lifetime through the 3 parameter Weibull distribution (which, in or view, is the best option), we have for the reliability function (which is also the percentage of products surviving after time t has elapsed):

$$R = \begin{cases} exp\left[-\left(\frac{t-\gamma}{\eta}\right)^{\beta}\right] & t \geq \gamma \\ 1 & t < \gamma \end{cases}$$

Where n is the scale parameter, β is the shape parameter and γ is the delay parameter. If we consider the delay parameter as the year in which the products entered into service (*i.e.*, were sold). Taking into account that Lifetime, sales and stock are not independent, if we model both the sales and the lifetime, as indicated above, the existing stock will result from calculations. We can see below two example of calculations using Weibull parameters typical of large household appliances (*e.g.*, fridges, washing machines, *etc.*) were the stock (and also the approximated stock evolution) can be estimated given the sales and the lifetime parameters. In the first case constant sales are assumed (which, unsurprisingly, result in constant stock) and in the second case a constant yearly increase in sales of 2% is assume (which will result, *ceteris paribus*, in a 2% yearly increase in stock).

Shape	**β**	2	14.2	**Average lifetime**
Scale	**η**	16	1467	**Stock**
Year	**Surv. factor**	**Sales**	**Surv.**	**Stock app.**
0	1.000	100.0	100.0	1368.8
-1	0.996	100.0	99.6	1368.8
-2	0.984	100.0	98.4	1368.8
-3	0.965	100.0	96.5	1368.8
-4	0.939	100.0	93.9	1368.8
-5	0.907	100.0	90.7	1368.8
-6	0.869	100.0	86.9	1368.8
-7	0.826	100.0	82.6	1368.8
-8	0.779	100.0	77.9	1368.8
-9	0.729	100.0	72.9	1368.8
-10	0.677	100.0	67.7	1368.8
…	…	…	…	
-39	0.003	100.0	0.3	
-40	0.002	100.0	0.2	

Shape	**β**	2	14.2	**Average lifetime**
Scale	**η**	16	1246	**Stock**
Year	**Surv. factor**	**Sales**	**Surv.**	**Stock app.**
0	1.000	100.0	100.0	1185.8
-1	0.996	98.0	97.7	1162.5
-2	0.984	96.1	94.6	1139.8
-3	0.965	94.2	91.0	1117.4
-4	0.939	92.4	86.8	1095.5
-5	0.907	90.6	82.1	1074.0
-6	0.869	88.8	77.1	1053.0
-7	0.826	87.1	71.9	1032.3
-8	0.779	85.3	66.5	1012.1
-9	0.729	83.7	61.0	992.2
-10	0.677	82.0	55.5	972.8
…	…	…	…	
-39	0.003	46.2	0.1	
-40	0.002	45.3	0.1	

The estimate of the yearly sales should be inserted by the user (i.e., the consultant conducting the Ecodesign preparatory study) using either real data or a model (*e.g.*, constant rate of growth), as should the Weibull parameters. It should be noticed that with minimal and straightforward changes this model also allows for assuming an evolution model for the stock (*e.g.*, constant stock) and using it to forecast next year sales or to consider Weibull lifetime parameters that change in time.

2.7 Critical Raw Materials (subtask 1.h)

Objectives

JRC was requested to critically revising the current approach for Critical Raw Materials (CRMs) within the MEErP .

Status Ecoreport tool: what's in there now?

Some guidelines on how to assess the impact of CRMs have been provided by the 2011 and 2013 revisions of the MEErP (with the introduction of the Critical Raw Material Index). However, their application occurred only in few preparatory studies performed so far.

Rationale and Action

JRC analysis highlighted that the concept of CRM-equivalent has not generated substantial outcomes since it was introduced in MEErP in 2011. Moreover, the CRM-equivalent index could not be easily associated to the definition of specific Ecodesign measures (e.g. use less, report quantities, making CRMs easier to be recycled, or find a substitute).

JRC therefore suggests to replace the assessment of the CRM equivalent Index by a new step-by-step approach, based on a sequential screening of CRMs contained in the product under scrutiny , and using the numerical results of the 2020 Criticality Assessment and the future 3-yearly updates.

The main advantage of this new approach is to streamline the analysis of CRMs in the products under study taking benefits of information already available. This approach is streamlined and could be potentially updated when newer information is produced (within future criticality assessment reviews).

Implementation:

Preliminary results have identified product groups for which analysis of certain CRMs could be prioritized. This analysis also concluded that generalized and systematic procedure to automatically identify ecodesign measures looks unlikely.

Guidance on how to conduct such analysis is provided, including some suggestions of strategies (e.g. use less, report quantities, making CRMs easier to be recycled, or find a substitute) that could support the mitigation of criticality (i.e. potentially translated into future product requirements).

JRC suggests to always start from the results of the latest criticality assessment and use them for an initial screening, also taking into account specific aspects of the product group under scrutiny.

Draft Step-by-step approach box

It is suggested to always start from the results of the latest criticality assessment (excel to be inserted into the ERT) and use them for an initial screening, also taking into account specific aspects and expertise related to the product group under scrutiny. A generalized and systematic procedure to automatically identify ecodesign measures looks unlikely.

With the above in mind, some recommendations are formulated:

Step 1: shortlist the CRMs that are potentially in the product group using available tables (see Annex I ,e.g. table A.3 to be included in ERT), and any other additional information related to the product group;

Step 2: when possible, collect quantitative data on the BoM of the shortlisted CRMs;

Step 3: look at information available (Substitution, RR, RIR, etc.), define a possible strategy, e.g.:

- Declare quantity when data is not available or of good quality, and/or
- Extend lifetime, especially in the case of low substitutability, and/or
- Improve recyclability and/or use recycled materials, especially in the case of low substitutability;

Some general rules / checklist:

- If RR is low, then check if recycling technology is available or if the product group is an exception (data on recycling is always an average across all product groups)

- If RR is high, but EoL-RIR is low, demand is probably growing, so it is unlikely that recycled materials can be available in adequate quantities. So, rather than recommending higher recycled content, a more adequate measure could then be an extension of lifetime.

2.8 Additional subtasks

Additional subtasks for Task 1 of the project include:

- Subtask 1.c (instructions on the use of the ERT): detailed guidance on the use of the different modelling will be provided after the finalisation of ERT review.

- Subtask 1.i (procedure for future updates): this subtask will investigate potential way to facilitate the update of the data in the ERT. This will be investigated in a later stage, once the current revision of the database will be completed.

- Subtasks 1.j (more sophisticated IT infrastructure): this task will explore the possibility of moving from the current version of the ERT to more sophisticated infrastructure (e.g. online tool). This task will be investigated in a later stage

- Subtasks 1.k (any other aspect raised by stakeholders): feedback from stakeholders have been collected after the first stakeholder meeting and considered for the current revision. Further comments are expected in the next stages.

3 Task 2 “More systematic inclusion of material efficiency aspects and of environmental footprint/ecological profile aspects in the design options and in the LLCC curve”

This chapter presents the progresses on Task 2 of the project “"Review of the MEErP - Methodology for Ecodesign of Energy-related Products" (MEErP)”[21]. Task 2 deals with the “More systematic inclusion of material efficiency aspects and of environmental footprint/ecological profile aspects in the design options and in the LLCC curve” of the MEErP.

As general objective of Task 2, we aimed to keep the existing logic of the MEErP while systematically introducing material efficiency aspects in the calculations - namely of the Least Life Cycle Costs (LLCC) curve - and assuring a strong link with design options. The inclusion of environmental footprint springs out naturally from the End-of-Life (EoL) effects that are modelled through the Circular Footprint Formula (CFF), as described in Tasks 1.d and 1.g. This reflects a strong link between Tasks 1 and 2 of this project. This link will become further evident in order parts of sub-modelling of Task 2, as will be depicted throughout this chapter.

