Requirements on material efficiency within the Ecodesign Directive

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REQUIREMENTS ON MATERIAL EFFICIENCY

WITHIN THE ECODESIGN DIRECTIVE

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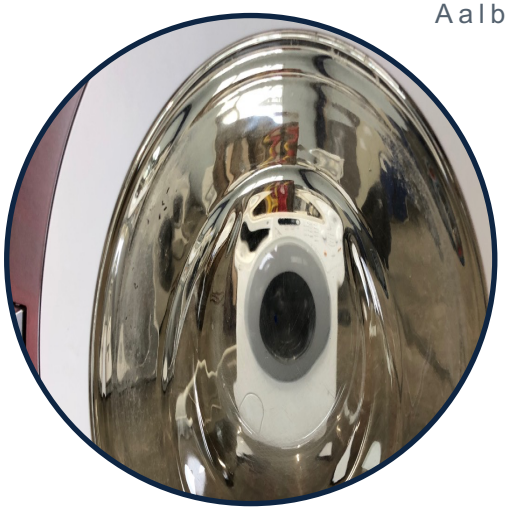

March 2021

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1 PREFACE

The report has been prepared for the Danish Energy Agency by Anja Marie Bundgaard, Rikke Dorothea Huulgaard, Arne Remmen and Maria Camilla Rincon Gil from the Department of Planning at Aalborg University. The report is the output of the project called *Analyse af eco-designkrav om ressourceeffektivitet og deres verificering*, which ran from November 2020 until the end of December 2020, and it is financed by the Danish Energy Agency. However, the content of this publication does not necessarily represent the official views of the Danish Energy Agency.

The main purpose of the report is to investigate existing and future material efficiency requirements under the Ecodesign Directive and the European Union (EU) energy labelling and their verification.

Several people have been interviewed in the process of writing this report and the authors would like to thank everyone for their valuable insights.

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2 EXECUTIVE SUMMARY

The Ecodesign Directive and the EU energy labelling have proven to be effective policy instruments to reduce energy consumption and thereby CO_2 emissions. It is estimated that the Ecodesign Directive and the EU energy labelling have resulted in savings in 2020 of approximately 9% of the current energy consumption and 7% of the carbon emissions (European Commission 2019). In the new circular economy action plan from the European Commission, the Ecodesign Directive is assigned a key role in the transition towards a circular economy; indeed, it is a policy tool which can ensure circular design of products entering the European Market. However, studies have shown that around 10%–20% of the products on the European Market are non-compliant with the ecodesign requirements (Petersson and Nielsen 2013); consequently, 10% of the total energy savings are lost (Baton et al. 2017). It is therefore key to ensure that existing and future material efficiency requirements, in support of a circular economy, can be verified in relation to market surveillance. This has precisely been the theme of this project.

This project has analysed existing and future material efficiency requirements under the Ecodesign Directive and the EU energy labelling and how these are verified. The point of departure for the analysis of the future material efficiency requirements is the work conducted under the standardisation mandate M/543 from the European Commission targeting material efficiency aspects under the Ecodesign Directive.

The document review of the adopted implementing measures under the Ecodesign Directive, covering 28 energy-related product groups, showed that 22 implementing measures include information requirements targeting material efficiency, while only nine include specific requirements. The specific requirements cover aspects such as durability (or reliability using the definition from EN 45552), availability of firmware, easy disassembly, spare parts availability, access to repair and maintenance information for professional repairers, data deletion options, disassembly for recyclability and guidelines for marking plastic and hazardous substances.

The standards developed under M/543 targeting material efficiency aspects are horizontal standards, which cannot be directly applied to energy-related products or product groups. The only exceptions are the standard on critical raw materials (EN 45558) and the standard on methods for providing information (EN 45559), which can be applied directly to products or product groups. The horizontal standards are intended to provide the framework for developing product or product group–specific standards. The horizontal standards focus on durability, remanufacture, repair, recyclability, reused components, recycled content and critical raw materials. The maturity level of the different methods in the horizontal standards varies, a factor that could also have an impact on the time horizon for their implementation. Only the standards on critical raw materials and providing information are considered directly applicable.

The concepts are also at different levels of maturity. It is more likely that specific criteria will be set for the reliability than for the durability of products because more standards already exist regarding reliability. The analysis of the future material efficiency requirements revealed that there is a considerable overlap between the durability standard (EN 45552); the standard on remanufacturing (EN 45553); and the standard on repair, reuse and upgrade (EN 45554), as they cover overlapping and similar aspects. This is an obvious consequence of the fact that a product's ability to be repaired or upgraded affects the product's durability and its ability to be remanufactured.

The study revealed two aspects not covered in detail by the standardisation mandate M/543, namely considerations regarding reduced resource or material consumption and chemicals and restrictions hereof. Both aspects are important in a transition to a circular economy.

The existing experience with control measurements of the adopted material efficiency requirements are still limited in Denmark. Denmark and the other Nordic countries, in particular Sweden, are considered to be some of the countries dedicating the most resources to market surveillance in Europe. It is therefore likely that the existing experience with control measurements through product testing in the EU member states is still limited. An exception is Sweden, which is further elaborated in chapter 8. The limited experience entails that there might be undiscovered difficulties in the verification and test of these requirements, which will not be uncovered before more experience with control measurements have been gained. A recommendation is therefore to make use of a future European project such as Eco-design Compliance Projects (EEPLIANT) to gain more experience with market surveillance of the material efficiency requirements across the EU member states.

