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Analysis and development of a scoring system for repair and upgrade of products

Final report

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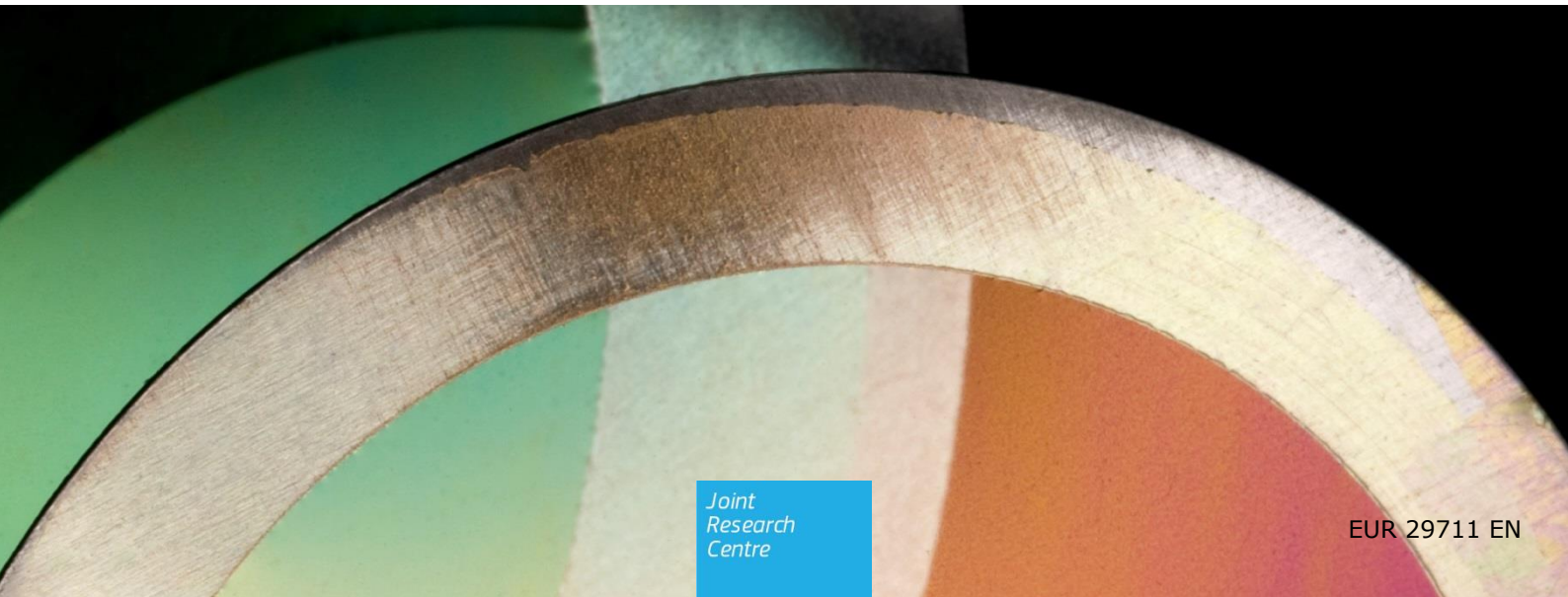

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EXECUTIVE SUMMARY

As part of the implementation of the EU action plan for the Circular Economy, the European Commission has carried out a study for the analysis and development of a possible scoring system to inform about the ability to repair and upgrade products. The overall aims of the study, described in the present report, are:

1) To develop a general approach for the assessment of the ability to repare/upgrade energy related products (ErP);

2) To test the feasibility and types of results derived using the general approach on three specific product groups (Laptops, Vacuum Cleaners and Washing Machines).

Building on the experience gained by CEN-CENELEC-JTC10 during the development of prEN 45554, a general framework has been proposed that provides technical guidance for the identification of most relevant aspects and priority parts for products on the market, as well as for scoring and aggregating different aspects of repair and upgrade.

A limited number of technical parameters have been selected which cover design characteristics and relevant operational aspects related to the repair/upgrade of products. Purely economic parameters are out of the scope of this study but they are addressed indirectly by the selected parameters since these can have an influence on the cost of repair/upgrade operations.

The assessment of products has been simplified by focusing, when relevant, on priority parts, to be defined on a product group basis taking into account aspects such as the frequency of failure/upgrade, the functional importance of parts, as well as qualitative information.

The assessment framework is composed of:

a) Pass/fail criteria that products have to fulfil in order to be considered as reparable/upgradable, and thus eligible for being assessed through the scoring criteria;

b) Scoring criteria, to rate the extent to which products are reparable or upgradable.

Scores can be aggregated and reported in different types of indices, which could be more or less suitable based on the final application of the scoring system. However, it was recognised that background information used for their quantification should be also provided for transparency reasons.

In order to understand specific aspects and needs for different types/groups of products, the general framework has been theoretically applied to three illustrative product groups: laptops, vacuum cleaners and washing machines. The assessment has been kept practical by focusing on key parameters for the analysed product groups.

This scoring system could serve as a technical reference for potential use in policy-making (e.g. Ecodesign, Energy Label, GPP, Ecolabel), for the design of a new label, or as public guidance document (for designers and consumer testing organisations). However, the study itself does not propose or pre-empt any future policy decision. Moreover, the scoring system may need to be revised periodically, in the logic of continuous methodological improvement and adaptation to changing market conditions. The applicability of the system should be also supported by future investigation aiming at:

- The analysis of how consumers can understand different types of information related to the repair/upgrade of products;

- The analysis of the performance of real products on the market to understand how parameters, rating and weighting of the scoring system should be adjusted, and how frequently they should be updated over time.

Finally, it has also to be observed that different aspects should be evaluated in a preliminary phase to understand which are the best material efficiency strategies to implement for a specific product (e.g. similar levels of benefits could be achieved either designing more reliable products that last longer, or that can be repaired/upgraded more easily). Durability of a product is relevant as long as a product has actually an extended service life. Reliability, reparability and upgradability are all durability aspects targeted to extending the service lifetime of products and tightly linked to each other. Also in the cases in which reliability could have higher importance, reparability and upgradability can be still complementary to extend the lifetime of products.

INTRODUCTION

The 2015 Communication from the Commission on an EU action plan for the Circular Economy[1] pointed out the importance of improving the resource efficiency of products in order to promote the transition towards a more circular economy in the EU. The Ecodesign Working Plan 2016-2019 [2] commits to explore the possibility of further developing product-specific and/or horizontal requirements in areas such as durability, reparability, upgradeability, ease of reuse, remanufacturing and recycling. In particular, extending the durability of products and improving their repair and upgrade possibilities can potentially benefit consumers, the environment and the economy by limiting the early replacement of products, increasing competitiveness on product design, supporting the EU repair market and saving resources.

In this context, the European Commission has been working on the development of a scoring system to inform about the reparability and - where relevant – upgradability of products placed on the market by manufacturers and retailers. Reparability and upgradability are here defined, respectively, as *the ability to restore the functionality of a product after the occurrence of a fault*, and *the ability to enhance the functionality of a product*. Both can refer to one or more parts of a product (Cordella et al. 2018a), where parts may be either hardware, software or firmware.

This study, carried out by the Commission's Joint Research Centre (Directorate B, Circular Economy & Industrial Leadership Unit) on behalf of DG ENV, has the aim to:

1) Develop a general approach for the assessment of products;

2) Test the feasibility and type of results of the general approach on three specific product groups (Laptops, Vacuum Cleaners, Washing Machines)[3].

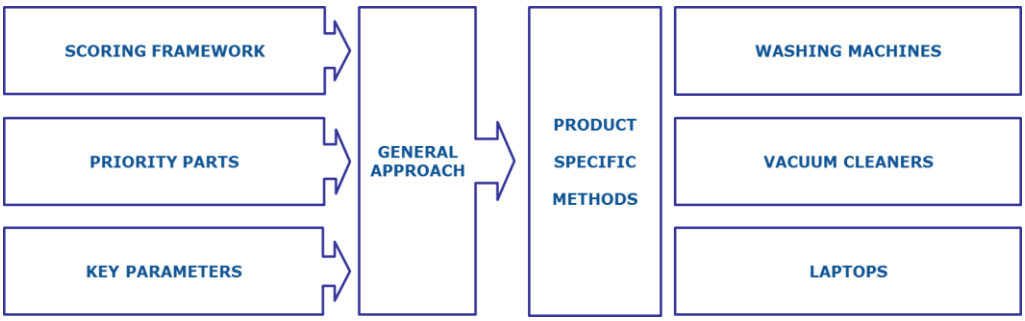


Figure 1: From general to product specific approaches

The study could serve as a technical reference for potential use in policy-making (e.g. Ecodesign, Energy Label, GPP, Ecolabel), for the design of a new label, or as public guidance document (for designers and consumer testing organisations). However, the study itself does not propose or pre-empt any future policy decision[4].

[1] COM(2015) 614 "Closing the loop - An EU action plan for the Circular Economy''

[2] COM(2016) 773 "Ecodesign Working Plan 2016-2019"

[3] Selection made to cover a limited number of appliances which are market relevant and for which the study team had in-house experience. The test refers here to a methodological check and should be complemented in a later stage by a practical analysis of products on the market.

[4] Complementary to this technical work, there will be a further behavioural study that will explore the consumers understanding of reparability/upgradability information provided via a label.

The focus is on design characteristics of products but it also explores the possibility to take into account relevant practices, such as the provision of an extended product warranty (i.e. commercial guarantee[5]), after-sales free repair services and others.

The research builds on the in-house experience in product policy implementation (Cordella et al. 2018b; Cordella et al. 2019) and in the assessment of material efficiency aspects of products (Alfieri et al. 2018a; Alfieri et al. 2018b; Cordella et al. 2018a), as well as on the available literature and on input from experts and other stakeholders. Experts and stakeholders who have been consulted during this process include manufacturers, retailers, repair enterprises, academia, environmental and consumer NGOs, Member States' representatives. Engagement with stakeholders has been very important to achieve coherent and balanced results, based on representative and up-to-date information. A consultative Technical Working Group (TWG) has been set up to facilitate this process[6].

Background information and initial input from stakeholders have been gathered at the beginning of the study via a questionnaire[7] (see Annex I and Annex II). Moreover, two meetings have been organised in order to obtain feedback and input directly from the TWG:

- 1st TWG meeting, on 26 June 2018 in Seville, to discuss the general approach, and to obtain product-specific preliminary guidance;

- 2nd TWG meeting, on 8 November 2018 in Brussels, to revise the general approach and to discuss on product-specific approaches.

This is the final version of the study report, which is structured as follows:

1. Analysis of methods for assessing reparability and upgradability of products;
2. Development of a general scoring system: priority parts, key parameters, rating and aggregation;
3. Product-specific considerations;
4. Additional considerations;
5. Conclusions.

Annexes

Background information about the process that led to the completion of the study, including minutes of the two TWG meetings, is available on the dedicate website: http://susproc.jrc.ec.europa.eu/ScoringSystemOnReparability/index.html.

[5] "commercial guarantee" means any undertaking by the trader or a producer (the guarantor) to the consumer, in addition to his legal obligation relating to the guarantee of conformity, to reimburse the price paid or to replace, repair or service goods in any way if they do not meet the specifications or any other requirements not related to conformity set out in the guarantee statement or in the relevant advertising available at the time of, or before the conclusion of the contract; (Consumer Rights Directive 2011/83/EU)

[6] The Technical Working Group has more than 150 registered stakeholders on March 2019 covering representatives of industry and trade associations (~47%), governmental agencies and standardisation committees (~21%), NGOs and repairers (~20%), research institutes and consultancies (~11%), and retailers (~1%)

[7] The questionnaire was launched on 7th April 2018 and made accessible from http://susproc.jrc.ec.europa.eu/ScoringSystemOnReparability/documents.html. The questionnaire was closed on 7 May 2018

1 METHODS FOR ASSESSING REPARABILITY AND UPGRADABILITY

Reparability and upgradability of products can be assessed at different levels which vary from more qualitative to more quantitative approaches (Cordella et al. 2018a). This study focuses on the evaluation of the reparability and upgradability of products based on parameters that can eventually be used for determining a score. An analysis of approaches available in the literature, and which are considered potentially relevant for the development of a scoring system on repair and upgrade, is provided in this section. Experience and views of stakeholders, shared in particular as input to the initial questionnaire, are provided in Annex II.

1.1 ADEME report on "benchmark international du secteur de la réparation"

The objective of this study (Hervier et al. 2018) is to create an international panorama of the repair sector by detailing the organization of the sector (actors, circuits, access to information), the state of the sector and its evolution, the actions to support the sector (taxation, guarantee, labels, support) and the potential replicability of certain actions in France. Examples of relevant initiatives identified in the analysed territories (Germany, Austria, Australia, Belgium, the Netherlands, Massachusetts, the United Kingdom, Sweden, South Korea and Japan) include:

- The creation of a repair federation (as in the Netherlands);
- The availability of spare parts and the provision of technical documentation by law (as in some states of the United States);
- The display of reparability information on products (as in Austria);
- The introduction of an international repair day (as in the United Kingdom);
- Economic (fiscal) measures to reduce the cost of repair (as in Sweden);
- The reset of the warranty in case of failure under warranty (as in Austria).

1.2 Austrian standard ONR 192102:2014

ONR 192102:2014 (ONR 2014) establishes criteria to obtain a quality label for durable, repair friendly designed electrical and electronic appliances (white and brown goods[8]). White goods undergoing this process are assessed against a set of 40 criteria; 53 criteria are instead considered for brown goods. The system is composed of both mandatory pass/fail criteria, and criteria based on graded classes. The latter ones are used to quantify a score, which is then related to a 5-10 quality level and an overall rating, as shown in Table 1.

[8] No official definition is provided, however, in general: i) white goods include large electrical products used domestically, such as refrigerators and washing machines; ii) brown goods include consumer electronics equipment for entertainment, such as televisions and media players.

Table 1: Conversion table for level of quality and rating in ONR 192102:2014

Points Rewarded	Quality Level	Rating
45 to 69	5	Good
70 to 94	6	
95 to 119	7	Very good
120 to 144	8	
145 to 174	9	Excellent
175 to 205	10	

1.3 Benelux study on "Repairability criteria for energy related products"

This study (Bracquené et el. 2018) aims to provide an overview of relevant criteria related to the reparability of products. The repair operation is divided into steps: product identification, failure diagnosis, disassembly and reassembly, replacement of spare parts, restoration to working condition. For the different steps of repair, the following categories of criteria are considered: information provision, product design, servicing. A score is assigned to each criteria and aggregated by repair step, category of criteria, and overall score. The methodology, reported to be in line with current developments of the draft prEN 45554 (see Section 1.12), introduce the concept of priority parts, differentiates between who carries out the evaluation (e.g. professionals vs. laymen) and has been tested in three case studies (i.e. two vacuum cleaners and one washing machine). An overview of the methodology is provided in Figure 2.

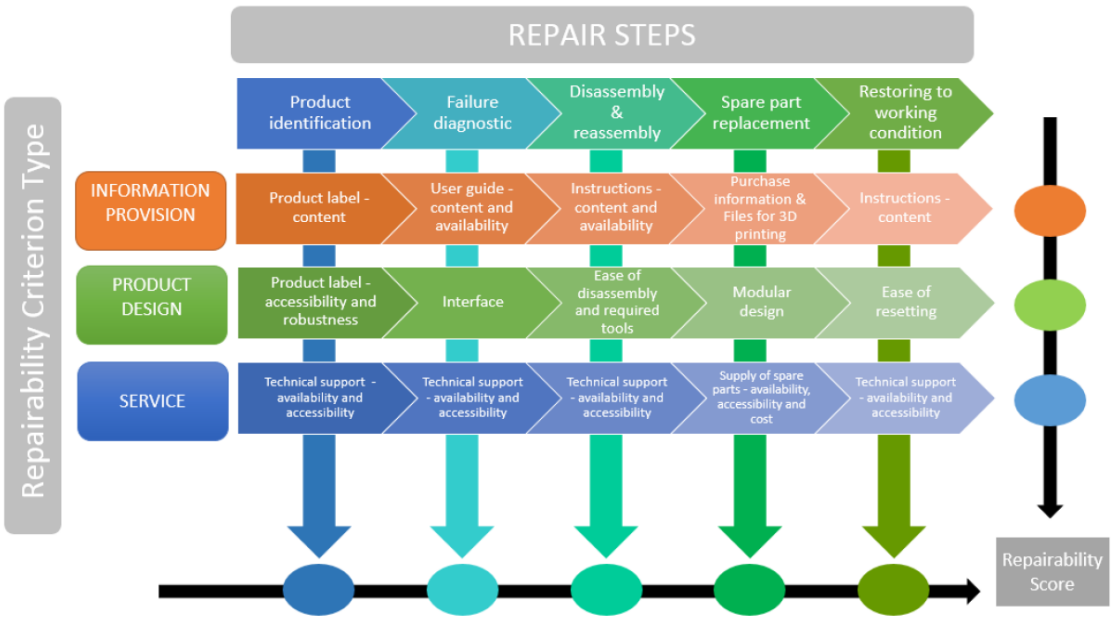


Figure 2: Overview of the Reparability assessment methodology followed in the Benelux study (Bracquené et al. 2018)

1.4 DEFRA' study "The Effectiveness of Providing Environmental Sustainability Information on Products in influencing purchasing behaviours"

This is a study commissioned by the UK Government (WRAP 2019) to review the existing evidence on how the provision of environmental information about products (including circular economy aspects) can influence more sustainable purchasing. Provisions may take the form of a label or logo displayed at point of sale, information that is provided prior to sale (e.g. on the internet), information accompanying the product for sustainable use and disposal, or information that can be searched out during ownership of the product (e.g. on the internet). The study ran during 2018 and should be reported in 2019.

1.5 DG ENV's "Study on socio-economic impact of increased reparability"

This study (Deloitte 2015) explores policy options to improve the reparability of products by analysing barriers to repair and the potential impacts that could result from the implementation of reparability requirements on four specific product groups: washing machine, dishwasher, coffee machine and vacuum cleaner. Five assessment scenarios were defined. Measures to ensure the availability of spare parts for at least a certain number of years and measures to enable an easier dismantling of products were identified to provide the highest potential benefits (e.g. in terms of resource savings). Scenarios that call for the provision of information either towards consumers or professionals could be easier to implement but with possible concerns over intellectual property rights or health and liability issues.

This was followed up by a second socio-economic analysis of the repair sector for different product groups in the EU (Tinetti et al. 2019). The study provides a mapping of the repair activities in 10 Member States of the EU (Austria, France, Germany, Greece, Italy, Poland, Portugal, Romania, Spain and Sweden) and further knowledge and evidence-basis for the development of effective measure to improve the reparability of products. Products in the scope include: small white goods, large white goods, (domestic) ICT equipment, brown goods. Main results of the study are that:

- The overall repair sector is fragmented and consists of repairers that differ in type and size, although there is a general tendency to centralisation of repair services with large repairers increasing their market share;

- The repair sector differs depending on the product category. The repair of computers and communication equipment represents a significantly higher share in terms of number of companies, employees and turnover. In 3 of the product categories analysed (white goods, brown goods and ICT equipment), the number of employees has been dropping, but the overall turnover has been increasing;

- The cost of repair appears a key barrier in all Member States. Behavioural aspects (e.g. preference for new products, mistrust and lack of awareness towards repair) may also constitute a significant barrier, especially for countries with less repair;

- The design of a product, spare parts availability as well as manuals and tools also have a significant role to play in the choice to repair or replace a product. There is evidence that some products are not designed to be repaired, and a general tendency to substitute products or components instead of repairing them, has also been reported;

- Competitiveness can promote innovation and decrease repair costs and prices. An extension of the legal guarantee period to five years, as well as measures

taken at national level (such as reduced VAT rates on repair activities, tax deductions on income taxes, tax exemptions for repairers for payroll taxes/social security taxes) could act as key drivers for increased repair rates. An increased awareness of consumers through labels and campaigns could also increase the demand of repair activities;

- Different initiatives have been developed to increase repair activities, both directly (e.g. repair cafes) and indirectly (e.g. promotion of reuse, extension of the legal guarantee).

1.6 DG JUST's "Behavioural Study on Consumers' Engagement in the Circular Economy"

An EU wide behavioural study (Cerulli-Harms et al. 2018), commissioned by the European Commission (DG Justice and Consumers), found that consumers were generally willing to engage in Circular Economy practices. However, actual engagement was rather low. While a majority of consumers repair products, a substantial share have not repaired products in the past, and/or have no experience with renting/leasing or buying second hand products. A reason for this low engagement in Circular Economy practices could be that consumers lack information regarding product durability and reparability as well as the lack of sufficiently developed markets (e.g. for second hand products, renting, leasing or sharing services). In the behavioural experiment, the provision of such information was found to be highly effective at shifting purchasing decisions towards products with greater durability and reparability. The survey and experiment also found that willingness to repair is discouraged if arranging repair is too complex. These findings indicate that there is a large potential to close the gap between consumers' willingness to engage and their actual engagement. DG Justice and Consumers plans to launch a new study in 2019 on the fitness of consumers' legal frameworks at EU and national level for the circular and low-carbon economy, which will also assess possible new measures for consumers.

1.7 "Design for Repairability" tool

Starting from the approach developed by iFixit for phones and tablets and on the further work of Flipsen et al. (2016), key design criteria to assess the reparability of a product have been included in the "Design for Repairability" tool[9]. This is a scoring system based on the assessment of 20 criteria related to the ability of consumers to repair a product by themselves (i.e. "Do-It-Yourself" repair). The tool aim is to assess brown goods (television sets, audio equipment, and similar household appliances). A 0-1-2 rate is assigned to each criteria and the overall score is then normalised to a 0-to-10 basis.

1.8 Ease of Disassembly Metric

The eDiM (ease of Disassembly Metric) method (Peeters et al. 2018, Vanegas et al. 2016, 2018) provides a quantitative indication of the time, and thus of the difficulty, needed to disassemble and reassemble a product or its parts. The eDiM method is based on the Maynard Operation Sequence Technique (MOST) (Zandin 2003) and requires information about parts in the product, disassembly sequence, fasteners, tools needed. The tasks necessary to disassemble and reassemble parts are listed and reference time values[10] are associated to each of them, representing the effort needed to perform such operation. Although this method cannot be used as a stand-alone tool since it does not

[9] www.repairability.org (accessed on 4 June 2018)
[10] from a database which can be adapted, extended and/or updated

represent entirely the repair process (e.g. availability of spare parts is not considered), it offers a theoretically comprehensive metric regarding the "disassemblability" of a product.

1.9 Groupe SEB's "Product 10Y Repairable" label

The "Product 10Y Repairable" label[11] is a company label that the Group SEB applies with the aim of promoting the reparability of the small household appliances that they commercialise. The label aims to indicate to consumers:

1) Proximity of authorised and trained repair centres;

2) Possibility to fully disassemble and reassemble the appliance without risk of damaging the product;

3) Fast availability of spare parts (24-48 hours shipment time), over time (to be in stock for 10 years or more) and at an affordable cost (at a maximum, each part must cost less than 50% of the total product cost).

1.10 i-Fixit scoring system

A 0-to-10 score is assigned by iFixit[12] to different categories of devices (e.g. laptops, smartphones), where a score of ten represents the easiest product to repair on the market. The scoring system considers indicators such as: ease of disassembly, availability of service manuals, types of fasteners used, type and number of required tools, possibility to upgradable the device, and modular design[13].

1.11 Labo Fnac's "indice de réparabilité"

Fnac-Darty has launched an index to assess the reparability of laptops[14]. The index is calculated based on 12 parameters, which are grouped in 4 areas:

1) Documentation (disassembly instructions, diagnosis support, maintenance tips),

2) Modularity and accessibility (ease of disassembly, modularity of main parts, use of tools),

3) Spare parts (availability, price, standardised parts),

4) Software/firmware (reset to original conditions, compatibility with open source software/firmware, updates).

The maximum score for the index, which represent the best repair scenario, is 100. The contribution from each area is proportional (i.e. 25%). The score is then normalised to a 0-10 scale.

1.12 prEN 45554 – General methods for the assessment of the ability to repair, reuse and upgrade energy related products

This is a draft standard which is currently being developed by CEN-CENELEC's JTC10 "Energy-related products – Material Efficiency Aspects for Ecodesign"[15], in response to

[11] http://www.groupeseb.co.uk/repairable.html (accessed on 24 May 2018)
[12] https://www.ifixit.com/ (accessed on 24 May 2018)
[13] https://www.ifixit.com/Info/Repairability#Section_Overview (accessed on 4 June 2018)
[14] http://labo.fnac.com/actualite/labo-fnac-lance-indice-de-reparabilite-des-pc-portables/ (accessed on 19 October 2018)

the standardisation mandate M/543[16]. The standard, planned to be published in 2020, aims to provide a toolbox of parameters and methods to assess the ability to repair, reuse and upgrade energy-related products (ErP). The standard provides a general approach, which should be tailored to specific products.

The last available draft (November 2018) included:

- Guidance for the identification of parts to be covered in the assessment;

- A list of product-related parameters influencing repair, reuse and upgrade;

- A list of parameters related to manufacturers' support to facilitate repair, reuse or to upgrade;

- Examples of possible classification and rating criteria for such parameters (Disassembly depth; Fasteners; Tools; Working environment; Skill level; Diagnostic support and interface; Availability of spare parts; Types and availability of information; Return models; Data transfer and deletion; Password and factory reset for reuse); and

- Quantitative assessment methods (Disassemblability index; Time for disassembly).

[15] https://www.cenelec.eu/dyn/www/f?p=104:7:1299206399119101::::FSP_ORG_ID:2240017 (accessed on 1 June 2018)

[16] M/543 COMMISSION IMPLEMENTING DECISION C(2015)9096 of 17.12.2015 on a standardisation request to the European standardisation organisations as regards Ecodesign requirements on material efficiency aspects for energy-related products in support of the implementation of Directive 2009/125/EC of the European Parliament and of the Council

1.13 Summary

Existing methods to assess the reparability and upgradability of products can be useful as starting point for the development of a scoring system. The following needs have been identified:

- Objectivity and reproducibility of assessment and verification methods;
- Ease of understanding the system and the reported information;
- Representativeness at EU level;
- Fair applicability to a broad scope of repair/upgrade strategies (DIY, independent professionals, authorised professionals, OEM), unless one or more strategies are clearly identified as more beneficial than others.

Moreover, it would be important to follow, as far as closely, widely-agreed methodologies. The experience gained for the development of prEN 45554 appears the most suitable resource to feed a reparability scoring system. The draft standard prEN 45554 has been broadly discussed since 2016 in the CEN-CENELEC standardisation process. This includes many experts representing stakeholders form different types of organisations. The draft standard can thus provide a reference framework for the selection of parameters, classification criteria and methods to assess the reparability and upgradability of products, although they will have to be tailored to specific categories of products. However, complementary elements needed for the developing of a scoring system (e.g. rating of parameters and aggregation of scores) must be considered and discussed in the context of this study.

2 DEVELOPMENT OF A SCORING SYSTEM FOR ASSESSING REPAIR AND UPGRADE OF GENERIC PRODUCTS

As shown in Figure 1, a scoring system for assessing the reparability and upgradability of generic products placed on the market is founded on three pillars (Cordella et al. 2018a):

I) Priority parts;

II) Key parameters for repair and upgrade;

III) Scoring framework.

The general approach can be tailored to specific products, as illustrated in Section 3.

2.1 Priority parts

Products are generally made of a large number of parts. In order to reduce the complexity of the assessment, it may be relevant to focus only on those parts that are more important for repair and/or upgrade operations, which are referred to in this context as "priority parts".

Priority parts have to be identified at product group level to enable the comparative assessment of products belonging to the same product group[17]. Aspects to consider for the selection of priority parts have been initially discussed with stakeholders and summarised in Annex II. It has been considered that a priority part:

i. Has to be functionally important;

ii. Is likely to fail or to be upgraded.

2.1.1 Functional importance

If a part (either hardware, software or firmware) is necessary to deliver either primary or secondary functions[18] of the product, it should have high priority. For example, the primary function of a washing machine is to clean, rinse and spin clothes. The secondary functions represent a breakdown of aspects that contribute to enable, supplement or enhance this process (Boyano et al. 2017a). Tertiary functions[19] are instead considered less relevant for the identification of priority parts. Functional importance of parts has to be considered in combination with the likelihood of failure/upgrade.

2.1.2 Frequencies of failure and upgrade

The frequencies of failure of parts can be seen as the most important aspect for determining priority parts, with respect to reparability issues.

Whilst the actual frequencies of failure for a specific product model can only be evaluated when market and users have gained experience with this model and typical repair requests have been identified, insights from products that are / have been on the market can assist the determination of priority parts at product group level.

[17] Whilst a list of functional parts for a product group is necessary for the assessment, it should be noted that manufacturers may have more detailed model-specific lists of functional parts

[18] According to prEN 45552 - General method for the assessment of the durability of energy-related products (October 2019; Public Enquiry version) - a primary function is necessary to fulfil the intended use, whilst a secondary function enables, supplements or enhances the primary function(s). Note: depending on the product, the function of a part could also include aesthetic aspects.

[19] According to prEN 45552 - General method for the assessment of the durability of energy-related products (October 2019; Public Enquiry version) - a tertiary function is any function that cannot be defined as a primary or a secondary function

Insights on parts that are more prone to fail could be for instance obtained in technical-scientific documents containing data on product's design analyses (e.g. Failure Mode and Effect Analysis, stress analysis and damage modelling), durability/reliability testing results, risk assessments, statistical surveys about accidental breakdowns and normal wear-out. Experts' judgements and field experience (e.g. demand of spare parts) are also a valuable source of information. All in all, insights can be provided by a broad pool of sources that include: manufacturers of products and parts, repairers, reuse and remanufacture organisations, consumer testing organizations, insurance companies, researchers and regulators.

According to the feedback received by stakeholders, most companies aim to have no more than a small fraction of products (e.g. less than 3%) failing during legal guarantee periods, because of cost reasons. Collection of data on failure rates for many products is therefore likely to be more comprehensive in the phase after the legal guarantee period.

The physical level (depth) at which failures occur should also be considered. For example, if the motor brushes within a washing machine motor are a common source of failure across products, and there is the possibility to fix or replace the brushes rather than replace the whole motor, it could be more relevant to consider the brushes as a priority part, rather than (or in addition to) the overall motor in which they are contained.

Frequencies of upgrade are relevant, in the case of upgradability, for prioritising those parts, software and firmware that are necessary to keep the product delivering user expectations. This is particularly important because it can to some extent determine the likelihood of obsolescence of the product.

Parts and components can need higher frequency of upgrade due to factors such as rapid technology change, changes in the use given to a part, design and specifications of a product. Also in this case, insights on these aspects can be provided by product group's experts and examining the reasons for replacement of still functioning products before their end of life. It should be noted that upgrade could also take place when a failure occur in order to enhance the functionality or capacity of a product. However, it could be difficult to predict, at the time of placing an appliance on the market, what future upgrades will be needed.

2.1.3 Economic and environmental considerations

The difficulty to disassemble and reassemble parts and the cost of spare parts have not been considered as critical aspects for the identification of priority parts in the assessment of the reparability and upgradability of products.

Priority parts can potentially cover both cheap and expensive parts. Expensive parts are normally very important from a functional point of view (e.g. the motor of a washing machine). However, also cheap parts can be fundamental for the functioning of the product (e.g. although carbon brushes are very cheap, they have to be repaired in case of failure). The lower the price of a part is the higher is the chance that the product will be repaired in case of failure. In case of failure of more expensive parts it could be more appealing to replace the product. For those parts it could be more relevant to focus on reliability/durability aspects. Moreover, there could be no cost associated to some priority parts (e.g. software/firmware upgrades in ICT products). Therefore, the economic value is not considered a good indicator for the prioritisation of parts.

Environmental aspects are also not considered relevant for the identification of priority parts because they are related to the assessment of the impacts associated to a product, and not to causes of repair/upgrade.

The repair/upgrade of products is often driven by other socio-economic factors. Economic considerations and difficulty to disassemble and reassemble parts are still

worthy of consideration in the scoring system where influencing the likelihood of the repair/upgrade process.

2.1.4 Selection and weighting

In the present context, priority parts are all parts necessary to deliver primary and secondary functions of a product, and that can be considered representative, all together, of the most typical failure and upgrade conditions.

The selection of priority parts has to be evaluated at product group level building on the quantitative information that is available. Cut-off rules could be applied on a product group basis to find a balance between representativeness of parts and complexity of the assessment. As a practical guidance, it is considered that:

1. Priority parts are functionally relevant parts that are typically associated with at least 3% of the typical failure rates for that product group. A weight equal to 1 could be assigned to such parts.

2. If failure rates are 10% or more, a high priority and a higher weight (=3) could be set for these parts.

However the refinement of the priority part list cannot rely only on quantitative information. The involvement of experts and qualitative considerations are also fundamental for the definition of priority parts: when a part is considered relevant as priority part based on qualitative considerations, a weight equal to 1 could be assigned to such part.

The definition of priority parts for a specific product group should go with the track of the associated failure modes and causes (which are useful for diagnostic functions).

Upgrade of parts, software and firmware should also be considered whenever they are evaluated as necessary to ensure that the product fulfil users' expectations during the expected lifetime[20]. This would also involve the analysis of the reasons for replacement of products before their end of life.

Selected priority parts for a product group may not be technologically relevant for all products of that product group, e.g. in case a priority part is not used in a specific product. At first instance, if a priority part is not used in a product (e.g. brushless inverter motors) that part can be excluded from the assessment.

Relevance of having a part replaceable is moreover dependent on the likelihood that such a replacement is needed for repairing or upgrading the product. Some design choices could reduce the need of replacing one or more parts because oriented toward an increase of the reliability and durability of the product (e.g. a battery for laptops may be potentially considered as less relevant for repair if it can keep at least X% of its original capacity after Y cycles). However, there could be still a need to replace the part after certain time. This should be assessed at product group level to understand if further specifications are needed to determine when a given part is deemed to be a priority part for reparability and upgradability, or not.

In case of substantial differences among products of the same group, a more granular approach considering sub-groups of products could be potentially considered as last option, when strictly necessary.

Some parts could be designed to be separable or bundled (e.g. drum, drum spider and related ball bearings of a washing machines). If parts are bundled, they can be still made available as spare parts. However, their complete disassembly is inherently limited and should be penalised (e.g. by assigning lower scores for parameters influencing the disassemblability).

[20] Due to fast technology change, change in use patterns, change in design and specifications

Finally, since actual failures can be observed only when products are on the market for a certain time, it could happen that priority parts change over time, e.g. due to technological innovations (e.g. shift from HDD to SSD). A periodical monitoring of products on the market and revision of priority parts is thus necessary.

2.2 Key parameters for repair and upgrade

The development of the scoring system needs the definition of parameters influencing repair and upgrade of products, and to be evaluated with respect to priority parts. In order to be included in the assessment framework, parameters have to be

i. Relevant for repair/upgrade;

ii. Stimulating an active market for repair/upgrade (in order to increase the likelihood of repair/upgrade) without undermining the product safety;

iii. Measurable and verifiable at the point of sale in an objective way (i.e. through repeatable and reproducible methods), independently from the territory and the year of assessment.

2.2.1 Preliminary considerations about repair and upgrade

Repair and upgrade of products can be influenced by different aspects of technical and/or socio-economic nature (e.g. purchase price of the product and labour cost of repair, demand for new vs. repaired/upgraded products, extended warranty/commercial guarantee, support networks facilitating the repair process, business models, compatibility issues). Scenarios/conditions where repair and upgrade operations are more likely to occur have been initially discussed with stakeholders and summarised in Table 2.