In order to take material efficiency aspects into account within MEErP, full use was made of the body of knowledge, namely nomenclature and modelling, produced by CEN-CENELEC Joint Technical Committee 10 on Energy-related products - Material Efficiency Aspects for Ecodesign (CEN-CLC/JTC 10). This technical committee developed a group of eight standards (the family of standards EN 4555X) containing generic principles to consider when addressing the material efficiency of energy-related products, such as extending product lifetime, ability to recycle materials from products at end-of-life, and use of recycled materials in products. By building on this work we are ensuring uniformity of concepts and nomenclature and avoiding doing duplicated work.

The development of a method to achieve the objectives of Task 2 is presented hereinafter.

3.1 Estimation of expected Lifetime (durability)

In order to properly analyse and model circular economy requirements, product lifetime must be taken into account. In fact, this parameter is absolutely paramount. In practical terms, following this approach would imply that an 'equivalent annual cost' (for a design option) should be calculated. With the use of the 'equivalent annual cost' it is possible to properly compare design options with different (expected) lifetimes, such as, for example, the base case (i.e. the average EU product), compared to a second product with increased durability (e.g. thanks to the higher quality of its components) and a third product with higher lifetime than the base case as a result of its improved design for reparability.

Also, not only costs are to be calculated on a yearly basis through normalisation by the expected lifetime, but also environmental impacts should be normalised the same way. Again, only this way will it be possible to properly compare the environmental impacts of design options with different expected lifetimes, namely by taking into account the trade-off between one-off impacts (like those associated with manufacturing or EoL) and recurrent impacts resulting from the use phase.

The lifetime of a product (durability under the nomenclature of EN 45552) will be calculated based on its initial lifetime expectation (reliability under the nomenclature of EN 45552) plus the lifetime increase due to repairability and upgradability.

$$Lt = L_0(1 + \Delta L_R)(1 + \Delta L_U)$$

, whereby

[21] Administrative Arrangement N ° JRC 35847-2020 // GROW SI2.831466

L_t, is the calculated expected lifetime

L_0 , is the initial lifetime

$\Delta L_{R,}$, is the % of lifetime increase attributed to repairability

ΔL_U, is the % of lifetime increase attributed to upgradability

Therefore, it is just needed to find L_0, ΔL_R and ΔL_U in order to be able to estimate the expected lifetime (durability). In order to do that, we rely heavily on the methods outlined in the EN 4555X family of standards. According to the procedures outlined there, a product will be modeled as a series assemble of a number of critical components for repair and upgrade, the failure of anyone of which will cause the product to fail. In the context of the MEErP, these critical components should be identified by the authors of the preliminary study. Then, we follow a strategy based on a discrete step scoring system for recyclability and upgradability as depicted in the following report[22]. In this framework, a set of 4 discrete levels for reliability, repairability and upgradability are defined linked to design options features the following way:

Level 1, meaning: potentially easy and quick disassembly (no special tools needed), availability of spare parts and comprehensible repair info to consumers, diagnostics comprehensible to consumers, public availability of software updates, data transfer and deletion function and password reset and settings restoration function

Level 2, meaning: possibility of disassembly with professional tools, availability of spare parts, repair info and diagnostic tools to independent repairers, as well as software updates, data transfer and deletion function and password reset and settings restoration function

Level 3, meaning: possibility of disassembly with proprietary tools, availability of spare parts, repair info and diagnostic tools only to authorised/official repairers, as well as software updates, data transfer and deletion function and password reset and settings restoration function

Level 4, meaning that the product cannot be repaired and must be replaced in case of failure (e.g. because parts are glued/welded, product cannot be opened, spare parts are not available, software cannot be updated).

Then, during the preparatory study values would be attributed to these parameters, as indicated in the tables bellow:

Reliability	
Level	**Initial lifetime (L_0)**
1	AA
2	BB
3	CC
4	DD

[22] Cordella M, Alfieri F, Sanfelix J, Analysis and development of a scoring system for repair and upgrade of products – Final report, EUR 29711 EN, Publications Office of the European Union, Luxembourg, 2019, ISBN 978-92-76-01602-1, doi:10.2760/725068, JRC114337

Repairability	
Level	**% increase in lifetime (ΔL_R)**
1	XX%
2	YY%
3	ZZ%
4	0%

Upgradability	
Level	**% increase in lifetime (ΔL_U)**
1	XX%
2	YY%
3	ZZ%
4	0%

Figure 14 - Example of tables used in the discrete step scoring system

In order to classify specific products as 1, 2, 3 or 4 the following features would be taken into account. This, again, is to be done during the preparatory study.

Aspect	Features
Reliability	Results of testes under specific standards Improved product physical structure More durable components (e.g. battery) Consumables availability Improved testing of performance over the time (e.g. stress tests and/or reliability) Extended guarantee Provision of information about use and maintenance Possibility of reuse
Repairability	Disassembly depth / sequence (no. steps to remove part) Fasteners (number and/or visibility) Tools (publicly available; proprietary) Disassembly time (calculation of standard time; eDiM) Diagnosis support and interfaces (type; self-diagnosis)

	Type and availability of information (comprehensiveness; target group availability) Spare parts (availability time; delivery time; target group; price)
Upgradability	Disassembly depth / sequence (no. steps to remove part) Fasteners (number and/or visibility) Tools (publicly available; proprietary) Disassembly time (calculation of standard time; eDiM) Diagnosis support and interfaces (type; self-diagnosis) Type and availability of information (comprehensiveness; target group availability) Software and firmware Safety, skills, and working environment Data transfer and deletion Password reset and restoration of factory settings Commercial guarantee

Figure 15 – Design features of the discrete step scoring system

Notice that the different repairability levels will mean different ease of repair, and therefore different repair costs. This is the parameter that will tilt the balance and alter the expected future lifetime.

A straightforward way of performing this analysis is by calculating the average cost-per-day of the repair and comparing it with the cost-per-day of the replacement. If C_R is the cost of the repairment and C_N is the cost of replacement and L_T is the expected lifetime of the replacement (assumed to be equal to the original expected lifetime of the unit that failed) and L_E is the expected future lifetime of the repair, then the product will be repaired if the following condition is met:

$$\frac{C_R}{L_E} \leq \frac{C_N}{L_T}$$

This equation can be easily manipulated in order to calculate a critical lifetime that will be used to establish a condition for the minimum expected future lifetime for repair/upgrade:

$$L_E \geq L_{Cr} = L_T \frac{C_R}{C_N}$$

It should be noticed that the analysis here proposed is based on cost alone but, by following the 'durability index' methodology[23], it could be based on environmental impacts, or at least in one environmental impact category. In fact, any method that would allow for the decision making on whether to repair or upgrade a product versus its replacement, could potentially be used here. The core of the process is that a decision on repair (or upgrade) or replace has to be taken, and a method to make that decision should be used, so that the decision is not arbitrary.

[23] Bobba S., Ardente, F. & Mathieux, F., 2015. Durability assessment of vacuum cleaners. Joint Research Centre (JRC) Technical Report. EUR 27512 EN

In order to make the calculations more tractable an additional simplification will be introduced: it is assumed that each critical component will be repaired or upgraded only once. Detailing, if a critical component fails for the second time, the product will be replaced even if the expected future lifetime of the repair/upgrade operation exceeds the critical lifetime.