Due to the horizontal nature of the standards, it is still difficult to evaluate how easy it will be to verify these types of aspects. The standards suggest different types of assessment methods and a few general remarks can be made on their verification.

- For the durability standard 45552, it will be potentially more complex to verify future durability requirements (covering both repair and remanufacturing steps) compared with future reliability requirements, as the reliability concept is further developed in the standardisation context.
- For the standard EN 45553 on remanufacturing, the assessment methods have not been well developed yet, as it primarily identifies important product attributes and criteria that are vital for remanufacturing processes.
- For the EN 45554 standard on repair, reuse and upgrade only, one of the assessment methods is based on a calculation, while the remaining criteria are evaluated based on a classification of the different aspects according to a scale ranging from A to E. This classification of the different criteria can embed a qualitative interpretation if the requirements for the different classifications are not well defined. Further study is therefore needed to examine the verification of these types of requirements.
- The EN 45556 standard on the proportion of reused component and the EN 45557 standard on recycled content can only be determined indirectly, as no methods exist to measure this directly. The verification is, therefore, by means of documented evidence from manufacturers and suppliers.
- The EN 45558 standard on critical raw materials and the EN 45559 standard on information can to some extent can be used directly on specific products and verified through document review.

To ensure verifiability of the future material efficiency requirements, it is essential that standards are developed and harmonised; they can then be used to check product compliance with the ecodesign requirements. Furthermore, accredited test laboratories should be available to perform the compliance check. The contracts with the accredited test laboratories should also have a dynamic structure to ensure that all ecodesign requirements can be tested at the same laboratory and to utilise synergies among the different policy areas.

3 INTRODUCTION

The Ecodesign Directive has been assigned a significant role in the first and second circular economy action plan from the European Commission, and various initiatives have been launched to support the uptake of ecodesign requirements targeting material efficiency. Due to this political attention on a circular economy and material efficiency, it is likely that more ecodesign requirements on material efficiency will be adopted in the implementing measures in the future. There are already requirements on material efficiency in some adopted implementing measures. Therefore, the main purpose of this project is to investigate existing and future material efficiency requirements under the Ecodesign Directive and the EU energy labelling and their verification. For the future material efficiency requirements, the outset is the work conducted under standardisation mandate M/543 from the European Commission targeting material efficiency requirements under the Ecodesign Directive. The project includes three primary tasks described below.

Chapter 4

This chapter includes a review and analysis of existing material efficiency requirements in the Ecodesign Directive and the EU energy labelling. The analysis will answer the following two questions:

- What characterises the existing material efficiency requirements in the Ecodesign Directive and the EU energy labelling?
- How are the existing material efficiency requirements verified by market surveillance authorities (MSA)?

Chapter 5

This chapter includes a review and analysis of the existing horizontal standards developed under standardisation mandate M/543 on material efficiency. The following information will be covered:

- What characterises the existing horizontal standards developed under standardisation mandate M/543?
- This analysis provides an overall assessment of the maturity level of the existing horizontal standards.
- This analysis provides an overall assessment of missing circular economy aspects in the existing horizontal standards on material efficiency

Chapter 6

This chapter includes an evaluation of the verifiability of the existing and future material efficiency requirements in relation to the capacity of MSA (the Danish Safety Technology Authority). The evaluation will answer the following questions:

- What characterises the verifiability of the existing material efficiency requirements?
- How verifiable are the existing material efficiency requirements in relation to the capacity of the Danish Safety Technology Authority?
- How verifiable are the new material efficiency criteria in the horizontal standards on material efficiency in relation to the capacity of the Danish Safety Technology Authority?
- How can verifiability of future material efficiency requirements be ensured?

3.1 DEFINITION OF RESOURCE EFFICIENCY AND MATERIAL EFFICIENCY

Resource efficiency in the project is defined as illustrated in Figure 1. In this understanding, resource efficiency can be enhanced through reduction, maintenance and repair, reuse and redistribution, remanufacturing and refurbishment and recycling of materials. Hence, resource efficiency includes reducing material and energy use in the whole life cycle of the product, including mining the materials, production, use and final disposal of the product. Resource efficiency can

also be enhanced by reuse or redistribution of the product again to enable multiple use-cycles. Improving the possibility for maintenance of the product, by making maintenance guidelines or repair manuals available, can expand product lifetime and enhance resource efficiency. Besides, resource efficiency can also be improved by increasing the potential for remanufacturing or refurbishment of the product, enabling the product or component to have multiple use-cycles. It can include aspects such as improving the reparability of the product or providing access to spare parts for a considerable period of time. Furthermore, resource efficiency of a product can be increased by enhancing the *recyclability* of the materials in the product, such as reducing or eliminating harmful substances that hinder the recycling of the materials. Some cross-cutting requirements such as *durability* can improve both the product's and its components' possibilities for maintenance, reuse and redistribution as well as remanufacture and refurbishment.