Table 2: Factors influencing repair and upgrade according to stakeholders

Aspects	Favourable conditions for Repair	Favourable conditions for Upgrade	Other comments
Functional and technological factors	- Conscious design aimed at reducing the complexity of products and the frequency of innovation cycles (especially for products where design and fashion are not important) - Provision of information about the product, and web-based access to such information - Functionality of the product must be fully recovered after repair - Other factors (e.g. functionalities offered by new technologies)	- Conscious design aimed at reducing the complexity of products, customising products and ensuring compatibility with open source software and firmware (especially for fast moving products where functions can be more important than aesthetics) - Provision of information about the product, including the possibility/availability of software/hardware upgrades - Upgrade must not negatively affect other functionalities of the product - Other factors (e.g. functionalities offered by new technologies)	
Behavioural factors (e.g. demand for new vs. repaired/upgraded products)	- Emotional attachment on the product - Education about material efficiency issues - Other factors (e.g. age of user, relationship with technology, attitude towards new vs. conserving the old, social pressures)	- Emotional attachment on the product - Education about material efficiency issues - Other factors (e.g. age of user, relationship with technology, attitude towards new vs. conserving the old, social pressures)	- Behavioural factors could be more relevant for upgrade
Economic factors (e.g. purchase price for	- Purchase price, which is associated with the quality of the	- Low prices for software/parts upgrades, compared to the product	- Very important for repair, not so

Aspects	Favourable conditions for Repair	Favourable conditions for Upgrade	Other comments
product and spare parts, labour costs)	product - Individual spare parts not more expensive than x% of new product (e.g. ~20-30%) and total of spare parts not more expensive than y% of new product. - Tax exemption for repair activities - Offering products as service, which would allow manufacturers to retain the product's value (although this does not ensure that repair will be carried out and could not result automatically in an optimised use of resources) - Use of extended product responsibility (EPR) fees to support the repair sector	purchase price - Tax exemption for upgrade activities - Offering products as service, which would allow manufacturers to retain the product's value (although this does not ensure that upgrade will be carried out and could not result automatically in an optimised use of resources) - Use of extended product responsibility (EPR) fees to support upgrading activities	relevant for upgrade - In general, the repair is carried out when its cost is below 30-40% of the value of the product, and below 30% for electronic products - The upper limit for upgrade is around 25% of the total cost of the product, however this depend on benefits obtainable with the upgrade itself. Upgrades of software or firmware are expected to be free of charge
Organisational factors (e.g. access to professional repair services or support networks)	- Official registration platform of professional repairers (receiving a licence to repair) - Support awareness and education to final users in circular economy aspects like repair - Manufacturer support network easily accessible - Availability of OEM qualified service engineers	- Support awareness and education to final users in circular economy aspects like repair - Manufacturer support network easily accessible - Expand repair options beyond manufacturer authorised networks (e.g. non-profit initiatives and DIY) - Proximity of upgrade providers - New business models: product as a	- Consumers sometimes do not know where to take their broken appliance to get them repaired - Manufacturers or their authorised repairers can provide official services, but these may be more expensive than independent repairers - Cooperation between manufacturers and independent

Aspects	Favourable conditions for Repair	Favourable conditions for Upgrade	Other comments
	- Repair options beyond manufacturer authorised networks (e.g. non-profit initiatives and DIY) - Proximity of repair providers - Limiting time and cost of repairs for the typical faults - New business models: product as a service and repair as a business strategy	service and repair as a business strategy	repairers should be stimulated
Legal factors (e.g. legal and commercial guarantees [21], liability issues)	- Provision of an additional commercial guarantee (X years): the guarantor can often organise repair cheaper than the consumer - The commercial guarantee, covering the entire product or only specific parts, can either be included in the price of the product or purchased at an extra cost. Cheaper guarantee extensions could give discounts for official repairs in order to create favourable conditions for	- The guarantee should cover also the use of the product after its upgrade - Business models (service models)	- It is important to understand how repair operations can affect consumer safety and liability - Companies should get more involved and contribute to the definition of which repairs can be done by whom - Cooperation between manufacturers and independent repairers should be stimulated - According to the Consumer Sales and Guarantees Directive 1999/44/EC, a minimum of 2 years

[21] As defined in the Directive 2011/83/EU of the European Parliament and of the Council of 25 October 2011 on consumer rights, the commercial guarantee (often also called (extended) "warranty") means any undertaking by the trader or a producer (the guarantor) to the consumer, in addition to his legal obligation relating to the guarantee of conformity, to reimburse the price paid or to replace, repair or service goods in any way if they do not meet the specifications or any other requirements not related to conformity set out in the guarantee statement or in the relevant advertising available at the time of, or before the conclusion of the contract.

Aspects	Favourable conditions for Repair	Favourable conditions for Upgrade	Other comments
	repair - Transparency of rules on how 3rd party repairs can affect or not legal and commercial guarantees[22] - Provision of a guarantee for repaired products - Mandatory information about availability and price of spare parts - Guarantees facilitating the handling of issues related to damages during shipments - Business models (service models)		legal guarantee must be offered by the seller for any product put on the market - Anecdotal evidence shows that consumers can encounter some difficulties in implementing their legal guarantee rights. For example, according to the information from "trop vite usé"[23] most of the complaints from mobile phones concerned appliances that were less than 2 years old. 70% of the users who reported a complaint tried to have their mobile phone repaired but only 7% succeeded. The study also reports that the greatest complaint from people who have repaired their appliances is that the same problems persist even once the products are returned, often related to issues within electronics circuits (e.g. printed circuit board [PCBs], which some companies do not consider as "their" problem)

[22] Longer guarantee times could hinder the independent repair sector as all repairs under guarantee would be done by the manufacturers' own repair service
[23] https://www.test-achats.be/trop-vite-use# (accessed on 23 May 2018)

2.2.2 Technical parameters selected for the assessment

The scientific/ technological literature provides examples of parameters that are used for assessing the reparability and upgradability of products (see for instance Commission Decision (EU) 2016/1371[24]; Flipsen et al. 2017; IEEE 2012, 2018). Such parameters are also connected to the concept of ease of disassembly, or "disassemblability", i.e. the ability to disassemble a product. Based on BS 8887-2[25] and EN 62542[26], product disassembly can be defined as "the non-destructive (reversible) taking apart of an assembled product into constituent materials and/or parts, in such a way that they could subsequently be reassembled and made operational". The irreversible process is instead defined here as dismantling. Product disassembly can be differentiated as Desai and Mital 2003) total (if concerning the whole product) or selective (if concerning one or more materials and/or parts). Ease of disassembly (Go et al. 2012) may cover aspects such as: number, type and positioning of materials and/or parts; their identification and accessibility; need of common/specialised tools; need for precision and force; time; ergonomics issues.

An effort to harmonise such concepts has been undertaken by CEN-CENELEC Joint Technical Committee JTC10 "Energy-related products – Material Efficiency Aspects for Ecodesign", which is in particular working on the prEN 45554 standard - General methods for the assessment of the ability to repair, reuse and upgrade energy related products (see section 1.12).

Building on the analysis of the information available in the literature, and on the feedback received from stakeholders through the initial questionnaire, JRC defined a preliminary list of technical parameters influencing repair and upgrade of a generic product (as reported in Annex II).

With "technical", reference is made to parameters that:

i. Describe attributes, related to the design and sale of products, which can be influenced by choices of manufacturers;

ii. Measurable and/or verifiable at the point of sale through repeatable and reproducible methods, or at least in an objective way;

iii. Are influenced only indirectly by changing socio-economic conditions over time across the EU.

Economic aspects (e.g. absolute prices, labour cost, VAT) do not generally fall into this category. Nevertheless, given the importance of costs for the likelihood to repair/upgrade a product (in place of replacing it), special attention is given to technical parameters that could contribute to make the repair/upgrade operation economically viable.

Technical parameters have been revised and rearranged, also based on further consultation with stakeholders. Table 3 shows the parameters considered as potentially suitable for the development of a scoring framework. These have been clustered by thematic areas that comprise:

a) Design for disassembly;

b) Repair/Upgrade process.

[24] Commission Decision (EU) 2016/1371 of 10 August 2016 establishing the ecological criteria for the award of the EU Ecolabel for personal, notebook and tablet computers (available at: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32016D1371&from=EN)

[25] BS 8887-2:2009 - Design for manufacture, assembly, disassembly and end-of-life processing (MADE). Terms and definitions

[26] EN 62542:2013 - Environmental standardization for electrical and electronic products and systems. Glossary of terms

The parameters listed can be relevant for assessing both reparability and upgradability of products, although upgradability may not be relevant for all products and is in general more applicable to ICT and other networked products. Based on the consultations held with stakeholders, the most important parameters would be those that are strictly necessary for carrying out a repair/upgrade operation (e.g. type and availability of information, availability of spare parts, software and firmware). This is in line with the outcomes of the behavioural study on "Consumers' engagement in the Circular Economy" (Cerulli-Harms et al. 2018), which indicates that spare parts, availability of repair services, and availability of information are important aspects for consumers.

Table 3: Technical parameters to take potentially into consideration when assessing the reparability and upgradability of generic products

Aspect	Parameter	Considerations
Design for disassembly[27]	1. Disassembly depth / sequence	The disassembly depth is the number of steps required to remove a part from a product. The analysis of disassembly depths is fundamental to assess the effort required to access and/or replace priority parts. The disassembly sequence is necessary to assess the disassembly depth. It is the order of steps needed to remove a part from a product (which might include getting access to fasteners). A step consists of an operation that finishes with the removal of a part, and/or with a change of tool[28]. The repair/upgrade operation can be facilitated by the availability of information about the steps needed to disassemble specific parts, as well as by design options where the number of disassembly steps is reduced. Some of this information may be relevant for some categories of repairers only, also because of safety reasons. Disassembly has to be reversible, i.e. to enable re-assembly without causing damages to functional parts of the product. Destructive disassembly (also referred to as "dismantling") does not count towards this parameter.
	2. Fasteners	Fasteners play an important role in the disassembly of a product. Fasteners are closely interlinked to the assessment of necessary tools and skills for repair, re-use or upgrade. The number and type of fasteners, as well as their visibility, may be used as a proxy for the time needed to repair or upgrade a product. However, their visibility (e.g. through labelling and marking) is not as important if repair manuals are available and if fasteners are physically accessible. For the assessment of fasteners, more important criteria are their reversibility and the re-usability.
	3. Tools	Tools needed for repair/upgrade contribute to determine the complexity of the operation itself. Manufacturers can play a significant contribution in defining such complexity. The tools needed are in fact determined by the product design and are therefore an objective

[27] This is considered sufficient to address the reversible disassembly of priority parts, as also done in prEN 45554 - General methods for the assessment of the ability to repair, reuse and upgrade energy related products (November 2018; Public Enquiry version). However, the inclusion of the reassembly of parts could be also considered in future applications.
[28] Commission Decision (EU) 2016/1371 of 10 August 2016 establishing the ecological criteria for the award of the EU Ecolabel for personal, notebook and tablet computers

Aspect	Parameter	Considerations
		characteristic. Categories of tools should be compiled for each product group. A need for proprietary tools would cause a lower score for this parameter because it limits the possibility to carry out a repair/upgrade. Proprietary tools are tools that are not available for purchase by the general public or for which any exclusive intellectual property rights prevent their open use under fair, reasonable, and non-discriminatory terms.
	4. Disassembly time	Alternatively, parameters influencing the disassembly process (#1, #2, #3) could be combined all together through the calculation of disassembly times based on standard time units (Zandin 2003), as done in eDiM (Peeters et al. 2018; Vanegas et al. 2016, 2018) Time can be important to determine the operational cost in case a service is paid, but it has also to be considered with other factors (e.g. the cost of spare parts). Moreover, its calculation is more complex and field research is needed in case of data gaps.
Repair/Upgrade process	5. Diagnosis support and interfaces	Diagnosis support is about the provision of information facilitating the identification of the problem or faulty part. It also relates to the type of interface available for a repair, re-use or upgrade process, including operations such as adjustment or resetting of parameters or settings. A design that allows a more accessible diagnostic and reset interface, would potentially enable a broader range of repair, re-use, upgrade operations. Depending on the product group, this information might be made available through self-diagnostic capabilities of the product or it might be made otherwise available by the manufacturer. A categorization of tools for diagnostic support and interfaces should be established at product-specific level. Reference to typical failure modes and causes associated with priority parts may also be appropriate.
	6. Type and availability of information	The provision of information is necessary to support the repair/upgrade operation and should recollect all the information mentioned in the other parameters (e.g. through user manuals). Types and availability of information refers to both the comprehensiveness of the information and the availability to various target groups. If access to such information is provided broadly (e.g. to independent operators), it could be expected that both repair costs

Aspect	Parameter	Considerations
		and effort to find suitable repair centres diminish since this could create a level-playing field between independent and authorised repair centres. The precise type and format of information that is to be considered should be specified at product-specific level. Depending on the type of information, this could be: - Either available publicly, restricted to particular target groups or confidential[29]; - Either available free of charge or after the payment of a fee. In case a fee is requested, this could be a potential barrier for repair/upgrade. A legal source of possible reference for the provision of information is the Commission Regulation (EU) No 566/2011 [30] about the access to vehicle repair and maintenance information. Availability of information may refer either to specific parts or the entire product
	7. Spare parts	The availability of spare parts is a paramount parameter to ensure that a repair/upgrade process can take place. Spare parts availability can refer to; i) Availability over a specific period of time; ii) Availability to various target groups; iii) Delivery time; iv) Price of spare parts.
	8. Software and firmware	Similarly with #7, the availability of software and firmware updates and/or support (including compatibility with open source programs) is a paramount parameter for some products (e.g. ICT products).
	9. Safety, skills, and working environment	Repairing or upgrading a product may require certain technical skills, which contribute to determine the complexity and cost of the operation itself.

[29] This issue is addressed in EN 45559:2019 - Methods for providing information relating to material efficiency aspects of energy-related products
[30] Commission Regulation (EU) No 566/2011 of 8 June 2011 amending Regulation (EC) No 15/2007 of the European Parliament and of the Council and Commission Regulation (EC) No 692/2008 as regards access to vehicle repair and maintenance information

Aspect	Parameter	Considerations
		Skills can comprise the ability to identify and localise a fault, to access a part within the product, handle parts and tools safely and manage any risk associated to the product, the environment and the operator. As a consequence, certain operations may require appropriate technical skills that most consumers do not have and it may be feasible only for certain target groups. As general principle, the design of products that can be repaired by the as widest as possible target group of repairers should be promoted. However, if there are safety issues and an appliance is not properly repaired, consumer safety could be compromised. If a consumer repairs a product by him/herself, manufacturers could be not liable for the safety of the product (although their brand reputation could be affected). In case relevant risks for consumers are identified, repair/upgrade of appliances should be made only by authorised repair operators or independent operators (with the necessary level of skills and liability insurance) to ensure the safety and conformity of products. What constitutes a "risk" needs to be defined on a product-by-product basis. This parameter needs to take into consideration the protection of consumers in accordance with Low Voltage Directive[31] and Machinery Directive[32] (depending on the type of product), which do not prevent repair but requires measures of technical nature for the protection of persons.
	10. Data transfer and deletion	Data transfer and deletion is needed in repair/upgrade operations associated with the continued use or reuse of products (where privacy of personal data must be ensured) or the cleaning of memory space (e.g. for the repair of a smartphone). Secure data deletion/transfer tools should be pre-installed or made available (e.g. via installed or downloadable tools such as an application, a cloud-based service or instructions detailing a manual process).
	11. Password reset and restoration of	Settings for password reset and restoration of factory settings is needed in repair/upgrade operations associated with the continued use or reuse of products (e.g. change of user in the

[31] Directive 2014/35/EU of the European Parliament and of the Council of 26 February 2014 on the harmonisation of the laws of the Member States relating to the making available on the market of electrical equipment designed for use within certain voltage limits

[32] Directive 2006/42/EC of the European Parliament and of the Council of 17 May 2006 on machinery, and amending Directive 95/16/EC (recast)

Aspect	Parameter	Considerations
	factory settings	same organisation). Password reset and restoration tools should be pre-installed or made available (e.g. via installed or downloadable tools such as an application, a cloud-based service or instructions detailing a manual process).
	12. Commercial guarantee	Commercial guarantees can be potentially a useful tool for controlling the risk of failure of products, and/or enabling the repair operation when needed. However, this come with some challenges that need to be evaluated carefully on a product-by-product level: - A (longer) guarantee could be seen as a proxy for longevity or reliability but it does not necessarily facilitate/imply the repair of the product so that a commitment to repair and clear transparency of provisions are needed; - If the commercial guarantee comes with too high costs there could be low uptake by consumers; if this comes for free it could orient the repair market towards the use of brand repairers (instead of independent repairers).

2.2.3 Other specific technical parameters not considered in the assessment

Other technical parameters, preliminarily included for discussion but not considered suitable for the assessment, at least individually, are reported in Table 4.

Table 4: Other specific technical parameters generally influencing repair and upgrade of products

Aspect	Parameter	Considerations
Design for disassembly	Ease of access	Access of parts is a complex design aspect that can have a major influence over the possibility and easiness of carrying out a repair/upgrade operation. However, this is actually an overarching aspect that can be disaggregated in specific aspects and addressed by other parameters (#1, #2, #3, #4).
Repair/Upgrade process	Working environment	This parameter refers to the degree of specialization of the environment required to perform the repair, re-use, upgrade process; which can take place for example at home, in a professional workshop or in a production environment. Safety provisions and equipment are some of the factors influencing where the repair, re-use, upgrade process can be performed. This parameter has been considered coverable with #9.
	Availability of OEM service networks	This parameter refers to the availability of official repair networks by manufacturers. When in place, repair services can include (or not): delivery of spare parts, provision of technical support, availability of trained professionals with access to repair literature, proprietary tools and software. The availability of OEM qualified service networks is considered a positive attribute for product reparability, however it is generally considered appropriate to ensure that the widest number of actors can carry out repair/upgrade operations, whenever possible. Considerations enabling the repair/upgrade of products have been integrated in other parameters (e.g. #6 and #9).
	Ease of restoring product to working condition after repair	This parameter has been removed since this is what the repair operation is carried out for. Moreover, the assessment and verification of this parameter can be done only when a repair takes place
	Safety issues	Consumer protection and safety is a key element. Safety issues should not be scored but rather integrated as minimum condition in other parameters (e.g. #9).

Aspect	Parameter	Considerations
	Return models	Whilst take-back systems can assist in OEM-based repair/upgrade processes, it is difficult to predict if such measures would increase reparability/upgradability of products. This could divert products from independent repairers and there could be cases where products are replaced rather than repaired.

Aspects as emotional attachment to products, attitude and education of consumers, repair costs, tax exemptions and labour cost reductions are considered to be mainly related to socio-economic issues which are out of the scope of this study, which is aimed at the development of a technical framework for the assessment of different products placed on the market.

2.3 Scoring framework

The technical parameters identified in the previous sections can be used to assess the reparability and upgradability of products. It should be noted that there is quite important overlap between repair and upgrade of products since both operations can be considered as the replacement of a part (in one case to return a faulty product to a condition where it can fulfil its intended use; in the other case to enhance the functionality, performance, capacity or aesthetics of a product). Some parameters that a first sight could be considered inherently associated with upgrade operations only (as #10 Password reset and restoration of factory settings and #11 Data transfer and deletion) can be in reality important also for the repair of the product, for instance in those cases associated with 2nd hand market or change of user within the same organisation.

A hybrid system is here proposed that combines:

a) Pass/fail criteria that products have to fulfil in order to be eligible for the repair/upgrade rating;

b) A scoring framework based on scoring criteria, indicating to what extent/ how much a product is reparable or upgradable.

A scoring framework inherently implies the presence of value choices and trade-offs between criteria. However, they should not come at the expenses of the actual possibility to repair/upgrade products, which is addressed through pass/fail criteria.

This requires the definition of:

- Classification/rating criteria, to evaluate single parameters in relation to a set of priority parts;

- Appropriate assessment and verification procedures;

- An aggregation mechanism, to combine the scores achieved for each parameter and priority parts.

To ensure a level playing field, criteria should:

i. Be measurable and enforceable in an objective way (i.e. not interpretable in different ways depending on who is doing the evaluation);

ii. Stimulate an active market for repair/upgrade (being the aim to favour product options and scenarios that can result in an easier repair or upgrade operation), without undermining the product safety

iii. Be adaptable to reflect specificities of groups/ types of products.

2.3.1 Classification, rating and assessment of individual parameters

Table 5, shows how the classification and rating of individual parameters should work. The proposal has been made building on the analysis of existing methods available in the literature, on the elements of discussion held during the development of prEN 45554 and on feedback received from stakeholders of this study.

Points ranging from 0 to 1 have been modulated proportionally to different rating classes for each parameter assessed at priority part/product level. 0 corresponds to the case in which repair/upgrade is not considered possible. Points above 0 have been set to conditions facilitating the repair/upgrade of products, with 1 being the ideal condition.

Pass and fail criteria have been also defined to enable repair/upgrade operations. These are the "minimum" entry level for the scoring system: a product that does not fulfil pass/fail criteria would score 0 in the assessment of reparability and upgradability even if

scoring higher for other parameters. Since the fulfilment of pass/fail criteria is by definition considered to enable main repair/upgrade operations, a score higher than 0 is in general assigned in the corresponding rating/classification criteria[33].

Table 5 refers to a generic product and it can be considered as the basis for the development of product-specific scoring frameworks. However, when the generic scoring framework is applied to specific products, it is necessary to evaluate the relevance of each pass/fail and rating criterion and to tailor the criteria in order to reflect the specificities of the product(s) and of the related priority part(s). In particular, this applies to the definition of aspects such as target group of repairers (which could vary depending on criteria and priority parts also based on safety and confidentiality considerations) and target time horizon.

When one or more parameters selected for a product group are not applicable to all products within that product group, such parameters are not taken into account in the assessment of those products. This has to be defined when shaping the scoring framework for specific product groups. In case of substantial differences among products, more granular approaches and further differentiation in terms of parameters and criteria could be explored. A periodical monitoring of products on the market and revision of criteria is also necessary.

With respect to the assessment and verification of criteria, this should be in general based, as far as possible, on information made available by manufacturers at the point of sale (e.g. manuals, on-line platforms, manufacturer website). Modalities of verification could change depending on the application[34], however, audits may be necessary (e.g. for quality assessment of the information or when such information is restricted, as well as to verify the fulfilment of criteria for years following the sale of products.

[33] In case of minimum eco-design measures on reparability/upgradability, these will be pass/fail criteria for the scoring. Products meeting such requirements will get at least the minimum score set for the corresponding parameters, which is in general different from 0 since these are conditions potentially enabling repair/upgrade. Higher scores would be assigned in case a more ambitious level is achieved. These could serve as inspiration to set requirements for best performing products with respect to reparability and upgradability (e.g. under Ecolabel and GPP)

[34] For example, in case of Ecodesign and Energy Label, Market Surveillance Authorities are in charge of verifying compliance with legislation of a sample of product models. A 3rd party verification is instead needed to all products applying for the Ecolabel. For GPP it is up the public authority to verify compliance.

Table 5: Classification and rating criteria for individual parameters

Parameter	Pass/fail criteria	Rating classes [(a)]	Support to assessment (A) and verification (V)
1) Disassembly depth/sequence	For each priority part, information about the disassembly sequence has to be available to the target group of repairers (see #6) Note(s): 1) target group of repairers to be defined for each priority part at product specific level 2) The disassembly sequence is defined as the order of steps needed to remove a part from a product (which might include getting access to fasteners). A step consists of an operation that finishes with the removal of a part, and/or with a change of tool[35]. 3) In general, it is considered that the removal of one or additional fasteners in a consecutive way and with the same tool has similar impact on the ease of disassembly. Therefore, the consequent removal of a group of fasteners with the same tool is considered a step.	A score is assigned for each priority part based on their disassembly depths (DD_i). A continuous rating can be calculated as: $S_{1,i} = 1 - (DD_i - 1) / (DD_{ref} - 1)$ where: DD_i is the depth for the priority part i; DD_{ref} is the reference depth for the priority part i. The score is set to 0 if ($DD_i - 1$) is greater than ($DD_{ref} - 1$). Alternatively, a discrete rating could be considered: I) DD_i < X steps = 1 pt. II) X < DD_i < Y steps = 0.75 pt. III) Y < DD_i < Z steps = 0.5 pt. IV) DD1 > Z steps = 0.25 pt. Where: X, Y and Z have to be defined for each priority part of the product group under assessment. Note(s): 1) The disassembly depth is the number of steps required to remove a part from a product. 2) Threshold values to be defined based on the analysis of representative products on the market.	A: A description supported by illustrations of the steps needed to disassemble priority parts is needed. The description has to show that the disassembly is reversible by including the steps needed for the reassembly of priority parts. V: physical disassembly and recording of the operation are needed. Note(s): This is considered sufficient to address the reversible disassembly of priority parts, as also done in the prEN 45554 (November 2018). The inclusion of the reassembly of parts in the rating could be considered as well in future applications.
2) Fasteners	None	A score is assigned for each priority part according to the reversibility and reusability of	A: A description supported by illustrations of the fasteners to be removed for the disassembly of

[35] Commission Decision (EU) 2016/1371 of 10 August 2016 establishing the ecological criteria for the award of the EU Ecolabel for personal, notebook and tablet computers

Parameter	Pass/fail criteria	Rating classes [(a)]	Support to assessment (A) and verification (V)
		the fasteners used for its assembly. I) Reusable: an original fastening system that can be completely re-used, or any elements of the fastening system that cannot be re-used are supplied with the new part for a repair, re-use or upgrade process = 1 pt. II) Removable: an original fastening system that is not reusable, but can be removed without causing damage or leaving residue which precludes reassembly or reuse of the removed part = 0.5 pt. III) Non-removable: original fastening systems are not removable or reusable, as defined above = 0 pt. Note(s): In case different types of fasteners are used in the assembly of a priority part, the worst score should be considered.	priority parts is needed. V: Physical disassembly and inventory of fasteners are needed.
3) Tools	The repair/upgrade process is feasible for each priority part with existing tools	A score is assigned for each priority part according to the complexity and availability of the tools needed for its repair/upgrade: I) Basic tools: repair/upgrade of the priority part is feasible without any tools, or with tools that are supplied with the product, or with the list of basic tools provided in note 1 = 1 pt. II) Product-specific tools (if needed/definable – see also note 3): repair/upgrade of the priority part is unfeasible with basic tools only; product-specific tools are also required that are not proprietary tools and that are necessary to repair/upgrade products produced by at least two different manufacturers = 0.75 pt. III) Other commercially available tools (if	A: Description of the repair/upgrade operations, including documentation of the tools to use, is needed. V: Physical disassembly and check of suitability of tools are needed.

Parameter	Pass/fail criteria	Rating classes [(a)]	Support to assessment (A) and verification (V)
		needed/definable – see also note 3): repair/upgrade of the priority part is unfeasible with basic and product-specific tools only; other tools are also required that are not proprietary tools = 0.5 pt. IV) Proprietary tools: repair/upgrade of the priority parts is feasible only with one or more proprietary tools = 0.25 pt. Note(s): 1) Lists of basic, specific, commercial tools to be defined at product group level, whenever needed. 2) Indicative list of basic tools (independently from the size and to be refined at product group level): Screwdriver for slotted heads, cross recess or for hexalobular recess heads (ISO2380, ISO8764, ISO10664); Hexagon socket key (ISO2936); Combination wrench (ISO7738); Combination pliers (ISO5746); Half round nose pliers (ISO5745); Diagonal cutters (ISO5749); Multigrip pliers (multiple slip joint pliers) (ISO8976); Locking pliers; Combination pliers for wire stripping & terminal crimping; Prying lever; Tweezers; Hammer, steel head (ISO15601); Utility knife (cutter) with snap-off blades; Multimeter; Voltage tester; Soldering iron; Hot glue gun; Magnifying glass. 3) Categories II and III could be merged into one intermediate category II-III if needed. Points would be rescaled proportionally. 4) Proprietary tools are tools that are not available for purchase by the general public or for which any applicable patents are not available to license under fair, reasonable, and	

Parameter	Pass/fail criteria	Rating classes [(a)]	Support to assessment (A) and verification (V)
		non-discriminatory terms. 5) In case specific lists are not defined, any tool not listed in the indicative list of basic tools could belong either to category IV or to an intermediate category II-III.	
4) Disassembly time	None	A score is assigned <u>for each priority part</u> based on their disassembly time (DT_i). A continuous rating can be calculated as: $S_{1,i} = 1 - DT_i / DT_{ref}$ where: DT_i is the disassembly time for the priority part i; DT_{ref} is the reference disassembly time for the priority part i. The score is set to 0 if DT_i is greater than DT_{ref}. Alternatively, a discrete rating could be considered: I) $DT_i < X$ = 1 pt. II) $X < DT_i < Y$ = 0.75 pt. III) $Y < DT_i < Z$ = 0.5 pt IV) $DT_i > Z$ = 0.25 pt. Where X, Y and Z (min) have to be defined for each priority part of the product group under assessment. Note(s): 1) This could be potentially used as partial/full substitute of the previous three parameters, where appropriate (to be decided at product-specific level). 2) Threshold values to be defined based on the analysis of representative products on the market.	A: Disassembly times, quantified for each priority part according to eDiM, and related data sources and calculation details are needed. In case additional research was needed to fill any data gap, supporting information has to be provided as well by the manufacturer. V: Physical disassembly, recording of the operation and check of calculations are needed. Note(s): This parameter could be more difficult to assess and verify due to relatively greater complexity and the current lack of widely accepted tools and data.
5) Diagnosis	None	A score is assigned <u>for the product</u> based on the	A: The following documentation is

Parameter	Pass/fail criteria	Rating classes [(a)]	Support to assessment (A) and verification (V)
support and interfaces		availability of diagnosis support and interfaces to aid the identification of typical failure modes associated to the priority part: I) Intuitive/ coded interface with public reference table: all main faults can be diagnosed either by i) a signal that can be intuitively understood, or ii) by consulting fault-finding trees and/or reference codes information supplied with the product = 1 pt. II) Publicly available hardware/ software interface: to be diagnosed, some of the main faults need the use of hardware, software and other support which is publicly available = 0.66 pt. III) Proprietary interface: to be diagnosed, some of the main faults need the use of proprietary tools, change of settings or transfer of software which are not included with the product = 0.33 pt. Note(s): 1) Main failure modes associated to the product group under assessment have to be identified 2) Publicly available hardware / software interface can include hardware functionality testing software tools developed by a third party, provided the software tools are publicly available and the manufacturer provides information on their accessibility and applicable updates. The product can be equipped with an appropriate interface for hardware and software to do fault diagnosis and reading, adjustment or resetting of parameters or settings (e.g. external memory device, data cable connection,	needed, where applicable: - Description of failure modes and related coding (if used); - Reference to the required hardware material /software tools required (if used); - Contact details of support service, services offered and associated costs (if any). V: Check of actual availability and operability.

Parameter	Pass/fail criteria	Rating classes [(a)]	Support to assessment (A) and verification (V)
		or from a remote source using a network connection). The port, slot, or connector that is used for the hardware and software interface is accessible without tools.	
6) Type and availability of information	Information is made available (for a sufficiently long period to be defined at product level) to different target groups, including: - Product identification and exploded view; - Instructions for regular maintenance; - Troubleshooting charts; - Repair or upgrade services offered by the manufacturer; - Safety issues related to the use, maintenance and repair, as well as guarantee issues (e.g. commitment to repair in case of failure, post-repair guarantee if any); - Disassembly sequences; - List of available updates, spare parts and recommended retail prices, as well as repair costs of the common failures as offered by the manufacturer. All this information has to be made available, as repair and maintenance information for professional repairers. Depending on the level of sensitiveness, a part of this information may also to be disclosed to other end users. Note(s):	a) A score is assigned for the product based on the cost and availability of all information required as pass/fail criterion: I) All information is available publicly at no additional cost for consumers = 1 pt; II) All information is available to independent repairers = 0.66 pt. III) All information is available to registered professional repairers = 0.33 pt. Note(s): 1) Independent repairers include any self-employed professional, as well as any legally established organisation, providing repair service, as well as reuse centres. 2) A single category for professional repairers could be considered, depending on the product. 3) Registered professional repairers have to meet the following conditions: - The professional repairer has the technical competence to repair the product and complies with the applicable regulations for repairers of electrical equipment in the Member States where it operates. Reference to an official registration system as professional repairer, where such system exists in the Member States concerned, has to be accepted as proof of compliance with this point; - The professional repairer is covered by	A: All relevant information for maintenance, repair and upgrade needs to be compiled and made available to the target group of repairers. V: Check of actual availability.

Parameter	Pass/fail criteria	Rating classes [(a)]	Support to assessment (A) and verification (V)
	1) The list above is illustrative and has to be shaped for specific products 2) Any safety issue associated with the use, maintenance and repair of the product has to be identified in accordance with Low Voltage Directive 2014/35/EU and Machinery Directive 2006/42/EC (depending on the type of product) and communicated transparently and publicly in any case. 3) Channels for communicating information may include printed manuals, websites, digital information carriers such as QR codes, DVDs or flash drives.	insurance covering liabilities resulting from its activity regardless of whether this is required by the Member State.	
7) Spare parts	For each priority part: i) Spare parts are declared to be available for X years after placing the last unit on the market ii) Spare parts are deliverable within Y working days iii) Lists of spare parts and recommended retail prices set by manufacturers (and/or contractors, if applicable) are made publicly available (see #6). Note(s): 1) X and Y to be defined at product group level, as well as the relevant groups. 2) This requirement does not apply in the case of unavoidable and temporary circumstances that are beyond manufacturer's control such as a natural	a) A score is assigned for each priority part based on the period of time during which spare parts are available: I) The spare part is declared to be available for a duration of X years = 1 pt. II) The spare part is declared to be available for a duration of Y years = 0.66 pt. III) The spare part is declared to be available for a duration of Z years = 0.33 pt. b) A score is assigned for each priority part based on the target groups: I) The spare part is available to all interested parties = 1 pt. II) The spare part is available to any self-employed professional as well as any legally established organization providing repair services = 0.66 pt. III) The spare part is available to service providers authorised by the product	A: Commitment by the manufacturer about the availability of spare parts over time, as well as provision of information about: - Delivery time; - Recommended retail price of spare parts; - Target groups; - Interface used. V: Check of actual availability.

Parameter	Pass/fail criteria	Rating classes [(a)]	Support to assessment (A) and verification (V)
	disaster. 3) For software and firmware, #8 applies instead of #7.	manufacturer to offer repair services = 0.33 pt. c) When relevant, a score is assigned to specific priority parts based on the spare part interface: I) The part is non-proprietary and has a standard interface = 1 pt. II) The part is either proprietary or does not have a standard interface = 0.5 pt. Score (#7) = Score (#7a) x Score (#7b) x Score (#7c) Note(s): 1) Time horizons for the availability of spare parts have to be refined at product level. Also a single time reference could be considered depending on the product. 2) Requirements on interfaces have to be evaluated and defined, when appropriate, for specific products/priority-parts, for instance based on the availability of reference standards. An example of a standard interface is an USB-connector. An example of a proprietary part with a non-standard interface (Class C) is a Laptop Battery Pack. 3) According to some stakeholders, a score could be assigned also based on the relative price of the spare part. However, price is not integrated in the rating because some parts could be inherently more expansive and because their price can vary significantly over products, parts, regions and time. Nevertheless, information about price of spare parts has to be made available according to the pass/fail requirement and could still allow the monitoring and comparison between different products.	

Parameter	Pass/fail criteria	Rating classes [(a)]	Support to assessment (A) and verification (V)
		5) For software and firmware #8 applies instead of #7	
8) Software and firmware	Software/firmware updates and support are offered for a duration of at least X years after placing the last unit of the model on the market. Full compatibility with open source Operating Systems and/or open source Virtual Machine software is ensured (where applicable). Information about how updates will affect the original system characteristics (e.g. RAM, CPU) is provided, and there is to be always the option to not install, to install or to uninstall the update. Note(s): 1) This applies to products for which software and firmware are considered a priority part. 2) X to be defined at product group level	a) A score is assigned <u>for the product</u> based on the period of time during which software/firmware updates and support are offered: I) Software/Firmware updates and support are offered for a duration of time post-manufacture of at least Y years = 1 pt. II) Software/Firmware updates and support are offered for a duration of time post-manufacture of at least X years = 0.5 pt. b) A score is assigned <u>for the product</u> based on the target groups: I) Software/Firmware updates and support is offered to all interested parties = 1 pt. II) Software/Firmware updates and support is offered to any self-employed professional as well as any legally established organization providing repair services = 0.66 pt. III) Software/Firmware updates and support is offered to service providers authorised by the product manufacturer to offer repair services = 0.33 pt. c) A score is assigned <u>for the product</u> based on the cost of the software/firmware update service: I) Software/Firmware updates and support are offered free of charge for the entire period of time (either X or Y) = 1 pt. II) Software/Firmware updates and support are offered free of charge for Z years = Z/X or Z/Y	A: Declaration about the duration of availability of software and firmware over time, as well as information about costs, and information about how updates will affect the original system characteristics. V: Check of actual availability, compatibility, and possibility to avoid/reverse the update.

Parameter	Pass/fail criteria	Rating classes [(a)]	Support to assessment (A) and verification (V)
		(depending on the period of time) pt. Score (#8) = Score (#8a) x Score (#8b) x Score (#8c) Note(s): 1) Duration of availability has to be defined at product group level. If needed, duration could be modulated in more categories and aligned to the requirement for spare parts. 2) The inclusion of one or more factors has to be evaluated and adapted at product specific level (e.g. this is typically publically available for laptops).	
9) Safety, skills and working environment	None	a) A score is assigned for each priority part based on the level of knowledge needed for its repair/upgrade, as well as the level of risk associated: I) The repair/upgrade can be carried out by a person with a general knowledge of basic repair, re-use, upgrade techniques and safety precautions but without any specific qualifications = 1 pt. II) The repair/upgrade has to be carried out by a person with specific training and/or experience related to the product category concerned, who is also aware of the risks involved in the process and is able to handle them correctly = 0.66 pt. III) The repair/upgrade can be carried out only by the manufacturer = 0.33 pt. b) A score is assigned for each priority part based on the working environment required for carrying-out the repair/upgrade operation, also	A: Description of repair/upgrade operations is provided by the manufacturer, including: - Level of skills required; - Risks associated and safety precaution; - Working environment conditions; - Liability issues; - Contact details in case of support. V: Check of the information provided.

Parameter	Pass/fail criteria	Rating classes [(a)]	Support to assessment (A) and verification (V)
		due to safety conditions: I) The repair/upgrade can be carried out without any working environment requirements (e.g. where the product is in use, or in generic environments) = 1 pt. II) The repair/upgrade has to be carried out in a working environment but not in a production site = 0.66 pt. III) The repair/upgrade can be carried out only in a production site that is comparable with the environment in which the product was manufactured = 0.33 pt. Score (#9) = Score (#9a) x Score (#9b) Note(s): This parameter needs to take into consideration the protection of consumers in accordance with Low Voltage Directive 2014/35/EU and Machinery Directive 2006/42/EC (depending on the type of product), which do not prevent repair but requires measures of technical nature for the protection of persons.	
10) Data transfer and deletion	None	A score is assigned for the product based on the availability of secure data transfer and deletion functionality: I) Built-in secure data transfer and deletion functionality is available to support the deletion or transfer of all data contained in data storage parts (i.e. hard drives and solid state drives) = 1 pt. II) Secure data transfer and deletion is permitted without restrictions, using freely accessible software or hardware solutions = 0.66 pt.	A: Information about the availability of secure data transfer and deletion functionality / service is needed. V: Check of actual availability.