The result of the application of this method is illustrated in Figure 3 below:

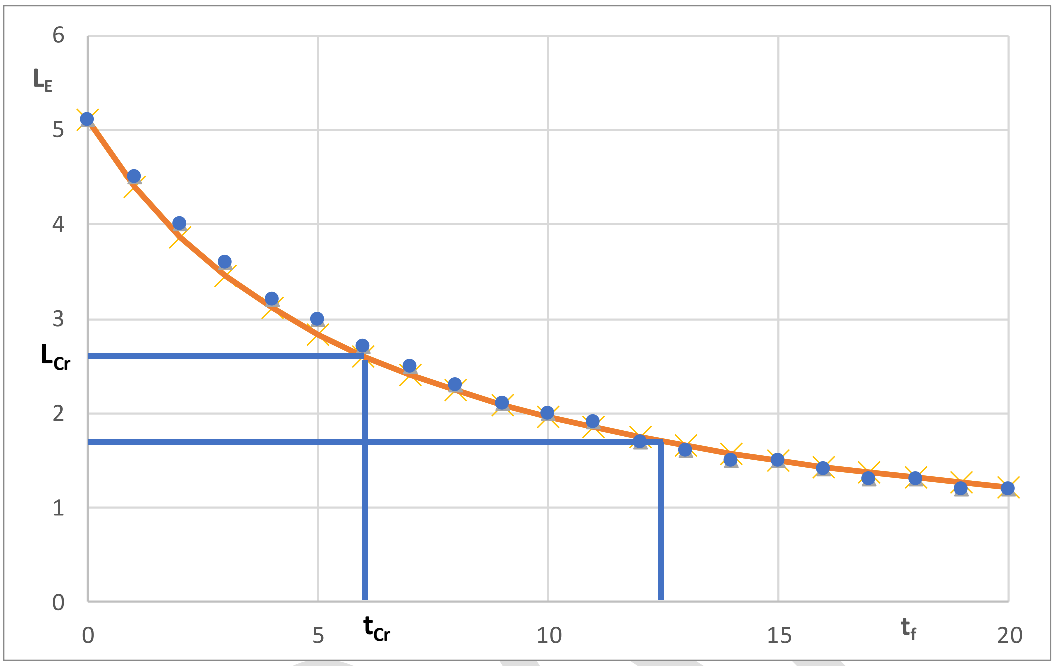

Figure 16 - Illustration of the relationship between failure time and expected future lifetime.

, whereby

t_{CR}, critical time of failure (after which replacement, rather than repair, is assumed to take place)

t_f , time of first failure

Then, after finding out the value of the maximum failure time (which corresponds to the minimum expected future lifetime) that will allow for repair/upgrade, a new value of expected lifetime can be calculated (again, by the authors of the preparatory study) that would allow for the estimation of the percent increased lifetime generated by the given level of repairability/upgradability.

Summarizing, we can present the following sequence of steps to be followed:

1) According to standards EN 4555X, a number of critical components for repair and upgrade are identified. For instance, according to EN45554, a priority part for repair and upgrade is determined by the likelihood of the need to replace or upgrade the part, the suitability of the part for reuse, and the functionality of the part.
2) These components will be treated as a series assembly for the lifetime analysis.
3) Using the initial lifetime of the product (the reliability previously estimated from the scoring system), technical parameters for the lifetime distributions of all components are estimated. <u>This is where the reliability design options will have an impact.</u>
4) **It is assumed that each product will at most_undergo 1 repair or upgrade operation, i.e., the second failure (either due to repair or upgrade needs) will bring about the product's end of life.**

5) The product's expected future lifetime after the repair or upgrade operation is calculated (given the time when the failure happened).

6) **A cost analysis is performed (given the relative cost of repair or upgrade compared to the purchase price of a new item) to determine the minimum (critical) lifetime extension that is economically viable (this is a repair or upgrade vs replace decision that is very similar to the 'durability index' model. Therefore, this model could be used here as well). <u>This step is where the repair and upgrade design options will show themselves (namely by impacting the cost of repair or upgrade)</u>.**

7) **Given the critical lifetime extension calculated before, a critical time of failure will be calculated, i.e., if the product fails for the first time before this critical time, then it will be repaired or upgraded, according to the case. If the first failure happens after this critical time, or if a second failure takes place, then the product will not be repaired or upgraded and will simply be replaced.**

8) New lifetime distribution curves are calculated taking into account the described repair or upgrade scenarios. New lifetimes are calculated.

9) Increased lifetimes (%) are calculated and used to fill in the scoring tables.

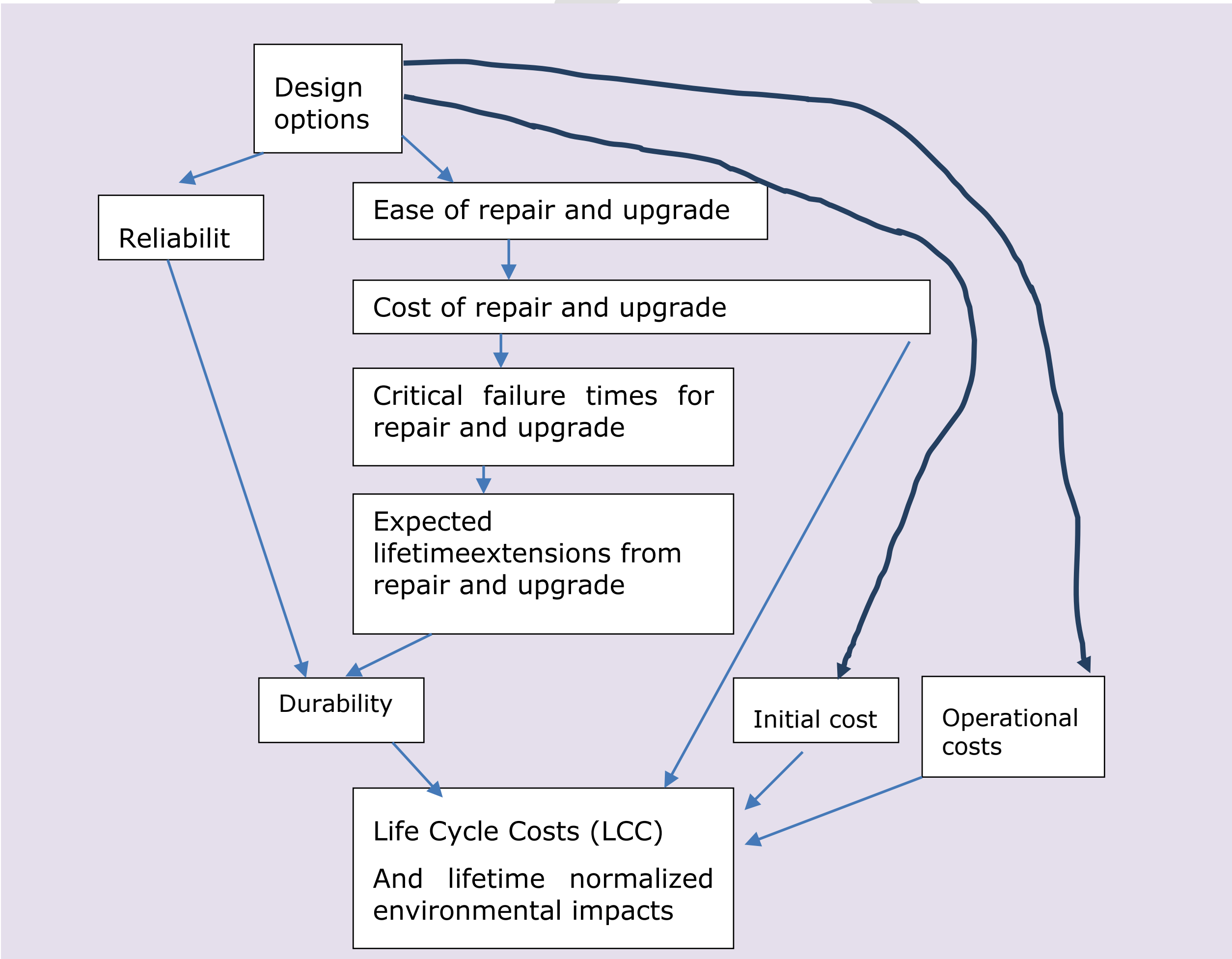

Figure 17 - Flowchart of the calculation process

As an illustration of the kind of results that can be possible to obtain, we present below an example of possible values for an electronic device (values are used for purely exemplification purposes):