In this conceptual understanding of resource efficiency, energy is considered an important resource. However, in this report the focus will be mainly on resource efficiency excluding energy efficiency, which is defined as material efficiency in the report. Consequently, the concept of material efficiency will be used throughout the rest of the report. Energy is excluded from the report because the focus is on the upcoming ecodesign requirements targeting broader environmental aspects rather than energy.

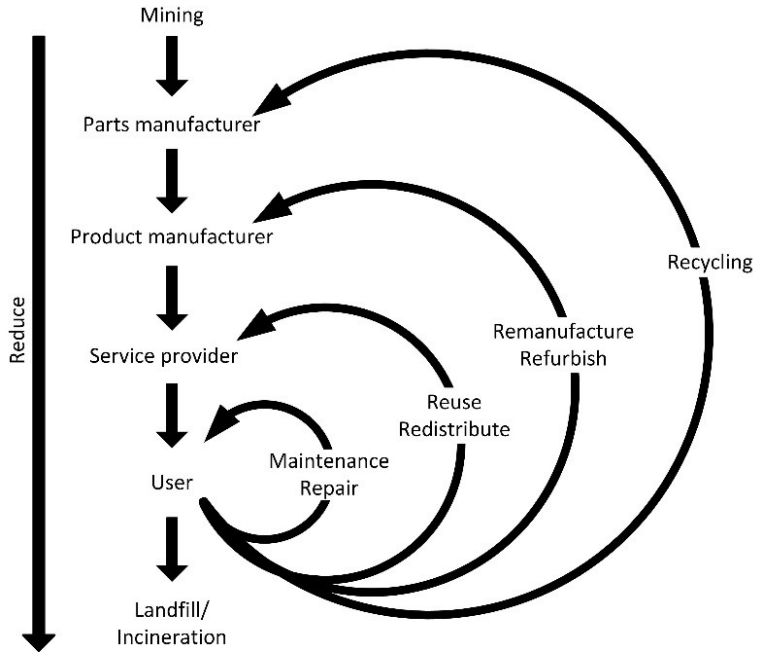

Figure 1: The applied understanding of resource and material efficiency related to a circular economy

4 REVIEW AND ANALYSIS OF MATERIAL EFFICIENCY REQUIREMENTS IN THE ECODESIGN DIRECTIVE

4.1 INTRODUCTION

The European Commission has established a set of product policy tools that aim to drive the market towards more sustainable production and consumption of products. Among these tools are the Ecodesign Directive – which aims to push the market through the implementation of minimum requirements – and the EU energy labelling which aim to differentiate products on the market regarding their energy performance and thus allow consumers to identify more sustainable products.

The Ecodesign Directive establishes a framework setting minimum ecodesign requirements for energy-related products (ErP) (European Commisssion 2009). A product group should represent a significant volume of sales and trade (> 200,000 units/year) to be considered for an implementing measure or a voluntary agreement. Consequently, regulated products must fulfil certain mandatory requirements in order to be placed on the EU market.

The Ecodesign Directive requires manufacturers and importers placing products on the EU market to improve their environmental performance and to consider the entire lifecycle of the products by making self-declarations regarding product conformity, following appropriate conformity assessments specified in the annex of the ecodesign directive for every product group.

MSA in each member state are responsible for verifying the compliance of the ecodesign requirements and energy labelling. According to the section “verification procedure for market surveillance purposed” in the Ecodesign Directive, the EU member states shall provide the information of the testing results to other member states and to the European Commission.

Section 4.2 aims to analyse the existing material efficiency requirements in the Ecodesign Directive. The adapted regulations will be reviewed to identify their main characteristics and the current existing verification procedures carried out by MSA. This section also includes a review of material efficiency requirements for EU energy labelling. However, only limited requirements were found; they are related to water consumption of water-using products. The following sections therefore focus on material efficiency requirements in the Ecodesign Directive.

4.2 CHARACTERISTICS OF EXISTING MATERIAL EFFICIENCY REQUIREMENTS IN THE ECODESIGN DIRECTIVE

A document review was performed regarding the 28 adopted implementing measures, with the aim of identifying all adopted ecodesign requirements targeting material efficiency. A full review can be found in Appendix 1. The annex of the Ecodesign Directive describes the ecodesign requirements for each product, and they can be classified into two types: (1) s*pecific requirements* and (2) *information requirements*. The data from the review of the 28 implementing measures have been classified and are colour coded: green indicates there are requirements for the specific product group, while red denotes there is no requirements targeting material efficiency. The information is shown in Table 1 and table 2. In total, 22 implementing measures include information requirements targeting material efficiency, while only nine implementing measures have specific requirements.