Parameter	Pass/fail criteria	Rating classes [(a)]	Support to assessment (A) and verification (V)
		III) Secure data transfer and deletion is available on request to support the deletion of all data contained in data storage parts (i.e. hard drives and solid state drives) = 0.33 pt.	
11) Password reset and restoration of factory settings	None	A score is assigned for the product based on the availability of an option for resetting the password and restoring the factory setting: I) Integrated reset: password reset and restoration of factory settings (whilst ensuring security of personal data of previous user) is permitted without restrictions, using functionality integrated within the product = 1 pt. II) External reset: password reset and restoration of factory settings (whilst ensuring security of personal data of previous user) is permitted without restrictions, using freely accessible software or hardware solutions = 0.66 pt. III) Service reset: password reset and restoration of factory settings (whilst ensuring security of personal data of previous user) is permitted using services offered by the manufacturer = 0.33 pt.	A: Information about the availability of a feature / service for password reset and restoration of factory settings is needed. V: Check of actual availability.
12) Commercial guarantee[36]	None	A score is assigned based on the availability of a "commercial guarantee" for the (entire) product offered by the guarantor, and including a "commitment to free repair as first remedy" in case of failures and, where relevant, a "commitment to upgrade the product	A: Guarantee contract is needed, with emphasis on "free repair first" clauses. V: Check of availability of guarantee, clauses statement and actual possibility of repair in case

[36] Not addressed in prEN 45554 General methods for the assessment of the ability to repair, reuse and upgrade energy related products (November 2018; Public Enquiry version)

Parameter	Pass/fail criteria	Rating classes [(a)]	Support to assessment (A) and verification (V)
		periodically": I) A long-term commercial guarantee is offered = 1 pt. II) A mid-term commercial guarantee is offered = 0.66 pt. III) A short-term commercial guarantee is offered = 0.33 pt. Alternatively, I) A long-term commercial guarantee is offered = 1 pt. II) Points modulated proportionally for intermediate cases. III) No commercial guarantee is offered = 0 pt. Note(s): 1) "Commercial guarantee" means any undertaking by the seller or a producer (the guarantor) to the consumer, in addition to his legal obligation relating to the guarantee of conformity, to reimburse the price paid or to replace, repair or service goods in any way if they do not meet the specifications or any other requirements not related to conformity set out in the guarantee statement or in the relevant advertising available at the time of, or before the conclusion of the contract[37]. 2) For the purpose of being able to be taken into account in the "Repair Score System", the commercial guarantee must be related to the	of failure.

[37] Consumer Rights Directive and Proposal on the Sales of Goods

Parameter	Pass/fail criteria	Rating classes [(a)]	Support to assessment (A) and verification (V)
		entire product (not only specific components), provided in the entire EU, be included in the sale price of the product, and the remedies proposed by the guarantor will not result in any costs for the consumer (e.g. it means that the repair is for free). 3) Long-, mid-, and short- terms to be defined at product group level or mirrored from the requirement on spare parts.	

Notes:

(a) An illustration of how scoring could be applied is given. Points have been modulated proportionally from 0 to 1; scores above 0 correspond to conditions enabling/facilitating the repair/upgrade of products

(b) Adapted from prEN 45554 General methods for the assessment of the ability to repair, reuse and upgrade energy related products (November 2018; Public Enquiry version)

2.3.2 Aggregation of individual parameters

The reparability and upgradability of products can be assessed with respect to a maximum of 12 parameters and N priority parts. In order to be considered reparable/upgradable, pass/fail criteria have to be fulfilled.

While some scores refer to priority parts (#1 Disassembly depth / sequence, #2 Fasteners, #3 Tools, #4 Disassembly time, #7 Spare parts, #9 Safety, skills and working environment), others are assigned for the whole product (#5 Diagnosis support and interfaces, #6 Type and availability of information, #8 Software and firmware, #10 Data transfer and deletion, #11 Password reset and restoration of factory settings, #12 Commercial guarantee), as also shown in Figure 3.

If pass/fail criteria are fulfilled, a maximum of (6 + 6 x N) scores can be potentially quantified that provide information about the repair and upgrade of products[38]. Such information can be provided at the level of individual parameters (e.g. #1 disassembly sequence/depth, #6 type and availability of information, #7spare parts) or aggregated (i.e. combining scores into indices).

Referring to one or more aggregate indices could facilitate the communication and interpretation of results. However, the aggregation of parameters would come with the risk of losing part of information. Moreover, it could imply the use of value choices (e.g. scores and weights to use for the aggregation) and the possibility of trade-offs across different parameters (e.g. a bad score in one parameter could be compensated with a high score in another parameter, and vice versa).

As supported by stakeholders, it seems appropriate both:

- To aggregate scores, in order to provide easy-to-communicate indices;
- To provide background information, in order to ensure transparency of calculations.

The approach illustrated in Figure 3 is proposed:

1. A score is calculated for each parameter. When scores are assigned at product level, the score for the product is considered. When scores are assigned at priority part level, the weighted average of the scores assigned to each priority parts can be calculated for each parameter. Weights assigned to priority parts should reflect the relative importance of the parts for a specific product group, as defined in Section 2.1[39]. In case one or more priority parts are not used in a product, the maximum score can be assigned to the related criteria. Alternatively, either the priority part is excluded from the assessment of that product, or the application of a more granular approach is explored if there is the need to better differentiate a product group in technological terms.
2. The resulting 12 scores could be combined into indices addressing for instance:
    a) Design for disassembly (#1-4)
    b) Repair and upgrade process (#5-11)
    c) Overall reparability and upgradability (#1-11)

[38] This reflects the complexity of assessing the reparability and upgradability of products. However, it could be that the totality of parameters will not have to be rated for a specific product because some of them are considered not/less relevant.

[39] This option would allow trade-offs between priority parts in the assessment and would add value choice elements inherently related to weighting operations. This could be overcome by considering for each parameter the worst score assigned to the different priority parts. This alternative approach could contribute to stimulate the improvement of the design of products with respect to reparability and upgradability. However, it could also come with less differentiation between products at assessment levels.

d) Commercial guarantee (#12)[40]

3. The combination is made by assigning a weight to each parameter (based on the specificities of a product group) and calculating the weighted average. As general rule, weights could be set to 1 by default and the weight is doubled when a parameter is considered more important for a specific product group. Should a parameter be not relevant for a particular sub-type of product, the highest score of that parameter is to be considered. Alternatively, the specific parameter can be excluded from the weighting procedure. The focus on a reduced number of indices could stimulate the removal of barriers to repair/upgrade.

The analysis of the reparability and upgradability can also be conducted at the level of specific priority parts (e.g. the battery and the display of a laptop) by calculating, for each priority part, the weighted average of the scores assigned to each parameter. The same weights considered in step 2 are applied.

The analysis of the reparability and upgradability of a product can be carried out considering single parameters individually and/or at aggregated level (i.e. the calculated indices). Additional indices could also be considered, if relevant, for example by combining the scores of the parameters referred to ICT upgradability (#6-8, #10-11).

Scores and indices are numbers between 0 and 1, which can be rescaled if needed. Annex II includes options proposed for discussion with stakeholders, as well opinions collected about the suitability of each option. The overall reparability/upgradability of products could be differentiated for example based on 5-10 classes.

Alternatively, information could be rearranged to provide different levels of reparability/upgradability as for example shown in the followings:

1) Level 1, meaning: potentially easy and quick disassembly (no special tools needed according to #3), availability of spare parts and comprehensible repair info to consumers (#6-7), diagnostics comprehensible to consumers (#5), public availability of software updates (#8), data transfer and deletion function (#10) and password reset and settings restoration function (#11)

2) Level 2, meaning: possibility of disassembly with professional tools (#3), availability of spare parts, repair info and diagnostic tools to independent repairers (#5-7), as well as software updates (#8), data transfer and deletion function (#10) and password reset and settings restoration function (#11)

3) Level 3, meaning: possibility of disassembly with proprietary tools (#3), availability of spare parts, repair info and diagnostic tools only to authorised/official repairers (#5-7), as well as as software updates (#8), data transfer and deletion function (#10) and password reset and settings restoration function (#11) .

4) 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).

It should be noted that different approaches could be necessary depending on intended application and related purposes (e.g. mandatory requirements or voluntary/mandatory label in a regulatory context, support tool for manufacturers, retailers and reviewers of products)[41]. A periodical revision of the aggregation mechanism, and of the scoring framework in general, is moreover necessary in the logic of continuous methodological improvement and adaptation to changing market conditions.

[40] Commercial guarantee does not directly address the reparability/upgradability of products but can be rather seen as a complementary measure

[41] The effectiveness of any possible communication tools and layouts will be tested in a later stage, as follow-up of and complementary to this study

Parameter	**Score [0-1] for priority part 1 (and weight)**	**…**	**Score [0-1] for priority part N (and weight)**	**Parameter Score** [0-1]	**Parameter Weight**	**RRU indices for product** [0-1]
#1 Disassembly depth / sequence	$S_{1,1}$ (ω_1)		$S_{1,N}$ (ω_N)	$S_1 = \sum_1^N \frac{S_{1,i} \cdot \omega_i}{\omega_i}$	W_1	Disassemblability Index (I_D) = $\frac{\sum_1^4 S_j \cdot W_j}{\sum_1^4 W_j}$
#2 Fasteners	$S_{2,1}$ (ω_1)	…	$S_{2,N}$ (ω_N)	$S_2 = \sum_1^N \frac{S_{2,i} \cdot \omega_i}{\omega_i}$	W_2	
#3 Tools	$S_{3,1}$ (ω_1)	…	$S_{3,N}$ (ω_N)	$S_3 = \sum_1^N \frac{S_{3,i} \cdot \omega_i}{\omega_i}$	W_3	
#4 Disassembly time	$S_{4,1}$ (ω_1)	…	$S_{4,N}$ (ω_N)	$S_4 = \sum_1^N \frac{S_{4,i} \cdot \omega_i}{\omega_i}$	W_4	
#5 Diagnosis support and interfaces	S_5	…	S_5	S_5	W_5	RRU Process Index (I_P) = $\frac{\sum_5^{11} S_j \cdot W_j}{\sum_5^{11} W_j}$
#6 Type and availability of information	S_6	…	S_6	S_6	W_6	
#7 Spare parts	$S_{7,1}$ (ω_1)	…	$S_{7,N}$ (ω_N)	$S_7 = \sum_1^N \frac{S_{7,i} \cdot \omega_i}{\omega_i}$	W_7	
#8 Software and firmware	S_8	…	S_8	S_8	W_8	
#9 Safety, skills and working environment	$S_{9,1}$ (ω_1)	…	$S_{9,N}$ (ω_N)	$S_9 = \sum_1^N \frac{S_{9,i} \cdot \omega_i}{\omega_i}$	W_9	
#10 Data transfer and deletion	S_{10}	…	S_{10}	S_{10}	W_{10}	Overall RRU Index (I_{RRU}) = $\frac{\sum_1^{11} S_j \cdot W_j}{\sum_1^{11} W_j}$
#11 Password reset and restoration of factory settings	S_{11}	…	S_{11}	S_{11}	W_{11}	
#12 Commercial guarantee	S_{12}	…	S_{12}	S_{12}	Not applied	Commercial guarantee Index (I_{CG}) = S_{12}
RRU indices for parts	$I_{RRU,1} = \sum_1^{12} \frac{S_{j,1} \cdot W_j}{W_j}$		$I_{RRU,N} = \sum_1^{12} \frac{S_{j,N} \cdot W_j}{W_j}$			

Note(s):
1) Single parameters can be analysed individually and/or at index level; all scores/indices are numbers between 0 and 1
2) The same weight is assigned when the same importance is given to priority parts or parameters

Figure 3: Aggregation of the scores assigned to the parameters assessed for a generic product

2.4 Summary

The scoring system for assessing the reparability and upgradability of generic products placed on the market is founded on three pillars:

I) Priority parts;

II) Key parameters for repair and upgrade;

III) Scoring framework.

Identification of priority parts needs to be made on a product group basis, and must take into account specific aspects for that product, such as the frequency of failure/upgrade and the functional importance of parts. Discussion and agreement with manufacturers, repairers and other relevant experts (e.g. from consumer testing organisations and environmental NGOs) is also fundamental.

A comprehensive list of parameters that could be used to assess the repair and upgrade of products is shown in Table 3. Parameters listed can be relevant for assessing both reparability and upgradability of products[42]. Based on the consultations held with stakeholders, the most important parameters would be those that are strictly necessary for carrying out a repair/upgrade operation (e.g. type and availability of information, availability of spare parts, software and firmware). This is in line with the outcomes of the behavioural study on "Consumers' engagement in the Circular Economy" (Cerulli-Harms 2018), which indicates that spare parts, availability of repair services, and availability of information are important aspects for consumers.

In terms of assessment and verification, different options of classification and rating are proposed in Table 5. These include both pass/fail criteria and rating classes, which all in all makes a hybrid system:

a) A binary system based on specific pass/fail criteria that products have to fulfil in order to be considered as reparable/upgradable, and thus eligible for being assessed through the scoring criteria (the products would otherwise score 0);

b) A scoring framework based on a selection of scoring criteria, indicating to what extent/ how much a product is reparable or upgradable.

Selection of parameters and their classification, rating and weighting should be:

i. Kept as much as possible close to the discussion held in the development of prEN 45554;

ii. Tailored to reflect specificities of groups / types of products and related priority part(s), and stimulate an active market for repair/upgrade (being the aim to favour product options and scenarios that can result in an easier repair or upgrade operation), without undermining the product safety;

iii. Measurable and enforceable by:

- Limiting the presence of value choices or expert judgements;

- Minimising the risk of resulting in different interpretations depending on who is conducting the evaluation.

With respect to the aggregation of the scores assigned to each individual parameters, the following approach is proposed:

1. A score is calculated for each parameter (when scores are assigned for each priority part, a weighted average is calculated) and can be combined into indices addressing: design for disassembly (#1-4), repair and upgrade process (#5-11), overall reparability and upgradability of a product (#1-11). The aggregation is made

[42] Upgradability may be relevant for all products and is in general more applicable to ICT and other networked products).

by assigning a weight to each parameter (based on the specificities of a defined product group) and calculating the weighted average. The availability of commercial guarantee can also be considered as a complementary metric. The focus on a reduced number of indices could stimulate the removal of barriers to repair/upgrade.

2. The analysis of the reparability and upgradability of specific priority parts of products can also be carried out by calculating, for the priority parts considered, the weighted average of the scores assigned to each parameter. Furthermore, additional indices could be quantified, for example by combining the scores of the parameters more relevant for the upgradability of ICT products (#5-8, #10-11).

When a priority part or a parameter does not apply to a specific product, the maximum score for that part or parameter can be considered. Alternatively they can be excluded from the assessment. In case of substantial differences among products of the same group, a more granular approach considering sub-groups of products could be explored when strictly necessary.

Apart from aggregated indices, relevant information used for the quantification of scores and indices should be also provided for transparency reasons.

Scores and indices are numbers between 0 and 1, which can be rescaled if needed, for instance resorting to 5-10 classes. Alternatively, information could be rearranged to provide different levels of reparability/upgradability.

Different approaches could be explored, depending on intended application and related purposes (e.g. mandatory requirements or voluntary/mandatory label in a regulatory context, support tool for manufacturers, retailers and reviewers of products), and tested in the follow-up of this study. A periodical revision of the scoring framework, is moreover necessary in the logic of continuous methodological improvement and adaptation to changing market conditions.

3 DEVELOPMENT OF PRODUCT-SPECIFIC SCORING SYSTEMS

The generic approach described in Section 2 needs to be adapted to reflect the specific characteristic of the evaluated products. As presented in this section of the report, the scoring framework has been preliminarily tailored to three product groups:

1. Laptops;
2. Vacuum cleaners;
3. Washing machines.

It is anticipated that further analyses would be necessary as follow-up of this study to understand the performance of real products on the market and how parameters, rating and weighting of the scoring system should be adjusted.

3.1 Repair and upgrade of different macro-categories of products

Because each product has its own characteristics and specificities, it should be assessed at group /individual level. Nevertheless, there are some aspects of the repair and upgrade operations that could allow a classification of different products in macro-categories of products.

For the purpose of describing generic aspects influencing the repair and upgrade of products according to such characteristics, an initial classification of products [43] is proposed as defined below:

a) Small appliances (e.g. vacuum cleaners, kettles, coffee machines, handheld drills, hair-dryers): goods which can be easily transported to a repair shop and which are generally perceived as less sophisticated (although this could not be the case in reality, thinking for example to robot vacuum cleaner and automated espresso machines);

b) Medium/large appliances (e.g. washing machines, dishwashers, refrigerators, freezers, cookers): goods for which a trained technician might normally come to your home to repair the product or you would have to make a dedicated logistics effort to transport them to be repaired;

c) Installed products (e.g. a boiler or heat pump, or air conditioning appliances): goods for which a trained technician would normally be required to come out to examine the products, and where the product repair is normally related to and interacts with the environment in which it is placed;

d) ICT products (e.g. imaging equipment, DVD players, mobile phones, tablets, personal computers, laptops): goods with a faster innovation cycle compared to the former categories and a size allowing a relatively easy displacement of the device for repair/upgrade[44].

Three main aspects influencing repair and upgrade choice have been discussed at macro-category level:

1. cost of repair/upgrade;
2. lifetime expectancy;
3. time to carry out a repair/upgrade operation.

[43] Consumables, like ink cartridge for printers, to be included in the definition of product

[44] Electronic products could be further split into 3 sub-groups: d1) Small & portable ICT products like smartphones, d2) Medium sized ICT products like desktop computers, d3) Large or installed ICT products like servers.

Additional considerations about the reparability and upgradability of the analysed product groups have been gathered from stakeholders during the course of the study and reported in Annex II.

3.1.1 Cost of repair/upgrade

Consumers' willingness to repair/upgrade their products (versus replacing them) is influenced, among other factors (e.g. fashion, technological evolution, energy efficiency), by the total cost of repair. If the total cost of repair reaches a certain percentage of the purchase price, it is very likely that consumers will prefer replacement over repair.

According to input from stakeholders, in general, the repair is carried out when its cost is below 30-40% of the value of the product, and below 30% for electronic products. For small appliances with relative low price (e.g. kettle, toaster) repair can be less attractive because of the relatively low price of new products. Regarding the upgrade of products, the upper limit is considered to be around 25% of the total cost of the product, however this depend on benefits obtainable with the upgrade itself. When linked to software or firmware (fixing of bugs and vulnerabilities), upgrades are expected to be free of charge.

3.1.2 Lifetime expectancy

The repair decision is also function of the product lifetime expectancy. Consumer's willingness to repair decrease as the product's lifetime gets close to the expected lifetime. A considerable variation of this function is present between the different categories and also within each product category. Based on input from stakeholders, rough and general indications about the lifetime expectancy of different macro-categories of products are reported below:

a) Small appliances: 5 to 10 years (depending on the product);

b) Medium/large appliances: 8 to 15 years (depending on the product);

c) Installed products: 10 to 20 years, or more (depending on the product);

d) Electronic products: 2 to 7 years (depending on the product).

3.1.3 Time to carry out a repair/upgrade operation

Stakeholders reported that in general a repair feasible with 1-2 weeks makes the repair option attractive for the all the product categories. However this parameter is product-specific and can vary significantly. For electronic products it is considered important also the availability of temporary devices to compensate the absence of the product during the repair operation. The upgrade operation, at least in some cases (e.g. software upgrade), could be less critical for consumers, as the appliance could be still function when a decision to upgrade the product is taken.

3.2 Laptops

3.2.1 Scope definition

For the purposes of this report, this product group covers "notebooks", also referred to as "laptops".

In accordance to the Commission Decision 2016/1371[45], the product group is defined as "computers designed specifically for portability and to be operated for extended periods of time either with or without a direct connection to an AC power source, and

- That utilise an integrated display;

- That are capable of operation on an integrated battery or other portable power source;

- That are typically designed to provide similar functionality to desktops, including operation of software similar in functionality to that used in desktops".

Sub-types of products are included within this definition, depending on their physical and functional characteristics:

A) Notebook computers with a non-detachable mechanical keyboard (using physical, moveable keys), pointing device and, depending on the model, a touch-sensitive screen

B) Computers meeting the definition of a Thin Client[46], designed specifically for portability, and meeting (A).

C) Notebook computers with a clam shell form factor and physical keyboard (A), but with a detachable touch-sensitive display which can act as an independent tablet computer upon detachment, where the keyboard and display portions of the product must be shipped as an integrated unit (also known as "Two-In-One Notebooks")

D) Computing devices designed for portability that meet all of the following criteria: (a) include an integrated display with a diagonal size greater than 6.5 inches and less than 17,4 inches; (b) lack an integrated, physical attached keyboard in its as-shipped configuration; (c) include and primarily rely on touchscreen input (with optional keyboard); (d) include and primarily rely on a wireless network connection (e.g. Wi-Fi, 3G, etc.); (e) include and are primarily powered by an internal rechargeable battery (with connection to the AC mains for battery charging, not primary powering of the device) (also known as "tablet computers" or "slate computers").

The preliminary considerations made in the following sections are intended for "category A" laptops.

The same approach could be adapted to take into account design differences between different types of product (e.g. in case of tablets, the keyboard is absent and data storage, RAM and Graphics Unit are integrated in the same PCB). Priority parts that are not relevant technologically or that are not used in a specific product can be excluded from the assessment. Bundles of priority parts could be also considered.

A more granular approach and further differentiation in terms of parameters and criteria could also be needed to reflect any substantial differences among sub-types of products (e.g. different lifetime expectations). This should be further investigated in case of implementation of this scoring framework.

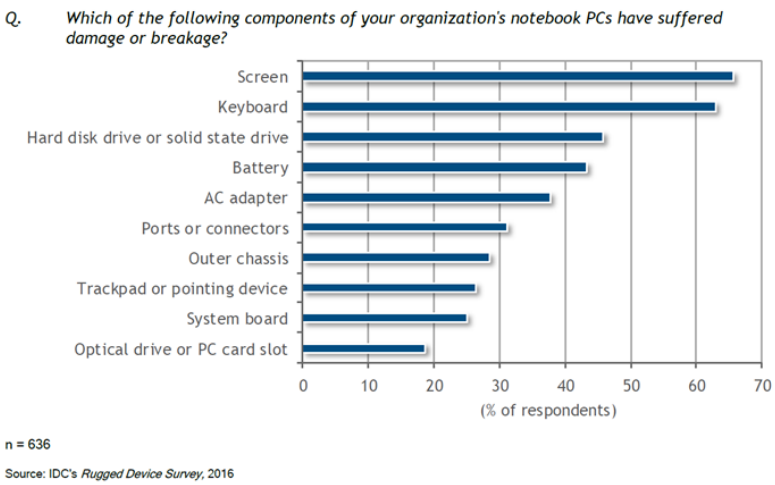
[45] Commission Decision (EU) 2016/1371 of 10 August 2016 establishing the ecological criteria for the award of the EU Ecolabel for personal, notebook and tablet computers

[46] From IEEE (2018): Independently-powered computers that rely on a connection to remote computing resources (e.g., computer server, remote workstation) to obtain primary functionality. Main computing functions (e.g., program execution, data storage, interaction with other Internet resources) are provided by the remote computing resources.

3.2.2 Priority parts

International Data Corporation (IDC) has provided insights on failures for laptops used by employees in US (IDC 2016). IDC surveyed IT Decision Makers in organizations of all sizes and across a broad range of vertical industries, including public safety, retail, healthcare, transportation, and utilities. The study, conducted in August 2016, points out that parts reported most frequently to suffer damage (Figure 4) are: screen, keyboard, data-storage drive (HDD or SSD), and battery.

Figure 4: Common parts of notebooks reported to suffer damage (IDC 2016)



These results are based on professional users with professional grade laptops. Domestic grade laptops with longer term use could experience more wearing failures. Some aging issues have been indicated by repair sector's experts and NGOs involved in the study:

- Screen hinges brackets fail due to fatigue;
- Fan and radiators fail to dissipate heat due to dust;
- Conductive silicon degrades and fails to conduct heat due to thermal stress and ageing;
- PCBs get rusted contacts and short-circuits due to liquid damage (corrosion);
- Charging ports fails due to wearing, bending and fatigue;
- EPS fails due to cable fatigue and/or thermal stress of components because of poor heat dissipation (EPS are usually sealed and hard to open);
- Battery lifetime diminishing over time.

Repair and reuse professionals contacted for the development of the JRC study "Analysis of material efficiency aspects of personal computers product group" (Tecchio et al. 2018) qualitatively confirmed the findings from IDC. The main frequent failures in notebooks would affect: displays, keyboards, hard drives, batteries, EPS, memories, fans, connectors (USB, network) and plastic elements such as small covers and outer frames. The study also reports that the following parts are frequently replaced: batteries; memories; Hard Disk Drives; Optical Disk Drives; fan and cooling fins, keyboards and keys, displays, plastic covers.

Based on confidential information shared by a testing consumer organisation, there is also quantitative evidence that:

- Battery, screen and storage drives (HDD and SSD) are the parts which are more likely to fail (>10% of the total failures for each priority part, before and after the first

2 guarantee years). Because of this, a high priority and a higher weight (=3) is set for these parts.

- Keyboards (and keys), cover and outer frames, ports and connectors (e.g. USB, network) are also likely to fail (>3%). Because of this, these are also considered relevant as priority parts but with a weight equal to 1.

According to the input received from stakeholders, other parts are suggested for inclusion in the list of priority parts (weight equal to 1) with broad level of agreement: external power supply (EPS), Optical Disk Drives, fan and cooling fins, trackpads, mother boards, BIOS battery (CMOS).

Stakeholders have also highlighted that the possibility to replace parts as memory (RAM) and solid state drives (SSD) and the possibility to update software, firmware and graphic processing unit (GPU) can be particularly relevant for upgrade (since users' needs generally increase with the use), as well as the compatibility with open-source OS and software.

The list of priority parts for laptops is summarised in Table 6.

Since architecture, technologies, and designs of products are rapidly evolving, it is thus recognised that some priority parts may be not relevant for some models (e.g. Optical Disk Drives). In such case, if no update of the framework is provided, such priority parts would not be considered in the assessment of the respective models of product.

Table 6: List of priority parts for laptops

Part [a]	Relevance for repair	Relevance for upgrade	Weight
1) Batteries	1) High frequency of damages as reported by IDC (b) and a testing consumer organisation 2) Identified in the JRC study about the "Analysis of material efficiency aspects of personal computers product group" (c) 3) Indicated by stakeholders involved in this study 4) Provision of main functionalities		3
2) Screen	1) High frequency of damages as reported by IDC (b) and a testing consumer organisation 2) Identified in the JRC study about the "Analysis of material efficiency aspects of personal computers product group" (c) 3) Indicated by stakeholders involved in this study 4) Provision of main functionalities		3
3) Storage drives (Hard Disk Drives / Solid State Drives)	1) High frequency of damages as reported by IDC (b) and a testing consumer organisation 2) Identified in the JRC study about the "Analysis of material efficiency aspects of personal computers product group" (c) 3) Indicated by stakeholders involved in this study 4) Provision of main functionalities	Indicated by stakeholders involved in this study because of the possible need of increasing the functionality of the product over time Note: for upgrade this could be less relevant if the device has a capacity above a certain capacity, or if an extension of storage is possible through external storage or cloud services.	3
4) Keyboards (and keys)	1) High frequency of damages as reported by IDC (b) and a testing consumer organisation 2) Identified in the JRC study about the		1

Part [a]	Relevance for repair	Relevance for upgrade	Weight
	"Analysis of material efficiency aspects of personal computers product group" (c) 3) Indicated by stakeholders involved in this study 4) Provision of main functionalities		
5) Covers and outer frames	1) High frequency of damages as reported by IDC (b) and a testing consumer organisation 2) Identified in the JRC study about the "Analysis of material efficiency aspects of personal computers product group" (c) 3) Indicated by stakeholders involved in this study 4) Provision of main functionalities		1
6) Ports and connectors (USB, network, charging port)	1) High frequency of damages as reported by IDC (b) and a testing consumer organisation 2) Identified in the JRC study about the "Analysis of material efficiency aspects of personal computers product group" (c) 3) Indicated by stakeholders involved in this study 4) Provision of main functionalities		1
7) External Power Supply (EPS) / AC Adaptor	1) High frequency of damages as reported by IDC (b) 2) Identified in the JRC study about the "Analysis of material efficiency aspects of personal computers product group" (c) 3) Indicated by stakeholders involved in this study		1

Part [(a)]	Relevance for repair	Relevance for upgrade	Weight
	4) Provision of main functionalities Note: Access to the internal component of an EPS is made complex due to safety reasons and out of scope since the focus is on the product. The entire part is normally replaced in case of failure, with the exception of EPS with disassemblable power cord. The assessment of this priority part has to be limited to the "Spare Parts" parameter.		
8) Fans and cooling fins	1) Identified in the JRC study about the "Analysis of material efficiency aspects of personal computers product group" (c) 2) Indicated by stakeholders involved in this study 3) Provision of main functionalities		1
9) Trackpad / pointing device	1) High frequency of damages as reported by IDC (b) 2) Provision of main functionalities		1
10) Mother board	1) High frequency of damages as reported by IDC (b) 2) Provision of main functionalities		1
11) BIOS Battery (CMOS)	1) Indicated by stakeholders involved in this study 2) Provision of main functionalities		1
12) Optical drive/ PC card slots	1) High frequency of damages as reported by IDC (b) 2) Identified in the JRC study about the "Analysis of material efficiency aspects of		1

Part [a]	Relevance for repair	Relevance for upgrade	Weight
	personal computers product group" (c) Note: According to some manufacturers "Optical drives" are disappearing from notebooks so that this priority part could be limited to PC Card Slots.		
13) Random Access Memory	Indicated by stakeholders involved in this study	Indicated by stakeholders involved in this study because of its significant impact on the performance. Note: this could be less relevant if the device has a capacity above a specific threshold. EU GPP Criteria for Computers and Monitors include a criterion on upgradability offering a choice between greater soldered-in RAM, with 4GB and 8GB identified as best practice, and upgradeable RAM sockets (Dodd et al. 2016). The thresholds of 4 GB and 8 GB identified in 2016 are probably not anymore representative of best practices.	1
14) Graphic Processing Unit		Indicated by stakeholders involved in this study	1
15) Software and Firmware		Indicated by stakeholders involved in this study as one of the most important aspects because laptops are strongly dependent on software (mainly the Operating System), drivers and firmware (BIOS) updates (a still working or reparable device can become a waste because of a lack of updates).	Not applicable since evaluated as separate product parameter

Notes:
a) When a part is not used the maximum score is assigned for that part
b) IDC (2016)
c) Tecchio et al. (2018)

3.2.3 Key parameters

Replacement of laptops is considered to be often due to the purchase of products with improved functionality. Possibilities to upgrade and reuse the product are very important for laptops and cover aspects as memory/storage capacity, software and firmware. Moreover, there is an apparent trend on the market towards compact designs limiting the disassembly of the product.

Based on the analysis of the product group and of the input provided by stakeholders, it has been considered that the following parameters listed in Table 5 are relevant in order to rate laptops:

- Disassembly depth/sequence (#1);
- Fasteners (#2);
- Tools (#3);
- Type and availability of information (#6);
- Spare parts (#7);
- Software and firmware (#8);
- Data transfer and deletion (#10);
- Password reset and restoration of factory settings (#11);
- Commercial guarantee (#12).

When one or more parameters are not applicable to a specific model of laptops, such parameters are not taken into account in the assessment of those products.

Some parameters have been excluded from the rating:

- Disassembly time (#4): although this parameter can be relevant since the repair duration affects repair costs, disassembly time is also covered indirectly by other parameters (e.g. disassembly depth, fasteners, tools, availability of repair information). Moreover, methodological developments are still needed before such parameter can be measured in a standardised and not-too-burdening way. Times for the complete disassembly of two laptops have been calculated in a recent study from JRC using the eDIM method (Peeters et al. 2018). Results, showed in

Table 7, indicate a certain difference in time (about 13.5 minutes vs. about 23 minutes, +68%). However, less difference can be expected at priority part level, which is what is relevant for the application of this scoring system (as well as in real life). Moreover, the definition of reference values for a representative sample of laptops, and the verification of the information provided in the scoring system, would require a significant amount of resources. In order to keep the scoring system simpler, it is considered that such parameter should be excluded from the assessment, at least for the moment. Given its potentiality, its application could be reconsidered in the future.

- Diagnosis support and interfaces (#5): for laptops it is considered that this parameter should be integrated in the parameter related to the provision of information (#6) and to cover failure modes associated with priority parts of laptops. Manufacturers of laptops normally provide diagnosis support for the most common failure modes of their products. Such information is usually accessible via the manufacturer's web and in most cases after registering the product for its identification. An example of support provided for display issues is available in the Apple's website[47] (see Figure 5).

- Safety, skills and working environment (#9): in general, no significant differentiation between different models on the market is expected in terms of safety (always to be ensured), skills and environment requirements for the repair of a certain priority part. On the other hand, even if differences exist they would be covered, at least partly, by other parameters that are easier to verify (e.g. disassembly depth, fasteners, tools, information).

Based on the feedback received from stakeholders, the following weights are preliminarily proposed for single parameters to reflect their relative importance for this product group:

- Disassembly depth/sequence (#1): normal weight (=1);
- Fasteners (#2): normal weight (=1);
- Tools (#3): normal weight (=1);
- Type and availability of information (#6): high weight (=2);
- Spare parts (#7): high weight (=2);
- Software and firmware (#8): high weight (= 2);
- Password reset and restoration of factory settings (#10): high weight (=2);
- Data transfer and deletion (#12): high weight (=2).

No weight is assigned to commercial guarantee (#12) since it is not proposed to be aggregated but considered as complementary metric.

A higher weight has been considered for aspects of laptops relating to software issues, and to the provision of information and spare parts. However, weights could be refined also based on the analysis of the variation of the characteristics of products on the market. This could also come with further reduction of parameters to assess in case no significant differentiation is found for one or more parameters.

Considering the indices defined in section 2.3.2, and based on the weights assigned above:

- The score of the Disassemblability Index would be 1/3 the score of #1 + 1/3 the score of #2 + 1/3 the score of #3;

[47] https://support.apple.com/en-gb/HT204267 (accessed on 17 September 2018)

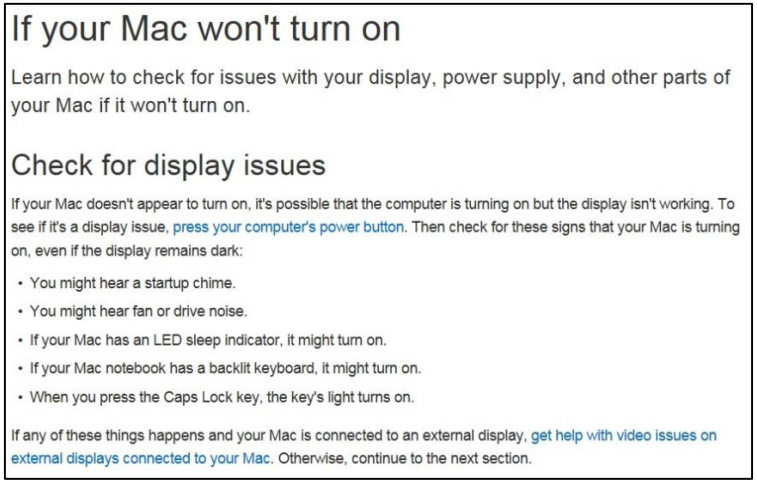
- The score of the RRU Process Index would be 1/5 the score of #6 + 1/5 the score of #7 + 1/5 the score of #8 + 1/5 the score of #10 + 1/5 the score of #11;

- The score of the Overall RRU Index would be 1/13 the score of #1 + 1/13 the score of #2 + 1/13 the score of #3 + 2/13 the score of #6 + 2/13 the score of #7 + 2/13 the score of #8 + 2/13 the score of #10 + 2/13 the score of #11

- The score of the Commercial Guarantee Index would be equal to the score of #12.

Table 7: Complete disassembly and reassembly of two laptop using eDIM (Peeters et al. 2018)

Notebook	Disassembly (s)							Reassembly (s)							eDIM (s)
	Tool change	Identification	Manipulation	Positioning	Disconnection	Removal	eDIM Disassembly	Tool change	Identification	Manipulation	Positioning	Fastening	Addition	eDIMR Reassembly	
Nr. 1	22	4	4	163	140	18	350	22	4	4	163	257	18	466	816
Nr. 2	27	0	2	283	253	24	589	27	0	2	283	451	24	787	1376



If your Mac won't turn on

Learn how to check for issues with your display, power supply, and other parts of your Mac if it won't turn on.

Check for display issues

If your Mac doesn't appear to turn on, it's possible that the computer is turning on but the display isn't working. To see if it's a display issue, press your computer's power button. Then check for these signs that your Mac is turning on, even if the display remains dark:

- You might hear a startup chime.
- You might hear fan or drive noise.
- If your Mac has an LED sleep indicator, it might turn on.
- If your Mac notebook has a backlit keyboard, it might turn on.
- When you press the Caps Lock key, the key's light turns on.

If any of these things happens and your Mac is connected to an external display, get help with video issues on external displays connected to your Mac. Otherwise, continue to the next section.

Figure 5: Example of diagnosis support provided by the manufacturer for display issue[48].

[48] https://support.apple.com/en-gb/HT204267 (accessed on 17 September 2018)

3.2.3.1 Disassembly depth/sequence

As pass/fail criterion for this parameter, the disassembly sequence has to be made available to the target group of repairers for all the priority parts listed in section 3.2.1 (see also 3.2.3.4).