Reliability	
Level	**Initial lifetime (L_0)**
1	6.3 yrs
2	5.7 yrs
3	5.2 yrs
4	4.7 yrs

Repairability	
Level	**% increase in lifetime (ΔL_R)**
1	6%
2	5%
3	3%
4	0%

Upgradability	
Level	**% increase in lifetime (ΔL_U)**
1	19%
2	17%
3	10%
4	0%

Figure 18 - Example of scoring system tables filled in

In the example above, you can see that the overall durability can float from a minimum of 4.7 years to a maximum of 8 years. Therefore a 70% increase in longevity (durability) is possible through an adequate choice of design options.

$$Lt_{min} = 4.7(1 + 0\%)(1 + 0\%) = 4.7\ yrs$$

$$Lt_{max} = 6.3(1 + 6\%)(1 + 19\%) = 8\ yrs$$

3.2 Estimating Costs

(work in progress)

The estimation of repair and upgrade costs, vis-à-vis the purchase cost, is a critical aspect of the proposed methodology. In order to make consistent estimates of this parameter it is proposed to follow the depicted procedure:

1. Material needs are to be taken from the Ecoreport Tool (see chapter 2.4 above). Costs for these materials are likely to be quite homogeneous throughout the EU and can be found through a simple market research activity. This should be done during the preliminary study.
2. Labour needs (in hours) can be estimated through the work carried out in producing the tables needed for the discrete steps scoring system presented. Then these hours must be multiplied by the labour costs of the specific Member State under consideration, and these can vary widely. A method to deal with this variation is proposed in the next section.

3.3 Dealing with Costs that can vary significantly across the EU

In order to apply the methodology described in the previous section, the repair and upgrade costs must be estimated. These will depend not only on the price of replacement materials and productive factors such as the cost of electricity, but also, and maybe more importantly, on the cost of labour, which can vary quite a bit across the EU. Therefore, some kind of averaging procedure has to be developed and applied in order to get to a single estimate of repair and upgrade costs.

We propose that the same kind of modelling being used for the sales and stock model of task 1.f is used to estimate the products' stock that is in place in each member state (obviously, for that the sales of each member state have to be individually estimated). Then, the cost of the repair or upgrade operation should be estimated for each Member State taking into account local conditions (i.e., the local price of labor). Finally, an EU average should be calculated for the repair /upgrade operations using the member state's in place stock as a weighting factor.

3.4 Dealing with other material efficiency parameters (e.g., recyclability)

When including material efficiency aspects in the analysis, other parameters besides durability become important. Obvious among those are Recycled content and Recyclability. These two parameters will be modelled through the Circular Footprint Formular (CFF). This will be implemented through the Ecoreport Tool (ERT) as detailed in Tasks 1.d and 1.g of the project. Default parameters are defined in the database for each material, based on average values in use in the PEF (Product Environmental Footprint), and displayed when materials are introduced in the Bill of Materials (BoM). Still, if relevant and if more specific information is available for the product in study, the user has the possibility to modify these entry values.

Although the models being described here in Task 2 have a limited contribution to the estimation of recycled contents, it could be used to better estimate recyclability for specific products, if it is believed that a specific value would be considerably better than default average value. The suggested way to better estimate specific values for recyclability is to use a discrete step scoring system identical in all aspects to the one used for the durability calculations.

Thus being, a discrete steps table will be created indicating the percentage of materials which can be recovered, as shown below:

Recyclability

Level	% recoverable mat. (rcycl%)
1	XX%
2	YY%
3	ZZ%
4	0%

Figure 19 - Discrete steps scoring system for recyclability

And, as before, in order to classify specific products as 1, 2, 3 or 4 a number of design options specific features would be taken into account. This, again, is to be done during the preparatory study.

Aspect	Features
Recyclability	• Improved dismantlability (e.g., reduced dismantling time, provision of instructions) • Information on material content and/or marking of parts/components • Restrict materials/substances hampering recycling • Cost-benefit assessment of selective recycling treatments (e.g. through manual or automatic separation) vs mechanical treatments (e.g. via fine shredding and sorting). • Reduce the number of different materials used within an assembly

Figure 20 - Design features of the discrete step scoring system for recyclability

As before, notice that the different recyclability levels will mean different ease of recovering materials, and therefore different material recovering costs. This is the parameter that will tilt the balance on the amount of material which is economically viable to be recovered and, therefore, will in fact be recovered.

Annex I – JRC notes on Critical Raw Materials in MEErP

A.1 Critical discussion on past approach for CRMs in MEErP

The following paragraphs critically discuss key documents that have been dealing with CRMs in MEErP (Methodology for Ecodesign of Energy-related Products) and/or in Ecodesign Directive context since 2011.

A.1.1 MEErP 2011 - Methodology Report (Part 1 and 2)

A first attempt to deal with CRMs in the MEErP indicators was proposed in 2011[24]. The stated request of the EC to the contractors was: "*for example to check possible design options that substitute or make it easier to recover CRM components*."

The authors of the report proposed to build a *Critical Raw materials Index*, based on their newly introduced concept of Tungsten-equivalent (or Antimony-equivalent).

The proposed approach requires as an input the content (in g per product) of all the CRMs for the EU (latest list – non stated by the authors). The Bill-of-Materials (bill-of-CRMs) would be subsequently converted into W-equivalent (or Sb-equivalent) by means of a related table with characterization factors[25].

The authors of the report concluded that: "To realize this on a structural and universal basis is not (yet) possible." The main reason is the lack of data to build the Bill-of-Materials (content of each of the CRMs for the EU). "Therefore, the EcoReport cannot incorporate the automatic calculation of the CRM indicator, but it supports and recommends that the outcome of a 'manual' calculation is integrated in the tool's outcome".

A.1.1.1 Critical remarks:

The concept of CRM-equivalent introduced in 2011 seems not supported by a clear rationale and subsequent guidance in order to associated it to an Ecodesign goal (e.g. use less, or report quantities, etc.)[26]. As a consequence, since it was introduced there are no successful examples to show how it could be linked to the initial request of the EC (*making CRMs easier to be recycled*, or *help finding a substitute*).

It is quite known that CRMs often provides special and very specific functions in products, as well as they are typically used in tiny quantities, which are however essential (similar to 'vitamins in human bodies'). It is therefore questioned an approach trying to fix the equivalence of one CRM to another. The reasons to support the concept of CRM equivalence are not stated in the MEErP (2011).

The characterization factors (CF) to convert the bill-of-CRMs into CRM equivalent developed in the MEErP have been calculated as in equation 1:

$$\textbf{eq. 1)}\quad \mathbf{CF_i} = A_i * B_i * C_i * (1-[D_i]) / [\, A_{sb} * B_{sb} * C_{sb} * (1-[D_{sb}])]$$

Where:

- CF_i= Characterisation factor of material "i";
- A_i= EU consumption of material "i";
- B_i = import dependency rate of material "i";
- C_i = Substitutability of material "i";
- D_i =Recycling rate of material "i";
- A_{sb} ; B_{sb} ; C_{sb} ; D_{sb} = same parameters as above, referred to material "antimony (Sb)".

[24] MEErP 2011 METHODOLOGY PART 1 FINAL

[25] A characterization factor for each of the CRMs for the EU was derived from some of the parameters used by the EC to calculate the supply risk (postconsumer recycling rate and substitutability), combined with other parameters (EU import dependence, current EU consumption).

[26] MEErP 2011 METHODOLOGY PART 1 FINAL : Initial request concerned to "check possible design options that substitute or make it easier to recover CRM components".