Table 1: Overview of material efficiency requirements in the 28 product groups

Regulation number	Product	Specific requirements	Information requirements
(EU) 2019/2020	Light sources and separate control gears		
(EU) 2019/2022	Household dishwashers		
(EU) 2019/2019	Household refrigerating appliances		
(EU) 2019/2023	Household washing machines		
(EU) 2019/2021	Electronic displays and televisions		
(EU) No 666/2013	Vacuum cleaners		
(EU) 2019/424	Computers and computer servers		
(EU) 2019/1784	Welding equipment		
(EU) 2019/2024	Refrigerating appliances with a direct sales function		
(EU) No 66/2014	Domestic ovens		
(EU) 2015/1188	Local space heaters		
(EU) 2015/1095	Professional refrigerated storage cabinets		
(EU) No 1253/2014	Residential ventilation units		
(EU) 2015/1189	Solid fuel boilers, supplementary heaters, temperature controls and solar devices		
(EU) No 813/2013	Space heaters and combination heaters		
(EU) No 814/2013	Water heaters, hot water storage tanks and packages of water heater and solar device		
(EU) 2016/2281	Air heating products, cooling products, high temperature process chillers and fan coil units		
(EU) No 622/2012	Circulators		
(EU) 2019/1781	Electric motors		
(EU) No 327/2011	Fans driven by motors with an electric input power between (EU) 125 W and 500 kW		
(EU) No 548/2014	Small, medium and large power transformers		
(EU) No 547/2012	Water pumps		
(EU) No 206/2012	Air conditioners		
(EU) No 932/2012	Household tumble dryers		
N/A	Household combined washer-dryer sets		
(EU) 2019/1782	External power supplies		
(EC) No 107/2009	Simple set-top boxes		
(EU) No 801/2013	Standby and off mode electric power consumption of electrical and electronic household and office equipment		

Note. Green means there are material efficiency requirements, while red means there are no material efficiency requirements.

The *information requirements* target end consumers, recyclers and professional repairers, as they include information on how to use and to maintain the products with the aim of minimising the environmental impact and to ensure longer product life expectancy. In addition, there is information on the period of availability and installation of spare parts, instructions of how to disassemble and to recycle or to dispose of the product at the end of its life. On the other hand, the *specific requirements* include aspects such as material consumption in the use phase, durability, firmware

availability, disassembly, spare parts availability, repair and maintenance information, data deletion, marking of plastics and hazardous substance.

Table 2: Overview of the categories of material efficiency aspects and types of requirements identified in the implementing measures

Category	Description	Type of identified requirements
Durability and reliability	Initiatives guaranteeing a minimum lifetime without limiting events	Requirements for the durability, reliability and lifespan of the product, including information of the minimum number of cycles before failure
Reparability, refurbishment and maintenance	Initiatives that improve product maintenance, remanufacturing and refurbishing potential	Maintenance instructions, availability of spare parts, easy access to disassembly without causing permanent damage Information requirements for the replacement of components
Recyclability	Initiatives that improve the recyclability of the product or the materials	Information relevant for disassembly, recycling and/or appropriate disposal of the product at the end-of-life Design for disassembly using commonly available tools
Reduction	Initiatives that reduce resource consumption during the entire lifecycle of the product	Efficient use of consumables and resources during use Information on the use of the product with fewer environmental impacts Declaration of content of critical materials and hazardous substances

4.2.1 CHARACTERISTICS OF SPECIFIC ECODESIGN REQUIREMENTS TARGETING MATERIAL EFFICIENCY

Specific ecodesign requirements targeting material efficiency aspects were identified in nine implementing measures. The specific ecodesign requirements are more challenging in terms of market surveillance because they require document control and control measurements. Table 3 provides a more detailed overview of the specific ecodesign requirements in the implementing measures targeting material efficiency.

Requirements targeting the durability of the products were identified for two product categories, namely electrical lamps and luminaries and vacuum cleaners. All requirements are reliability requirements of either the entire product (lighting equipment) or components of the product (the hose and motor of vacuum cleaners). Thereby, the requirements do not target durability as it is defined in standard EN 45552. Two implementing measures also set requirements targeting availability of firmware and security updates.

The implementing measures include a few ecodesign requirements, which could potentially improve reuse, repair and refurbishment of the products. It includes requirements on the disassembly of certain components and spare parts, the availability of spare parts, the availability of repair and maintenance information of professional repairers and a functionality to ensure data deletion. What characterises many of these ecodesign requirements targeting reuse, repair and refurbishment is that they do not target the specific product design. Instead, they set requirements for the framework around the product to ensure the availability of spare parts, firmware and repair and maintenance information. This is in contrast to many existing ecodesign requirements in the adopted implementing measures, which primarily set specific design requirements to the functionality of the products.

Three implementing measures also include requirements that shall ensure better recycling of the materials by guaranteeing that certain components can be removed and marking plastics. Furthermore, an implementing measure

covers ecodesign requirements such as marking components containing hazardous substances, declaration of mercury content and a restriction of the use of flame retardants in certain components. Hence, the ecodesign requirements overlap with the Restriction of Hazardous Substances Directive (RoHS) Directive. However, the advantage of setting requirements targeting hazardous substances in the Ecodesign Directive is that it is possible to set product-specific requirements instead of generic requirements.