An example for this criterion has been found in Dell's website[49], where removal guides are provided for "customer replaceable units" of a number of laptop models. Some of the parts included in these guides are considered priority parts under this assessment (battery, key board, SDD storage). Figure 6 illustrates the steps required to disassemble the keyboard of a computer based on the information provided in one of the Dell's guide[50]. For the example provided, each disassembly step has a description of the sub-steps needed and a supporting illustration, when necessary, indicating the number of fasteners to be removed and the tools required. The description shows that the part can be removed without damaging it, neither the product.

Many laptops on the EU market registered under the EPEAT certification scheme[51] fulfil criteria about the provision of disassembly information (IEEE 2018).

For enabling the rating, a reference value for the disassembly depth of priority parts should defined based on the analysis of the steps required to remove them in a representative sample of products. In order to include this parameter in the assessment, further investigation and involvement of stakeholders would be required. A continuous rating should be applied as indicated in Table 5 to simplify the assessment and verification[52].

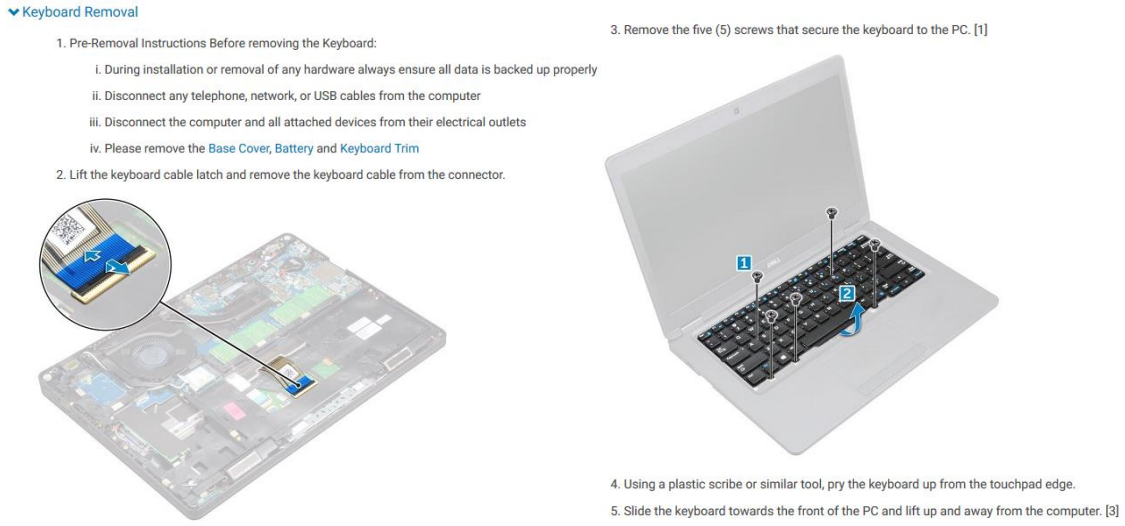


Figure 6: Example of steps required to disassemble the keyboard of a laptop[53]

[49] https://www.dell.com/support/article/es/es/esbsdt1/sln304947/latitude-14-5480-teardown-removal-guide-for-customer-replaceable-units-crus-?lang=en (Accessed on 17 September 2018)
[50] The consecutive removal of more connectors with the same tool is considered as one disassembly step in the referenced document.
[51] https://ww2.epeat.net (Accessed on 17 December 2018)
[52] In case a discrete classification and rating system is used, there would be the need to define more than 1 reference value
[53] https://www.dell.com/support/article/es/es/esbsdt1/sln304947/latitude-14-5480-teardown-removal-guide-for-customer-replaceable-units-crus-?lang=en (accessed on 17 September 2018)

3.2.3.2 Fasteners

Disassembly steps usually come together with the description of how to remove each of the fasteners and connectors used to assemble different parts. Providing information about the type of connectors used should be a relatively easy task.

The assessment of this parameter is based on the ability of removing and reusing fasteners. Manufacturers have to provide such information in the form of a table. An example is showed in Table 8, which is based on the information provided by Dell in one of their removal guides[54]. Each fastener would be evaluated based on the information given in the table and the corresponding score would be given to each priority part.

Table 8: Example of fasteners used to assemble priority parts

Priority part	**Type of fasteners (number)**	**Class**		
		I) Reusable	**II) Removable but not reusable**	**III) Non removable**
Back cover	Screws (8)	X		
Battery	Connector (1) Screw (1)	X X		

Using the rating presented in Table 5, the score assigned for the parameter "fasteners" to the priority parts of a product having the characteristics reported in Table 8 would be 1 for the back cover and 1 for the battery since all fasteners used are reusable.

In the hypothetical case where different classes of fasteners/connectors were used for assembling a priority part (e.g. using 4 reusable screws and some soldering), the score would be that corresponding to the worst case (0 because a component soldered is considered not removable).

3.2.3.3 Tools

The manufacturer has to declare as minimum criterion that the repair/upgrade process is feasible with existing tools for each priority part. Then, the list of tools required for the complete disassembly of each priority part has to be scored according to their complexity and availability as described in Table 5.

The information to provide could include a graphical representation of the tools and/or identification codes. An example is given in Figure 7, showing some tools that can be needed for the disassembly of a laptop. These are included in the list of common tools reported in Table 5, so their use would allow getting a score equal to 1 (level I).

[54] https://www.dell.com/support/article/es/es/esbsdt1/sln304947/latitude-14-5480-teardown-removal-guide-for-customer-replaceable-units-crus-?lang=en (accessed on 17 September 2018)

1	Small Phillip's head screwdriver
2	Plastic Scribe
3	Small Flat head screwdriver

Figure 7: Example of tools used in the disassembly of laptops[55]

For laptops, the list of basic tools (level I = 1 pt) has been revised based on input from stakeholders:

- Screwdriver for slotted heads, cross recess or for hexalobular recess heads (ISO2380, ISO8764, ISO10664);
- Hexagon socket key (ISO2936);
- Combination wrench (ISO7738);
- Combination pliers (ISO5746);
- Half round nose pliers (ISO5745);
- Diagonal cutters (ISO5749);
- Multigrip pliers (multiple slip joint pliers) (ISO8976);
- Locking pliers;
- Combination pliers for wire stripping & terminal crimping;
- Prying lever;
- Tweezers;
- Hammer, steel head (ISO15601);
- Utility knife (cutter) with snap-off blades;
- Multimeter;
- Voltage tester;
- Soldering iron;
- Hot glue gun;
- Magnifying glass;
- Clean, soft, lint-free cloth;

[55] https://www.dell.com/support/article/es/es/esbsdt1/sln304947/latitude-14-5480-teardown-removal-guide-for-customer-replaceable-units-crus-?lang=en (accessed on 17 September 2018)

- Magnifying glass;
- Quick grip clamps;
- Nonslip gloves;
- Painters tape;
- Isopropyl alcohol (IPA) wipe.

In addition to basic tools, other commercially available tools could be considered (Level II = 0.66 pt). An indicative and non-exhaustive list of product-specific tools to be considered as other commercially available tools has been suggested by stakeholders:

- Bench power supply (for electric testing);
- Micro soldering iron;
- Oscilloscope;
- Fume extractor (workshop requirement);
- Solder fux;
- "Tin" solder;
- Ultrasonic cleaning system;
- Oven for drying;
- Hot air welding device;
- Ultrasonic cleaning solution;
- Brush (for cleaning);
- Microscope;
- ESD-safe workstation, including ESD mat and wrist or heel strap;
- ESD bags (for storing ESD-sensitive parts);
- ESD-safe tweezers;
- Suction cup;
- Pentalobe screwdriver;
- Torque driver;
- IPR security bit for use with Torque driver;
- Trilobe screwdriver;
- Torx screwdrivers;
- Black stick or other nonconductive nylon or plastic flat-blade tool;
- Thermal grease syringe.

Finally, there could still be the need of Proprietary tools (Level III = 0.33 pt).

However, some manufacturers highlighted the risk that list of tools could become out of date as technology advances.

3.2.3.4 Type and availability of information

This parameter includes a pass/fail criterion about the availability of information.

1) From placing on the market of the first unit of a model and until a minimum period of at least 4 years (see considerations below for spare parts)[56] after placing the last unit of the model on the market, the manufacturer, importer or authorised representative has to provide access to repair and maintenance information to professional repairers in the following conditions:

a) The manufacturer's, importer's or authorised representative's website has to indicate the process for professional repairers to register for access to information; to accept such a request, the manufacturers, importers or authorised representatives may require the professional repairer to demonstrate that

(i) The professional repairer has the technical competence to repair laptops and complies with the applicable regulations for repairers of electrical equipment in the Member States where it operates. Reference to an official registration system as professional repairer, where such system exists in the Member States concerned, has to be accepted as proof of compliance with this point;

(ii) The professional repairer is covered by insurance covering liabilities resulting from its activity regardless of whether this is required by the Member State.

b) The manufacturers, importers or authorised representatives have to accept or refuse the registration within 5 working days from the date of request;

c) Manufacturers, importers or authorised representatives may charge reasonable and proportionate fees for access to the repair and maintenance information or for receiving regular updates. A fee is reasonable if it does not discourage access by failing to take into account the extent to which the professional repairer uses the information;

d) Once registered, a professional repairer has access, within one working day after requesting it, to the requested repair and maintenance information. The information may be provided for an equivalent model or model of the same family, if relevant.

e) The repair and maintenance information has to include:

- The unequivocal identification of the machine;

- A disassembly map or exploded view, including detailed step-by-step disassembly instructions for batteries and other priority parts and including information supporting the operation (e.g. tools needed, recommended torque for fasteners, diagnostic and error resetting codes);

- Technical manuals of instructions for repair, including safety issues, testing procedures for after repair and reference values for measurements;

- List of necessary repair and test equipment;

- Component and diagnosis information (such as minimum and maximum theoretical values for measurements);

- Wiring and connection diagrams and circuit board schematics of electronic parts (including the key (legend) with numbers and symbols explanations);

- Diagnostic fault and error codes (including manufacturer-specific codes, where applicable);

[56] Information has to be available for at least 5 years in EU Ecolabel and Blue Angel.

- Instructions for installation of relevant software and firmware including reset software; and

- Information on how to access data records of reported failure incidents stored on the product (where applicable).

It should be observed that such information is made available publicly for "best-performing" products certified according to EPEAT[57]. Manufacturers like Dell also provide a guide to their customers with indications about how to replace some parts in their laptop models[58].

2) User instructions have also to be provided in the form of a user manual on a free access website of the manufacturer, importer or authorised representatives. This has also to include instructions for the user to perform maintenance operations, which as a minimum has to include information on:

- The unequivocal identification of the machine;

- Correct installation, use, maintenance and upgrade of relevant hardware, software and firmware (including how to optimise the lifetime of the battery and ergonomic aspects);

- Functional specification and compatibility of parts (as batteries and External Power Supplies) with other products;

- Identification of errors, the meaning of the errors, and the action required, including identification of errors requiring professional assistance;

- Skills needed and environmental conditions for the repair operations[59];

- How to access to professional repair (internet webpages, addresses, contact details);

- Any implications of self-repair or non-professional repair for the safety of the end-user and for the legal guarantee, and when applicable, also to the commercial guarantee;

- The minimum period during which the spare parts for the machine are available.

Moreover, in accordance with Table 5, also information on price of spare parts has to be provided publicly.

These prescriptions are considered as a pass/fail criterion in this preliminary definition of a scoring system for laptops.

The rating of this parameter is based on the target group of repairers and on the cost of the repair and maintenance information (1):

I) Public availability at no additional cost for consumers = 1 pt;

II) Available only to registered professional repairers = 0.5 pt.

This information has to be available as PDF, HTML or paper form and has to be provided in the official language(s) of the country(ies) in which the product is on the market. Channels for communicating information may include printed manuals, websites, digital information carriers such as QR codes, DVDs or flash drives.

[57] Based on IEEE (2018)
[58] https://www.dell.com/support/article/es/es/esbsdt1/sln304947/latitude-14-5480-teardown-removal-guide-for-customer-replaceable-units-crus-?lang=en (accessed on 18 September 2018)
[59] E.g. according to the Commission Regulation No 617/2013 with regard to ecodesign requirements for computers and computer servers, if a notebook computer is operated by battery/ies that cannot be accessed and replaced by a non-professional user, manufacturers shall provide in the technical documentation, and make available on free-access websites and on the external packaging of the notebook computer, the following information "The battery[ies] in this product cannot be easily replaced by users themselves"

3.2.3.5 Spare parts

As pass / fail criterion, manufacturers, importers or authorised representatives have to ensure the availability of priority parts (as spare parts) for a defined period of time after placing the last unit of the model on the market. These could also include approved-by-manufacturer compatible spare parts produced by third parties (similarly to the requirements set in EU Ecolabel[60], Blue Angel (2017) and EPEAT[61]). The list of spare parts and the procedure for ordering them have to be publicly available on the free access website of the manufacturer, importer or authorised representative. A list with the prices of spare parts has also to be disclosed.

Based on the analysis of data reported in a study of JRC (Tecchio 2018), 4 years is considered as minimum time horizon for the availability of spare parts. Based on the same source, 7 years are considered as more ambitious threshold for the rating. Requirements set in Ecolabel and Blue Angel set spare parts availability of at least 5 years. This is considered as threshold for class II. TCO instead requires that the brand owner shall guarantee the availability of spare parts for at least 3 years from the time that production ceases and instructions on how to replace these parts shall be available to professionals upon request (TCO 2017). EPEAT requires that manufacturers declare if spare parts are available for use in the repair of the product, and if available, the length of time during which the spare parts are available after the end of production.
The Groupe SEB's "Product 10Y Repairable" label[62] claims that the delivery time of spare parts has to be shorter than 2 days. According to stakeholders for this product group, this would not be viable from a business perspective and would result in expenses that would be ultimately passed to the consumers. Similarly to other product groups, it is considered that the delivery time should be within 15 working days.

For some parts, standard interfaces have been identified based on the availability of standards:

- IEC TS 62700[63] provides specification for connectors and plugs;

- USB type-C (see Figure 8) electric receptacles are specified in the IEC 62680-1-3[64];

- IEC 63002[65] instead defines interoperability guidelines for external power supplies (EPS) used with portable computing devices. This International Standard is applicable to EPS under 100 W for portable computing devices, with a focus on power delivery application for notebook computers, tablets, smartphones and other related multimedia devices.

- The Recommendation ITU-T L.1002 (10/16) (ITU-T 2016) sets out technical specification for common EPS, designed for use with portable ICT devices, also referred in the recommendation as Universal Power Adaptor (UPA). The basic EPS configuration suggested by ITU-T L.1002 consists of an EPS with a detachable input cable[66] and a detachable output cable to the ICT device[67] (see Figure 9). A detachable

[60] Commission Decision (EU) 2016/1371 of 10 August 2016 establishing the ecological criteria for the award of the EU Ecolabel for personal, notebook and tablet computers
[61] Based on IEEE 2018
[62] http://www.groupeseb.co.uk/repairable.html (accessed on 24 May 2018)
[63] IEC TS 62700:2014 - DC power supply for notebook computers
[64] IEC 62680-1-3:2018 - Universal serial bus interfaces for data and power - Part 1-3: Common components - USB Type-C™ Cable and Connector Specification
[65] IEC 63002:2016 - Identification and communication interoperability method for external power supplies used with portable computing devices
[66] Detachable alternating current (AC) cable: A detachable cable used to connect the power adapter to the AC mains for powering through two connectors, one on the universal power adapter side and the other on the AC mains side.
[67] Detachable direct current (DC) cable: A detachable DC cable connects the power adapter to the ICT device for powering through two connectors, one on the universal power adapter side and the other on the ICT device side

DC cable is required as the DC cable is generally the weakest point of the portable power supply and the main point of failure. Adapters which have captive cables, in case of failure of the latter, require all the rest of the equipment and in particular its active part, to be discarded, adding up unnecessary e-waste and cost for the users that could be a barrier for repair. Furthermore, the detachable cable enables more reuse and an increased lifetime of the power supply unit. The Recommendation ITU-T L.1002 suggests implementing the USB type-C connector for the interface of EPS, in order to support broad reusability and interoperability.

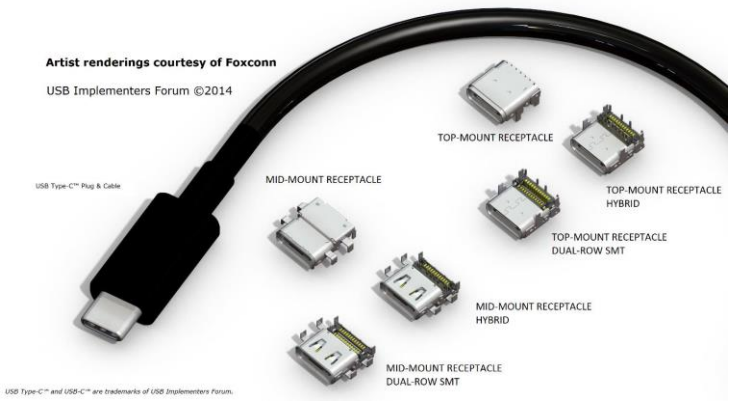


Figure 8: USB type-C cable and connectors (USB Implementers Forum 2016)

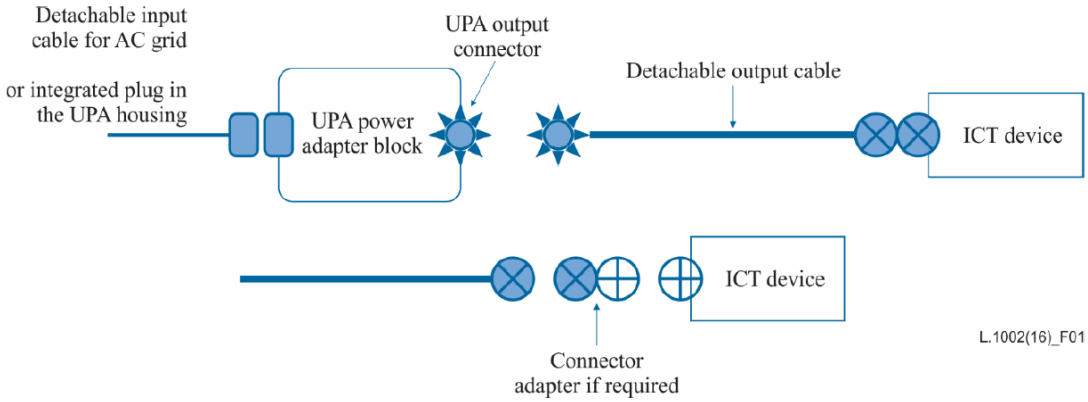


Figure 9: Basic Universal Power Adaptor (UPA) configurations and connection options (ITU-T 2016)

For at least the following priority parts it could be thus possible to rate the parameter related to spare parts also based on the use of standard interfaces:

- Ports and connectors;-
- EPS (for power supplies up to 100 W).

As shown in Table 5, the score for spare parts is calculated for each priority part as the product of three factors:

a) Availability of spare parts overtime (modulated based on the information described above):

I) The spare part (or compatible spare parts) is declared by the manufacturer to be available for at least 7 years = 1 pt;

II) The spare part (or compatible spare parts) is declared by the manufacturer to be available for at least 4 years = 0.5 pt.

b) Target group (unvaried):

I) The spare parts is available publicly = 1 pt;

II) The spare parts is available to professional repairers = 0.5 pt.

c) Interface (only for parts identified above as of high relevance for laptops, i.e. ports, connectors, EPS up to 100 W):

I) The part is not proprietary and has a standard interface = 1 pt;

II) The part is either proprietary or does not have a standard interface = 0.5 pt.

The overall score of this parameter for each priority part is the product of the three scores described above.

3.2.3.6 Software and firmware

Manufacturers have to fulfil the following pass/fail criteria:

- Software (at least for the Operating System) and firmware updates and support are offered to end users for a duration of 4 years (as required for spare parts), including the possibility to use open source Operating Systems or open source Virtual Machine software;

- Information about the impact of future updates on the original system characteristics (e.g. RAM, CPU) has to be provided, and there has to be always the option to not install, to install or to uninstall the update.

The parameter is then rated based on the availability over time of updates and support (in analogy with spare parts), as well as on the cost associated with the service, according to the information provided in Table 5.

A score is assigned for the product based on the period of time during which software/firmware updates and support are offered:

I) Software/Firmware updates and support are offered for at least 7 years = 1 pt;

II) Software/Firmware updates and support are offered for at least 4 years = 0.5 pt.

A score is assigned for the product also based on the cost of the software/firmware update service:

I) Software/Firmware updates and support are offered free of charge for the entire period of time during which the service is offered (either 4 or 7 years) = 1 pt;

II) Software/Firmware updates and support are offered free of charge for X years = either X/7 or X/4 pt, depending on the entire period of time during which the service is offered.

The overall score for this parameter is the product of the two scores described above.

3.2.3.7 Secure data transfer and deletion

Data deletion aims to facilitate reparability/reusability of the whole products without the risk of transfer of any sensitive and personal data in reused equipment.

According to the draft Commission Regulation on servers and data storage "Secure data deletion" means the effective erasure of all traces of existing data from a data storage

device, overwriting the data completely in such a way that access to the original data, or parts of them, becomes infeasible for a given level of effort (EC 2018a).

Different methods used for data deletion are appropriate for different types of memories. Data deletion of HHD and SSD is declared by some manufacturers (e.g. HP Secure Erase) (HP 2018) to be compliant with specific standards (e.g. Guidelines for Media Sanitization by NIST (2014)).

Secure data deletion tools should built-in (or as second option made available on request) and should permanently delete all user data without compromising the functionality of the device for further use.

According to the prEN 45554, simplified transfer of data from an old to a new product should also be made available via installed or downloadable tools such as applications, cloud-based services or instructions detailing a manual process.

This parameter is considered of high relevance for laptops and can be evaluated based on the availability of data transfer and deletion functionalities as shown in Table 5.

3.2.3.8 Password reset and restoration of factory settings

According to a JRC study on computers (Tecchio et al. 2018), some laptops include passwords or registration systems which can hinder access to the device in case of repair and reuse.

For example, the Basic Input Output System (BIOS) instructs the computer on how to perform a number of basic functions such as booting and keyboard control. BIOS is also used to identify and configure the hardware in a computer such as the hard drive, CPU, memory[68]. For these reasons the access to BIOS can be important for the repair operations. Unlike the operating system, which is often downloaded from internet or provided on a compact disc, and which needs to be installed by the user or manufacturer, the BIOS is pre-installed when the computer is purchased. The BIOS setup utility is accessed in various ways depending on the model of laptop, but usually it is needed a password that in case of reuse is normally unknown. In this case the BIOS password can be only removed by the manufacturer or by an authorized service provider. The costs to reset BIOS passwords can range between 30 and 120 euro according to a previous JRC study (Tecchio et al. 2018), which could not be economically viable and hinder any possibility of repair/reuse.

Resetting a laptop to factory settings might be necessary if the operating system is damaged, the hard drive is corrupted, the computer is infected by a virus, or in case transferring ownership of the laptop. The restoration to factory setting function can be specific software provided by the manufacturer with the laptop. This software can be used to reinstall some of the hardware drivers and software programs that originally came with the laptop and can also aid back-up operations (see 3.2.3.7 "secure data transfer and deletion"). Laptops manufacturers provide support for the download of drivers and software (e.g. Toshiba[69] and HP[70]). However, it was remarked by some stakeholders that the full list of hardware drivers is not always easily accessible.

User's passwords can be typically reset through the restoration of factory settings. However, some systems (as the iCloud or the device enrolment programme from Apple) cannot be reset without the original password created by the first user. This could hamper possibility to repair and upgrade the product for the 2nd hand market, if no factory reset was made by the first user.

[68] https://www.lifewire.com/bios-basic-input-output-system-2625820 (accessed on 20 December 2018)
[69] https://support.toshiba.com/drivers (accessed on 15 March 2019)
[70] https://support.hp.com/us-en/document/c01868333 (accessed on 15 March 2019)

As indicated in Table 5, rating of this parameter is based on the availability of functions for password reset and factory setting restoration (integrated = 1pt; external = 0.66 pt; service offered = 0.33 pt).

3.2.3.9 Commercial guarantee

The Commission Decision (EU) 2016/1371 on personal, notebook and tablet computers[71] includes a criterion on commercial guarantees: "The applicant shall provide at no additional cost a minimum of a three year guarantee effective from purchase of the product. This guarantee shall include a service agreement with a pick-up and return or on-site repair option for the consumer. This guarantee shall be provided without prejudice to the legal obligations of the manufacturer and seller under national law."

As described in Table 5, a score is assigned to the product based on the availability of a "commercial guarantee" and including a "commitment to free repair" the product in case of failure and a "commitment to upgrade the product periodically". In analogy with spare parts, 7 years are taken as reference for the rating:

- 1 point is assigned if a commercial guarantee is offered, in addition to the legal obligations, covering a period post-sale of at least 7 years.

- 0 points are assigned in case of fulfilment of only the minimum legal requirements of 2 years.

- Points are modulated proportionally for intermediate cases.

Commercial guarantees must be related to the entire product, provided in the entire EU, be included in the sales price of the product, and not result in any additional costs for consumers.

The commercial guarantee must be provided in the entire EU, be related to the entire product, be included in the sale price of the product, and the remedies proposed by the guarantor will not result in any costs for the consumer (e.g. it means that the repair is for free).

[71] Commission Decision (EU) 2016/1371 of 10 August 2016 establishing the ecological criteria for the award of the EU Ecolabel for personal, notebook and tablet computers

3.2.4 Overview

The overview of parameters, criteria and weights preliminarily proposed for laptops is presented in Table 9.

Table 9: Parameters, criteria and weights preliminarily proposed for laptops

Parameter	Pass/fail criteria	Rating classes	Assessment and verification	Weight of the parameter
1) Disassembly depth/sequence	For each priority part, information about the disassembly sequence has to be available to the target group of repairers (see #6)	None (no rating is proposed since data regarding disassembly depths has not been collected for this study)	A: A description supported by illustrations of the steps needed to disassemble priority parts is needed. The description has to show that the disassembly is reversible by including the steps needed for the reassembly of priority parts. V: physical disassembly and recording of the operation are needed.	Normal = 1
2) Fasteners and connectors	None	A score is assigned for each priority part according to the reversibility and reusability of the fasteners used for its assembly. I) Reusable: an original fastening system that can be completely re-used, or any elements of the fastening system that cannot be re-used are supplied with the new part for a repair, re-use or upgrade process = 1 pt. II) Removable: an original fastening system that is not reusable, but can be removed without causing damage or leaving residue which precludes reassembly or reuse of the removed part = 0.5 pt. III) Non-removable: original fastening	A: A description supported by illustrations of the fasteners to be removed for the disassembly of priority parts is needed. V: Physical disassembly and inventory of fasteners are needed.	Normal = 1

Parameter	Pass/fail criteria	Rating classes	Assessment and verification	Weight of the parameter
		systems are not removable or reusable, as defined above = 0 pt. Note: In case different types of fasteners are used in the assembly of a priority part, the score corresponding to the worst type of fasteners case will be considered.		
3) Tools	The repair/upgrade process is feasible for each priority part with existing tools	A score is assigned for each priority part according to the complexity and availability of the tools needed for its repair/upgrade: I) Basic tools: repair/upgrade of the priority part is feasible without any tools, or with tools that are supplied with the product, or with the list of basic tools provided in note 1 = 1 pt. II) Other commercially available tools: repair/upgrade of the priority part is unfeasible only with basic tools and requires the use of other tools that are commercially available = 0.66 pt. III) Proprietary tools: repair/upgrade of the priority parts is feasible only with one or more proprietary tools = 0.33 pt. Note: 1) The list of basic tools includes: - Screwdriver for slotted heads, cross recess or for hexalobular recess heads (ISO2380, ISO8764, ISO10664); - Hexagon socket key (ISO2936); - Combination wrench (ISO7738); - Combination pliers (ISO5746);	A: Description of the repair/upgrade operations, including documentation of the tools to use, is needed. V: Physical disassembly and check of suitability of tools are needed.	Normal = 1

Parameter	Pass/fail criteria	Rating classes	Assessment and verification	Weight of the parameter
		- Half round nose pliers (ISO5745); - Diagonal cutters (ISO5749); - Multigrip pliers (multiple slip joint pliers) (ISO8976); - Locking pliers; Combination pliers for wire stripping & terminal crimping; - Prying lever; - Tweezers; - Hammer, steel head (ISO15601); - Utility knife (cutter) with snap-off blades; - Multimeter; - Voltage tester; - Soldering iron; - Hot glue gun; - Magnifying glass; - Clean, soft, lint-free cloth; - Magnifying glass; - Quick grip clamps; - Nonslip gloves; - Painters tape; - Isopropyl alcohol (IPA) wipe.		
4) Disassembly time	none	none	none	none
5) Diagnosis support and	none	none	none	none

Parameter	Pass/fail criteria	Rating classes	Assessment and verification	Weight of the parameter
interfaces				
6) Type and availability of information	Information requirements for professional repairers and final users (see section 3.2.3.4).	I) A score of 1 is assigned for the product if all the information of the pass/fail criterion is made available publicly at no additional cost for consumers. II) Otherwise, 0.5 points are assigned.	A: All relevant information for maintenance, repair and upgrade needs to be compiled and made available to the target group of repairers. V: Check of actual availability.	High = 2
7) Spare parts	- Manufacturers, importers or authorised representatives have to make available to professional repairers the spare parts listed in section 3.2.2 - Spare parts have to be available for a minimum period of 4 years after placing the last unit of the model on the market - The list of these spare parts and the procedure for ordering them have to be publicly available on a free access website. - The delivery of the spare parts has to be within 15 working days after having received the order. - Price of spare parts to be also disclosed	For each priority part:, a) Availability of spare parts over time: I) The spare part (or compatible spare parts) is declared by the manufacturer to be available for at least 7 years = 1 pt; II) The spare part (or compatible spare parts) is declared by the manufacturer to be available for at least 4 years = 0.5 pt. b) Target group I) The spare parts is available publicly = 1 pt; II) The spare parts is available to professional repairers = 0.5 pt. c) Interface (only for ports, connectors, EPS up to 100 W): I) The part is not proprietary and has a standard interface = 1 pt; II) The part is either proprietary or does not have a standard interface = 0.5 pt. Score (#7) = Score (#7a) x Score (#7b) x Score (#7c)	A: Commitment by the manufacturer about the availability of spare parts over time, as well as provision of information about: - Delivery time - Recommended retail price of spare parts - Target groups - Interface used. V: Check of actual availability.	High = 2

Parameter	Pass/fail criteria	Rating classes	Assessment and verification	Weight of the parameter
8) Software and firmware	Software (at least for the Operating System) and firmware updates and support are offered to end users for a duration of 4 years after placing the last unit of the model on the market, including the possibility to use open source Operating Systems or open source Virtual Machine software. Information about the impact of future updates on the original system characteristics (e.g. RAM, CPU) has to be provided, and there has to be always the option to not install, to install or to uninstall the update.	a) A score is assigned for the product based on the period of time during which software/firmware updates and support are offered: I) Software/Firmware updates and support are offered for at least 7 years = 1 pt; II) Software/Firmware updates and support are offered for at least 4 years = 0.5 pt. b) A score is assigned for the product based on the cost of the software/firmware update service: I) Software/Firmware updates and support are offered free of charge for the entire period of time during which the service is offered (either 4 or 7 years) = 1 pt; II) Software/Firmware updates and support are offered free of charge for X years = either X/7 or X/4 pt, depending on the entire period of time during which the service is offered. Score (#8) = Score (#8a) x Score (#8b)	A: Declaration about the duration of availability of software and firmware over time, as well as information about costs, and information about how updates will affect the original system characteristics. V: Check of actual availability, compatibility, and possibility to avoid/reverse the update.	High = 2
9) Safety, skills and working environment	none	none	none	none
10) Data transfer and deletion	None	A score is assigned for the product based on the availability of secure data transfer and deletion functionality: I) Built-in secure data transfer and deletion functionality is available to support the deletion or transfer of all data contained in data storage parts (i.e. hard drives and solid	A: Information about the availability of secure data transfer and deletion functionality / service is needed. V: Check of actual availability.	High = 2

Parameter	Pass/fail criteria	Rating classes	Assessment and verification	Weight of the parameter
		state drives) = 1 pt. II) Secure data transfer and deletion is permitted without restrictions, using freely accessible software or hardware solutions = 0.66 pt. III) Secure data transfer and deletion is available on request to support the deletion of all data contained in data storage parts (i.e. hard drives and solid state drives) = 0.33 pt.		
11) Password reset and restoration of factory settings	None	A score is assigned for the product based on the availability of an option for resetting the password and restoring the factory setting. I) Integrated reset: password reset and restoration of factory settings (whilst ensuring security of personal data of previous user) is permitted without restrictions, using functionality integrated within the product = 1 pt. II) External reset: password reset and restoration of factory settings (whilst ensuring security of personal data of previous user) is permitted without restrictions, using freely accessible software or hardware solutions = 0.66 pt. III) Service reset: password reset and restoration of factory settings (whilst ensuring security of personal data of previous user) is permitted using services offered by the manufacturer = 0.33 pt.	A: Information about the availability of a feature / service for password reset and restoration of factory settings is needed. V: Check of actual availability.	High = 2
12) Commercial guarantee	None	A score is assigned based on the availability of a "commercial guarantee" for the (entire) product offered by the guarantor, and	A: Guarantee contract is needed, with emphasis on "free repair first" clauses.	Not Applied

Parameter	Pass/fail criteria	Rating classes	Assessment and verification	Weight of the parameter
		including a "commitment to free repair as first remedy" in case of failures and a "commitment to upgrade the product periodically". I) 1 point is assigned if a commercial guarantee is offered, in addition to the legal obligations, covering a period post-sale of at least 10 years. II) Points are modulated proportionally for intermediate cases. III) 0 points are assigned in case of fulfilling only the minimum legal requirements of 2 years. Note: 1) "Commercial guarantee" means any undertaking by the seller or a producer (the guarantor) to the consumer, in addition to his legal obligation relating to the guarantee of conformity, to reimburse the price paid or to replace, repair or service goods in any way if they do not meet the specifications or any other requirements not related to conformity set out in the guarantee statement or in the relevant advertising available at the time of, or before the conclusion of the contract. 2) For the purpose of being able to be taken into account in the "Repair Score System", the commercial guarantee must be related to the entire product (not only specific components), provided in the entire EU, be included in the sale price of the product, and	V: Check of availability of guarantee, clauses statement and actual possibility of repair in case of failure.	

Parameter	Pass/fail criteria	Rating classes	Assessment and verification	Weight of the parameter
		the remedies proposed by the guarantor will not result in any costs for the consumer (e.g. it means that the repair is for free).		

3.3 Vacuum cleaners

3.3.1 Scope definition

For the purposes of this report, the product group "vacuum cleaners" covers, following the proposal done for the revision of the current Ecodesign regulation (Rames et al. 2018):

i) Robot vacuum cleaners, which are battery operated vacuum cleaners that are capable of operating without human intervention within a defined perimeter, and that consist of a mobile part and of a docking station and/or other accessories to assist their operation;

ii) Cordless vacuum cleaners, which are vacuum cleaners powered only by batteries, other than robot vacuum cleaners;

iii-a) Mains operated vacuum cleaners, which are vacuum cleaners powered by electric mains;

iii-b) Hybrid vacuum cleaners, which are vacuum cleaners that can be powered by both electric mains and batteries.

Some of the different models within each product subgroup are illustrated in Figure 10. The scope excludes industrial vacuum cleaners, which are designed to be part of an industrial process.

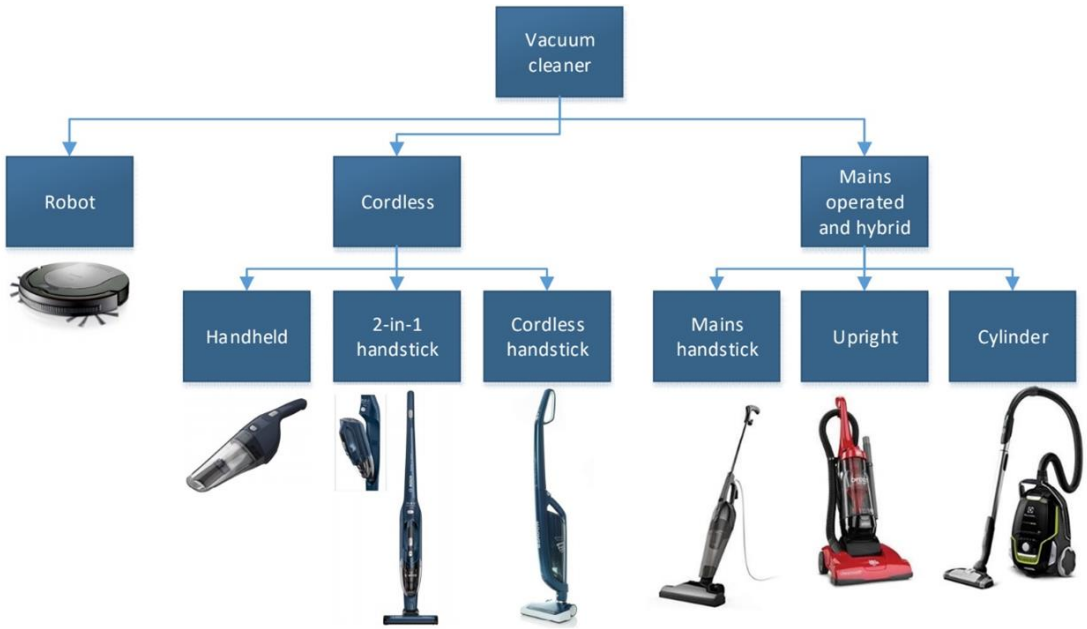


Figure 10: Vacuum cleaners types under the scope of the study (Rames et al. 2018)

It is anticipated that the variety of the scope could imply differences in terms of priority parts and key parameters to use for the assessment of different types of product. This can be especially the case for cordless and mains operated vacuum cleaners.