All these values refer to the first edition of the EU methodology for the assessment of CRMs published in 2011[27]. However, 2 out of 4 parameters were not used in the criticality calculations in 2011 (A_i= EU consumption of material and B_i = import dependency rate), whereas the latter has been used for the first time in the criticality calculations in 2017.

Moreover, in the list of CRMs for the EU, there are no materials 'more critical' than others. A raw materials is in fact either *critical* to the EU or *not critical*, which might even be considered in conflict with the concept of CRM equivalent.

Based on the above, the proposed methodology to calculate the CRM-equivalent appears to be a combination of parameters extracted from the EC criticality assessment, though the criteria for the selection of the relevant parameters and the way to combine them remains largely unstated.

A.1.2 MEErP 2013 – Methodology Report (Part 1)

In respect to the 2011 version, the 2013[28] MEErP report provided some additional guidance on how to use the CRM-equivalent. Moreover, CRM info was proposed to be added in the EcoReport tool in a separate spreadsheet, as a guide for preparatory studies.

Concerning the interpretation of the CRM indicator, the MEErP 2013 states that "the CRM indicator addresses the topic not from environmental but from scarcity perspective. The CRM indicator can help to assess whether the use of some rare earth would be better or worse than the use of e.g. platinum group metals from scarcity perspective"[29]. However, as observed by some stakeholders "*CRM is a complex issue and is related mainly to economic issues - not only environmental issues. A more qualitative and in-depth approach is needed to grasp the scarcity or criticality dimension, such as the methodology currently used by the European Commission to identify CRMs. This issue should be separated from a material efficiency objective*"[30].

A.1.2.1 Critical remarks

In MEErP 2013 it is not questioned if and how the Characterization factors provide an assessment of "scarcity", nor it is provided a practical guidance on how such results could drive some eco-design measures.

So, even in the 2013 version, it remains unclear how a CRM Index should be associated to the environmental assessment, or scarcity assessment, concerning the resource use. This is also discussed in the recent preparatory study for the Ecodesign and Energy Labelling workplan 2020-2024[31].

CRMs were addressed in a limited number of ecodesign preparatory studies (see complete list in Worpkplan 2020-2024 preparatory study). Below, we analyze a couple of preparatory studies that came up with tangible requirements.

A.1.3 JRC report and preparatory study on enterprise servers

A JRC report in 2015[32] acknowledges that complete data on the content of CRMs in products is hard to obtain. The study investigated data from literature to estimate the average content of CRM in the servers product group and their location into components. Moreover, the study highlighted that CRMs are difficult to be recycled from waste, due to their low concentration in the waste. Some strategies (e.g. selective disassembly of certain components before the shredding) could facilitate the recovery of certain CRMs.

[27] COM(2011)25 final of 2.2.2011

[28] BIO Intelligence Service (2013a), Material-efficiency Ecodesign Report and Module to the Methodology for the Ecodesign of Energy-related Products (MEErP), Part 1: Material Efficiency for Ecodesign – Draft Final Report. Prepared for:European Commission - DG Enterprise and Industry.

[29] BIO Intelligence Service (2013b), Material-efficiency Ecodesign Report and Module to the Methodology for the Ecodesign of Energy-related. Products (MEErP). Part 2 – Enhancing MEErP For Ecodesign

[30] BIO Intelligence Service (2013a).

[31] Viegand Maagøe A/S et al. Preparatory study for the Ecodesign and Energy Labelling Working Plan 2020-2024. Task 3 - Preliminary analysis of product groups and horizontal initiatives final. Assistance to the European Commisison, April 2021.

[32] Analysis of material efficiency requirements of enterprise servers - Laura Talens Peiró, Fulvio Ardente (2015) - ISBN 978-92-79-51893-5 ISSN 1831-9424 doi: 10.2788/409022

For such reason, the study suggested potential requirements on CRMs in enterprise servers including the provision of an exploded diagram of the product and a declaration of content of certain CRMs (especially rare earths contained in HDDs) and their location in order to facilitate recycling.

Such requirements were then integrated into the Ecodesign preparatory study[33,34] and later on in the regulation 2019/424[35].

A.1.4 Preparatory Study on Ecodesign and Energy Labelling of Batteries

The CRM equivalent index was furthermore used in some preparatory studies. In particular, the recent preparatory study on Ecodesign and Energy Labelling of Batteries (2019)[36]. The study identifies two CRMs relevant for battery (i.e. cobalt and natural graphite). Although not a CRMs at the time of the study, also lithium (that became critical in the 2020 list), manganese, and nickel are assessed, because considered as potentially relevant, as their “criticality threshold can be passed when the demand for the three materials increases”. New characterisation factors for the lithium, manganese, and nickel (4.07 , 0.02 and 0.19 kg Sb eq. / kg CRM respectively) are calculated in this preparatory study, based on the MEErP 2011 methodology (see equation 1). Reference values for this calculation are taken from the “Study on the review of the list of Critical Raw Materials Non-critical Raw Materials Factsheets”[37] (2017) and complemented by additional literature (especially concerning the recycling rates of non-CRM materials). Also previous values of CF for cobalt and natural graphite have been updated.

The study also provides the share of the CRM indicator for each material compared to the total CRM indicator for battery system. It concludes that for the CRM in EV batteries “lithium and cobalt are the biggest contributors to the CRM indicator for the EV base cases (BC1 to 5) and for the ESS base cases (BC 6 and 7) lithium and natural graphite. This is because cobalt and lithium have high CRM characterisation factors compared to the other materials. The high CF of cobalt is caused by the import dependency and for lithium because it is not being recycled”.

Interestingly the study concludes with some practical recommendations for implementing measures. In particular it states that “Encouraging the emergence of a circular economy for batteries and their constituent materials in the EU can be supported introducing mandatory requirements for provision of information about recycled content for certain materials including CRM. Assessing CRM availability in stocks is an important objective of pillar 1 of the European Battery Alliance, thus, it could be important to declare their indicative quantities (or indicative range of quantities) in products put on the market”[38]. Mandatory declaration and targets for recycled content for cobalt and lithium (and also lead and nickel) are actually proposed in the draft battery regulation[39] that was derived from the preparatory study.

A.2 Proposed approach for CRMs in MEErP

A.2.1 List of concepts and principles

In order to facilitate the discussion, building form the past experience a list of relevant concepts and principles for the assessment of CRMs in products is presented as bulleted list.

In such a list, no ranking or priorities are given, as well as different perspectives are presented. The main objective is to reflect on what is available, or what has proved to be more or less feasible in the past.

[33] Berwald, A. et al, Bio by Deloitte (2015) Ecodesign Preparatory Study on Enterprise Servers and Data Equipment https://op.europa.eu/en/publication-detail/-/publication/6ec8bbe6-b8f7-11e5-8d3c-01aa75ed71a1 .

[34] The preparatory study also calculated the CRM index (in ton equivalent of Sbeq.), although these results have been not further used in the impact interpretation.