Table 3: Overview of the specific ecodesign requirements targeting material efficiency aspects

Material efficiency aspects		Requirement	Product groups
Reduce		Minimum requirements of water consumption	Household washing machines
Maintenance	Durability	Lumen maintenance factor and survival factor	Electrical lamps and luminaries
		The hose shall be useable after 40,000 oscillations under strain. Operational motor lifetime shall be greater than or equal to 500 hours.	Vacuum cleaner
	Firmware	Availability of firmware and security updates for a period of time	Electronic displays and televisions Computers and computer servers
Reuse, repair and refurbishment	Disassembly	The light sources and separate control gears shall be replaceable with the use of commonly available tools and without permanent damage to the containing product.	Electrical lamps and luminaries
		The spare parts can be replaced with the use of commonly available tools and without permanent damage to the appliance.	Household dishwashers Household refrigerating appliances Household washing machines Electronic displays and televisions Welding equipment Refrigerating appliances with a direct sales function
		Joining, fastening or sealing techniques do not prevent disassembly for repair or reuse purposes of certain components.	Computers and computer servers
	Spare parts	Availability of spare parts for a certain period	Household dishwashers Household refrigerating appliances Household washing machines Electronic displays and televisions Welding equipment Refrigerating appliances with a direct sales function
		The manufacturer or representative shall ensure the delivery of the spare parts within 15 working days after having received the order.	Household washing machines Welding equipment Refrigerating appliances with a direct sales function

	Repair and maintenance information	Access to repair and maintenance information for professional repairer under a reasonable and proportionate fee	Household refrigerating appliances Household washing machines Electronic displays and television Welding equipment
	Data deletion	Functionality ensuring data deletion should be made available	Computers and computer servers
Recycling	Disassembly	Requirements for dismantling for material recovery and recycling while avoiding pollution according to the Waste Electrical and Electronic Equipment Directive (WEEE Directive)	Household refrigerating appliances
		Shall ensure that joining, fastening or sealing techniques do not prevent the removal, using commonly available tools, of the components include in the directive on batteries and accumulators and waste batteries and accumulators	Electronic displays and televisions
	Plastic	Marking plastics	Electronic displays and televisions
	Hazardous substances	Marking components containing flame retardants	Electronic displays and televisions
		Restrictions on the use of flame retardants	Electronic displays and televisions
		Declaration of mercury content in integrated displays	Computers and computer servers

4.3 THE VERIFICATION OF MATERIAL EFFICIENCY REQUIREMENTS BY MARKET SURVEILLANCE AUTHORITIES

Since the summer of 2018, the market surveillance of the Ecodesign Directive in Denmark has been the responsibility of the Danish Safety Technology Authority. The market surveillance consists of three primary tasks (1) **control of web-shops**, (2) **document control** and (3) **control measurements** through testing the products (Sikkerhedsstyrelsen 2021). Most implementing measures include requirements regarding information that should be available. Web-shop controls check whether this information is in fact available at the homepages and in the manuals (Sikkerhedsstyrelsen 2021). Document control includes a review of the technical documentation proving compliance with the ecodesign requirements for that specific product (Sikkerhedsstyrelsen 2021). The relevant documentation is gathered from the manufacturers, importers or authorised representatives of the product (Uldbæk 2020). While the needed documentation will depend on the specific requirements in the implementing measures, it typically includes: sales material, technical documentation, data sheets, information forms, user manuals and declarations of conformity (Sikkerhedsstyrelsen 2021). During control measurement, the specific product is then tested to verify if it complies with the documentation (Sikkerhedsstyrelsen 2021). The control measurements are conducted by accredited test laboratories. If the product does not comply, and the producer does not accept the first test results, then three additional products are tested to confirm the results. Products are typically selected for control measurements based on document control (Sikkerhedsstyrelsen 2021).

The information requirements in the implementing measures are typically tested through web-shop controls, whereas the specific requirements are tested through document control and control measurements (Uldbæk 2020). Hence, the information requirements targeting material efficiency are verified through web-shop controls (Uldbæk 2020). The Danish experience with verifying the material efficiency requirements through control measures – product testing at accredited laboratories – has been limited (Westphalen 2020; Uldbæk 2020). Indeed, no products have been tested in this respect yet. Consequently, the existing material efficiency requirements have only been verified by requesting and reviewing the technical documentation proving conformity with the Ecodesign requirements (Uldbæk 2020; Westphalen 2020).

In 2020, a Nordsyn project was initiated with the purpose of establishing control measurements of lighting sources, where the adopted material efficiency requirements will also be within the scope of the product testing (Uldbæk 2020). The specific testing is conducted by the Swedish Energy Agency, and each of the Nordic counties has the possibility to

send 5–10 different light sources for testing (Uldbæk 2020). The submitted lighting sources undergo a screening test covering 3–4 specific requirements in the implementing measures (Uldbæk 2020). Those that fail the screening will then undergo a full test including 20 units and covering all the specific requirements in the implementing measures (Uldbæk 2020). With this project, the Danish MSA are gaining some of the first practical experience with control measurements of the already adopted specific ecodesign requirements targeting material efficiency. Participating in the Nordsyn project that tests light sources has also made it possible for Denmark to undertake product testing of lighting sources, which was otherwise not possible, because the test laboratory with which Denmark had a framework agreement lost their accreditation during the contract period and therefore could not test lighting sources (Uldbæk 2020).