In order to handle this issue, when one or more parameters selected for a product type are not applicable to another type, such parameters are excluded from the assessment of those products. The same principle applies to priority parts.

3.3.2 Priority parts

Insights on typical frequencies of failure for upright and cylinder vacuum cleaners, belonging to the mains operated and hybrid types, are provided in the "Review study on Vacuum cleaners" (Rames et al. 2018) prepared for the European Commission. These are reported in Table 10.

Table 10: Faults experienced in Upright Vacuum Cleaners and Cylinder Vacuum Cleaners (mains operated and hybrid types) (Rames et al. 2018)

Upright vacuum cleaners		**Cylinder vacuum cleaners**	
Suction deteriorated	24.3%	Suction deteriorated	19.5%
Blocked filters	21.7%	Blocked filters	17.8%
Belt broken (drive-belt rotating brush)*	16.9%	Other	15.7%
Split hose	13.7%	Broken accessories	12.2%
Motor broken	13.4%	Brush not working properly	10.8%
Brush not working properly	12.0%	Casing cracked/chipped/broken	10.1%
No suction	10.0%	Overheating	8.7%
Brush not working at all	9.4%	Split hose	7.7%
Casing cracked/chipped/broken	8.9%	Motor broken	6.6%
Other	8.6%	Power cutting out	5.2%
Broken accessories	8.3%	Power cable faulty	5.2%
Overheating	6.3%	No suction	5.2%
Power cable faulty	5.1%	Brush not working at all	4.9%
Wheels/castors broken	4.9%	Handle broken	3.8%
Handle broken	4.6%	Power not working at all	3.8%
Power not working at all	3.7%	Controls broken	2.4%
Power cutting out	3.1%	Wheels/castors broken	2.4%
Handle loose	2.3%	Belt broken (drive-belt rotating brush)	2.1%
Controls broken	0.6%	Handle loose	1.7%
Total	**177.7%**	**Total****	**146.0%**

** maintenance issue; belt costs 2-5 euros*

*** >100% with multiple faults*

According to Table 10, the most common faults of both upright vacuum cleaners and cylinder vacuum cleaners are related to suction and blocked filters. These problems can be interconnected, as well as related to a lack of maintenance because filters should be changed regularly.

The Benelux study on reparability (Bracquené et al. 2018) also provides quantitative information on priority parts based on surveys carried out by consumer testing organisations ("Which?" and "Test Aankoop"). In particular, according to the analysis of data from "Test Aankoop", the top 5 parts which together represent 40% of all failure modes are:

- Spilt/broken hose (15%);
- Power cable (11%);
- Brushes/Nozzles (5%);
- Switches/Electronic Board (5%);
- Wheels (4%).

Stakeholders involved in in the present study have also provided additional suggestions: filters (ease of access and cleaning), motor and motor brushes, cable reel, hose, nozzles (or suction head)[72]. Batteries where also identified as priority part for cordless vacuum cleaners, together with their charger or charging station.

Priority parts where to focus the scoring system have been defined based on the above information and input from stakeholders, as summarised in Table 11. The list is also supported by quantitative information confidentially shared by a consumer testing organisation.

Based on the available information:

- Motor and motor brushes, filters, hose, battery (for robot, cordless and hybrid vacuum cleaners) and power cable are parts which are more likely to fail. Because of this, a high priority and a higher weight (=3) is set for these parts.
- A weight equal to 1 is instead assigned to other parts in accordance with the indications provided in section 2.1.4.

As described previously, priority parts which are not used in specific product types do not have to be taken into consideration for the assessment of that product type. For example, batteries and battery chargers / charging stations do not apply to main operated vacuum cleaners.

[72] It has been reported that vacuum cleaners are rarely repaired in northern countries and that these typically require the change easily replaceable parts such as the handle, hose and nozzle. More repair operations are done in southern-eastern Europe, which also include the replacement of the motor brushes.

Table 11: List of priority parts for vacuum cleaners

Part	Relevance for repair	Relevance for upgrade	Weight
1) Motor	1) Provision of main functionalities 2) Very relevant in terms of failure rates Note: The implementation of durability requirements according to the Commission Regulation 666/2013 should mitigate the risk for premature failures of this part. However, repair in case of breakage has to be enabled		3
2) Motor brushes	1) Provision of main functionalities 2) Very relevant in terms of failure rates Note: This priority part is not assessed for brushless motors.		3
3) Filters	According to some stakeholders, blocked filters are one of the most common failures which could even lead to the breakage of the motor. However, filters have to be changed periodically and this could be also considered as a maintenance activity.		3
4) Hose	1) Provision of main functionalities 2) Very relevant in terms of failure rates Note: The implementation of durability requirements according to the Commission Regulation 666/2013 should mitigate the risk for premature failures of this part. However, repair in case of breakage has to be enabled		3
5) Battery	1) Provision of main functionalities for: i) Robot vacuum cleaners,		3

Part	Relevance for repair	Relevance for upgrade	Weight
	ii) Cordless vacuum cleaners, iii-b) Hybrid. 2) Very relevant in terms of failure rates		
6) Power cable	1) Provision of main functionalities (for mains operated vacuum cleaners) 2) Very relevant in terms of failure rates Note: It refers to malfunctioning of the power cable and not to the power cable reel		3
7) Belt broken (drive-belt rotating brush)	1) Provision of main functionalities for upright vacuum cleaners (representing 5% of the market, not applicable to robot vacuum cleaners) 2) Relevant in terms of failure rates		1
8) Wheels	1) Provision of main functionalities 2) Relevant in terms of failure rates		1
9) Switches/Electronic Board	1) Provision of main functionalities 2) Relevant in terms of failure rates		1
10) Battery charger / charging station	1) Provision of main functionalities for: i) Robot vacuum cleaners, ii) Cordless vacuum cleaners, iii-b) Hybrid vacuum cleaners. 2) Relevant in terms of failure rates		1
11) Brushes/Nozzles	1) Provision of main functionalities 2) Relevant in terms of failure rates	New nozzles with improved designs can increase the performance of vacuum cleaners	1

Part	Relevance for repair	Relevance for upgrade	Weight
12) Software/firmware		Relevant for i) robot vacuum cleaner	Not applicable since evaluated as separate product parameter

Note(s):
a) When a part is not used the maximum score is assigned for that part
b) Parts for which "bundled" is not specified have necessarily to be assessed separately

3.3.3 Key parameters

According to stakeholders, key aspects associated to the repair/upgrade of vacuum cleaners are related to:

- Ease of access and replacement of priority parts;
- Availability and cost of spare parts;
- Interoperability between parts (e.g. tubes, nozzles, dust bags and filters) and availability of standardised interfaces.

Moreover, software/firmware upgradability is relevant for robot vacuum cleaners.

It has been considered that the following parameters listed in Table 5 are relevant in order to rate vacuum cleaners:

- Disassembly depth/sequence (#1);
- Fasteners (#2);
- Tools (#3);
- Type and availability of information (#6);
- Spare parts (#7);
- Software and firmware (#8) (relevant only for robot vacuum cleaners);
- Commercial guarantee (#12).

When one or more parameters are not applicable to a specific model of vacuum cleaners, such parameters are not taken into account in the assessment of those products.

Some parameters have been excluded from the rating:

- Disassembly time (#4): although this parameter can be relevant since the repair duration affects repair costs, disassembly time is also covered indirectly by other parameters (e.g. disassembly depth, fasteners, tools, availability of repair information). Moreover, methodological developments are still needed before such parameter can be measured in a standardised and not-too-burdening way. The eDIM method was used in the Benelux study (Bracquené et al. 2018) to estimate disassembly (and reassembly) times of two illustrative models representing two different types of vacuum cleaners (see Table 12). However, the definition of reference values for a representative sample of vacuum cleaners, and the verification of the information provided in the scoring system, would require a significant amount of resources. In order to keep the scoring system simpler, it is considered that such parameter should be excluded from the assessment, at least for the moment. Given its potentiality, its application could be reconsidered in the future.

- Diagnosis support and interfaces (#5): although this parameter is relevant for failure identification and can help to increase the number of repair operations, it does not seem important for vacuum cleaners since failures and faulty parts are considered by many stakeholders as being rather easy to identify. Nevertheless, provision of information in the user manual with trouble shooting / common faults needs to be ensured.

- Safety, skills and working environment (#9): in general, no significant differentiation between different models on the market is expected in terms of safety (always to be ensured), skills and environment requirements for the repair of a certain priority part. On the other hand, even if differences exist they would be covered, at least partly, by other parameters that are easier to verify (e.g. disassembly depth, fasteners, tools, information).

- Data transfer and deletion (#10): This aspect is becoming more relevant with the diffusion of the Internet of Things. However, this does not seem to be at this stage a key barrier for the repair/upgrade of the product.

- Password reset and restoration of factory settings (#11): This aspect does not seem relevant for this product group.

Table 12: eDIM results for the partial disassembly of a canister vacuum cleaner and upright vacuum cleaner (Bracquené et al. 2018)

Disassembly target	Steps (nr.)	Tool changes (nr.)	Connections (nr.)	eDIM (s)	% of total disassembly and reassembly
Canister vacuum cleaner					
Total disassembly	33	9	50	847	100
Split/broken hose (incl RC)	2	0	2	20	2
Tube	3	0	3	30	4
Motor	19	9	40	756	89
Brushes/Nozzle	1	0	1	10	1
Power cable	18	5	25	372	44
Broken casing	4	1	19	233	28
Filter casing	6	0	6	43	5
Wheels	21	7	34	600	71
Upright vacuum cleaner					
Total disassembly	33	15	118	1729	100
Filter casing	3	0	4	29	2
Broken casing	2	0	3	16	1
Brushes/Nozzle	1	0	1	6	<1
Wheels	7	5	17	655	38
Motor	10	4	47	579	33
Battery	10	3	44	514	30

Based on the feedback received from stakeholders, the following weights are preliminarily proposed for single parameters to reflect their relative importance for this product group:

- Disassembly depth/sequence (#1): high weight (=2);

- Fasteners (#2): high weight (=2);

- Tools (#3): high weight (=2);

- Type and availability of information (#6): high weight (=2);

- Spare parts (#7): high weight (=2);

- Software and firmware (#8) (only for robot vacuum cleaners): normal weight (=1).

No weight is assigned to commercial guarantee (#12) since it is not proposed to be aggregated but considered as complementary metric.

A higher weight has been assigned to aspects for vacuum cleaners relating to mechanical issues, and to the provision of information and spare parts. However, weights could be refined also based on the analysis of the variation of the characteristics of products on the market. This could also come with further reduction of parameters to assess in case no significant differentiation is found for one or more parameters.

Considering the indices defined in section 2.3.2, and based on the weights assigned above:

- The score of the Disassemblability Index would be 1/3 the score of #1 + 1/3 the score of #2 + 1/3 the score of #3;

- The score of the RRU Process Index would be 2/5 the score of #6 + 2/5 the score of #7 + 1/5 the score of #8;

- The score of the Overall RRU Index would be 2/11 the score of #1 + 2/11 the score of #2 + 2/11 the score of #3 + 2/11 the score of #6 + 2/11 the score of #7 + 1/11 the score of #8;

- The score of the Commercial Guarantee Index would be equal to the score of #12.

3.3.3.1 Disassembly depth/sequence

As pass/fail criterion for this parameter is that the disassembly sequence has to be available to the target group of repairers for all priority parts listed in section 3.3.1 (see also 3.3.3.4).

Information for end users to facilitate such operation was not available for the two models of vacuum cleaners analysed in the Benelux study (Bracquené et al. 2018). The steps recommended to disassemble priority parts were described in the service manual of one of the models, which was not available to final users. For the disassembly steps of priority parts where there is no safety issue (e.g. risk of electric shock) the disassembly steps should be made available to everybody. This is the case for priority parts that are normally replaced by consumers (e.g. filters and hoses), where instructions about disassembly and reassembly are normally provided with pictograms in the user manuals (although it should be noted that this could be considered also as maintenance information).

For enabling the rating, a reference value for the disassembly depth of priority parts should defined based on the analysis of the steps required to remove them in a representative sample of products. In order to include this parameter in the assessment, further investigation and involvement of stakeholders would be required. A continuous rating should be applied as indicated in Table 5 to simplify the assessment and verification[73].

[73] In case a discrete classification and rating system is used, there would be the need to define more than 1 reference value

3.3.3.2 Fasteners

This parameter is considered to be applicable as indicated in Table 5. In case different types of fasteners are used, the score corresponding to the worst case is considered.

3.3.3.3 Tools

The manufacturer has to declare as pass/fail criterion that the repair/upgrade process is feasible with existing tools for each priority part. Then, the list of tools required for the complete disassembly of each priority parts has to be scored according to their complexity and availability as described in Table 5. The information to provide could include a graphical representation of the tools and/or identification codes.

For vacuum cleaners, the list of basic tools (level I = 1 pt) has been revised based on input from stakeholders: Screwdriver for slotted heads, cross recess or for hexalobular recess heads (ISO2380, ISO8764, ISO10664); Hexagon socket key (ISO2936); Combination wrench (ISO7738); Combination pliers (ISO5746); Half round nose pliers (ISO5745); Diagonal cutters (ISO5749); Multigrip pliers (multiple slip joint pliers) (ISO8976); Locking pliers; Combination pliers for wire stripping & terminal crimping; Prying lever; Tweezers; Hammer, steel head (ISO15601); Utility knife (cutter) with snap-off blades; Multimeter; Voltage or socket tester; Soldering iron; Hot glue gun; Magnifying glass.

Filters and hoses are normally disassembled without the need of any tool. This would correspond to level I.

In addition to basic tools, other commercially available tools could be considered (Level II = 0.66 pt). An indicative and non-exhaustive list of product-specific tools to be considered as other commercially available tools has been suggested by stakeholders:

- Insulation resistance test meter;
- ESD protection mat;
- Torx screwdrivers;
- Suction tester.

It was indicated also that for some robot and cordless type vacuum cleaners a diagnostic software interface/tool might be needed.

Finally, there could still be the need of Proprietary tools (Level III = 0.33 pt).

Necessary tools can be described also in the user manual, or in the service manual if any safety risk is involved. As an example, in the two vacuum cleaners assessed in the Benelux study (Bracquené et al. 2018) the information about tools needed is provided in the service manual.

3.3.3.4 Type and availability of information

This parameter includes a pass/fail criterion about the availability of information.

1) After the placing on the market of the first unit of a model and until a minimum period of at least 5 years (see considerations below for spare parts) after placing the last unit of the model on the market, the manufacturer, importer or authorised representative has to provide access to repair and maintenance information to professional repairers in the following conditions:

> a) The manufacturer's, importer's or authorised representative's website has to indicate the process for professional repairers to register for access to information; to accept such a request, the manufacturers, importers or

authorised representatives may require the professional repairer to demonstrate that

(i) The professional repairer has the technical competence to repair vacuum cleaners and complies with the applicable regulations for repairers of electrical equipment in the Member States where it operates. Reference to an official registration system as professional repairer, where such system exists in the Member States concerned, has to be accepted as proof of compliance with this point;

(ii) The professional repairer is covered by insurance covering liabilities resulting from its activity regardless of whether this is required by the Member State.

b) The manufacturers, importers or authorised representatives have to accept or refuse the registration within 5 working days from the date of request;

c) Manufacturers, importers or authorised representatives may charge reasonable and proportionate fees for access to the repair and maintenance information or for receiving regular updates. A fee is reasonable if it does not discourage access by failing to take into account the extent to which the professional repairer uses the information;

d) Once registered, a professional repairer has access, within one working day after requesting it, to the requested repair and maintenance information. The information may be provided for an equivalent model or model of the same family, if relevant.

e) The repair and maintenance information has to include:

- The unequivocal identification of the machine;

- A disassembly map or exploded view, including detailed step-by-step disassembly instructions for priority parts and including information supporting the operation (e.g. tools needed, recommended torque for fasteners, diagnostic and error resetting codes);

- Technical manuals of instructions for repair, including safety issues, testing procedures for after repair and reference values for measurements;

- List of necessary repair and test equipment;

- Component and diagnosis information (such as minimum and maximum theoretical values for measurements);

- Wiring and connection diagrams and circuit board schematics of electronic parts (including the key (legend) with numbers and symbols explanations);

- Diagnostic fault and error codes (including manufacturer-specific codes, where applicable);

- Instructions for installation of relevant software and firmware including reset software (where applicable); and

- Information on how to access data records of reported failure incidents stored on the product (where applicable).

2) User instructions have also to be provided in the form of a user manual on a free access website of the manufacturer, importer or authorised representatives. This has also to include instructions for the user to perform maintenance operations, which as a minimum has to include information on:

- The unequivocal identification of the machine;

- Correct installation, use, maintenance and upgrade of the product;

- Functional specification and compatibility of parts with other products;

- Identification of errors, the meaning of the errors, and the action required, including identification of errors requiring professional assistance;

- Skills needed and environmental conditions for the repair operations (see the example for laptops in section 3.2.3.4);

- How to access to professional repair (internet webpages, addresses, contact details);

- Any implications of self-repair or non-professional repair for the safety of the end-user and for the legal guarantee, and when applicable, also to the commercial guarantee;

- The minimum period during which the spare parts for the machine are available.

Moreover, in accordance with Table 5, also information on price of spare parts has to be provided publicly.

These prescriptions are considered as a pass/fail criterion in this preliminary definition of a scoring system for vacuum cleaners.

The rating of this parameter is based on the target group of repairers and on the cost of the repair and maintenance information (1):

I) Public availability at no additional cost for consumers = 1 pt;

II) Available only to registered professional repairers = 0.5 pt.

This information has to be available as PDF, HTML or paper form and has to be provided in the official language(s) of the country(ies) in which the product is on the market. Channels for communicating information may include printed manuals, websites, digital information carriers such as QR codes, DVDs or flash drives.

For the two vacuum cleaners analysed in the Benelux study (Bracquené et al. 2018) only product identification and instructions for regular maintenance are made available to all target groups. Information about the repair costs are not provided by the manufacturers, although the price of spare parts is normally available at their website.

Table 13 shows a list of prices for vacuum cleaners spare parts (Rames et al. 2018) a significant variation is in general observed. Table 14 provides some indications about the relative price of spare parts compared to the purchase price of a vacuum cleaner (Bracquené et al. 2018) Information on the price of spare parts at the point of sale can be of high relevance to consumers.

Table 13: Retail price range for spare parts of vacuum cleaners (Rames et al. 2018)

Spare part type	Price (EUR)		
	Min	Max	Average
Wheels	2.3	50.9	18.8
Switch	3.7	46.9	14.6
Cable/rewind	9.5	96.7	31.1
Motor	20	147.7	54.8
Carbon brush	5.4	53.5	12.6
Heads	9.3	137	48.9
Bag frame	4	36.2	17.5
Hose and grips	18.1	107.4	48.2
Belts (upright)	2.3	18.9	6.7
Brush (uprights)	6.8	35.7	18.1
Batteries (robot)	17.1	120.8	59
Brush (robot)	13.3	45.9	27.6
Filters (robot)	18.7	26.7	24.1
Battery charger	5	88.9	23.8
Bags 5 pack			8.6

Table 14: Relative price of spare parts compared to the catalogue price for a canister vacuum cleaner **(Bracquené et al. 2018)**

Part description	Sold by manufacturer % of catalogue price	Sold by third party % of catalogue price
Filter casing		6.2
Exhaust foam		1.3
Non-washable filter	5.7	
Caster assembly		2.6
Motor		20.6*
Electronic (control board)		12.4*
Hose (including remote control)		16.1
Tube	6.2	
Accessory holder	2.5	
Tri-active nozzle		16*

* similar or potentially compatible spare part

3.3.3.5 Spare parts

As pass/fail criterion, manufacturers, importers or authorised representatives have to ensure the availability of priority parts (as spare parts) for a defined period of time after placing the last unit of the model on the market. The list of spare parts and the procedure for ordering them have to be publicly available on the free access website of the manufacturer, importer or authorised representative. A list with the prices of spare parts has also to be disclosed.

Table 15 shows the average lifetime for different types of vacuum cleaners, which vary from 5 to 8 years depending on the type (Rames et al. 2018). In the Benelux study (Bracquené et al. 2018) the lifespan of a vacuum cleaner is reported to range between 5 to 9 years, and 8 years is taken as representative value. Based on the analysis of such data, 5 years is considered as minimum time horizon for spare parts.

Spare parts for vacuum cleaners can be normally ordered either through the manufacturer's website or through third-party providers (Rames et al. 2018). However, for the two vacuum cleaners analysed in the Benelux study (Bracquené et al. 2018), only few spare parts (e.g. nozzles, tubes and filter bags) can be purchased by consumers directly from manufacturers. A more extended list of spare parts is instead reported in the service manual but these are available for professional repairers only.

The Groupe SEB's "Product 10Y Repairable" label[74] claims that the delivery time of spare parts has to be shorter than 2 days. According to stakeholders for this product group, this would not be viable from a business perspective and would result in expenses that would be ultimately passed to the consumers. Similarly to other product groups, it is considered that the delivery time should be within 15 working days. A list with prices of spare parts has also to be disclosed.

Table 15: Average expected lifetimes of vacuum cleaners (Rames et al. 2018)

Vacuum cleaner type	Average lifespan (years)	Standard variation (years)
Cylinder domestic	8	2
Upright domestic		
Cylinder commercial	5	2
Upright commercial		
Cordless	6	3
Robot		

Since no standard interfaces have been identified for vacuum cleaners, the score for spare parts is calculated for each priority part as the product of two factors:

a) Availability of spare parts overtime (modulated based on the information described above):

I) The spare part (or compatible spare parts) is declared by the manufacturer to be available for at least 8 years = 1 pt;

[74] http://www.groupeseb.co.uk/repairable.html (accessed on 24 May 2018)

II) The spare part (or compatible spare parts) is declared by the manufacturer to be available for at least 5 years = 0.5 pt.

b) Target group (unvaried):

I) The spare parts is available publicly = 1 pt;

II) The spare parts is available to professional repairers = 0.5 pt.

3.3.3.6 Software and firmware

The assessment of this parameter, to be carried out at product level, is considered to be relevant only for robot-type vacuum cleaners.

As pass/fail criterion for this parameter, software/firmware updates and support have to be offered to end users for a duration of 5 years (as required for spare parts).

The following requirements are instead considered not relevant for vacuum cleaners:

- Full compatibility with open source Operating Systems is ensured (since there seem to be no open source OS installed in vacuum cleaners);

- Information about the impact of future updates on the original system characteristics (e.g. RAM, CPU) has to be provided, and there has to be always the option to not install, to install or to uninstall the update (since this does not seem to be an issue for vacuum cleaners).

According to feedback from stakeholders, for robot type vacuum cleaners the connection with the diagnosis/update software is wireless, which allows consumers to have access to control and predictive maintenance features from portable devices. Software updates can enhance product functions.

The parameter is then rated based on the availability over time of updates and support (in analogy with spare parts), as well as on the cost associated with the service, according to the information provided in Table 5.

A score is assigned for the product based on the period of time during which software/firmware updates and support are offered:

I) Software/Firmware updates and support are offered for at least 8 years = 1 pt;

II) Software/Firmware updates and support are offered for at least 5 years = 0.5 pt.

A score is assigned for the product also based on the cost of the software/firmware update service:

I) Software/Firmware updates and support are offered free of charge for the entire period of time during which the service is offered (either 5 or 8 years) = 1 pt;

II) Software/Firmware updates and support are offered free of charge for X years = either X/8 or X/5 pt, depending on the entire period of time during which the service is offered.

The overall score for this parameter is the product of the two scores described above.

3.3.3.7 Commercial guarantee

As described in Table 5, a score is assigned to the product based on the availability of a "commercial guarantee" and including a "commitment to free repair" the product in case of failure. In analogy with spare parts, 8 years are taken as reference for the rating:

- 1 point is assigned if a commercial guarantee is offered, in addition to the legal obligations, covering a period post-sale of at least 8 years.

- 0 points are assigned in case of fulfilling only the minimum legal requirements of 2 years.

- Points are modulated proportionally for intermediate cases.

Commercial guarantees must be related to the entire product, provided in the entire EU, be included in the sales price of the product, and not result in any additional costs for consumers.

The commercial guarantee must be provided in the entire EU, be related to the entire product, be included in the sale price of the product, and the remedies proposed by the guarantor will not result in any costs for the consumer (e.g. it means that the repair is for free).

3.3.4 Overview

The overview of parameters, criteria and weights preliminarily proposed for vacuum cleaners is presented in Table 16.

Table 16: Parameters, criteria and weights preliminarily proposed for vacuum cleaners

Parameter	Pass/fail criteria	Rating	Assessment and verification	Weight of the parameter
1) Disassembly depth/sequence	For each priority part, information about the disassembly sequence has to be available to the target group of repairers (see #6)	None (no rating is proposed since data regarding disassembly depths has not been collected for this study)	A: A description supported by illustrations of the steps needed to disassemble priority parts is needed. The description has to show that the disassembly is reversible by including the steps needed for the reassembly of priority parts. V: physical disassembly and recording of the operation are needed.	High = 2
2) Fasteners	None	A score is assigned for each priority part according to the reversibility and reusability of the fasteners used for its assembly. I) Reusable: an original fastening system that can be completely re-used, or any elements of the fastening system that cannot be re-used are supplied with the new part for a repair, re-use or upgrade process = 1 pt.	A: A description supported by illustrations of the fasteners to be removed for the disassembly of priority parts is needed. V: Physical disassembly and inventory of fasteners are needed.	High = 2

Parameter	Pass/fail criteria	Rating	Assessment and verification	Weight of the parameter
		II) Removable: an original fastening system that is not reusable, but can be removed without causing damage or leaving residue which precludes reassembly or reuse of the removed part = 0.5 pt. III) Non-removable: original fastening systems are not removable or reusable, as defined above = 0 pt. Note: In case different types of fasteners are used in the assembly of a priority part, the score corresponding to the worst type of fasteners case will be considered.		
3) Tools	The repair/upgrade process is feasible for each priority part with existing tools	A score is assigned for each priority part according to the complexity and availability of the tools needed for its repair/upgrade: I) Basic tools: repair/upgrade of the priority part is feasible without any tools, or with tools that are supplied with the product, or with the list of basic tools provided in note 1 = 1 pt. II) Other commercially available tools: repair/upgrade of the priority part is unfeasible only with basic tools and requires the use of other tools that are commercially available = 0.66 pt. III) Proprietary tools: repair/upgrade of the priority parts is feasible only with one or more proprietary tools = 0.33 pt.	A: Description of the repair/upgrade operations, including documentation of the tools to use, is needed. V: Physical disassembly and check of suitability of tools are needed.	High = 2

Parameter	Pass/fail criteria	Rating	Assessment and verification	Weight of the parameter
		Note: 1) The list of basic tools includes: Screwdriver for slotted heads, cross recess or for hexalobular recess heads (ISO2380, ISO8764, ISO10664); Hexagon socket key (ISO2936); Combination wrench (ISO7738); Combination pliers (ISO5746); Half round nose pliers (ISO5745); Diagonal cutters (ISO5749); Multigrip pliers (multiple slip joint pliers) (ISO8976); Locking pliers; Combination pliers for wire stripping & terminal crimping; Prying lever; Tweezers; Hammer, steel head (ISO15601); Utility knife (cutter) with snap-off blades; Multimeter; Voltage or socket tester; Soldering iron; Hot glue gun; Magnifying glass		
4) Disassembly time	none	none	none	None
5) Diagnosis support and interfaces	none	none	none	none
6) Type and availability of information	Information requirements for professional repairers and final users (see section 3.3.3.4).	I) A score of 1 is assigned for the product if all the information of the pass/fail criterion is made available publicly at no additional cost for consumers. II) Otherwise, 0.5 points are assigned.	A: All relevant information for maintenance, repair and upgrade needs to be compiled and made available to the target group of repairers. V: Check of actual availability.	High = 2
7) Spare parts	- Manufacturers, importers or authorised representatives have to make available to professional repairers the spare parts	For each priority part:, a) Availability of spare parts over	A: Commitment by the manufacturer about the availability	High = 2

Parameter	Pass/fail criteria	Rating	Assessment and verification	Weight of the parameter
	listed in section 3.3.2 - Spare parts have to be available for a minimum period of 5 years after placing the last unit of the model on the market - The list of these spare parts and the procedure for ordering them have to be publicly available on a free access website. - The delivery of the spare parts has to be within 15 working days after having received the order. - Price of spare parts to be also disclosed	time: I) The spare part (or compatible spare parts) is declared by the manufacturer to be available for at least 8 years = 1 pt; II) The spare part (or compatible spare parts) is declared by the manufacturer to be available for at least 5 years = 0.5 pt. b) Target group I) The spare parts is available publicly = 1 pt; II) The spare parts is available to professional repairers = 0.5 pt. Score (#7) = Score (#7a) x Score (#7b)	of spare parts over time, as well as provision of information about: - Delivery time - Recommended retail price of spare parts - Target groups - Interface used. V: Check of actual availability.	
8) Software and firmware	Software and firmware updates and support are offered to end users for a duration of 5 years after placing the last unit of the model on the market. Note: only for robot-type models	a) A score is assigned for the product based on the period of time during which software/firmware updates and support are offered: I) Software/Firmware updates and support are offered for at least 8 years = 1 pt; II) Software/Firmware updates and support are offered for at least 5 years = 0.5 pt. b) A score is assigned for the product based on the cost of the software/firmware update service: I) Software/Firmware updates and support are offered free of charge for the entire period of time during which the service is offered (either 5 or 8	A: Declaration about the duration of availability of software and firmware over time, as well as information about costs, and information about how updates will affect the original system characteristics. V: Check of actual availability, compatibility, and possibility to avoid/reverse the update.	Normal = 1

Parameter	Pass/fail criteria	Rating	Assessment and verification	Weight of the parameter
		years) = 1 pt; II) Software/Firmware updates and support are offered free of charge for X years = either X/8 or X/5 pt, depending on the entire period of time during which the service is offered. Score (#8) = Score (#8a) x Score (#8b)		
9) Safety, skills and working environment	none	none	none	none
10) Password reset and restoration of factory settings	none	none	none	none
11) Data transfer and deletion	none	none	none	none
12) Commercial guarantee	None	A score is assigned based on the availability of a "commercial guarantee" for the (entire) product offered by the guarantor, and including a "commitment to free repair as first remedy" in case of failures. I) 1 point is assigned if a commercial guarantee is offered, in addition to the legal obligations, covering a period post-sale of at least 8 years. II) Points are modulated proportionally for intermediate cases. III) 0 points are assigned in case of fulfilment of minimum legal requirements of 2 years.	A: Guarantee contract is needed, with emphasis on "free repair first" clauses. V: Check of availability of guarantee, clauses statement and actual possibility of repair in case of failure.	Not Applied

Parameter	Pass/fail criteria	Rating	Assessment and verification	Weight of the parameter
		Note: 1) "Commercial guarantee" means any undertaking by the seller or a producer (the guarantor) to the consumer, in addition to his legal obligation relating to the guarantee of conformity, to reimburse the price paid or to replace, repair or service goods in any way if they do not meet the specifications or any other requirements not related to conformity set out in the guarantee statement or in the relevant advertising available at the time of, or before the conclusion of the contract. 2) For the purpose of being able to be taken into account in the "Repair Score System", the commercial guarantee must be related to the entire product (not only specific components), provided in the entire EU, be included in the sale price of the product, and the remedies proposed by the guarantor will not result in any costs for the consumer (e.g. it means that the repair is for free).		

3.4 Washing machines

3.4.1 Scope definition

For the purposes of this report, this product group covers "household washing machines", also referred to as "washing machines".

These are defined in this context as automatic machines which:

i. Clean and rinse household laundry by using water, chemical, mechanical and thermal means;

ii. Have a spin extraction function;

iii. Are electric mains-operated;

iv. Are declared by the manufacturer in the Declaration of Conformity (DoC) as complying with the Low Voltage Directive 2014/35/EU or with the Radio Equipment Directive 2014/53/EU.

In general, it appears clear that washing machines could be handled as a single group, similarly to how they are regulated under the Ecodesign framework.

The preliminary considerations made in the following sections are relevant for washing machines only. Other products as washer dryers and dishwashers should be assessed separately due to technical differences[75]. Nevertheless, according to stakeholders, the main difference would be in terms of priority parts.

3.4.2 Priority parts

A comprehensive database on repair services, provided by the Reparatur und Service Zentrum (R.U.S.Z), was analysed in a JRC study about the durability of washing machines (Tecchio et al. 2017) (see Figure 11).

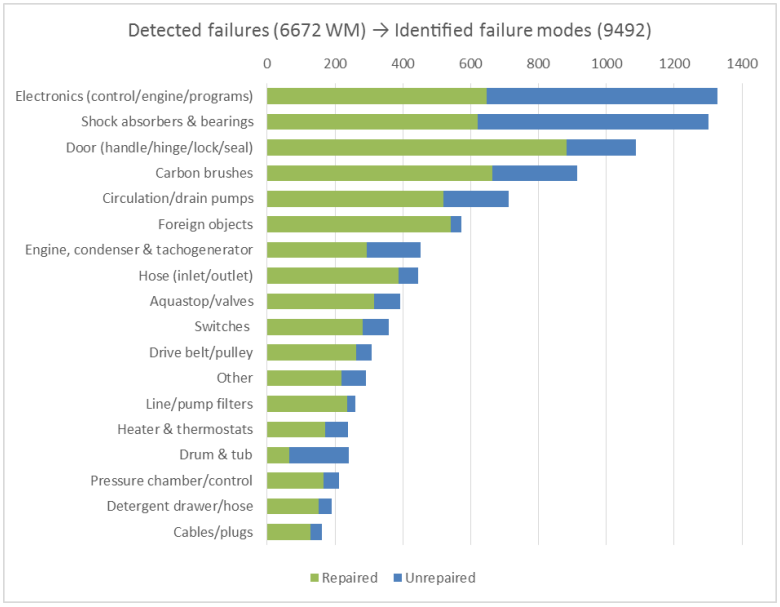


Figure 11: Analysis of failure modes for washing machines (Tecchio et al. 2017)

[75] For example, the circulation of air and accumulation of dust could represent a critical aspect for washer-driers. Filters cannot block 100% of the dust, therefore users should be able to easily access the interior of the machine and clean it

According to stakeholders, recurring failure modes of washing machines include:

- Electronics faults (including central and motor control boards and panels, program selectors, relays, line filters, etc.),
- Shock absorbers wearing, ball bearings wearing and rust due to seal failure, and spider deformation,
- Door seal perforation and locking failure,
- Carbon brushes wearing and motor tachometer coil failure in brushed universal motors[76],
- Draining pump shaft, piping perforation or obstruction and inlet valve obstruction.

Depending on their severity, such recurring failures can cause the interruption or poor functioning of the device.

Main parts affected by failure modes have been identified for the revision of the Ecodesign regulation No 1015/2010 for household washing machines (Boyano et al. 2017a, 2017b, EC 2018b):

1. Motors;
2. Motor brushes;
3. Transmission between motor and drum;
4. Pumps;
5. Shock absorbers and springs;
6. Washing drum, drum spider and related ball bearings;
7. Heaters and heating elements, including heat pumps;
8. Piping and related equipment including all hoses, valves, filters and aquastops;
9. Printed circuit boards;
10. Electronic displays;
11. Pressure switches;
12. Thermostats and sensors;
13. Software and firmware including reset software;
14. Door, door hinge and seals, door locking assembly;
15. Other seals and plastic peripherals as detergent dispensers.

This information is in line with the indications provided by stakeholders for this study, suggesting that priority parts for repair should include: motor brushes, pumps, shock absorbers, drum/ball bearings, heaters, door hinges, drum spiders and seals, water supply valves, Printed Circuit Boards (electronic control and user interface boards, as well as motor, drive belt and engine PCBs). Furthermore, software and firmware could be important, but only for connected devices.

Also based on confidential information shared by a testing consumer organisation, there is quantitative evidence that the above list cover parts that have the highest frequency of failures for washing machines[77]. From Figure 11, it is considered that a higher weight (=3) should be assigned to:

[76] In brushed motors (universal motors) tachometer coil is important to give speed feedback to the motor controller

[77] Other parts can be functionally important (e.g. legs and balance counterweight) but no evidence has been found about their relevance in terms of failure rates

- Motor brushes;
- Shock absorbers and springs;
- Washing drum, drum spider and related ball bearings (separately or bundled);
- Printed circuit boards;
- Electronic displays;
- Door, door hinge and seals, door locking assembly.

A weight equal to 1 is instead proposed for the other priority parts.