[35] Commission Regulation (EU) 2019/424 of 15 March 2019 laying down ecodesign requirements for servers and data storage products pursuant to Directive 2009/125/EC of the European Parliament and of the Council and amending Commission Regulation (EU) No 617/2013. https://op.europa.eu/s/oDsa

[36] Preparatory Study on Ecodesign and Energy Labelling of Batteries. https://ecodesignbatteries.eu/files/attachments/ED%20Battery%20study%20Task5%20draft_f.pdf

[37] https://ecodesignbatteries.eu/sites/ecodesignbatteries.eu/files/attachments/ED%20Battery%20study%20Task5_v3_20190823.pdf

[38] https://ecodesignbatteries.eu/sites/ecodesignbatteries.eu/files/attachments/ED_Battery_Task%207_V45_final_corrected.pdf

[39] https://ec.europa.eu/environment/waste/batteries/pdf/Proposal_for_a_Regulation_on_batteries_and_waste_batteries.pdf

- No clear justifications on the calculation and interpretation of a CRM Index were found in original method description (in 2011), whereas some partial and heterogeneous guidance and interpretations have been provided in the later literature we investigated. In particular, some of the parameters used to calculate the CRM index (e.g. the recycled content, recyclability, substitutability, etc.) seemed to be more relevant in the assessment than the CRM index itself. Therefore, it is suggested to discontinue the use of such index.
- CRMs provides essential functions in products, which in turn translates into valuable services to society. There are therefore no a priori reasons to introduce or suggest limitations to the use of CRMs, because less CRMs can in principle impact the product functionality.
- Applications of a general principle of resource efficiency is certainly to be incentivized, i.e. solutions that maximize the benefits to society per unit of CRM utilized. For instance, higher recyclability, higher reparability, longer service time, lower intensity of use, etc.
- Higher durability, recyclability and higher substitutability support a more secure supply and more resilient value chains and contribute to the third pillar of the Raw Materials Initiative.
- Lack of comprehensive, quantitative and qualitative information is one of the biggest problems in the context of CRMs.
- Producers that disclose information on CRMs should be incentivized (overcoming their original reluctance in disclosing detailed information on their product). Information should be provided in format and detail that do no cause data confidentiality issues.
- While a generalized and complete analysis of the bill-of-CRMs might be too difficult, and even un-necessary, a targeted reporting is likely to be a pragmatic and effective first step for CRMs in MEErP.
- A promising approach seems to be the one focusing on specific CRMs used in the product groups by shortlisting product groups based on their likelihood to contain relevant amount CRMs. This could simplify the analysis in preparatory studies, since they could be guided on focusing on a restricted number of CRMs.
- The analysis of priority product groups could also be useful to eventually develop requirements for other socio-economic aspects, for instance linked to materials responsible sourcing.
- Data collected during the EC criticality assessments (every 3 years) can help understand how and how much CRMs are used across different product groups. Such data can also help setting priorities and mitigation strategies, by e.g.: identifying which products groups use large quantities of given CRMs (prioritize); highlighting dissipative[40] uses; identifying data gaps on CRMs; better understanding the potential role of recycling and recycled content (to be potentially incentivized), also taking into account situations where substitution is particularly complicated. It therefore appears very important to exploit these synergies between various work streams on raw materials.
- The constructive dialogue with the industry can also allow building information/data on CRMs and filling data gaps.

A.2.2 Building blocks and sources of data

A novel approach for the analysis of CRMs in MEErP can build on the numerical results of the latest EC criticality assessment (with a dossier updated every 3 years). Materials in the scope of this assessment include all the CRMs for the EU. Similar information on all CRM candidates could also be made available.

The criticality assessment dossier contains relevant information for Ecodesign as:

- For all CRMs in the List for the EU[41], there is readily-available quantitative information on end-uses, in turn connected to NACE-2 sectors (publicly available) and often more disaggregated (4 or 6 digit level).

[40] Uses that very likely correspond to the dispersion of the materials in different compartments (e.g. air, water, soil, landfills) due to currently insurmountable technical and economic barriers to recycling.

[41] The same information is available also for non-CRMs

- For each end-use, the criticality dossier contains detailed information on known substitutes, which is translated into two substitution indexes[42]: $SI_{EI\ application}$ (based on cost and technical performance and functionality of the substitute materials) and $SI_{SR\ application}$ (based on three parameters related to "production and criticality aspects" of the substitute materials).
- For all CRMs, the criticality dossier contains numerical information on current recycling (in particular, about the EoL recycling input rate (EoL-RIR) and for some materials also EoL recycling rate (Eol-RR)[43]).

Building on the above information, it is possible to short-list and/or rank uses and product group with significant uses of CRMs (e.g. identifying product groups that use large quantities of a given CRM[44]).

Products that fall under this short list (see example drafted by the JRC in Table A.3) could start to focus on main CRMs that they contain (not on all CRMs, which would often create an un-necessary burden for the scrutiny).

The approach could in principle be used already during the preparatory study for new Ecodesign workplan where the consultants and the European Commission could already flag product groups where a specific focus on critical raw materials could be initiated.

The short-listing exercise should be re-run for each preparatory study, taking into account specific elements, components and/or expertise related to the product group.

The **main advantage** of this new approach is to streamline the analysis and avoid starting from scratch each time. The EC could prioritize product groups according to their content in CRMs, for example already when discussing the Ecodesign work plans and when launching new preparatory studies. Preparatory studies will be more focused in their analysis. Consultants that will perform preparatory studies will use general guidance on how to retrieve information about the content of CRMs relevant for the product under scrutiny and will combine such general guidance with their specific expertise (See Section 2.3). Industry players that will contribute to the preparatory studies will be requested to provide information useful for Ecodesign (e.g. steel products usually contain some amount of Fluorspar, but this would be not relevant for Ecodesign purposes). This information collected during preparatory study could be also useful to fill data gaps and contribute, on the other side, to future revision of the EU CRMs lists.

Info on current recycling could help understanding in which way recycling can contribute further to the overall objectives of eco-design and to reduce supply risk as well. Info on existing substitutes could suggest e.g. to prioritize product groups where no substitutes exist.

Some mitigation strategies could be then tackled through Ecodesign measures (e.g. increasing lifetime, improving recyclability, recycled content, reporting content, etc.), though a procedure that could be automatically applied to all cases is not applicable at the moment.

Table A.1[45] shows some of the information provided by the EC criticality assessments, and in particular, the uses of CRMs and their current recycling (End-of-Life Recycling Input rate – EoL-RIR[46]). However, not all the end-uses considered in the full criticality assessment are publicly available. Table A.1 can be considered as a starting point for steering the discussion, although this is not an exhaustive list of all potential uses of CRMs in energy related products. The full table, with all the data is provided in chapter A.3 and is made of 232 rows, corresponding to 30 CRMs and their main end-uses.

[42] Assessment of the Methodology for Establishing the EU List of Critical Raw Materials, Publications Office of the European Union, Luxemburg, 2017, 978-92-79-69612-1, doi:10.2760/73303, JRC106997

[43] Talens Peiro, L., Nuss, P., Mathieux, F. and Blengini, G., Towards Recycling Indicators based on EU flows and Raw Materials System Analysis data, EUR 29435 EN, Publications Office of the European Union, Luxembourg, 2018, ISBN 978-92-79-97247-8 (online), doi:10.2760/092885 (online), JRC112720

[44] E.g. 60% of Indium is used in Flat panel displays (European Commission, Study on the EU's list of Critical Raw Materials – Final Report 2020).

[45] Table extracted from the COM(2020)474final (2020 list of CRMs for the EU).

[46] The EoL-RIR represents the contribution of recycling to meet the current demand for a certain material.

Table A.1 2020 List of CRMs for the EU - Annex 1 of COM(2020)474final[47].