Among EU member states, Denmark and the other Nordic countries are considered to be some of the countries dedicating the most resources to market surveillance (using the most resources and doing the most product testing) (Krivosik and Attali 2014; Uldbæk 2020). A conclusion is therefore that the existing experience with control measurements of the adopted material efficiency requirements are still limited within the EU member states. This finding is also consistent with other studies, which have concluded that primarily the energy requirements are tested during control measurements (Krivosik and Attali 2014). Consequently, there might be undiscovered difficulties in the verification and test of these requirements that will not be uncovered before more experience with control measurements have been gained. An exception is Sweden, which due to their slightly different set-up with in-house test facilities have some experience with testing the material efficiency requirements. This is further elaborated in chapter 8.

A recommendation is therefore to make use of future European projects on market surveillance of the Ecodesign Directive and energy labelling to gain more experience with market surveillance of the material efficiency requirements across the EU member states. Previous projects have included the Eco-design Compliance Projects (ECOPLIANT), ATLETE I and II and Come on Labels. More information on the ECOPLIANT projects is provided in section 6.1.2. This would also be increasingly relevant as more material efficiency requirements are introduced in the implementing measures.

5 ANALYSIS OF EXISTING HORIZONTAL STANDARDS

5.1 INTRODUCTION

One of the initiatives launched in connection with the circular economy action plan from 2015 was the standardisation mandate M/543 on horizontal standards covering a broad variety of material efficiency aspects. The work of the standardisation mandate has recently been finalised and has resulted in the development of various horizontal standards covering material efficiency aspects (see Table 4). These standards can potentially impact how future ecodesign requirements might look. However, the maturity level of the different methods in the horizontal standards varies, and this could also have an impact on the time horizon for their implementation. One example is standard EN 45558 on critical raw materials, which was the first standard to be finalised and is one of only two standards that can be applied rather directly to the product groups. Therefore, declaration of critical raw materials will most likely be introduced in the short term in the ecodesign requirements, and it has already been introduced for welding equipment. The other standard, which is directly applicable, is EN 45559 on providing information related to material efficiency aspects of energy-related products.

Another aspect of importance for the uptake of material efficiency requirements and its implementation is verification and the ease of verification by MSA to ensure compliance. This aspect is also strongly related to the standards, as the purpose of these standards is to ensure that assessment measures that can be used to ensure compliance with the legislation are developed.

Finally, previous studies have shown that the political processes and stakeholder consultation forums also have a strong influence on the requirements (Bundgaard, Mosgaard, and Remmen 2017; Talens Peiró et al. 2020). Therefore, the key stakeholders (industry, non-governmental organisations and policy makers) have to be consulted to establish their focus areas and interests when analysing which future requirements to expect in new ecodesign regulation.

Table 4: Overview of standards developed under standardisation mandate M/543 by CEN, CENELEC and ETSI

Standards and technical reports developed under standardisation mandate M/543
TR 45550 Definitions related to material efficiency
TR 45551 Guide on how to use generic material efficiency standards when writing energy-related product-specific standardisation deliverables (discontinued)
EN 45552 General method for the assessment of the durability of energy-related products
EN 45553 General method for the assessment of the ability to remanufacture energy-related products
EN 45554 General methods for the assessment of the ability to repair, reuse and upgrade energy-related products
EN 45555 General methods for assessing the recyclability and recoverability of energy-related products
EN 45556 General method for assessing the proportion of re-used components in energy-related products
EN 45557 General method for assessing the proportion of recycled material content in energy-related products
EN 45558 General method to declare the use of critical raw materials in energy-related products
EN 45559 Methods for providing information relating to material efficiency aspects of energy-related products
TR 103 476 V.1.1.2 Circular Economy (CE) in Information and Communication Technology (ICT); Definition of approaches, concepts and metrics
ETSI Standard – Specific metrics, methods and parameters for assessment of material and resource efficiency aspects of ICT network infrastructure goods in the context of circular economy
TR 103 476 V.1.1.1 Circular Economy (CE) in Information and Communications Technology (ICT); Definition of approaches, concepts and metric

Note. European Committee for Standardization (CEN), European Committee for Electrotechnical Standardization (CENELEC) and the European Telecommunications Standards Institute (ETSI)

5.2 REVIEW OF EXISTING HORIZONTAL STANDARDS

The following section provides a short review of the horizontal standards developed under standardisation mandate M/543 and emphasises their key characteristics. The focus will be on the standards developed by the Joint Technical Committee 10 (JCT10) a joint working group by the European Committee for Standardization (CEN) and the European Committee for Electrotechnical Standardization (CENELEC). These standards are named EN 4555x (see Table 4). The standard TR 45550 on definitions related to material efficiency gathers the definitions of all the standards EN 45552–45559. We will not present this standard in detail, as the relevant definitions are included in the presentation of each standard.

5.2.1 EN 45552: GENERAL METHOD FOR THE ASSESSMENT OF THE DURABILITY OF ENERGY-RELATED PRODUCTS

The scope of EN 45552 – General method for the assessment of the durability of energy-related products (hereafter referred to as the durability standard) – is to define a framework including the parameters and methods needed for assessing the reliability and durability of energy-related products. The standard should be used as an outset to prepare the product-specific or product group–specific standards.