Table 17: List of priority parts for washing machines

Group of priority parts	Relevance for repair	Relevance for upgrade	Weight
1) Motor	1) Identified as relevant in the Ecodesign regulation for washing machines 2) Indicated by stakeholders involved in this study		1
2) Motor brushes	1) Identified as relevant in the Ecodesign regulation for washing machines 2) Indicated by stakeholders involved in this study 3) High frequency of failure (> 10%) Note: As indicated by stakeholders, failure of motors is frequently related to the carbon brushes, which are very small and cheap elements compared to the motor, and usually can easily be replaced. Note: This priority part is not assessed for brushless motors.		3
3) Transmission between motor and drum (drive belt)	1) Identified as relevant in the Ecodesign regulation for washing machines 2) Indicated by stakeholders involved in this study		1
4) Pumps	1) Identified as relevant in the Ecodesign regulation for washing machines 2) Indicated by stakeholders involved in this study		1
5) Shock absorbers and springs	1) Identified as relevant in the Ecodesign regulation for washing machines 2) Indicated by stakeholders involved in this study 3) High frequency of failure (> 10%) Note: The unbalance due to the failure / incorrect functioning of the shock absorber can be the cause of further relevant failures, including wear-out of the bearings		3

Group of priority parts	Relevance for repair	Relevance for upgrade	Weight
6) Washing drum, drum spider and related ball bearings	1) Identified as relevant in the Ecodesign regulation for washing machines 2) Indicated by stakeholders involved in this study 3) High frequency of failure (> 10%) Note: these could be either separate or bundled		3
7) Heaters and heating elements, including heat pumps	1) Identified as relevant in the Ecodesign regulation for washing machines 2) Indicated by stakeholders involved in this study Note: these could be either separate or bundled		1
8) Piping and related equipment including all hoses, valves, filters and aquastops	1) Identified as relevant in the Ecodesign regulation for washing machines 2) Indicated by stakeholders involved in this study Note: these could be either separate or bundled		1
9) Printed Circuit Boards	1) Identified as relevant in the Ecodesign regulation for washing machines 2) Indicated by stakeholders involved in this study 3) High frequency of failure (> 10%) Notes: - Typically present in new washing machines (but not in all existing devices) - The PCB should be available independently from the power supply		3
10) Electronic displays	1) Identified as relevant in the Ecodesign regulation for washing machines 2) Indicated by stakeholders involved in this study		3

Group of priority parts	Relevance for repair	Relevance for upgrade	Weight
	3) High frequency of failure (> 10%) Note: Not applicable to all washing machines		
11) Pressure switches	1) Identified in preliminary work made by JRC on washing machines 2) Indicated by stakeholders involved in this study		1
12) Thermostats and sensors	1) Identified in preliminary work made by JRC on washing machines 2) Indicated by stakeholders involved in this study		1
13) Software and firmware, including reset software	1) Identified in preliminary work made by JRC on washing machines 2) Indicated by stakeholders involved in this study as relevant for connected devices only. Note: Not applicable to all washing machines		Not applicable since evaluated as separate product parameter
14) Door, door hinge and seals, door locking assembly	1) Identified as relevant in the Ecodesign regulation for washing machines 2) Indicated by stakeholders involved in this study 3) High frequency of failure (> 10%)		3
15) Other seals and plastic peripherals as detergent dispensers	1) Identified in preliminary work made by JRC on washing machines 2) Indicated by stakeholders involved in this study		1

Notes:
a) When a part is not used the maximum score is assigned for that part
b) Parts for which "bundled" is not specified have necessarily to be assessed separately

3.4.3 Key parameters

In washing machines, both the availability of spare parts and the ease of disassembly of broken parts strongly affect the reparability of the product. For many failures modes, the cost of repair is reported to be linked mainly to the duration of the repair operation and to the labour cost (Prakash et al. 2016) and the cost of the spare part. Moreover, the availability of diagnosis support interfaces, repair information and commercial guarantee can have a positive influence on the cost of repair and on the likelihood that consumers will repair the product after a failure.

It has been considered that the following parameters listed in Table 5 are relevant in order to rate washing machines:

- Disassembly depth/sequence (#1);
- Fasteners (#2);
- Diagnosis support and interfaces (#5);
- Type and availability of information (#6);
- Spare parts (#7);
- Software and firmware (#8);
- Commercial guarantee (#12).

When one or more parameters are not applicable to a specific model of washing machine, such parameters are not taken into account in the assessment of those products. This could be for example the case of software and firmware.

Some parameters have been excluded from the rating:

- Tools (#3)[78]: the revised Ecodesign regulation for household washing machines (EC 2018b) requires that main parts of washing machines have to be replaceable with the use of commonly available tools and without permanent damage. Since this corresponds to the maximum score achievable for this parameter, the parameter itself becomes unnecessary.

- Disassembly time (#4): although this parameter can be relevant since the repair duration affects repair costs, disassembly time is also covered indirectly by other parameters (e.g. disassembly depth, fasteners, availability of repair information). Moreover, methodological developments are still needed before such parameter can be measured in a standardised and not-too-burdensome way. The definition of reference values for a representative sample of washing machines, and the verification of the information provided in the scoring system, would require a significant amount of resources. In order to keep the scoring system simpler, it is considered that such parameter should be excluded from the assessment, at least for the moment. Given its potentiality, its application could be reconsidered in the future.

- Safety, skills and working environment (#9): since product and consumer safety has always to be ensured, the most likely repair scenario for the repair of washing machines requires the intervention of professionals. This has been recognised

[78] Tools for washing machines have been categorised in 2 classes based on the input of stakeholders: I) Basic tools: Screwdriver for slotted heads, cross recess or for hexalobular recess heads (ISO2380, ISO8764, ISO10664); Hexagon socket key (ISO2936); Combination wrench (ISO7738); Combination pliers (ISO5746); Half round nose pliers (ISO5745); Diagonal cutters (ISO5749); Multigrip pliers (multiple slip joint pliers) (ISO8976); Locking pliers; Combination pliers for wire stripping & terminal crimping; Prying lever; Tweezers; Hammer, steel head (ISO15601); Utility knife (cutter) with snap-off blades; Multimeter; Voltage tester; Soldering iron; Hot glue gun; Magnifying glass; II) Other tools (including: torx and socket wrenches, torx screwdrivers, stecker screwdrivers, tube and torque spanners, adjustable plier, pully tightening support, optical interface for diagnosis and software update, laptop computer, safety checking devices (to check whether there leakages)

indirectly in the revised Ecodesign regulation, where the access to information and to most of spare parts are requested for professional repairers while the same access enabling self-repair by end users is requested only for the door system and plastic peripherals. Therefore, no significant differentiation is expected for this parameter between products on the market. On the other hand, information for a correct use, maintenance and repair of the washing machine (like cleaning or changing the filters) should be provided (see section 3.4.3.4).

- Data transfer and deletion (#10): This aspect is becoming more relevant with the diffusion of the Internet of Things, and thus associable with smart washing machines. However, this does not seem to be at this stage a key barrier for the repair/upgrade of the product.

- Password reset and restoration of factory settings (#11): The revised of Ecodesign regulation include a requirement about the availability of reset software, at least for professional repairers. Newer washing machines may come with a reset feature that allows restarting the device once an error code or fault occurs. This can come as a specific button or with reset positions to clear problems with a programme. However, it was reported by stakeholders that, on a machine without a reset button, the reset could be done by unplugging the washing machine and then plugging it back. Based on these elements, and in order to keep the assessment simpler, it is considered that this aspect is not critical for the reparability of this product group. The inclusion of such parameter could be revaluated in the future.

Based on the feedback received from stakeholders, the following weights are preliminarily proposed for single parameters to reflect their relative importance for this product group:

- Disassembly depth/sequence (#1): high weight (=2);

- Fasteners (#2): high weight (=2);

- Diagnosis support and interfaces (#5): high weight (=2);

- Type and availability of information (#6): high weight (=2);

- Spare parts (#7): high weight (=2);

- Software and firmware (#8): normal weight (= 1).

No weight is assigned to commercial guarantee (#12) since it is not proposed to be aggregated but considered as complementary metric.

A higher weight has been assigned to aspects for washing machines relating to mechanical issues, to the identification of failures, and to the provision of information and spare parts. However, weights could be refined also based on the analysis of the variation of the characteristics of products on the market. This could also come with further reduction of parameters to assess in case no significant differentiation is found for one or more parameters.

Considering the indices defined in section 2.3.2, and based on the weights defined above:

- The score of the Disassemblability Index would be 1/2 the score of #1 + 1/2 the score of #2;

- The score of the RRU Process Index would be 2/7 the score of #5 + 2/7 the score of #6 + 2/7 the score of #7 + 1/7 the score of #8;

- The score of the Overall RRU Index would be 2/11 the score of #1 + 2/11 the score of #2 + 2/11 the score of #5 + 2/11 the score of #6 + 2/11 the score of #7 + 1/11 the score of #8;

- The score of the Commercial Guarantee Index would be equal to the score of #12.

3.4.3.1 Disassembly depth/sequence

As described in Table 5, manufacturers have to make available the disassembly sequence for each priority part to target group of repairerss, in this case constituted at least by professional repairers. A mandatory requirement about access to Repair and Maintenance Information for professional repairers has been introduced in the revised Ecodesign regulation for washing machines (see also section 3.4.3.4).

Furthermore, the disassembly process of a washing machine can involve several steps. As an example, Table 18 reports the results of an analysis carried out for a washing machine evaluated in the Benelux study on reparability (Bracquené et al. 2018) The analysis provides an illustrative example about the number of disassembly steps for each specific part investigated in the study.

Table 18: Example of number of steps required for the partial disassembly of a washing machine (Bracquené et al. 2018)

Disassembly target	Number of steps
Total disassembly	38
(Drain) Pumps	7
Hose (in/out)	9
Aquastop/Valves	3
Filters	1
Motor (other)	4
Drive belt	3
Shock absorbers	6
Bearings	15
Drum & tub	15
Electronics (programs)	5
Door seals	6
Door lock	5
Other (hinges)	4
Heater & thermostats	6

Note: The consecutive removal of more connectors with the same tool is considered as one disassembly step in the referenced document.

For washing machines, the disassembly depth could be scored on the basis of a continuous rating, as reported in Table 5. For each priority part, the reference Disassembly Depth would need to be defined as the greatest value among the Disassembly Depths calculated for a sample of representative washing machines on the market. In order to include this parameter in the assessment, further investigation and involvement of stakeholders would be required. In case the Disassembly Depths of a product were greater than the reference Disassembly Depth, the score of this parameter would be set to 0.

3.4.3.2 Fasteners

This parameter is considered to be applicable as indicated in Table 5. In case different types of fasteners are used, the score corresponding to the worst case is considered.
A stakeholder has observed that non-removable fastening system having interlocked parts could contribute to prolong the durability of the product. However, no quantitative information has been found in support.

3.4.3.3 Diagnosis support and interfaces

Self-diagnosis/test features are already provided in some models to support customers in the use and maintenance of the product, as well as to identify failures and facilitate repair.

Diagnosis of failures can cover most of the priority parts of the washing machine. In several cases the interface is provided by error codes in the washing machine display. Based on input from industry stakeholders, it seems that software/diagnosis tools can either be proprietary tools available only to official repairers, or publicly available tools that consumers can use at home. This is considered to support the classification system provided in in Table 5.

A non-exhaustive list of failure modes that should be detectable for each priority part is described below:

- Motors and motor brushes: stalled motor, motor overheating, motor overcurrent, carbon brushes wearing, motor tachometer coil failure;

- Pumps: water level does not change after the drain pump is on, draining pump shaft failure, leakage;

- Shock absorbers and springs: detection of an off-balance load, wearing;

- Washing drum, drum spider and related ball bearings: frictions issues, ball bearings wearing;

- Heaters and heating elements, including heat pumps: open heater, derived-to-earth heater, shorted-open or out-of-range thermistor;

- Piping and related equipment including all hoses, valves, filters and aquastops: not correct hoses connection, piping perforation or obstruction and inlet valve obstruction;

- Printed Circuit Boards: electronics faults including central and motor control boards and panels, program selectors, relays, line filters, etc.;

- Electronic displays: non-visible diplay, problems with touch control layer;

- Thermostats and sensors: malfunctioning of sensors (e.g. leakage detector, presostats, load sensor, intake sensor);

- Door hinge and seal: seal perforation and water spill;

- Door locking assembly separable into its constituent sub-components: door lock failure and water spill.

3.4.3.4 Type and availability of information

The revised Ecodesign regulation for washing machines (EC 2018b) provides minimum requirements for the provision of information.

1) After a period of 2 years after the placing on the market of the first unit of a model and until a minimum period of 10 years after placing the last unit of the model on the

market, the manufacturer, importer or authorised representative has to provide access to repair and maintenance information to professional repairers in the following conditions:

a) The manufacturer's, importer's or authorised representative's website has to indicate the process for professional repairers to register for access to information; to accept such a request, the manufacturers, importers or authorised representatives may require the professional repairer to demonstrate that

(i) The professional repairer has the technical competence to repair washing machines and complies with the applicable regulations for repairers of electrical equipment in the Member States where it operates. Reference to an official registration system as professional repairer, where such system exists in the Member States concerned, has to be accepted as proof of compliance with this point;

(ii) The professional repairer is covered by insurance covering liabilities resulting from its activity regardless of whether this is required by the Member State.

b) The manufacturers, importers or authorised representatives have to accept or refuse the registration within 5 working days from the date of request;

c) Manufacturers, importers or authorised representatives may charge reasonable and proportionate fees for access to the repair and maintenance information or for receiving regular updates. A fee is reasonable if it does not discourage access by failing to take into account the extent to which the professional repairer uses the information;

d) Once registered, a professional repairer has access, within one working day after requesting it, to the requested repair and maintenance information. The information may be provided for an equivalent model or model of the same family, if relevant.

e) The repair and maintenance information has to include:

- The unequivocal identification of the machine;

- A disassembly map or exploded view;

- Technical manuals of instructions for repair;

- List of necessary repair and test equipment;

- Component and diagnosis information (such as minimum and maximum theoretical values for measurements);

- Wiring and connection diagrams;

- Diagnostic fault and error codes (including manufacturer-specific codes, where applicable);

- Instructions for installation of relevant software and firmware including reset software; and

- Information on how to access data records of reported failure incidents stored on the household washing machine or washer-dryer (where applicable).

2) User instructions have also to be provided in the form of a user manual on a free access website of the manufacturer, importer or authorised representatives. This has also to include instructions for the user to perform maintenance operations, which as a minimum has to include information on:

- Correct installation;

- Correct use of detergent, softeners and other additives, and main consequences of incorrect dosage;

- Foreign object removal from the machine;

- Periodic cleaning, including optimal frequency, and limescale prevention and procedure;

- Door opening between cycles, if appropriate;

- Periodic checks of filters, including optimal frequency, and procedure;

- Identification of errors, the meaning of the errors, and the action required, including identification of errors requiring professional assistance;

- How to access to professional repair (internet webpages, addresses, contact details);

- Any implications of self-repair or non-professional repair for the safety of the end-user and for the legal guarantee, and when applicable, also to the commercial guarantee;

- The minimum period during which the spare parts for the machine are available.

Moreover, information on price of spare parts has to be reported publicly to enter the scoring system, in accordance with the general rules set in Table 5 of this document.

These prescriptions are considered as a pass/fail criterion in this preliminary definition of a scoring system for washing machines.

The rating of this parameter is based on the target group of repairers and on the cost of the repair and maintenance information (1):

I) Public availability at no additional cost for consumers = 1 pt;

II) Available only to registered professional repairers = 0.5 pt.

Channels for communicating information may include printed manuals, websites, digital information carriers such as QR codes, DVDs or flash drives.

3.4.3.5 Spare parts

The revised Ecodesign regulation for washing machines (EC 2018b) requires manufacturers, importers or authorised representatives to make available to professional repairers at least the following spare parts, for a minimum period of 10 after placing the last unit of the model on the market:

- motor and motor brushes;

- transmission between motor and drum;

- pumps;

- shock absorbers and springs;

- washing drum, drum spider and related ball bearings (separately or bundled);

- heaters and heating elements, including heat pumps (separately or bundled);

- piping and related equipment including all hoses, valves, filters and aquastops (separately or bundled);

- printed circuit boards;

- electronic displays;

- pressure switches;

- thermostats and sensors;

- door, door hinge and seals, other seals, door locking assembly and plastic peripherals such as detergent dispensers.

The list of these spare parts and the procedure for ordering them have to be publicly available on the free access website of the manufacturer, importer or authorised representative, at the latest 2 years after the placing on the market of the first unit of a model and until the end of the period of availability of these spare parts. The availability of these spare parts may be limited to registered professional repairers.

Door, door hinge and seals, other seals, door locking assembly and plastic peripherals such as detergent dispensers have to be made available also to end users. The list of these spare parts and the procedure for ordering them (as well as the repair instructions) have to be publicly available on the free access website of the manufacturer, importer or authorised representative, when placing the first unit of a model on the market and until the end of the period of availability of these spare parts.

During the period mentioned above, the manufacturer, importer or authorised representative has to ensure the delivery of the spare parts within 15 working days after having received the order.

These prescriptions are considered as pass/fail criterion in the preliminary definition of a scoring system for washing machines.

Considering the already ambitious level of the Ecodesign requirement on spare parts in terms of availability over time, and the difficulty to identify standard interfaces for this product group, the rating of this parameter is based only on the target group to which spare parts are available:

I) The maximum of points (1) is assigned if spare parts are made available publicly;

II) 0.5 points are assigned if spare parts are made available for professional repairers only.

3.4.3.6 Software and firmware

Internet of Things (IoT) has been affecting the way we use household appliances like washing machines. Software and firmware updates are expected to have an increased relevance in the next few years in order to support intelligent system to monitor and control washing machine through internet by an IoT based wireless sensor network. Moreover, many failures could be resolved through software upgrade. New connected appliances have this feature along with diagnosis and self-repair guides with smart application apps. However, the market penetration of smart washing machines seems to be still marginal.[79]

The revised Ecodesign regulation for washing machines (EC 2018b) includes the availability of software and firmware (including reset software) for professional repairers under the requirement on spare parts. As pass/fail criterion for the scoring system, the same approach used for spare parts is applied here.

Full compatibility with open source Operating Systems is not considered relevant for this product group.

Information about how updates will affect the original system characteristics has to be provided The consumption of energy and water of the product and any of the other declared parameters shall not deteriorate after a software or firmware update when measured with the same test standard originally used for the declaration of conformity, except with explicit consent of the end-user prior to the update. No performance change shall occur as a result of rejecting the update.

[79] https://www.statista.com/statistics/506589/smart-washing-machine-market-increase-uk-statistic/ (accessed on 24 September 2018)

However, there should be always the option to not install, to install or to uninstall an update.

The parameter is then rated based on the availability of updates and support to the target group of repairers and the cost associated with the service, according to the information provided in Table 5.

A score is assigned for the product based on the target groups:

I) Software/Firmware updates and support are offered publicly = 1 pt.

II) Software/Firmware updates and support are offered to professional repairers only = 0.5 pt.

A score is assigned for the product also based on the cost of the software/firmware update service:

I) Software/Firmware updates and support are offered free of charge for at least 10 years = 1 pt;

II) Software/Firmware updates and support are offered free of charge for X years = X/10 pt.

The overall score for this parameter is the product of the two scores described above.

3.4.3.7 Commercial guarantee

Different manufacturers include an extended guarantee on their products for different lengths of time. A list of manufacturers and the length of the guarantees offered in the UK has been found[80] (see Figure 12).

As described in Table 5, a score is assigned to the product based on the availability of a "commercial guarantee" for the entire product and including a "commitment to free repair as first remedy" in case of failure.

In analogy with spare parts, 10 years are taken as reference for the rating:

- 1 point is assigned if a commercial guarantee is offered, in addition to the legal obligations, covering a period post-sale of at least 10 years;

- 0 points are assigned in case of fulfilment of minimum legal requirements of 2 years;

- Points are modulated proportionally for intermediate cases.

Commercial guarantees must be related to the entire product, provided in the entire EU, be included in the sales price of the product, and not result in any additional costs for consumers.

The commercial guarantee must be provided in the entire EU, be related to the entire product, be included in the sale price of the product, and the remedies proposed by the guarantor will not result in any costs for the consumer (e.g. it means that the repair is for free).

[80] http://extendedwarrantycomparison.co.uk/washing-machine-extended-warranty-comparison-guide/ (accessed on 19 October 2018)

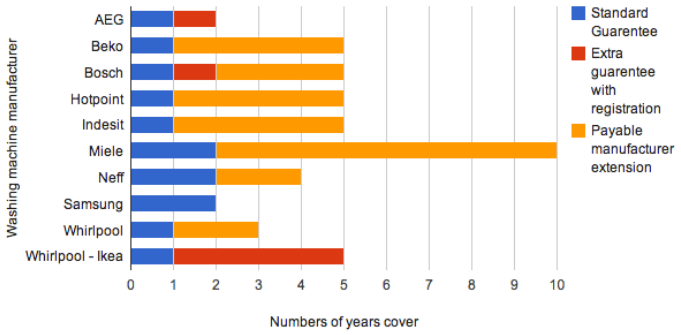


Figure 12: Guarantees offered by manufacturers of washing machines in the UK[81]

[81] http://extendedwarrantycomparison.co.uk/washing-machine-extended-warranty-comparison-guide/ (accessed on 19 October 2018)

3.4.4 Overview

The overview of parameters, criteria and weights preliminarily proposed for washing machines is presented in Table 19.

Table 19: Parameters, criteria and weights preliminarily proposed for washing machines

Parameter	Pass/fail criteria	Rating	Assessment and verification	Weight of the parameter
1) Disassembly depth/sequence	For each priority part, information about the disassembly sequence has to be available to the target group of repairers (see #6)	None (no rating is proposed since data regarding disassembly depths has not been collected for this study)	A: A description supported by illustrations of the steps needed to disassemble priority parts is needed. The description has to show that the disassembly is reversible by including the steps needed for the reassembly of priority parts. V: physical disassembly and recording of the operation are needed.	High = 2
2) Fasteners	None	A score is assigned for each priority part according to the reversibility and reusability of the fasteners used for its assembly. I) Reusable: an original fastening system that can be completely re-used, or any elements of the fastening system that cannot be re-used are supplied with the new part for a repair, re-use or upgrade process = 1 pt. II) Removable: an original fastening system that is not reusable, but can be removed without causing damage or leaving residue which precludes reassembly or reuse of the removed part = 0.5 pt. III) Non-removable: original fastening	A: A description supported by illustrations of the fasteners to be removed for the disassembly of priority parts is needed. V: Physical disassembly and inventory of fasteners are needed.	High = 2

Parameter	Pass/fail criteria	Rating	Assessment and verification	Weight of the parameter
		systems are not removable or reusable, as defined above = 0 pt. Note: In case different types of fasteners are used in the assembly of a priority part, the score corresponding to the worst type of fasteners case will be considered.		
3) Tools	None	None	None	None
4) Disassembly time	None	None	None	None
5) Provision of diagnosis support and interfaces	None	A score is assigned for the product based on the availability of diagnosis support and interfaces to aid the identification of typical failure modes associated to the priority part: I) Intuitive/ coded interface with public reference table: all main faults can be diagnosed either by i) a signal that can be intuitively understood, or ii) by consulting fault-finding trees and/or reference codes information supplied with the product = 1 pt. II) Publicly available hardware/ software interface: to be diagnosed, some of the main faults need the use of hardware, software and other support which is publicly available = 0.66 pt. III) Proprietary interface: to be diagnosed, some of the main faults need the use of proprietary tools, change of settings or transfer of software which are not included with the product = 0.33 pt.	A: The following documentation is needed, where applicable: Description of failure modes and related coding (if used); Reference to the required hardware material /software tools required (if used); Contact details of support service, services offered and associated costs (if any). V: Check of actual availability and operability.	High = 2

Parameter	Pass/fail criteria	Rating	Assessment and verification	Weight of the parameter
		Note: 1) A preliminary list of main failure modes associated to the product group under assessment is reported in section 3.4.3.3 2) Publicly available hardware / software interface can include hardware functionality testing software tools developed by a third party, provided the software tools are publicly available and the manufacturer provides information on their accessibility and applicable updates. The product can be equipped with an appropriate interface for hardware and software to do fault diagnosis and reading, adjustment or resetting of parameters or settings (e.g. external memory device, data cable connection, or from a remote source using a network connection). The port, slot, or connector that is used for the hardware and software interface is accessible without tools.		
6) Availability and type of information	Information requirements according to the revised Ecodesign regulation (EC 2018b, see also section 3.4.3.4) Price of spare parts to be also disclosed (See #7)	I) A score of 1 is assigned for the product if all the information of the pass/fail criterion is made available publicly at no additional cost for consumers. II) Otherwise, 0.5 points are assigned.	A: All relevant information for maintenance, repair and upgrade needs to be compiled and made available to the target group of repairers. V: Check of actual availability.	High = 2
7) Spare parts	In accordance with the revised Ecodesign regulation: - Manufacturers, importers or authorised representatives have to make available to professional repairers the spare parts listed in	For each priority part, I) The maximum of points (1) is assigned if the spare part is made available publicly; II) 0.5 points are assigned if the spare part is made available for professional repairers only.	A: Commitment by the manufacturer about the availability of spare parts over time, as well as provision of information about:	High = 2

Parameter	Pass/fail criteria	Rating	Assessment and verification	Weight of the parameter
	section 3.4.3.5 - Spare parts have to be available for a minimum period of 10 after placing the last unit of the model on the market - The list of these spare parts and the procedure for ordering them have to be publicly available on the free access website at the latest 2 years after the placing on the market of the first unit of a model and until the end of the period of availability of these spare parts. - The availability of these spare parts may be limited to registered professional repairers. Door, door hinge and seals, other seals, door locking assembly and plastic peripherals such as detergent dispensers have to be made available also to end users. - The delivery of the spare parts has to be within 15 working days after having received the order. Price of spare parts to be also disclosed		- Delivery time - Recommended retail price of spare parts - Target groups - Interface used. V: Check of actual availability.	
8) Software and firmware	In accordance with the revised Ecodesign regulation (EC 2018), software/firmware updates and support are offered for a duration post-manufacture of at least 10 years. Information about how updates will affect the original system characteristics (including the energy and water consumption) has to be	a) A score is assigned for the product based on the target groups: I) Software/Firmware updates and support are offered publicly = 1 pt. II) Software/Firmware updates and support are offered to professional repairers only = 0.5 pt. b) A score is assigned for the product also based on the cost of the software/firmware	A: Declaration about the duration of availability of software and firmware over time, as well as information about costs, and information about how updates will affect the original system characteristics. V: Check of actual	Normal = 1

Parameter	Pass/fail criteria	Rating	Assessment and verification	Weight of the parameter
	provided and there is to be always the option to not install, to install or to uninstall the update. No performance change shall occur as a result of rejecting the update	update service: I) Software/Firmware updates and support are offered free of charge for at least 10 years = 1 pt; II) Software/Firmware updates and support are offered free of charge for X years = X/10 pt. The overall score for this parameter is the product of the two scores described above.	availability, compatibility, and possibility to avoid/reverse the update.	
9) Safety, skills and working environment	None	None	None	None
10) Password reset and restoration of factory settings	None	None	None	None
11) Data transfer and deletion	None	None	None	None
12) Commercial guarantee	None	A score is assigned based on the availability of a "commercial guarantee" for the entire product offered by the guarantor, and including a "commitment to free repair as first remedy" in case of failures I) 1 point is assigned if a commercial guarantee is offered, in addition to the legal obligations, covering a period post-sale of at least 10 years. II) Points are modulated proportionally for intermediate cases. III) 0 points are assigned in case of fulfilment of minimum legal requirements	A: Guarantee contract is needed, with emphasis on "free repair first" clauses. V: Check of availability of guarantee, clauses statement and actual possibility of repair in case of failure.	Not Applied

Parameter	Pass/fail criteria	Rating	Assessment and verification	Weight of the parameter
		of 2 years. Note: 1) "Commercial guarantee" means any undertaking by the seller or a producer (the guarantor) to the consumer, in addition to his legal obligation relating to the guarantee of conformity, to reimburse the price paid or to replace, repair or service goods in any way if they do not meet the specifications or any other requirements not related to conformity set out in the guarantee statement or in the relevant advertising available at the time of, or before the conclusion of the contract. 2) For the purpose of being able to be taken into account in the "Repair Score System", the commercial guarantee must be related to the entire product (not only specific components), provided in the entire EU, be included in the sale price of the product, and the remedies proposed by the guarantor will not result in any costs for the consumer (e.g. it means that the repair is for free).		

4 ADDITIONAL CONSIDERATIONS

This section compiles additional issues and opinions pointed out by stakeholders and related to the development of the scoring system for assessing the reparability and upgradability of products and its possible policy implications at EU level.

4.1 Reparability and upgradeability vs. reliability of products

Some stakeholders underlined that the preliminary analysis of products would be needed to assess and discuss on advantages and drawbacks associated to different material efficiency measures for those products (e.g. reliability vs. reparability) and to alternative options which could be used to provide durability-related information to consumers (including a scoring system for assessing reparability and upgradability of products).

It has been remarked that durability of a product is relevant as long as a product has actually an extended service life (this is for instance not the case for functionally obsolete products kept unused in a drawer). Reliability, reparability and upgradability are all measures targeted to extending the service lifetime of products and tightly linked to each other. At least for some product groups, reliability could have higher importance than reparability and upgradeability. Reparability can be still complementary in those cases but should not come at the expenses of a bad reliability, which would imply frequent reparations (at the cost of users and the environment).

4.2 Link to policy framework and standardisation

According to some industry stakeholders, the necessary services to ensure the proper and safe repair of products are already available on the market. Repair is part of brands after-sales strategies and a way for companies to compete to offer appropriate services to consumers. Nevertheless, complaints received by consumer associations around Europe show that the repair service offered by some companies does not reflect this, especially during the legal guarantee period.

Industry stakeholders are in general in favour of developing an internal evaluation tool for assessing the reparability and upgradability of products (e.g. as done in standardisation). However, some of them have concerns with respect to the possible use of such a tool as the basis for setting legal requirements, due to the inherent elements of subjectivity associated to any rating and weighting approach.

According to them, for any regulatory application, the Better Regulation agenda must apply to ensure coherence and legal certainty. When legal requirements are set, they must be clear and consistent, supporting innovation and creating the conditions for competitiveness.

Legal requirements that are based on evaluation methods that are not sufficiently precise would impact the current competitive landscape between companies and will lead to market distortions. It has to be possible to verify any requirement efficiently, which is done by market surveillance authorities in case of Ecodesign and Energy Label.

Measurement methods used for regulatory purposes should thus respect the following requirements:

i) They have to leave no or minimal room of interpretation or doubt;

ii) They have to be enforceable by Member States;

iii) They do not have to cause excessive burdens (e.g. in terms of costs, duration, laboratory capacity).

Moreover, some industry stakeholders wished to link formally the ongoing work of the JTC10 WG 3 to this scoring system for reparability and upgradeability.

4.3 Safety and liability of the product

Consumer protection and safety were reported to be a key element to maintain trust with consumers and not to jeopardise efforts for the circular economy. In some cases, the repair of products may need appropriate technical skills that most consumers do not have. If a product is not properly repaired, consumer safety could be compromised. If a consumer has repaired a product, the liability for the safety of the product is not with the manufacturer, although it was reported by some industry representatives that there could be always the likelihood of negative media and publicity which cannot be easily corrected. According to some manufacturers, to ensure the safety and conformity of products, repair of appliances should be made by authorised repair operators only. On the other hand, other stakeholders consider that it should be possible for consumers and/or independent repair operators to make repairs during the legal guarantee period without voiding the guarantee.

4.4 Communication issues

Communicating information must not be misleading and has to be transparent, simple and understandable by consumers, who should be able to know if a product can be repaired/upgraded easily and at an affordable cost or not.

Some stakeholders consider that any aggregation of results into one overall score is not advisable, as it will always run the risk of being misinterpreted, depending on consumers' individual conditions and the use situation, and the type of product being examined.

Transparency on all calculations is a "must", in order to:

- Establish trust in the assessment and allow retro-feedback to improve the framework
- Increase consumers' awareness on what makes a product more or less repairable
- Foster competition between manufacturers to produce more reparable goods.

4.5 Follow-up

The study should be to followed-up by an analysis of real products on the market aimed to understand how to adjust parameters, rating and weighting of the scoring system and how frequently to maintain/update it over time for specific categories of products. Some stakeholders indicated their intention to support a possible testing phase.

5 CONCLUSIONS

The present study aimed at investigating how to develop a possible scoring system to inform about the ability to repair and upgrade products placed on the market, which is a key element for the implementation of the EU action plan for the Circular Economy.

Existing methods to assess the reparability and upgradability of products have been analysed and used as starting point for the development of a general scoring system. The following needs have been identified:

- Objectivity and reproducibility of assessment and verification methods;
- Ease of understanding;
- Representativeness at EU level;
- Fair applicability to a broad scope of repair/upgrade strategies.

The general framework described in this report provides technical guidance for the identification of most relevant aspects and priority parts (i.e. hardware and software parts of products) for products on the market and for scoring and aggregating different aspects of repair and upgrade.

Although inherent to any scoring framework, elements of subjectivity (e.g. expert judgements and value choices for the definition of rating and weighting criteria) have been limited as far as possible by referring to existing standards/legislation, and to parameters considered to be assessable and verifiable in a homogeneous and fair way across the EU. In this respect, the experience gained by CEN-CENELEC-JTC10 during the development of prEN 45554 is considered as the most robust discussion ground, on which to build complementary elements (e.g. rating of parameters and aggregation of scores).

A limited number of technical parameters (12) has been selected that cover design characteristics (4) as well as relevant operational aspects related to the repair/upgrade of products (8). Technical parameters may also address economic aspects indirectly (for example the easiness of disassembling has an impact on the duration of a repair and therefore its cost).

The assessment of products has been simplified by focusing on priority parts to be defined on a product group basis, taking into account aspects such as the frequency of failure/upgrade, the functional importance of parts, as well as qualitative information. A hybrid system is proposed which is based on:

a) Pass/fail criteria that products have to fulfil in order to be considered as reparable/upgradable, and thus eligible for being assessed through the scoring criteria;

b) Scoring criteria, to rate the extent to which products are more or less reparable/upgradable.

Scores can be aggregated and reported in different types of indices, which could be more or less suitable based on the final application of the scoring system. However, it is recognised that background information used for their quantification should be also provided for transparency reasons.

It is also apparent that a scoring system has to be tailored to reflect specificities of groups/ types of products. The general framework has been preliminarily tailored for three illustrative product groups in order to better understand specific aspects and needs when assessing the reparability and upgradability of products:

- Laptops, which is an example where a type of product belonging to the family of notebooks is assessed;
- Vacuum cleaners, which is an example where the product is assessed with a more granular scope;

- Washing machines, which is an example where an entire product group is commonly assessed.

At product group level, further simplification has been sought by focusing on key parameters only and in order to keep the assessment practical. In this respect, it is interesting to observe that the development of a scoring system results far less complicated where solid legislation boundaries are set (this is for instance the case for washing machines, for which the Ecodesign regulation No 1015/2010 has been revised in 2019).

This scoring system could serve as a technical reference for potential use in policy-making (e.g. Ecodesign, Energy Label, GPP, Ecolabel), for the design of a new label, or as public guidance document (for designers and consumer testing organisations). However, the study itself does not propose or pre-empt any future policy decision.

Moreover, it is anticipated that the assessment framework should be revised periodically, in the logic of continuous methodological improvement and adaptation to changing market conditions. In particular, the applicability of the scoring system should be supported by future investigation aiming at:

- The analysis of how consumers understand different types of information related to the repair/upgrade of products delivered through alternative communication vehicles;

- The analysis of the performance of real products on the market to understand how parameters, rating and weighting of the scoring system should be adjusted (also by integrating standard methods, when available), and how frequently they should be updated over time.

Finally, it has to be observed that different material efficiency aspects should be evaluated in a preliminary phase to understand which are the best strategies to implement for a specific product (e.g. similar levels of benefits could be achieved either designing more reliable products that last longer, or that can be repaired/upgraded more easily). Durability of a product is relevant as long as a product has actually an extended service life. Reliability, reparability and upgradability are all durability aspects targeted to extending the service lifetime of products and tightly linked to each other. Also in the cases in which reliability could have higher importance, reparability and upgradability can be still complementary to extend the lifetime of products.

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ANNEX I – INITIAL QUESTIONNAIRE FOR STAKEHOLDERS

Part 1) Existing methods, labels, or schemes for the assessing reparability and upgradability of products

Q1.1 Please give your opinion on the methods, labels or schemes listed below, and which can be used to assess the reparability and upgradability of products

Please fill in the table below based on your knowledge about the reported methods and labels. If you are not familiar, please indicate that the "method is not known".

Method/Label	*Familiarity with the method*	*Advantages*	*Disadvantages*	*Overall opinion about the diffusion and robustness of the use of the method as a scoring system*
Austrian standard ONR 192102				
Design For Repairability tool				
i-Fixit scoring system				
Groupe SEB's Product Repairable label				
prEN 45554 - General methods for the assessment of the ability to repair, reuse and upgrade energy related products				

Q1.2 Please provide information regarding any other methods, labels or schemes which you are aware of, and which can be used to assess the reparability and upgradability of products

Please fill in the table below about additional methods and labels.

Method/Label	*Scope*	*Advantages*	*Disadvantages*	*Familiarity with the method, and overall opinion about diffusion and robustness of the use of the method as a scoring system*

Part 2) Aspects influencing the reparability and upgradability of products in general

Q2.1 Which are in your opinion the most relevant parameters influencing repair and upgrade of products? How could these be assessed and verified?

Please fill in the table below by firstly evaluating their relevance based on your experience (H: high, M: medium, L: low, N: no), and secondly describing if and how they could be assessed and verified in practice. Note: an example of assessment and verification option could be to make available the instructions about the steps needed to disassemble a part.