Raw materials	EoL-RIR	Selected Uses
Antimony	28%	Flame retardants Defence applications Lead-acid batteries
Baryte	1%	Oil & gas drilling Filler in rubber, plastics, paints and paper Medical applications Radiation protection Chemical applications
Bauxite	0%	Aluminium production
Beryllium	0%	Electronic and Communications Equipment automotive, aero-space and defence components
Bismuth	0%	Pharmaceutical and animal feed industries Medical applications Low-melting point alloys
Borate	1%	High performance glass Fertilisers Permanent magnets
Cobalt	22%	Batteries Superalloys Catalysts Magnets
Coking coal	0%	Coke for steel Carbon fibres Battery electrodes
Fluorspar	1%	Steel and iron making Refrigeration and Airconditioning Aluminium making and other metallurgy
Gallium	0%	Semiconductors Photovoltaic cells

[47] Selection of columns

Raw materials	EoL-RIR	Selected Uses
Germanium	2%	Optical fibres and Infrared optics Satellite solar cells Polymerisation catalysts
Hafnium	0%	Superalloys Nuclear control rod Refractory ceramics
Indium	0%	Flat panel displays Photovoltaic cells and photonics Solders
Lithium	0%	Batteries Glass and ceramics Steel and aluminium metallurgy
Magnesium	13%	Lightweight alloys for automotive, electronics, packaging or construction Desulphurisation agent in steelmaking
Natural graphite	3%	Batteries Refractories for steelmaking
Natural Rubber	1%	Tires Rubber components for machinery and household goods
Niobium	0%	High-strength steel and superalloys for transportation and infrastructure High-tech applications (capacitors, superconducting magnets, etc)
Phosphate rock	17%	Mineral fertilizer Phosphorous compounds
Phosphorus	0%	Chemical applications Defence applications
Scandium	0%	Solid Oxide Fuel Cells Lightweight alloys
Silicon metal	0%	Semiconductors Photovoltaics Electronic components Silicones

Raw materials	EoL-RIR	Selected Uses
Strontium	0%	Oil & gas drilling Ceramic magnets Aluminium alloys Medical applications Pyrotechnics
Tantalum	0%	Capacitors for electronic devices Superalloys
Titanium	19%	Lightweight high-strength alloys for e.g. aeronautics, space and defence Medical applications
Tungsten	42%	Alloys e.g. for aeronautics, space, defence, electrical technology Mill, cutting and mining tools
Vanadium	2%	High-strength-low-alloys for e.g. aeronautics, space, nuclear reactors Chemical catalysts
Platinum Group Metals	21%	Chemical and automotive catalysts Fuel Cells Electronic applications
Heavy Rare Earth Elements	8%	Permanent Magnets Lighting Phosphors Catalysts Batteries Glass and ceramics
Light Rare Earth Elements	3%	

A.2.3 Proposed approach for analysing CRM and identifying priorities

Building on the numerical results of the 2020 Criticality Assessment[48], general guidance on how to short-list CRMs of higher interest/priority is provided below, including suggesting strategies for mitigation of criticality (through potential Ecodesign requirements). Expertise specific to the product group is then to be combined with such general guidance in order to obtain a meaningful short list.

An ad hoc Excel table associated to this report will be developed, which includes the data of the 2020 Criticality Assessment and is updated every three years, is made of 232 rows, corresponding to 30 CRMs and their end-uses and 17 columns, and the following columns describing:

- Name of the material
- The application where the material is used
- The average share of the material in that specific application
- The NACE 2 code of the sector corresponding to each application

[48] https://ec.europa.eu/docsroom/documents/42849

- The value added of each corresponding sector expressed in million EUR
- The corresponding 6 digit CPA[49]
- Additional specifications related to the corresponding sector
- The End-of-Life Recycling Input Rate[50] (EoL-RIR) of each material[51]
- The End-of Life Recycling Rate[52]
- Additional remarks on the CRM applications
- Column highlighting CRMs relevant for certain applications (priority uses to which focus for the further analysis in the preparatory studies), identified as explained in chapter A.3.
- Low priority materials (as used in product groups out of scope)
- Materials for which the objective of increasing recycling could be applied (preliminary)
- Materials for which the objective of declaring quantity could be applied (preliminary)
- Materials for which the objective of extending life time could be applied (preliminary)
- Substitution index ($SI_{EI\ application}$): based on cost and technical performance and functionality of the substitute materials
- Substitution index ($SI_{SR\ application}$): based on three parameters related to "production and criticality aspects" of the substitute materials:
- global production of the substitute material compared to the candidate material
- if the substitute is critical
- if the substitute is a primary product or mined as a co-/by-product

Columns A to H contains information published in the CRM reports and disclosed to the general public. They are extracted from the excels and the factsheets used in the criticality assessment.

Column "C" reports all the main applications for CRMs as identified during the criticality assessment. It is worth to notice that such applications represents a larger set from which the "Selected uses" published in the COM(2020)474final (also presented in Table A.1) were extracted. Column K reports additional remarks concerning additional relevant uses for CRM.

The EOL-RIR is reported in column I. Data are from the criticality assessment, and in turn from MSA studies. This is an average over all considered applications, whereas information on specific applications are generally not available. It could be relevant, within a preparatory study, to check with involved industries if these average values are representative of the studied product group.

The end-of-life-recycling-rate (EOL-RR), reported in column J refers to the current recycling of products at end of life. Data are mainly from MSA studies for the EU, or from UNEP-IRP[53] when EU data is not available. Even in this case, the excel file reports average data, whose representativeness for the studied products should be checked/assessed.

Columns from "L" to "P" are intended to summarise key information and to guide the preparatory study to set LOW/HIGH priority CRM for Ecodesign purposes and including suggestions on potential mitigation strategies, i.e. Recycle More, Declare Quantity, Extend Life, etc.

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49 https://ec.europa.eu/eurostat/statistics-explained/index.php/Glossary:Statistical_classification_of_products_by_activity_(CPA)

50 The end-of-life recycling input rate (EOL-RIR) is the percentage of the total material input into the production system that comes from functional recycling of post-consumer scrap (input perspective).

51 Talens Peiro, L., Nuss, P., Mathieux, F. and Blengini, G., Towards Recycling Indicators based on EU flows and Raw Materials System Analysis data, EUR 29435 EN, Publications Office of the European Union, Luxembourg, 2018, ISBN 978-92-79-97247-8 (online), doi:10.2760/092885 (online), JRC112720

52 The end-of-life recycling rate (EOL-RR) is the share of a material in waste flows that is actually recycled (output perspective).

53 UNEP (2011) Recycling Rates of Metals - A Status Report. Paris: United Nations Environment Programme (UNEP).

For example, materials having very low values for both EOL-RIR and EOL-RR suffer probably of techno-economic barriers for their recycling. For these materials, is probably not effective nor feasible to push for improved recyclability. Attention should also be on extending products' (or components') lifetime. Another obvious strategy for potential ecodesign requirements could be to focus on mandatory declarations of critical raw materials (e.g. quantities of the materials contained in the products or in some specific components), in particular when data in insufficient. Such requirements could make reference to the CEN-CENELEC horizontal standard EN 45558:2019 that provides a general methodology for declaration of the use of critical raw materials in energy-related products in the context of the Ecodesign Directive (2009/125/EC), and that provides a means for information on the use of CRMs to be exchanged up and down the supply chain and with other relevant stakeholders.

In addition, low substitutability (columns "Q" and "R") suggest to intensify efforts to e.g. recycle more or use more efficiently.

This information is mainly intended for an initial screening. Feasibility and potential benefits of such strategies would require as in-depth assessment as done for other material efficiency measures.

Draft Step-by-step approach box

JRC suggests to always start from the results of the latest criticality assessment and use them for an initial screening, also taking into account specific aspects and expertise related to the product group under scrutiny. A generalized and systematic procedure to automatically identify ecodesign measures looks unlikely, as suggested by the principles discussed in this report.

With the above in mind, some recommendations are formulated:

Step 1: shortlist the CRMs that are potentially in the product group using table A.1, table A.3 (the corresponding full table), and any other additional information related to the product group;

Step 2: when possible, collect quantitative data on the BoM of the shortlisted CRMs;

Step 3: look at information available in the above tables (Substitution, RR, RIR, etc.), define a possible strategy, e.g.:

- Declare quantity when data is not available or of good quality, and/or
- Extend lifetime, especially in the case of low substitutability, and/or
- Improve recyclability and/or use recycled materials, especially in the case of low substitutability;

Some general rules / checklist:

- If RR is low, then check if recycling technology is available or if the product group is an exception (data on recycling is always an average across all product groups)
- If RR is high, but EoL-RIR is low, demand is probably growing, so it is unlikely that recycled materials can be available in adequate quantities. So, rather than recommending higher recycled content, a more adequate measure could then be an extension of lifetime.