The durability standard defines two key concepts: reliability and durability. Reliability is defined as “the probability that a product function as required under given conditions, including maintenance for a given duration without limiting event” (Technical Committee CEN-CENELEC/JTC 10 2020a, 6). Here, a limiting event is defined as the occurrence of an event that results in a primary or secondary function no longer is delivered.

Durability is defined as “the ability to function as required, under defined conditions of use, maintenance and repair, until a limiting state is reached” (Technical Committee CEN-CENELEC/JTC 10 2020a, 6). Here, a limiting state is defined as a condition after one or more limiting events (Technical Committee CEN-CENELEC/JTC 10 2020a, 6). Hence, both reliability and durability describe the product’s ability to function as required under certain conditions. However, the scope of the two concepts is different. In the durability standard, reliability covers the steps until the product needs repair due to a limiting event, whereas durability includes potential repair and remanufacturing of the product until a limiting state is reached and the product reaches its end of life. Hence, durability can be considered a measure of the most likely maximum normal use of a product before it reaches its end of life, while reliability is directly related to the probability of product failure given normal environmental and operating conditions. Figure 2 provides an overview of the relation between the two concepts.

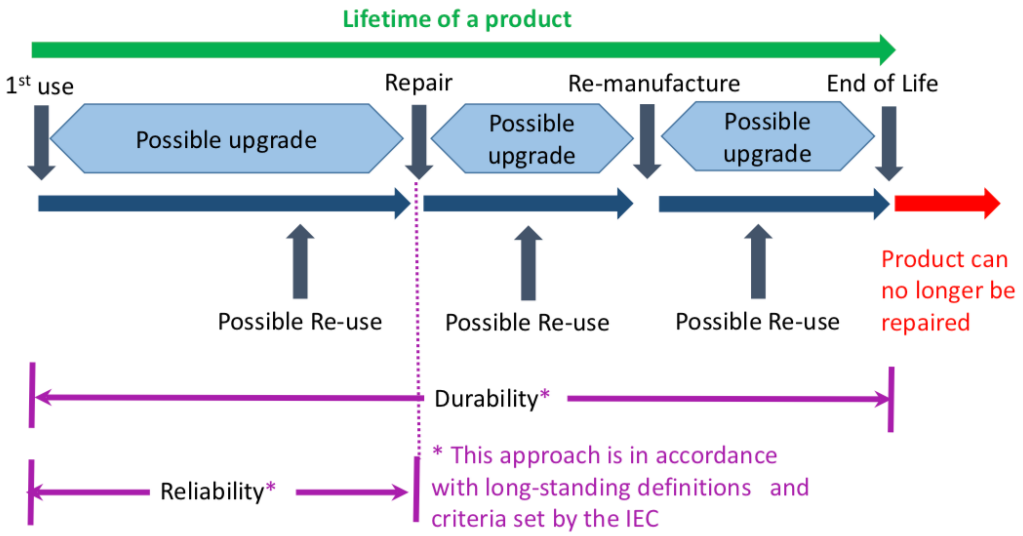

Figure 2: An overview of the concept of reliability and durability and their relation (adapted from Froggatt and Giegerich 2020, 22) IEC stands for the International Electrotechnical Commission.

In addition to the definition of durability and reliability, the durability standard includes a procedure for a general reliability and durability assessment, as illustrated in Figure 3.

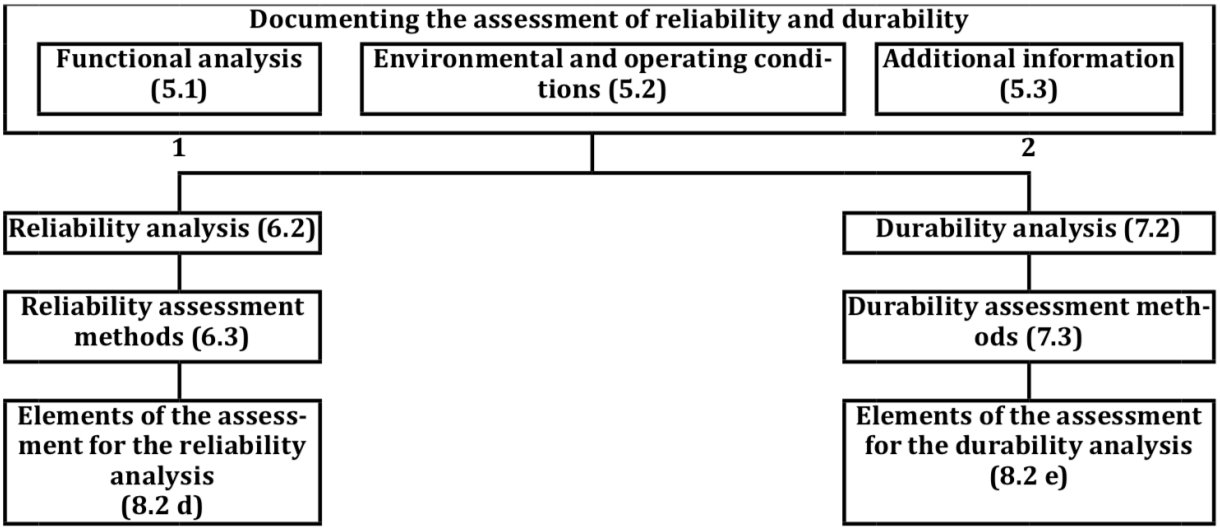

Figure 3: Procedure for a general reliability and durability assessment (adapted fromTechnical Committee CEN-CENELEC/JTC 10 2020a, 14)

As the outset for both the reliability and durability analysis and assessment, a functional analysis of the product has to be made, the environmental operating conditions should be described and additional information needs to be developed.