Parameter	*Relevance for repair (High/Medium/Low/No)*	*Relevance for upgrade (High/Medium/Low/No)*	*Options for the assessment and verification*
Disassembly sequence			
Type, number and visibility of fastenings and connectors			
Tools needed (availability, complexity, cost)			
Ease of access to parts			
Working environment (e.g. home, professional repair site, manufacturing plant)			
Level of skills required to undertake the operations			
Provision of diagnostic support and interfaces			
Availability of spare parts			
Availability and ease of installation of software and firmware			
Availability of information (e.g. repair and/or upgrade manuals,			

Parameter	*Relevance for repair (High/Medium/Low/No)*	*Relevance for upgrade (High/Medium/Low/No)*	*Options for the assessment and verification*
exploded diagrams)			
Others [82] (please specify)			

Q2.2 Besides the technical aspects listed above, other factors currently limit the repair and upgrade of products (e.g. purchase price and labour costs, demand for new vs. repaired/upgraded products, support networks facilitating the repair process, business models, compatibility issues). In your opinion, under which conditions are repair and upgrade operations more likely to occur?

Aspect	*Favourable conditions for repair*	*Favourable conditions for upgrade*
Functional, technological and behavioural factors (e.g. demand for new vs. repaired/upgraded products)		
Economic factors (e.g. purchase price for product and spare parts, labour costs)		
Organisational factors (e.g. access to professional repair services or support networks)		
Legal factors (e.g. legal guarantee, liability issues)		
Others (please specify)		

[82] For instance, an overall measure of disassemblability (ease/difficulty of the disassembly operation), as combination of some of the parameters listed in the table

Part 3) Conditions influencing the reparability and upgradability of specific families of products

In Part 3 of the questionnaire, we would like you to consider the different motivations and aspects regarding repair and upgrading for different families of products. These might be split in various ways, but we have suggested - as examples – four representative subsets based on the following characteristics:

(a) **Small appliances** (e.g. vacuum cleaners, kettles, coffee machines, handheld drills, hair-dryers): goods which can be easily transported to a repair shop and which are generally perceived as less sophisticated by consumers attempting to repair them;

(b) **Medium/large appliances** (e.g. washing machines, dishwashers, refrigerators, freezers, cookers): goods for which a trained technician might normally come to your home to repair the product or you would have to make a dedicated logistics effort to transport them to be repaired;

(c) **Installed products** (e.g. a boiler or heat pump, or air conditioning appliances): goods for which a trained technician would normally be required to come out to examine the products, and where the product repair is normally related to and interacts with the environment in which it is placed;

(d) **ICT products** (e.g. imaging equipment, TVs, DVD players, mobile phones, tablets, personal computers, laptops): goods with a faster innovation cycle compared to the former categories and a size allowing a relatively easy displacement of the device for repair/upgrade.

Q3.1 Do you agree with the suggested subdivisions into the four families of products described above?

GRADED RESPONSE: Completely agree – mostly agree – partly agree – disagree mostly – Completely disagree

Q3.2 Do you have alternative approaches to propose?

OPEN QUESTION/RESPONSE

Q3.3 Which are the specific technical and economic conditions that could make repair attractive for the above mentioned families of products from a consumers-targeted perspective? Please also consider the alternative aspects/ suggestions, if any.

Aspect	*Small appliances*	*Medium/Large appliances*	*Installed products*	*ICT products*
Max cost of repair which would make it attractive, expressed as % of the product's purchase price				
Minimum lifetime expectancy for the product at the time of purchase, which would make repair attractive (in years)				
Maximum time of repair, including delivery of spare parts,				

Aspect	*Small appliances*	*Medium/Large appliances*	*Installed products*	*ICT products*
which would make it attractive (in weeks)				
Other comments				

Q3.4 Which are the specific technical and economic conditions that could make upgrade attractive for the above mentioned families of product from a consumers-targeted perspective? Please also consider the alternative aspects/ suggestions, if any.

Aspect	*Small appliances*	*Medium/Large appliances*	*Installed products*	*ICT products*
Max cost of upgrade which would make it appealing (free of charge, or expressed as % of the product's purchase price)				
Minimum lifetime expectancy for the product, at the time of purchase, which would make upgrade attractive (in years)				
Maximum time of upgrade, including delivery of new parts/functions, which would make it attractive (in weeks)				
Other comments				

Part 4) Identification of priority parts

Q4.1 Do you consider that the draft standard prEN 45554 is suitable as basis for the development of a generic scoring system for the assessment of the repair/upgrade of products?

YES

Up to a certain extent

NO

Q4.2 Please describe which modifications and integrations are needed in the context of this study about the development of a scoring system, or where other parameters and aspects could be used either to complement or replace those described in the standard.

Please reply (OPEN RESPONSES)

Q4.3 From the aspects listed below, which in your opinion are more relevant to identify priority parts with respect to reparability?

Please firstly evaluate their relevance based on your experience (H: high, M: medium, L: low, N: no), and secondly provide indications for differentiating between priority and non-relevant parts

Parameter	*Relevance (H/M/L/N)*	*Further indications for evaluating the importance of parts with respect to reparability*
Frequency of failure of parts		
Functional importance of parts and software		
Economic value of parts (e.g. purchase price) and related repair operations as % of the product price		
Environmental impacts of parts as % of the total environmental impacts of the product		
Steps needed to disassembly parts		
Others (please specify)		

Q4.4 From the aspects listed below, which in your opinion are more relevant to be able to identify priority parts with respect to upgradability?

Please firstly evaluate their relevance based on your experience (H: high, M: medium, L: low, N: no), and secondly provide indications for differentiating between priority and non-relevant parts

Parameter	*Relevance (H/M/L/N)*	*Indications for evaluating the importance of parts with respect to upgradability*
Frequency of upgrade of parts and software, where relevant		
Functional importance of hardware and software, where relevant		
Economic value of parts (e.g. purchase price) and software, where relevant, as % to the product price		
Environmental impacts of parts and software, where relevant, as % of the total environmental impacts of the product		
Steps/time needed to disassemble parts and uninstall and reinstall software, where relevant		
Others (please specify)		

Part 5) Guidance for scoring and aggregating different aspects of repair and upgrade

Parameters identified in the former sections can be used to assess the reparability and upgradability of products through pass/fail criteria and/or scoring systems. This requires the definition of rating criteria to use for the evaluation of single parameters. An example is provided below which presents three classes of scores: 0 (negative attribute), 0.5 (neutral attribute), 1 (positive attribute).

Parameter	*Description of the proposed rating criteria (illustrative purposes only)*
Availability of spare parts	Score: • 0 points: Original spare parts are not available to replace priority parts • 0.5 points: Original spare parts are available for less than 5 years after purchase of the product, and not for all priority parts • 1 point: Original spare parts are widely available to replace all priority parts. Availability is ensured for at least 5 years following the end of production of the model
Types of tools needed	Score: • 0 points: Advanced specialized tools (like a soldering iron, a puller and/or proprietary screwdrivers) are needed to disassemble priority parts • 0.5 points: Specialized tools (like torx screwdrivers, electric drill and small magnets) are needed to disassemble priority parts • 1 point: No tools or only basic tools (like scissors, flathead and cross recess (Phillips) screwdrivers) are needed to disassemble priority parts

The score can be normalised to a different scale (e.g. 0 to 1, 0 to 5, or 0 to 10). Moreover, scores could be weighed (if some criteria are considered to be more important) and aggregated into one or more indices.

Q5.1 Taking the examples provided above for spare parts and tools, which rating criteria would you apply to each <u>single</u> parameter described in Q2.1 in order to evaluate their influence on reparability and upgradability of products?

Parameter	*Description of the proposed rating criteria* *(see the examples provided in the introduction to section 5)*
Disassembly sequence	
Type, number and visibility of fastenings and connectors	
Tools needed (availability, complexity, cost)	
Ease of access to parts	
Working environment (e.g. home, professional repair site, manufacturing plant)	

Parameter	*Description of the proposed rating criteria* *(see the examples provided in the introduction to section 5)*
Level of skills required to undertake the operations	
Provision of diagnostic support and interfaces	
Availability of spare parts	
Availability and ease of installation of software and firmware	
Availability of information (e.g. repair and/or upgrade manuals, exploded diagrams)	
Others[83] (please specify)	

Q5.2 Reparability and upgradability of products could be reported for instance either with respect to one or more single parameters (e.g. type of tools needed vs. all the identified parameters) and either in isolate or aggregated form (i.e. as individual parameter's score or as combined scores for a set of parameters). Which level of aggregation should be reached when reporting the reparability and upgradability of products?

Please choose and explain why

Options	*Y/N*	*Comment*
Only a limited number of individual parameters (e.g. the 3-4 most relevant ones) should be considered and reported separately		
All relevant parameters related to product-design (e.g. disassembly sequence and tools needed) should be aggregated into 1 index		
All relevant parameters related to the repair service support (e.g. spare parts and information availability) should be aggregated into 1 index		
All relevant parameters related to design characteristics should be aggregated into 1 index, and all relevant parameters related to operation characteristics should be aggregated into another index		
All relevant parameters should be aggregated into 1 overall index		
Others (please specify)		

Q5.3 In case of aggregation, should an equal weight be considered for all relevant parameters or should a weighting factor be assigned to some parameters to reflect their relatively higher importance with respect to the others (see question 2.1)? (e.g. the score of a high relevance parameter could weight 3 times that of a low relevance parameter)

[83] For instance, an overall measure of "disassemblability" (ease/difficulty of the disassembly operation), as combination of some of the parameters listed in the table

Please reply and explain how and why

Q5.4 With reference to questions 5.1 and 5.2, which scale should be used to report the product reparability/upgradability score?

Please firstly evaluate their suitability (H: high, M: medium, L: low, N: no), and secondly provide supporting comments to explain why.

Reporting option	*Suitability (H/M/L/N)*	*Supporting comments*
Binary (pass/fail)		
Traffic lights		
0-to-5 stars		
Alphabetic (A, B, C, D, E, F, G)		
Decimal number between 0-1 (or a number between 0-10 or 0-100)		
Other iconographies and/or scales (please specify)		

Part 6) Specific aspects and needs for the product groups under assessment

Q6.1 Considering the information provided on products in general (see sections 1, 2, 3 and 4), which are the specific aspects of importance for the reparability and upgradability of laptops/ vacuum cleaners/ washing machines?

Please specify the product group and indicate the related specificities

Product	*Specific aspects influencing reparability*	*Specific aspects influencing upgradability*
Laptops		
Vacuum cleaners		
Washing machines		

Q6.2 Considering the information provided about the general scoring system approach (see sections 4 and 5), which are the specific needs to take into account for the potential design of a scoring system for laptops/ vacuum cleaners/ washing machines?

Please specify the product group and indicate the related specificities

Product	*Specific needs for assessing reparability*	*Specific needs for assessing upgradability*
Laptops		
Vacuum cleaners		
Washing machines		

Q6.3 Please provide any additional comments you might have about other specific aspects (e.g. links with standards, ecodesign measures, and market specificities)

Please specify the product group and indicate the related specificities

Product	*Additional comments*
Laptops	
Vacuum cleaners	
Washing machines	

ANNEX II – ANALYSIS OF RESPONSES TO THE INITIAL QUESTIONNAIRE

Part 1) Number of responses

25 responses to the initial questionnaire were received[84]. This corresponds to about one reply out of four from the stakeholders registered in the Technical Working Group for this project[85].

In terms of organisations:

- 15 responses were received from industry and trade associations (equivalent to 60% of the respondents);
- 3 responses each were received from governmental agencies and NGOs (12%);
- 2 responses were received from independent repairers (8%);
- 1 response each was received from academia and retailers.

In terms of geographical representativeness of the respondents:

- 6 respondents are based in Belgium (24%);
- 4 respondents are based in France (16%);
- 3 respondents are based in Germany (12%);
- 2 respondents are based in Italy (8%), as well as in Spain and in the Netherlands;
- Other respondents are based in Czech Republic, Denmark, Ireland, Sweden and the UK.

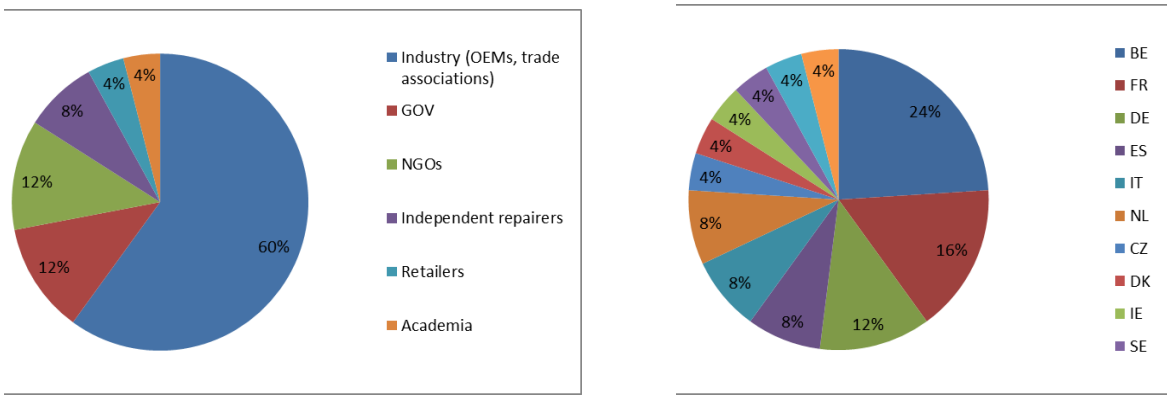

Figure A.1: representativeness of respondents to the initial questionnaire

[84] The questionnaire was launched on 7th April 2018 and made accessible from http://susproc.jrc.ec.europa.eu/ScoringSystemOnReparability/documents.html. The questionnaire was closed on 7th May 2018.

[85] The share of participation to the questionnaire would be higher if calculated based on the number of organisations, since more representatives per organisation are in general registered as stakeholders.

Part 2) Methods for assessing reparability and upgradability

Input received from stakeholders for different methods are reported below.

a) Austrian standard ONR 192102:2014

14 out of 25 (56%) stakeholders who responded to the initial questionnaire reported to know, up to a certain point, the standard. However, only half of them declared to be satisfactorily/ sufficiently familiar with the approach.

According to some stakeholders, advantages of ONR 192102 include:

- A comprehensive overview of criteria, covering both white and brown goods (especially valid for washing machines) and both horizontal and service support issues;

- Provision of a practical labelling framework specifically focused on reparability;

- Involvement of experts and associated actors, and further application by different organisations.

On the other hand, some stakeholders have commented that ONR 192102 presents the following weaknesses:

- It covers only a part of ICT products;

- It is a national standard and therefore it may be representative for the Austrian market only. Some stakeholders moreover argue that it was developed without sufficient involvement of relevant industry sectors;

- It mixes aspects such as ease of use, durability, reparability, service support, quality management, documentation and commercial guarantee;

- The standard does not have criteria for different target groups or skill levels, and some criteria are either over-specific, not neutral, or ambiguous;

- The scale of the scoring system is based on manufacturers' information and trade-offs between different criteria are allowed, which brings some elements of subjectivity;

- The criteria and their means of verification are not always clearly defined;

- It is complex and costly.

The overall opinion of stakeholders about ONR 192102 is summarised below.

- Some stakeholders consider that it could be a good starting point for evaluating the reparability of products, although it comes with some limitations;

- Other stakeholders do not consider that the standard as such is suitable for the development of a scoring system to use for regulatory purposes, as they see that improvements are needed, especially in terms of robustness and scope, as well as the fact that this standard is presently not widely used.

b) i-Fixit scoring system

17 out of 25 (68%) stakeholders who responded to the initial questionnaire declared to have certain knowledge of the i-Fixit scoring system. However, only 5 of them declared to have high level of familiarity with the method.

According to some stakeholders, advantages of the i-Fixit scoring system include:

- It is useful for design purposes;

- It is simple, practical and clear for consumers;

- It is seemingly fair and lists both positive and negative items;

- It combines qualitative and quantitative methods;

- It allows for the weighting of criteria;

- It provides repair guides for different high-tech products, also documenting the number and type of operations and required tools, in an independent manner;

- It provides a score in a publicly available and popular platform, which can help to increase awareness regarding the topic.

On the other hand, some stakeholders have commented that the the i-Fixit method presents the following weaknesses:

- The current version is oriented towards the assessment of specific product categories (ICT products) and therefore it is not applicable to all products. Methods could, however, be adapted for other products and scenarios;

- The scoring and weighting system used seems not sufficiently transparent. The methodological guidance is currently unpublished and is under revision;

- The availability and cost of spare parts are not included in the assessment;

- It is oriented towards consumers, including self-repairs (e.g. repair information for free, no proprietary screws, number of screws) and some industry stakeholders argue that this discriminates against other repair strategies that would result in repairable devices as well;

- The scoring methodology is partly subjective (e.g. "discretionary feel after taking apart", "parts not tightly packed", "no excessive use of adhesives", "no substantial prying effort", "critical parts easily replaceable");

- Weighting of scoring should be calibrated based on surveys to show where major issues are. Also, surveys per se could be potentially replaced by durability tests, but those tests are very expensive;

- Reparability of products is more complex than a 1-10 scoring metric;

- It is not a fully scientific approach.

The overall opinion of stakeholders about the i-Fixit method is summarised below:

- In general, many stakeholders seem to consider the method as a good resource for the development of a scoring system.

- However, the assessment has been noted as suffering from a degree of partiality/subjectivity, which would not make it good for legislation-related purposes, and its understanding/ use may be restricted to medium-high skilled persons (i.e. not common users).

- Moreover, it has been reported that there is limited availability of information about how the scoring system actually works, as well as missed consideration of major aspects, such as the availability of spare parts, and their cost.

c) "Design for Repairability" tool

8 out of 25 (32%) stakeholders who responded to the initial questionnaire declared to know the tool up to a certain point. However, only half of them were "satisfactorily familiar" with the approach.

According to some stakeholders, the only advantage of the "Design for Repairability" tool is its ease of understanding and use.

On the other hand, some stakeholders have commented that the "Design for Repairability" tool presents the following weaknesses:

- It focuses on brown goods and is too general (no distinction between product categories);

- Some criteria are over-specific or not neutral, and they are - for instance - oriented to repairs made by consumers (whilst not all failures should be fixed by users, for safety reasons); also, the criteria poorly represent B2B interests/ activities;

- It mixes the evaluation of product design, service support, health & safety, commercial aspects, and external factors such as 3rd-party provision of repair information;

- Some key aspects - in an objective way – are absent (e.g. ease of disassembly);

- Criteria and means of verification are not always clearly defined, and results are heavily influenced by operator skills;

- It has been developed without the involvement of relevant industry sectors.

The overall opinion of stakeholders about the "Design for Repairability" tool is summarised below:

- Some stakeholders considers that the this could be a good starting point for evaluating the reparability of products, although some improvements have to be applied.

- Nevertheless, other stakeholders pointed out that the tool is not sufficiently robust, as well as that it is possibly over-simple and too general to be used for regulatory purposes.

d) Groupe SEB's "Product 10Y Repairable" label

8 out of 25 (32%) stakeholders who responded to the initial questionnaire have declared a certain knowledge of the Groupe SEB's "Product 10Y Repairable" label, while other 3 stakeholders reported to have low knowledge.

According to some stakeholders, advantages of the Groupe SEB's "Product 10Y Repairable" label include:

- It is a label that ensures that all criteria are respected;

- It is an easily understandable and usable approach, which is also in line with the Ecodesign Directive's philosophy;

- It takes into account availability and price of spare parts, and provides a commitment on the period during which the product can be repairable and on the cost of repair during that period.

On the other hand, some stakeholders have commented that the Groupe SEB's "Product 10Y Repairable" label presents the following weaknesses:

- It is a binary pass/fail concept so that no information is provided if the product is not repairable, nor if it is not possible to differentiate between products for labelling purposes;

- It is biased towards professional repair, it needs a strong network of repairers, and it does not take into account aspects for other target groups (e.g. lower skill levels);

- It is a private label based on an internal procedure and, because of it, it cannot neither be applied to all categories of products for all brands nor be used for external verification;

- It is too general and simplistic and does not provide clear definitions.

The overall opinion of stakeholders regarding Groupe SEB's "Product 10Y Repairable" label is summarised below:

- Some stakeholders consider the label as a good starting point to assess the reparability of products.

- Other stakeholders consider that the method does not allow taking into account the complexity of design and repair at a satisfactory level.

e) prEN 45554 - General methods for the assessment of the ability to repair, reuse and upgrade energy related products

15 out of 25 (60%) stakeholders who responded to the initial questionnaire have declared to be "somehow familiar" with prEN 45554.

According to some stakeholders, advantages of prEN 45554 would include:

- It provides a toolbox with qualitative and quantitative methods;

- It addresses a comprehensive range of aspects and takes into account a wide range of repair/upgrade scenarios and target groups;

- It allows a framework for the selection of most appropriate criteria and methods to assess the reparability and upgradability of a specific product;

- It is technologically neutral and compatible with a scoring system concept;

- Measurable parameters are proposed, and the classification methods are rather objective and relatively simple to apply;

- It has been broadly discussed with stakeholders from different organisation during the standardisation processes.

On the other hand, some stakeholders have commented that prEN 45554 presents the following limitations:

- The standard is still in a draft form and unpublished, and the assessment criteria are not yet well defined;

- It is theoretical and needs to be tailored to product-specific levels, including the assignment of scores and weights;

- Little guidance for aggregation is provided.

The overall opinion of the stakeholders regarding prEN 45554 is summarised below:

- Results of the assessment must not be subjective, but instead must be repeatable and reproducible. A solid standardisation base is needed to secure measurable and enforceable legal requirements. Therefore, this seems the best ground to develop a high-level assessment framework and to set the basis for the development of product-specific approaches. The majority of stakeholders support the standardisation work done within CEN-CENELEC, although it is not clear if this could fit for regulatory purposes at the time being.

- However, the standard is still under development and has a too general approach. Further investigation will be moreover needed to capture accurately the specificities of single product groups.

The standard prEN 45553 regarding remanufacturing of ErP was also mentioned as a potential source of inspiration for the development of a scoring system on reparability and upgradability.

Part 3) Repair and upgrade parameters

Figure A.2 and Figure A.3 show how respondents qualitatively evaluated the parameters identified in Q2.1 of the questionnaire, as relevant for repair and upgrade. The relevance of the parameters was ranked by giving a score to each of the options (high = 3; medium = 2; low = 1; no = 0), as reported in Table A.1. The results showed in Table A.1 are merely indicative of the relevance of each parameter on the basis of the feedback received from stakeholders. It can be observed that all parameters are relevant for both reparability and upgradability.

The most important parameter for reparability of products, according to the feedback received, is the availability of spare parts. This is followed by: ease of access to parts, information on the disassembly sequence, and availability of information. Working environment was judged the least important parameter, but still relevant for repair.

The most important parameter for the upgradability of products, according to the feedback received, is instead the availability and ease of installation of software and firmware (where applicable). This is followed by: ease of access to parts, provision of diagnostic support and interfaces, availability of information, and availability of spare parts. The relative importance of the disassembly sequence and other parameters related to disassemblability are rated lower in the case of upgradability than for reparability. The working environment is the least important parameter, but is still relevant for repair.

Table A.2 summarises the initial input received with regard to the assessment and verification of these parameters.

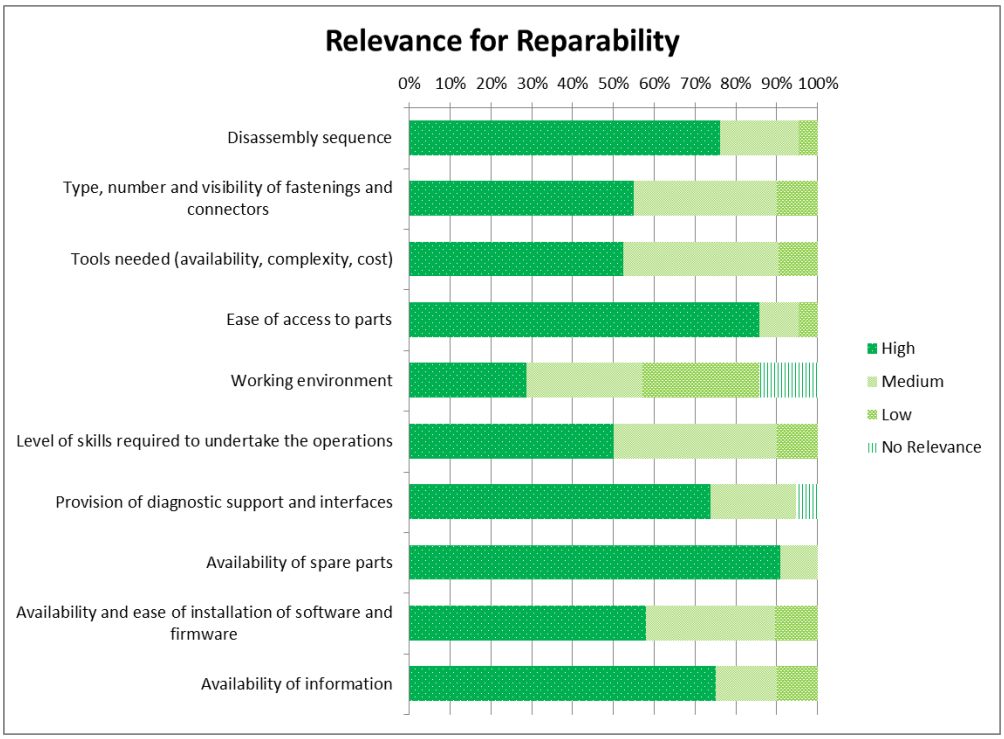

Figure A.2: Relevance of parameters influencing reparability on the basis of the input received from the respondents to the initial questionnaire

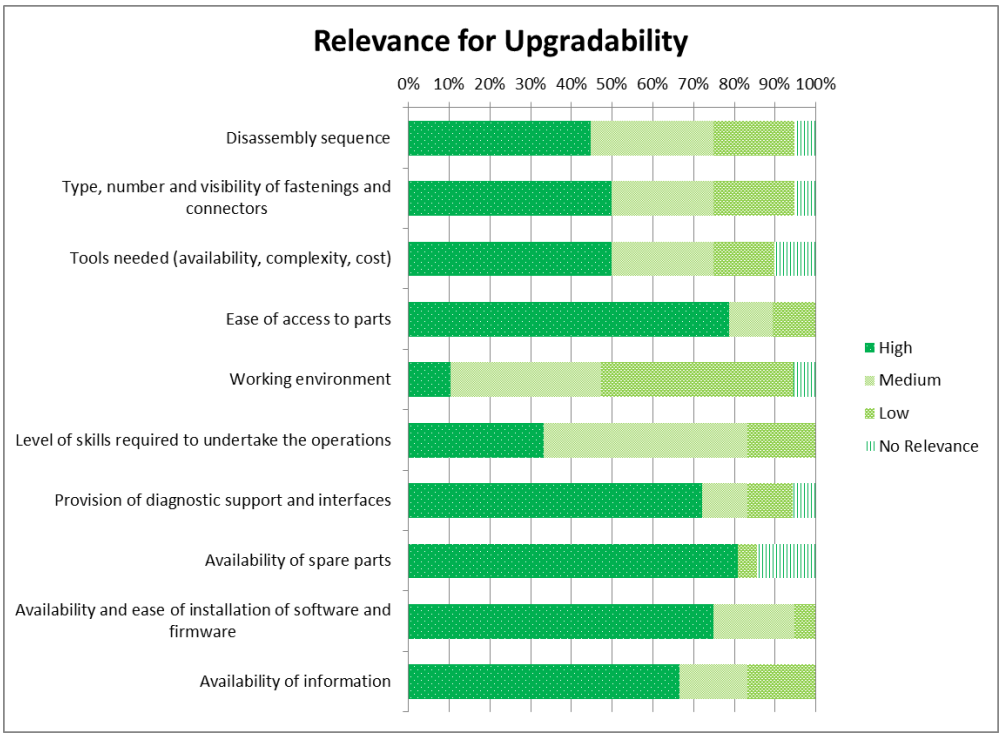

Figure A.3: Relevance of parameters influencing upgradability on the basis of the input received from the respondents to the initial questionnaire

Table A.1: Ranking of the parameters based on the analysis of the input received from the respondents to the initial questionnaire

Reparability		Upgradeability	
Availability of spare parts	2.9	2.7	Availability and ease of installation of software and firmware
Ease of access to parts	2.8	2.7	Ease of access to parts
Disassembly sequence	2.7	2.5	Provision of diagnostic support and interfaces
Availability of information	2.7	2.5	Availability of information
Provision of diagnostic support and interfaces	2.6	2.5	Availability of spare parts
Availability and ease of installation of software and firmware	2.5	2.2	Type, number and visibility of fastenings and connectors
Type, number and visibility of fastenings and connectors	2.5	2.2	Level of skills required to undertake the operations
Tools needed (availability, complexity, cost)	2.4	2.2	Disassembly sequence
Level of skills required to undertake the operations	2.4	2.2	Tools needed (availability, complexity, cost)
Working environment	1.6	1.5	Working environment

Table A.2: Technical parameters generally influencing repair and upgrade of products

Parameter	Technical considerations
1. Disassembly sequence	Assessment and verification based on documentation of disassembly steps in instruction manuals and/or other on-line information systems (e.g. I4R platform for recyclers). Penalisations to apply in case of destructive disassembly of some parts. Alternatively, calculation of disassembly times based on standard time units (e.g. MOST, eDIM, iFIXIT). In case of data gaps, time to be determined through field research.
2. Type, number and visibility of fastenings and connectors	Assessment and verification based on information provided by the manufacturer (e.g. with illustrated disassembly instructions). Information could be provided in manuals and/or other on-line platforms. A categorisation is required, which should be performed according to prEN 45554. Marking was also suggested to improve visibility of fasteners.
3. Tools needed (availability, complexity, cost)	The manufacturer should document the type of tools needed to repair the product. The use of standard/basic tools should be granted, but a penalisation applied when proprietary tools are needed. A categorisation is required, which should be done according to prEN 45554. Other aspects suggested for possible consideration are cost and complexity.
4. Ease of access to parts	This element is considered to be a difficult parameter to assess and verify, as it also requires the satisfactory definition of "priority part", which is also very much related to other parameters (1, 2, 3, as well as identification of parts). The measurement of standardised time units could be used.
5. Working environment (e.g. home, professional repair site, manufacturing plant)	The classification used in prEN 45554 was suggested for assessment and verification, although some refinements and clarifications may be needed to allow verification. Safety issues and type of operations should be considered in the classification. Moreover, it was suggested its possible split into 'repair at home' and 'repair by professionals', which would require the definition of which operations can be performed by a user.
6. Level of skills required to undertake the operations	Assessment and verification based on documentation provided by the manufacturer indicating which operations can be performed by the users.
7. Provision of diagnostic support and interfaces	The classification used in prEN 45554 was suggested for assessment and verification. Information to be provided by the manufacturer, e.g. troubleshooting, manual or portals for authorised repairers.

Parameter	Technical considerations
8. Availability of spare parts	Information by the manufacturer about the availability of spare parts in years, complemented by verification of actual availability. The definition of "parts that are more likely to fail" is needed. Price of spare parts and their delivery time are also important, although these might perhaps fit better as minimum requirement.
9. Availability and ease of installation of software and firmware	Declaration by the manufacturer about the availability of software and firmware in years, complemented by verification of actual availability.
10. Availability of information (e.g. repair and/or upgrade manuals, exploded diagrams)	Assessment and verification based on the public information supplied by the manufacturer (e.g. manuals, on-line platforms, manufacturer website), complemented by audits for assessing the availability of restricted information. Classification of information for different users is needed, as presented in prEN 45554.

In addition to the parameters discussed above, the repair and upgrade of products can also be limited by other aspects (e.g. purchase price of the product and labour cost of repair, demand for new vs. repaired/upgraded products, guarantee issues, support networks facilitating the repair process, business models, compatibility issues). Stakeholders were asked to provide scenarios/conditions for these aspects, where repair and upgrade operations are more likely to occur. compiles this initial additional feedback from stakeholders.

Based on the elements gathered, the following parameters ae considered of potential interest for discussing about the development of a scoring system to assess the repair and upgrade of products:

11. Guarantee issues;
12. Return of models;
13. Data transfer and deletion;
14. Safety issues;
15. Availability of OEM qualified service engineers;
16. Ease of restoring product to working condition after repair.

Other aspects highlighted by stakeholders, such as emotional attachment to products, attitude and education of consumers, repair costs, tax exemptions and labour cost reductions are considered to be mainly related to socio-economic issues, which would be difficult to integrate in a scoring system.

Part 4) Priority parts

Figure A.4 and Figure A.5 show the indications gathered from the participants in the initial questionnaire regarding the relevance of different aspects. From the two figures it can be seen that:

- The failure of parts is in general indicated as the most important aspect for repair, which is followed by the functional importance of the part itself. The difficulty to disassembly parts, expressed in this case in terms of steps, is also somehow important but is ranked lower. Stakeholders ranked economic and environmental aspects per se with lower importance.

- In the case of upgradability, the differences in importance are fuzzy between frequency of upgrade, functional importance, economic value and the difficulty to disassemble parts, expressed in this case in terms of steps. The relative importance of the frequency of failure/replacement is lower compared to reparability, whilst it becomes slightly higher for the economic value. Stakeholders also gave a low ranking to environmental aspects per se.

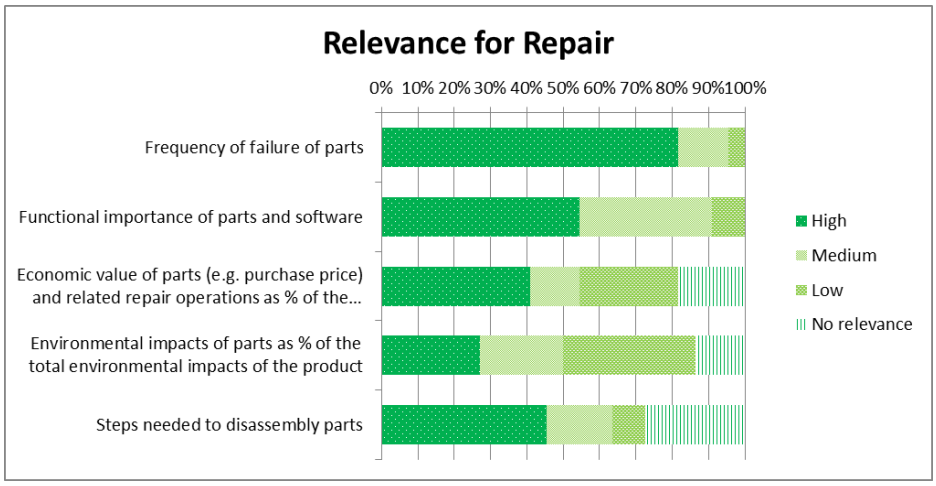

Figure A.4: Relevance of different aspects for the definitions of priority parts for repair

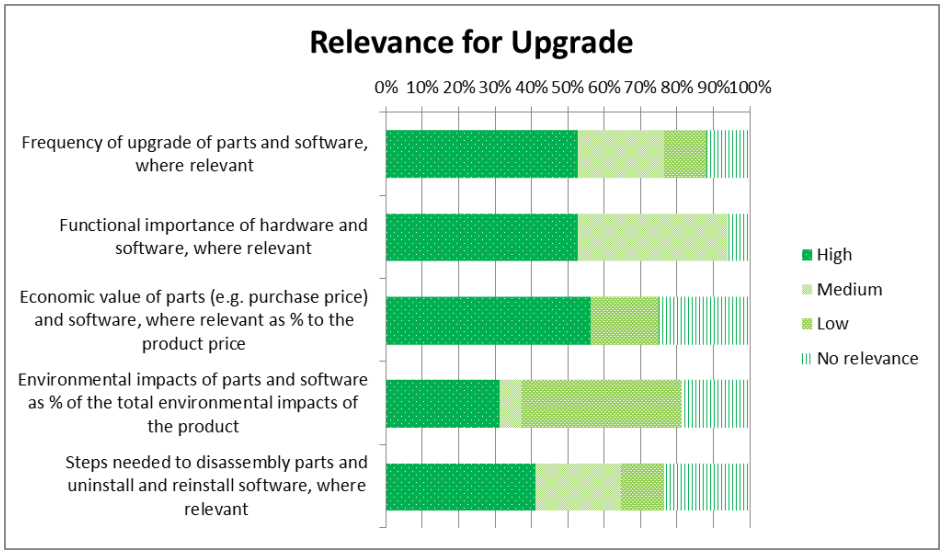

Figure A.5: Relevance of different aspects for the definitions of priority parts for upgrade

a) Frequencies of failure and upgrade

The frequency of the failure of parts is in general seen by stakeholders as the most important aspect for determining priority parts, with respect to reparability issues. This is also related to reliability concepts defined as the mean time between failures. Nevertheless, the frequency of failures can only be evaluated when market and users have gained experience with a certain product and typical repair requests have been identified.

According to the feedback received by stakeholders, most companies aim to have no more than a small fraction of products (e.g. less than 3%) failing during legal guarantee periods, because of cost reasons. Data on failure rates should thus be collected after the legal guarantee period.

The frequency of upgrade of parts and software is highly relevant for the upgradability of products and it can to some extent determine the likelihood of obsolescence of the product. The frequency of upgrade is not a criterion in itself, but is reflected by its consequence in factors such as rapid technology change, changes in the use given to a part, design and specifications of a product.

b) Functional importance

If a part (either hardware or software) is important for the functioning of the product, it should have high priority. The part is instead less relevant if related to secondary functions. Functional importance of parts is nevertheless relevant only if combined with likelihood of failure/upgrade.

From a technical point of view, the functional importance of parts could be for instance categorised as follows:

a. The part does not affect the functioning nor the performance of the product

b. The part can affect the performance of the product

c. The part can affect the functioning of the product.

User experience and more subjective elements such as aesthetics and personalisation could also play a role, especially for upgradability. However, according to the feedback received, lists of functional parts cannot be generalised and could also depend on the market strategy of manufacturers.

c) Price of parts and cost of repair/upgrade

According to some of the feedback received, the cost of the spare part should not define how important it is for the product (e.g. although carbon brushes are very cheap, a washing machine cannot work without them).