A.3 Example of how to shortlist CRMs relevant for certain applications

As a concrete example on how the available information from criticality assessments could be used in the context of eco-design, CRMs used in certain application have been prioritized based on the following criteria:

1. The initial criterion is to filter by NACE-2 sectors (Table A.2) and screen out sectors (and the corresponding applications) of low interest for MEErP (e.g. phosphates used as animal feed, or all CRMs used in *C19 - Manufacture of coke and refined petroleum products*).
2. The second criterion consists in identifying materials which are predominantly used in a single application, looking at Column D, which is particularly helpful to identify "high concentrations" of CRMs (e.g. indium in flat displays).
3. Information about recycling in columns I and J can suggest mitigation strategies, e.g. recycle more, or extend life. Therefore, attention was focused on CRMs uses for which a big gap between EoL-RIR and EoL-RR was detected.

Table A.2 NACE-2 sectors used in the criticality assessment.

NACE-2 sector
C10 - Manufacture of food products
C19 - Manufacture of coke and refined petroleum products
C20 - Manufacture of chemicals and chemical products
C21 - Manufacture of basic pharmaceutical products and pharmaceutical preparations
C22 - Manufacture of rubber and plastic products
C23 - Manufacture of other non-metallic mineral products
C24 - Manufacture of basic metals
C25 - Manufacture of fabricated metal products, except machinery and equipment
C26 - Manufacture of computer, electronic and optical products
C27 - Manufacture of electrical equipment
C28 - Manufacture of machinery and equipment n.e.c.
C29 - Manufacture of motor vehicles, trailers and semi-trailers
C30 - Manufacture of other transport equipment
C31 - Manufacture of furniture
C32 - Other manufacturing

Results of the short-listing process are shown in Table A.3, where 45 combinations of CRMs and the corresponding applications are highlighted. These represent the starting point for further investigation. Such Table A.3 could be incorporated into the EcoReport tool.

It is worth of noticing that the EOL-RIR and EOL-RR values (in columns "I" and "J") are average values across all the applications. It is envisaged that future preparatory studies could try to get more precise data for the application under scrutiny.

Table A.3 Short list of 45 combinations of CRMs and specific application derived from the proposed methodology (draft).*

* all these initial recommendations (in violet columns) are to be re-checked and/or completed when running a preparatory study, taking into account specific aspects of the product group and using adequate expertise.

B	C	D	E	I	J	L	N	O	P
Material	Application	Share	NACE-2 sector	EOL-RIR	EOL-RR	High priority	RECYCLE MORE or ADD RECYCL CONTENT	DECLARE Q.TY	EXTEND LIFE
Beryllium	Electronic and telecommunications equipment	42%	C26 - Manufacture of computer, electronic and optical products	0%	0%	X		X	
Beryllium	Transport and Defence : Vehicle electronics	17%	C26 - Manufacture of computer, electronic and optical products	0%	0%	X			
Cobalt	Magnets	7%	C27 - Manufacture of electrical equipment	22%	32%	X	X		
Cobalt	Battery	3%	C27 - Manufacture of electrical equipment	22%	32%	X	X		
Dysprosium	Magnets	100%	C25 - Manufacture of fabricated metal products, except machinery and equipment	0%	0%	X		X	
Erbium	Lighting	26%	C27 - Manufacture of electrical equipment	1%	1%	X		X	
Europium	Lighting	100%	C27 - Manufacture of electrical equipment	38%	34%	X		X	
Fluorspar	Refrigeration and air conditioning	9%	C27 - Manufacture of electrical equipment	1%	4%	X			
Gadolinium	Magnets	38%	C25 - Manufacture of fabricated metal products, except machinery and equipment	1%	1%	X		X	
Gadolinium	Lighting	25%	C27 - Manufacture of electrical equipment	1%	1%	X		X	
Gadolinium	Magnetic Resonance Imaging - MRI	8%	C21 - Manufacture of basic pharmaceutical products and pharmaceutical preparations	1%	1%	X			
Gallium	Integrated circuits	70%	C26 - Manufacture of computer, electronic and optical products	0%	0%	X		X	
Gallium	Lighting	25%	C27 - Manufacture of electrical equipment	0%	0%	X		X	
Gallium	CIGS solar cells	5%	C26 - Manufacture of computer, electronic and optical products	0%	0%	X			
Germanium	Infrared optics	47%	C26 - Manufacture of computer, electronic and optical products	2%	12%	X		X	
Germanium	Optical fibres	40%	C27 - Manufacture of electrical equipment	2%	12%	X		X	
Germanium	Satellite solar cells	13%	C26 - Manufacture of computer, electronic and optical products	2%	12%	X			
Ho, Tm, Lu, Yb	Glass - Optical applications	100%	C26 - Manufacture of computer, electronic and optical products	1%	1%	X		X	
Indium	Flat panel displays	60%	C26 - Manufacture of computer, electronic and optical products	0%	0%	X		X	
Indium	Solders	11%	C26 - Manufacture of computer, electronic and optical products	0%	0%	X			
Indium	PV cells	9%	C26 - Manufacture of computer, electronic and optical products	0%	0%	X			
Iridium	Electronics	39%	C26 - Manufacture of computer, electronic and optical products	14%	25%	X	X	X	
Lanthanum	Batteries	10%	C27 - Manufacture of electrical equipment	1%	1%	X		X	
Lanthanum	Lighting	2%	C27 - Manufacture of electrical equipment	1%	1%	X			
Lithium	Batteries and products containing batteries	1%	C27 - Manufacture of electrical equipment	0%	0%	X			
Natural graphite	Batteries	9%	C27 - Manufacture of electrical equipment	3%	8%	X			
Neodymium	Magnets	41%	C25 - Manufacture of fabricated metal products, except machinery and equipment	1%	3%	X		X	
Neodymium	Batteries	14%	C27 - Manufacture of electrical equipment	1%	3%	X		X	
Palladium	Electronics	4%	C26 - Manufacture of computer, electronic and optical products	28%	47%	X	X		
Platinum	Medical and Biomedical	4%	C32 - Other manufacturing	25%	54%	X	X		X
Platinum	Electronics	1%	C26 - Manufacture of computer, electronic and optical products	25%	54%	X	X		
Praseodymium	Magnets	27%	C25 - Manufacture of fabricated metal products, except machinery and equipment	10%	na	X	X	X	
Praseodymium	Batteries	13%	C27 - Manufacture of electrical equipment	10%	na	X			
Rhodium	Electronics	0%	C26 - Manufacture of computer, electronic and optical products	28%	62%	X	X		

Ruthenium	Electronics	48%	C26 - Manufacture of computer, electronic and optical products	11%	8%	X	X	X	
Samarium	Magnets	97%	C25 - Manufacture of fabricated metal products, except machinery and equipment	1%	1%	X		X	
Scandium	Solid Oxide Fuel Cells (SOFCs)	91%	C27 - Manufacture of electrical equipment	<1%	2%	X		X	
Strontium	Magnets	9%	C28 - Manufacture of machinery and equipment n.e.c.	0%	1%	X			
Tantalum	Capacitors	40%	C26 - Manufacture of computer, electronic and optical products	13%	40%	X		X	
Tantalum	Sputtering targets	20%	C26 - Manufacture of computer, electronic and optical products	13%	40%	X			
Terbium	Lighting	68%	C27 - Manufacture of electrical equipment	6%	30%	X	X	X	X
Terbium	Magnets	32%	C25 - Manufacture of fabricated metal products, except machinery and equipment	6%	30%	X	X	X	X
Titanium	Medical equipment	6%	C28 - Manufacture of machinery and equipment n.e.c.	19%	91%	X			
Tungsten	Lighting and electronic uses	6%	C26 - Manufacture of computer, electronic and optical products	42%	63%	X	X		
Yttrium	Lighting	50%	C27 - Manufacture of electrical equipment	31%	29%	X	X	X	

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