On the other hand, if a part is likely to fail and is key for the functioning of the product, the price of replacement should not be too high: the lower the price, the higher is the likelihood of repair. The price for repair is highly dependent on the labour costs.

For upgrade it was reported by some stakeholders that the economic value is not a good indicator, since this could penalise high-quality products and ICT products, where subsequent important upgrades (software) can often come for free.

d) Environmental impacts of parts

Although considered important for the sustainability of products, some concerns were received from stakeholders:

- Environmental considerations can be relevant only if combined with the failure/upgrade likelihood. Repair and upgrade hold the potential to increase the lifetime of products and reduce their impacts. However, the repair/upgrade of products is often driven by other socio-economic factors;

- It could result in false incentives for repair and upgrade, for instance, as a consequence of the integration of many functions in circuit boards, which would be detrimental for the economic feasibility of repair.

- There is no commonly agreed or standardised method to analyse the environmental impact of appliances.

e) Disassembly of parts and reinstallation of software

Split views were registered for this aspect:

- On the one hand, there are those who think that the difficulty of disassembly, for instance expressed in terms of disassembly steps, is important to identify priority parts. However, it has to be considered that different kinds of appliances exist. For instance, a freestanding fridge will have fewer steps to access a certain part than for a built-in fridge.

- On the other hand, there are those who do not consider the difficulty to undertake disassembly relevant in assessing the importance of parts to be repaired/ upgraded. This could be viewed more as an outcome of the assessment, and not as an element to decide what should be assessed, since the latter depends mainly on the frequency of failure/upgrade.

Some stakeholders suggested referring to the measurement of disassembly and reassembly times based on standard time units instead of considering disassembly steps only.

f) Additional considerations

The feedback received from stakeholders recommends that ad-hoc lists of priority parts need to be determined:

- On a product-by-product basis and taking into account for different models of the same product on the market,

- After engaging with manufacturers, repairers and other relevant experts,

- Including expert-judgement, safety and functional considerations,

- Taking into consideration the likelihood that a replacement may be needed for repairing or upgrading the product, and the conditions under which a given part is deemed to be a priority part (e.g. batteries with a life below X recharge cycles, electric motors that last below X hours of operation),

- Limited accessibility should be considered for certain features (e.g. water tightness and climate resistance).

Moreover, additional aspects should be taken into account when determining priority parts with regard to upgradability:

- The complexity of the product, since the likelihood of the need to upgrade appliances can increase with the complexity of their design,

- Evaluation of parts for upgrading is expected to focus mainly, but not exclusively, on parts subject to rapid technology changes, or changes in use profiles over the lifetime of the product. Specific attention, however, should be given to the role of software and firmware. For laptops, the operating system is

the most important part which determines functionality and which requires frequent updating. Hardware parts such as storage chips can be relevant in cases below a certain minimum configuration,

- Parts that are planned to be upgraded and have standardised interfaces in products should have the highest priority. However, it is difficult to predict, at the time of placing an appliance on the market, what will be the future updates. Updates can be to an extent predicted based on market and user experience with the product, or similar products.

Part 5) Classification and rating

Different options for the classification of individual parameters have been reported in Table A.3. These take into account elements of discussion held during the development of prEN 45554 and the feedback received from stakeholders. The classification and rating options shown refer to generic products, and would have to be tailored to specific product group(s) and related priority part(s), if they were to be used in practice.

Table A.3: Initial indications for the classification and rating of different parameters

Parameter	Classification/rating options [(a) (b)]	Technical considerations of the study team
1) Disassembly sequence (DS)	A) Based on number of steps required to remove a part from a specific product: I. Less than X steps II. Between X and Y steps III. More than Y steps	Favourite option for the study team since objective and practical. Disassembly steps could be replaced by disassembly time (e.g. based on eDiM).
	B) Semi-quantitative based on design characteristics: I. Can be disassembled into individual parts. Time required to do it is low. II. Can be disassembled into individual parts. Time required to do it is acceptable. III. Can be disassembled into individual parts but time taken is very long. IV. Can be disassembled into individual parts but some critical parts are gathered together in blocks that cannot be disassembled. V. Cannot be disassembled into individual parts or some parts are likely to be broken during the process.	Alternative classification, more complete but including elements that risk being more subjective
	C) Percentile score within known spread: Score = (DSmax – DSi) / (DSmax – DSmin) Where: - DS_{max} is the longest disassembly sequence (or time), for that part in a group of products - DS_{min} is the shortest disassembly sequence (or time), which could be 1 as mimimum value, for that part in a group of products	Possible normalisation approach to refer class scores to a number from 0 to 1

Parameter	Classification/rating options [a] [b]	Technical considerations of the study team
	- DS_i is the disassembly sequence (or time) of the analysed product	
2) Type, number and visibility of fastenings and connectors	A) Semi-quantitative based on type of fastenings and connectors: I. Reusable fasteners are used: the original fasteners can be reused for the new part or the fastener is supplied with the part II. Removable fasteners are used: the original fasteners are not reusable, but can be removed without causing damage or leaving residue which precludes reassembly (in case of repair or upgrade) or reuse of the removed part (in case of reuse) III. Non-removable fasteners are used: the original fasteners are not removable or reusable	Favourite option for the study team since objective and practical. Visibility could be less relevant if indicated in repair manuals
	B) Semi-quantitative based on type and number of fastenings and connectors: I. Fastenings are standard/widely available and clearly visible and they are a limited number so that time required for disassembly is low II. Fastenings are standard/widely available and clearly visible and they are a reasonable number so that time required for disassembly is acceptable III. Fastenings are standard/widely available and clearly visible but they are so numerous that the time required for disassembly is very long IV. Fastenings used are standard/widely available but some are not clearly visible V. Proprietary or rare fastenings are used	Alternative classification, more complete but including elements that risk being subjective
	C) Semi-quantitative based on type, number and location of fastenings and connectors: I. Fasteners/connectors are reversible, easy to localise, and less than X in number OR only reversible "click" fastenings/connectors are used and easy to localise II. Fasteners/connectors are reversible, easy to localise, and more than X in number III. One or more non-reversible fastenings/connectors (e.g. glue, soldering, connectors that break when disassembled) are used OR reversible fastenings/connectors are used but they are not	Alternative classification, more complete but including elements that risk being more subjective

Parameter	Classification/rating options [a] [b]	Technical considerations of the study team
	immediately visible. D) Percentile score within known spread: Score = F_i / F_{max} Where: - F_{max} is the score corresponding to the best classification achievable for the product (in terms of identification and removal of fastenings/connectors) - F_i is the score corresponding to the class of the analysed product	Normalisation of above approaches to refer class scores to a number from 0 to 1
3) Tools needed (availability, complexity, cost)	A) Semi-quantitative based on type and availability of tools: I. Common tools: Repair/upgrade operation feasible without any tools, or with tools that are supplied with the product, or with common general purpose tools II. Product-specific tools (if needed): Repair/upgrade operation feasible either with no specific tools, or a finite list of specific tools III. Other commercially available tools (if needed): Repair/upgrade operation feasible without the use of proprietary tools IV. Proprietary tools: Repair/upgrade process feasible only with one or more proprietary tools, which are not available to the general public. V. No tools: Repair/upgrade operation is unfeasible with existing normally-available tools B) Semi-quantitative based on type, availability, cost, and number of tools: I. Maximum X types (e.g. 1, 2) of standard/common tools are required II. A limited number of tools are required, some of which are expensive III. Many different type of widely available tools are required, and some of them are expensive IV. Special tools are required that are not easy to obtain V. Proprietary tools are required. C) Percentile score within known spread:	Favoured option for the study team since objective and practical. Visibility could be less relevant if indicated in repair manuals Alternative classification, more complete but including elements that risk being more subjective Normalisation of above approaches to refer class

Parameter	Classification/rating options [a] [b]	Technical considerations of the study team
	Score = T_i / T_{max} Where: - T_{max} is the score corresponding to the best classification achievable for the product (in terms of type, availability and cost of tools) - T_i is the score corresponding to the class of the analysed product	scores to a number from 0 to 1
4) Ease of access to parts	A) See Parameters 1, 2 and 3	Although important, this parameter is considered the sum of the disassembly sequence, fastenings and tools. Time for disassembly could be an alternative and overall indicator, as described for parameter 1. However, this could add significant complications, possibly also in terms of assessment and verification.
	B) Semi-quantitative based on design characteristics: I. All the priority parts are easy to access (quick access, few steps required) II. All priority parts can be accessed and require a limited number of steps/time III. All priority parts can be accessed but some of them require too many steps IV. All priority parts can be accessed but it is difficult to know how without instructions due to the complexity of the product design V. Some priority parts are not easy to access because glue or other permanent assembly methods are used	Risk of subjective classification
	C) Percentile score within known spread: Score = A_i / A_{max} Where: - A_{max} is the score corresponding to the best classification achievable for the product (in terms of ease of accessibility) - A_i is the score corresponding to the class of the analysed product	Normalisation of above approaches to refer class scores to a number from 0 to 1
5) Working environment (e.g.	A) Semi-quantitative based on conditions of work:	Favoured option for the study team since it is

Parameter	Classification/rating options [a] [b]	Technical considerations of the study team
home, professional repair site, manufacturing plant)	I. General environment: repair/upgrade can be performed where the product is in use without special conditions II. Workshop environment: repair/upgrade cannot be performed in the environment where the product is in use but does not require a production site environment III. Production site environment: repair/upgrade can only be carried out in an environment that is comparable with the environment in which the product was manufactured	objective and practical.
	B) Semi-quantitative based on type of repair/upgrade process: I. Repair/upgrade can be easily done at home II. Professional repair sites are required only for the repair/upgrade of parts that involve safety aspects III. Professional repair sites are required for the repair/upgrade of some priority parts IV. Repair/upgrade of all priority parts can be done only in the manufacturing plant V. Repair/upgrade of parts can be done only in the manufacturing plant	Alternative classification, that includes elements that risk being more subjective.
	C) Percentile score within known spread: Score = WE_i / WE_{max} Where: - WE_{max} is the score corresponding to the best classification achievable for the product (in terms of type of environment) - WE_i is the score corresponding to the class of the analysed product	Normalisation of above approaches to refer class scores to a number from 0 to 1
6) Level of skills required to undertake the operations	A) Semi-quantitative based on skills required: I. The repair/upgrade process can be carried out by a person without any specific experience or related qualifications (layman) II. The repair/upgrade process can be carried out by a person with a general knowledge of basic repair/upgrade techniques and safety precautions (generalist, if needed). III. The repair/upgrade process has to be carried out by a person with specific training and/or experience related to the product category concerned (independent expert)	Favoured option for the study team since it is objective and practical

Parameter	Classification/rating options [a] [b]	Technical considerations of the study team
	IV. The repair/upgrade process has to be carried out by a person who is directly trained and audited by the manufacturer (authorised expert) V. The repair/upgrade process has to be carried out by the manufacturer VI. The repair/upgrade process is not feasible with any existing skill	
	B) Semi-quantitative based on skills required: I. Reparable/upgradable by everyone with a basic knowledge II. Reparable/upgradable by everyone after tutorial watching or documentation reading III. Reparable/upgradable only for trained specialists.	Alternative and simpler classification
	C) Percentile score within known spread: Score = S_i / S_{max} Where: - S_{max} is the score corresponding to the best classification achievable for the product (in terms of skills needed) - S_i is the score corresponding to the class of the analysed product	Normalisation of above approaches to refer class scores to a number from 0 to 1
7) Provision of diagnostic support and interfaces	A) Semi-quantitative based on type of diagnosis interface: I. Visually intuitive interface: a repair/upgrade process that can be carried out by just a visual interface that can be understood without the need for any supporting documentation or software II. Coded interface with public reference table: a repair/upgrade process that can only be carried out with supporting documentation or software, and through reading and/or entering codes which are available in a table, which is supplied with the product and / or publicly available III. Publicly available hardware / software interface: a repair/upgrade process that can only be carried out through the use of hardware and software which is publicly available (This can include hardware functionality testing software tools developed by a third party, provided the software tools are publicly available and the manufacturer provides information	Favoured option for the study team since objective and practical

Parameter	Classification/rating options [a] [b]	Technical considerations of the study team
	on their accessibility and applicable updates. The product can be equipped with an appropriate interface for hardware and software to do fault diagnosis and reading, adjustment or resetting of parameters or settings (e.g. external memory device; data cable connection; or from a remote source using a network connection). The port, slot, or connector that is used for the hardware and software interface is accessible without tools) IV. Proprietary interface: a repair/upgrade process that can only be carried out using proprietary tools for diagnosis, change of settings or transfer of software, which are not included with the product, that process is categorised as needing a proprietary interface V. Not possible with any type of interface: a repair/upgrade process that cannot be carried out with any type of interface	
	B) Semi-quantitative based on type of diagnostic equipment: I. Only basic and common diagnostic equipment is required (e.g., easily-obtainable polymeters and similar) II. Diagnostic equipment and interfaces are standard/common and are required for a limited type of reparations III. Diagnostic equipment and interfaces are standard/common but it is required for most of the reparations IV. Expensive (not special) diagnostic equipment/interfaces required Special/proprietary diagnostic equipment is required	Alternative classification but more ambiguous/subjective
	C) Semi-quantitative based on type of diagnosis interface and manufacturer support: I. Manufacturer support (e.g. website, troubleshooting FAQ, help line) available, and repair/upgrade can be carried out with the use of hardware and software which is publicly available II. Repair/upgrade can be carried out with the use of hardware and software which is publicly available III. Repair/upgrade can be carried out through the use of hardware and software which is proprietary IV. No diagnosis interface nor support	Alternative classification including also manufacturer support

Parameter	Classification/rating options [a] [b]	Technical considerations of the study team
	D) Percentile score within known spread: Score = DI_i / DI_{max} Where: - DI_{max} is the score corresponding to the best classification achievable for the product (in terms of intuitiveness and accessibility of interface and support tools required) - DI_i is the score corresponding to the class of the analysed product	Normalisation of above approaches to refer class scores to a number from 0 to 1
8) Availability of spare parts	A) Semi-quantitative based on the availability of spare parts to target groups: I. Spare parts are publicly available to all interested parties II. Spare parts are available at least to independent repair service providers III. Spare parts are available at least to manufacturer-authorised repair services IV. Spare parts are available to the manufacturer only V. No spare parts are available	Favoured option for the study team since it is objective and practical. Also time considerations can be integrated
	B) Semi-quantitative based on the availability over time of spare parts: I. The required spare part(s) is/are available for a duration of time post-manufacture that reflects the expected maximum useful life of the product (long-term). II. The required spare part(s) is/are available for a duration of time that reflects the expected average useful life of the product (mid-term) III. The required spare part(s) is/are available for 2 years after the time of sale of the product (short-term) IV. The required spare part(s) is/are available at the time of sale, but the duration of availability cannot be determined.	Complementary, if not integrated.
	C) Semi-quantitative based on the availability of spare parts, including also time and cost considerations: I. Spare parts are available for 10 years or more, and price is reasonable compared to the product price II. Spare parts are available for 5-9 years, and price is reasonable	Alternative classification, more complete but with risk to be subjective.

Parameter	Classification/rating options [a] [b]	Technical considerations of the study team
	compared to the product price III. Spare parts are available for less than 5 years, and price is expensive compared to the product price IV. Spare parts are available only for priority parts V. Spare parts are not available	
	D Percentile score within known spread: Score = TG_i / TG_{max} x D_i / D_{max} Where, - TG_{max} is the score corresponding to the best classification achievable for the product (in terms of target group) - TG_i is the performance of the product (in terms of target group) - D_{max} is the score corresponding to the best classification achievable for the product (in terms of availability of spare parts) - D_i is the score corresponding to the class of the analysed product (in terms of availability of spare parts)	Normalisation of above approaches to refer class scores to a number from 0 to 1
9) Availability and ease of installation of software and firmware	A) See parameter 8	Favoured option
	B) Semi-quantitative based on the availability of software/firmware for a certain time and cost: I. Software/Firmware updates are periodically available; bug/vulnerability fixing is free of charge for 5 years or more. Upgrades for improvements have a reasonable price or are free of charge. II. Software/Firmware updates are periodically available; bug/vulnerability fixing is free of charge for 5 years or more. Upgrades for improvements are expensive. III. Software/Firmware updates are periodically available, bug/vulnerability fixing is free of charge for 5 years or more IV. Software/Firmware support is offered free of charge for critical bugs/vulnerabilities only and for less than 3 years V. Software/firmware support is not offered	Alternative option
	C) Semi-quantitative based on the availability of information to target	Possibility to differentiate between software and

Parameter	Classification/rating options [(a) (b)]	Technical considerations of the study team
	groups: I. Software and firmware is publicly available to all interested parties II. Software and firmware is available only to authorized experts and manufacturers D) Percentile score within known spread: Score = T_i / T_{max} Where, - T_{max} is the score corresponding to the best classification achievable for the product (in terms of type, availability and cost of tools) - T_i is the score corresponding to the class of the analysed product	firmware offered "free of charge" vs. "at a cost" and between automatic download from the internet vs. multi-step procurement process Normalisation of above approaches to refer class scores to a number from 0 to 1
10) Availability of information (e.g. repair and/or upgrade manuals, exploded diagrams)	A) Semi-quantitative based on comprehensiveness of available information: I. Complete information available: A repair, reuse or upgrade process, for which all relevant information is available. Complete information may include circuit board schematics of electronic parts, functional specification of parts (e.g. resistance value of resistors, viscosity grade of lubricants) and information on compatibility of parts with other products. II. Comprehensive information available: A repair, reuse or upgrade process, for which not all relevant information is available as described above, but for which reasonably comprehensive information is available. Comprehensive information may include step-by-step disassembly instructions with identification of tools needed, recommended torque for fasteners, diagnostic and error resetting codes, testing procedures, reference values for measurements III. Basic information available: A repair, reuse or upgrade process, for which complete or comprehensive information is not available as described above, but for which some information is available. Basic information may include product identification, instructions for regular maintenance, an overview of repair or upgrade services offered by the manufacturer, troubleshooting charts, a list of available updates, an exploded view and spare parts list.	Favoured option for the study team since it is objective and practical. Also target group considerations can be integrated

Parameter	Classification/rating options [a] [b]	Technical considerations of the study team
	IV. No information available: A repair, reuse or upgrade process, for which no relevant information is available. Alternative: I. automatic troubleshooting and provision of any information that might be relevant for the specific problem/reparation/upgrade via an app, download link or the like AND access to chat/phone support with employee II. online availability of repair and upgrade manuals by search on the product/model number III. only provision of legally defined material and nothing more	
	B) Semi-quantitative based on target group: I. Publicly available: A repair/upgrade process for which the relevant information (comprehensive or complete information to facilitate repair/upgrade, as relevant) is available to all interested parties. II. Available to independent repair service providers: A repair/upgrade process for which the relevant information (the procedure by which each target group can obtain the relevant information, including any fees related to the access to the information concerned) is not publicly available as described above, but is available to any self-employed professional, as well as any legally established organisation, providing repair services (Channels for communicating information to independent service providers may include printed manuals, password-protected websites and digital information carriers such as DVDs or flash drives) III. Available to manufacturer-authorised repair service providers: A repair/upgrade process for which the relevant information (the procedure by which each target group can obtain the relevant information, including any fees related to the access to the information concerned) is not available to the general public or to independent repair service providers as described above, but is available to service providers authorised by the product manufacturer to offer repair services. IV. Available to the manufacturer only: A repair, reuse or upgrade process, for which the relevant information (the price for repair or upgrade by the manufacturer of the part, for which	Complementary, if not integrated. Information is considered to be available to a target group must also consider the unequivocal identification of the product and of the information available for that product, based on the commercial product name.

Parameter	Classification/rating options [a] [b]	Technical considerations of the study team
	information availability is assessed) is not available to the general public or to independent or authorised repair service providers as described above, but is available to the product manufacturer. Alternative: I. Repair/upgrade information is publicly available to all interested parties II. Repair/upgrade information is available to independent repair service providers III. Repair/upgrade information is available only to manufacturer-authorised repair services IV. Repair/upgrade information is available after the payment of a fee V. Repair/upgrade information is not available C) Percentile score within known spread: - Score = TG_i / TG_{max} x C_i / C_{max} Where, - TG_{max} is the score corresponding to the best classification achievable for the product (in terms of target group) - TG_i is the score corresponding to the class of the analysed product (in terms of target group) - D_{max} is the score corresponding to the best classification achievable for the product (in terms of comprehensiveness of information) - D_i is the performance of the product (in terms of comprehensiveness of information)	Normalisation of above approaches to refer class scores to a number from 0 to 1
Others		
11) Guarantee issues	A) Semi-quantitative based on the "commercial guarantee/ extended warranty" offered by manufacturers/retailers, for example with repair being the first option of remedy (e.g. "commitment to free repair") I. More than 6 years of commercial guarantee offered as included in the price of the product. II. 5 years of commercial guarantee offered as included in the price of the product	This parameter can be seen as a possibly relevant "proxy indicator" for the reparability or the durability/quality of products. Further discussion is needed, in particular with respect to its evaluation options and to the reference to entire product or specific parts (e.g. the motor of a washing machine).

Parameter	Classification/rating options [a] [b]	Technical considerations of the study team
	III. 4 years of commercial guarantee offered as included in the price of the product IV. 3 years of commercial guarantee offered as included in the price of the product V. No commercial guarantee available	
	B) Semi-quantitative based on the possibility of repair by non-authorised repairers	Based on repairability.org, more critical than the option above.
	I. Repair by non-authorised repairers will not affect the warranty of the product II. Repair by non-authorised repairers will void the warranty of the product	
	C) Percentile score within known spread: Score = G_i / G_{max} Where, - G_{max} is the score corresponding to the best classification achievable for the product (in terms of guarantee) - G_i is the score corresponding to the class of the analysed product	Normalisation of above approaches to refer class scores to a number from 0 to 1
12) Return models	A) semi-quantitative based on return models offered by the manufacturer to facilitate repair: I. Lease, product as a service: A repair/upgrade process, for a product which is sold as a subscription model (a service is sold instead of a product.) The customer does not own the product, and instead it remains property of the manufacturer. For the repair, reuse or upgrade process it is sent back to a location designated by the manufacturer. II. Advanced replacement scheme: A repair/upgrade process, for which there is a service contract between customer and manufacturer in which an advanced replacement scheme is applied. The manufacturer commits to collect the defective product and replace it immediately with a new/remanufactured/repaired unit. The defective product is sent to a location designated by the manufacturer for repair after which it can be used again for advance replacement for another customer.	This parameter and the related classification/rating can be relevant for all products.

Parameter	Classification/rating options [a] [b]	Technical considerations of the study team
	III. Mail-back program: A repair/upgrade process, for which the manufacturer offers a program whereby the user posts the product to a location designated by the manufacturer. IV. User delivers product: A repair/upgrade process, for which the user drops product off at local repair facility or at a collection point of a local shop from where product is shipped to a repair facility. V. No return model: A repair/upgrade process, for which no collection is organised. Product repair is left up to the owner. B) Percentile score within known spread: Score = RM_i / RM_{max} Where: - RM_{max} is the score corresponding to the best classification achievable for the product (in terms of return model) - TG_i is the score corresponding to the class of the analysed product	Normalisation of above approach to refer class scores to a number from 0 to 1
13) Data transfer and deletion	A) semi-quantitative based on availability of data transfer and deletion functionality: I. Built in: built-in secure data transfer and deletion functionality is available to support the deletion of all data contained in data storage parts (i.e. hard drives and solid state drives) in function of the risks faced and in order to grant the security of personal data and to facilitate the reuse of these parts. II. On request: secure data transfer and deletion is available under request to support the deletion of all data contained in data storage parts (i.e. hard drives and solid state drives) in function of the risks faced and in order to grant the security of personal data and to facilitate the reuse of these parts. III. Not available: A reuse process, for which secure data transfer and deletion is not available B) Percentile score within known spread: Score = D_i / D_{max} Where: - D_{max} is the score corresponding to the best classification achievable	This parameter and the related classification/rating, proposed by stakeholders, can be relevant for ICT products.

Parameter	Classification/rating options [(a) (b)]	Technical considerations of the study team
	for the product (in terms of data transfer and deletion) - D_i is the score corresponding to the class of the analysed product	
14) Safety issues	A) semi-quantitative based on the risks associated with repair operations: I. There are no injury risks involved in the repair of the product II. There is some risk of injury during the repair process, so that the repair cannot be undertaken by the consumer III. There is a high risk of injury during the repair process, so that the repair cannot be undertaken by non-authorised repairers.	Consideration of this parameter proposed by stakeholders. Classification inspired by repairability.org. However, it can be merged with parameter 5, unless other specific points are raised.
15) Availability of OEM qualified service engineers	A) Semi-quantitative based on the availability of OEM qualified service engineers: I. The manufacturer provides support of OEM qualified service engineers during the warranty period II. The manufacturer provides support of OEM qualified service engineers at any time III. The manufacturer does not provide support of OEM qualified service engineers B) Percentile score within known spread: Score = OR_i / OR_{max} Where: - OR_{max} is the score corresponding to the best classification achievable for the product (in terms of availability of OEM qualified service engineers) - OR_i is the score corresponding to the class of the analysed product	This parameter, proposed by stakeholders, can be relevant, alone or integrate in other parameters. Normalisation of above approach to refer class scores to a number from 0 to 1
16) Ease of restoring to full working condition after repair	A) Semi-quantitative based on the ease of restoring the product to working condition post-repair: I. The product functions as before, with no or minimal loss of quality and aesthetics II. The product functions as before, however there is some loss of quality and/or aesthetics III. The product does not function as before	Consideration of this parameter proposed by stakeholders. Classification inspired by repairability.org (although subjective)

Parameter	Classification/rating options [a] [b]	Technical considerations of the study team
	B) Percentile score within known spread: Score = R_i / R_{max} Where: - R_{max} is the score corresponding to the best classification achievable for the product (in terms of ease of restoring to working conditions) - R_i is the score corresponding to the class of the analysed product	Normalisation of above approach to refer class scores to a number from 0 to 1

Notes:

(a) To be tailored to specific product group(s) and referred to priority part(s)

(b) A score can be assigned to each class and for each parameter. However, for some parameters it could be more relevant to have minimum pass/fail criteria or reporting on the underlying information (e.g. "spare parts available for X years").

Part 6) Aggregation of individual parameters

Views of stakeholders with respect to the aggregation of information is compiled in Table A.4.

Table A.4: Technical considerations about aggregation levels for the scoring system – responses from stakeholders

Options	Technical considerations
Only a limited number of individual parameters (e.g. the 3-4 most relevant ones) are considered and reported separately	More than half of respondents to the initial questionnaire expressed some concerns over covering only a limited number of parameters, because: - This would not be sufficient to evaluate the reparability of products. - A restricted list of parameters may result in optimisation of the assessed parameters at the expense of others, leading to repair-unfriendly scenarios (despite the good rating of the assessed parameters). Less than half of respondents instead favoured focusing on a limited number of parameters separately, which would ensure transparency. However, the relevant issue is whether the product is reparable or not. Separate information might not be easy to understand by consumers, whilst aggregated information could be less valuable. A possible solution to this issue could be to rate parameters separately, and then to aggregate them into an overall score. This would be important to ensure that key information is not lost, and that the process is transparent. Information could be either provided in a label or in a data sheet.
All relevant parameters related to product design (e.g. disassembly sequence and tools needed) are aggregated into one index	More than a half of respondents to the initial questionnaire expressed some concerns over the aggregation of product-design parameters into one index, because: - It would imply implicit value choices or judgements in the evaluation. Moreover, it could allow trade-offs across parameters, so that a "good" rating could be achieved at the expense of other important aspects. - It could result in loss of information, and it should be checked, for instance via appropriate assessment methods with consumers, if the delivered message is sufficiently well understood.
All relevant parameters related to the repair service support (e.g. spare parts and information availability) are aggregated into one index	More than half of respondents to the initial questionnaire expressed some concerns over the aggregation of parameters related to the repair service support into one index, because: - It would imply implicit value choices or judgements in the evaluation. Moreover, it could allow trade-offs

Options	Technical considerations
	across parameters, so that a "good" rating could be achieved at the expense of other important aspects. - It could result in loss of information, and it should be checked, for instance through consumer assessment methods if the delivered message is understood. Less than half of respondents were favourable to this approach, which could integrate aspects such as: support offered by OEM, availability and delivery time of spare parts. The approach could be complemented by the provision of separate additional information (e.g. X years of spare parts availability).
All relevant parameters related to design characteristics are aggregated into one index, and all relevant parameters related to operation characteristics are aggregated into another index	More than half of respondents to the initial questionnaire expressed some concerns over the aggregation of parameters related to product design, and to the repair service support into two indices, because: - It would imply implicit value choices or judgements in the evaluation. Moreover, it could allow trade-offs across parameters, so that a "good" rating could be achieved at the expense of other important aspects. - It could result in loss of information, and it should be checked, for instance through consumer assessment methods if the delivered message is understood. Less than half of respondents instead favoured showing two indices. This could be complemented by the provision of separate additional information (e.g. X years of spare parts availability).
All relevant parameters are aggregated into one overall index	About half of respondents to the initial questionnaire expressed some concerns over the aggregation of all relevant parameters into one index, because: - It would imply implicit value choices or judgements in the evaluation. Moreover, it could allow trade-offs across parameters, so that a "good" rating could be achieved at the expense of other important aspects. - It could result in loss of information, and it should be checked, for instance through consumer assessment methods if the delivered message is understood. Less than half of respondents instead favoured showing two indices. This could be complemented by the provision of separate additional information (e.g. X years of spare parts availability).

If aggregation of scores were actively proposed, most respondents to the initial questionnaire considered that different parameters should have different weights.

Weighting should reflect the importance of each parameter for the repair/ upgrade operation.

Some stakeholders suggested that the highest weight should be assigned to the availability of parts. Tools and information (including software) were in general considered by stakeholders as more important than disassembly sequences, type of fasteners, working environment, skills, and diagnostic support. Visibility of fasteners was also considered more important than the type of fastener. However, weighting implies implicit value choices or judgements between parameters which could change depending on the industry sector concerned and on the product considered (B2B vs. B2C).

It was also suggested by some stakeholders that weighting could be combined with "pass/fail" criteria for some parameters. For instance, disassembly sequence only becomes relevant if a certain pass threshold is reached.

Indications provided by stakeholders did not conclusively converge to one widely supported option, since they identified pros and cons are for each alternative analysed.

A possible option resulting from the analysis of the comments received from stakeholders is the following:

1. A selection of relevant parameters for a certain product group is made;
2. Minimum requirements for the product group are set (to ensure reparability/upgradability of the product), as well scoring requirements;
3. Scoring requirements are weighted and aggregated into a single index to differentiate between different product options;
4. Details of individual parameters are provided for transparency reasons.

Part 7) Reporting options to assess products

Reporting options proposed for discussion with stakeholders are included in Table A.5, as well opinions collected about the suitability of each option.

Table A.5: Technical considerations regarding scales for reporting the final score – responses from stakeholders

Scale for reporting	Suitability (*)	Technical considerations
Binary (pass/fail)	In general "Low" (1.1 out of 3 as average)	In general, stakeholders consider that a pass/fail approach could be too simple and might not allow the assessment of the degree of reparability/upgradability of products and differentiating between them. Nevertheless, some separate binary criteria could be integrated into a scoring system. On the other side, other stakeholders think that this could be a realistic approach, since consumers might be not interested in knowing a percentage of chance, but could rather prefer a commitment from manufacturers (for instance, that products will be repaired at a maximum cost for a given period).
Traffic lights	In general "Low" (1 out of 3 as average)	In general, stakeholders consider that traffic light symbols could be easy to understand. However, they might not facilitate a sufficient differentiation between products.
0-to-5 stars	In general "Medium"/"High" (2 out of 3 as average)	In general, stakeholders consider that this kind of grading could be useful to differentiate between products in an intuitive way. Other symbols (e.g. spanners/ wrenches) might be more suitable to use for this purpose rather than stars.
Alphabetic (A, B, C, D, E, F, G)	In general "Medium" (1.4 out of 3 as average)	In general, this approach raised split views from stakeholders: - On the one hand there are those who think that aligning with a similar approach to that used in the EU Energy Labelling scheme would be good - On the other hand, there are those who consider that this could be confusing.
Decimal number between 0-1 (or a number between 0-10 or 0-100)	In general "Medium"/"High" (1.9 out of 3 as average)	In general, stakeholders consider this kind of grading as the most understandable system to differentiate between products. The scale could be from 0 to 10. Numerical scores could also be represented as bar charts. However, there is the risk that this option is too detailed and uncertain. For instance, a small difference in score between two products may not correspond to a noticeable/ reliable difference in reality.

(*) Based on the analysis of the feedback received from stakeholders (for all options answers to the initial questionnaire ranged from "No" to "Low", "Medium" or "High")

Part 8) Repair and upgrade of macro-categories of products

With respect to the initial classification of products, respondents to the initial questionnaire pointed out that:

- Although categorisation of products into families may seem logical, there is a sensible variation of function, performance and complexity between products and models of the same type. Reparability and upgradability is product specific.

- Personal computers and laptops (but also tablets and servers) are the most modular products. Hard drives and memories have standardised interfaces and can be upgraded in many cases. TVs and DVD players are very different and not modular at all. Electronic products could be split at least into 3 sub-groups: d1) Small & portable ICT products like smartphones, d2) Medium sized ICT products like desktop computers, d3) Large or installed ICT products like servers.

- There are some fuzzy areas. For instance:

    - With the increasing diffusion of connected devices ("internet of things"), it is likely that category (a) overlaps with category (d) and that some aspects apply to both (e.g. the availability of software updates)

    - Products as DVD players could also belong to group a)

    - Products such as large TVs could belong also to group b).

Stakeholders were asked to define a series of scenarios/conditions under which the repair and upgrade operations would be more favourable, or more likely to happen. The input from stakeholders has been collated and summarised in Table A.6 (Repair) and Table A.7 (Upgrade), respectively.

Table A.6: Conditions that could make repair attractive from a consumers-targeted perspective

Aspect	Small appliances	Medium/Large appliances	Installed products	Electronic products
Maximum cost of repair which would make it attractive, expressed as % of the product's purchase price	In the range of 15-40%, although it depends highly on the product and its technological development. Repair could be less attractive for this product category because of the relatively low price of new products.	In the range 15-40%	In the range 15-40%	In general up to 30%, however repair cost threshold is a function of different aspects motivating the repair decision (e.g. functional needs, emotional attachment).
Minimum lifetime expectancy for the product at the time of purchase, which would make repair attractive (in years)	From 5 to 10 years, depending on the product. Due to the lower attractiveness of repair for this product category, guarantee coverage is considered more important.	From 8 to 15 years, depending on the product.	From 10 to 20 years, depending on the product	From 5 to 7 years depending on the product.
Maximum time to repair, including delivery of spare parts, which would make it attractive (in weeks)	In general, 1 week max. However this could rise up to 2-10 weeks for some stakeholders. Availability of spare parts is crucial.	In general 1-2 weeks max. In case the product is difficult to replace a larger period can be accepted by the consumer. Availability of spare parts is crucial.	In a wide range (few days – 2 weeks). In case the product is difficult to replace a larger period can be accepted by the consumer.	In a wide range (few days – 2 weeks) Maximum acceptable time for repair is highly subjective and depends on the customers' emotional and functional reliance or needs. Important to provide temporary devices to replace the absence of the product during the time of repair.
Other comments	For all products also the following aspects are highlighted as relevant: - Cultural aspects and habits (i.e. what consumers use to do when a product breaks or becomes functionally obsolete) - The availability of an effective service network of trained professionals (either service engineers of the manufacturer or			

Aspect	Small appliances	Medium/Large appliances	Installed products	Electronic products
	independent authorised and qualified professionals). This leads to proximity and quality, which contributes positively to the repair decision. - The ease of access to a repair shop is considered more relevant for small appliances. No matter how cheap the repair is, many consumers might be willing to pay for new products solely due to the inconvenience of taking it to a repair/service location.			

Table A.7: Conditions that could make upgrade attractive from a consumers-targeted perspective

Aspect	Small appliances	Medium/Large appliances	Installed products	Electronic products
Maximum cost of upgrade which would make it appealing (free of charge, or expressed as % of the product's purchase price)	Range of costs reported from 5% to 25% of the product's purchase cost. High dependent on the product type and upgrade benefits.	Range of costs reported from 5% to 25% of the product's purchase cost. High dependent on the product type and upgrade benefits.	Range of costs reported from 10% to 25%. Due to the difficulty of new installation, upgrading might be more attractive than for other product groups.	Range of costs reported from 0% to 20%. Free of charge when linked to software or firmware upgrade (bug fixes or vulnerabilities). Hardware upgrade reported in the range of 10-20% of the product's purchase price.
Minimum lifetime expectancy for the product, at the time of purchase, which would make upgrade attractive (in years)	From 5 to 10 years, depending on the product.	From 7 to 15 years, depending on the product.	From 10 to 20 years, depending on the product	From 5 to 7 years in general.
Maximum time of upgrade, including delivery of new parts/functions, which would make it attractive (in weeks)	From 1 week to 5 weeks. This is considered a less critical point from the point of view of the consumer, as the appliance is still functional.	Highly dependent on product. This is considered a less critical point from the point of view of the consumer, as the appliance is still functional.	Highly dependent on product. This is considered a less critical point from the point of view of the consumer, as the appliance is still functional.	From 1 day to 1 week is reported as maximum time of upgrade. Also in this case time is considered a less critical aspect.
Other comments	For upgradability it is more difficult to find objective conditions. There can be significant variations also between products of the same product category, depending on the complexity of their design.			

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