5.2.1.1 Reliability analysis and assessment

The purpose of the reliability analysis is to link functions to failure modes, sites and mechanisms. The reliability analysis should therefore include a failure mode and effect analysis or a failure mode, effect and criticality analysis. The analysis

should allow the identification of the failure modes, failure mechanisms, the locations of the failures and the parts that are involved in the failure of each analysed functions.

The purpose of the reliability assessment is to determine the reliability of a product and if relevant, set up measurement methods for testing or accelerated testing of a defined set of functions or parts of a product or product group. The method can either be to test a physical sample or calculations from data. Preferably, the whole product should be tested, but if that is not possible, functions or parts of the product while integrated in the product should be tested. If that is also not possible, functions or parts of the product when not integrated in the product should be tested. The results of the reliability analysis and assessment can be expressed as a probability of failure or survival or time to failure.

5.2.1.2 Durability analysis and assessment

The purpose of the durability analysis is to examine the ability of any function or part identified in the functional analysis to function as required, including possible maintenance and repair actions. The unit expressing the durability can be calendar time, operating cycles, distance run, etc. If the durability assessment method focuses on physical ageing, wear-out or fatigue, it should not include repair. However, if the product is repairable, an additional durability assessment should be made covering the repair actions.

The durability analysis shall include (1) environmental and operating conditions; (2) identification of functions; (3) identification of magnitude and locations of stresses; (4) identification of likely failure sites, mechanisms and modes; and (5) identification of the durability using damage models and acceleration factors.

The durability assessment method should establish measurement methods for testing or accelerated testing of the identified functions or parts of a product or product group. The methods should be reliable, repeatable, reproducible and not prohibitively expensive or too time consuming. The testing should either concern testing of a physical sample or calculation from data.

5.2.2 EN 45553: GENERAL METHOD FOR THE ASSESSMENT OF THE ABILITY TO REMANUFACTURE ENERGY-RELATED PRODUCTS

This standard provides a general method for assessing the ability of an energy-related product to be remanufactured. The standard defines remanufacturing as “an industrial process which produces a product from used products or used parts where at least one change is made which influence the safety, original performance, purpose or type of the product” (Technical Committee CEN-CENELEC/JTC 10 2020b, 5). The standard does this by identifying seven general processes that are crucial in the remanufacturing process of an energy-related product (inspection, disassembly, cleaning, reprocessing, assembly, testing and storage). The product’s ability to be remanufactured depends on the feasibility of performing these seven steps. Each remanufacturing process step is linked to one or more specific product attributes, which affect the products ability to be remanufactured. An overview of the links between the remanufacturing process steps and the product attributes is provided in Table 5.

Table 5: Criteria for assessing the product attributes (adapted from Technical Committee CEN-CENELEC/JTC 10 2020b, 7)

Product Attribute	Remanufacturing Process Step						
	Inspection	Disassembly	Cleaning	Reprocessing	Assembly	Testing	Storage
Ability to be identified	X					X	X
Ability to locate access points and fasteners		X			X		
Accessibility of parts		X	X	X	X	X	
Ability to be disassembled/ assembled		X			X		X
Wear and damage resistance during the remanufacturing process steps	X	X	X	X	X	X	X

The product's "ability to be identified" covers aspects that can determine the condition of the energy-related product or its parts, which parts need reprocessing (repair, replacement, rework, upgrade or special care) and information about relevant legislation, when the product was placed on the market. The product's "ability to locate access points and fasteners" covers aspects that can help localise key elements relevant in relation to the disassembling and assembling of the product. "Accessibility of parts" covers how accessible the different parts are and which parts the operator needs to clean, repair, upgrade or replace during the remanufacturing process. The "ability to be disassembled and assembled" describes the ability of the product to be separated into parts and for its part to be assembled again. The product attribute "wear and damage resistant during the remanufacturing process steps" describes the ability of the product to withstand all the treatment that is needed during the remanufacturing processes. Typical criteria relevant for the different product attributes listed in the standard are provided in Table 6.

Table 6: Typical criteria relevant for the product attributes

Product attribute	Typical criteria relevant for the product attribute
Ability to be identified	Access for diagnostics Information on how to determine its functionality Information on the status of the functionality Information on wear-sensitive parts Indication of the applicable legislation Indication of parts containing hazardous substances Indication of the need for special care
Ability to locate access points and fasteners	Indication of where access points are located Indication of where fasteners are located Provision of diagrams/drawings with the location of access points and fasteners
Accessibility of parts	Any surface that requires cleaning should be capable of being cleaned Access to parts during disassembly Modularity of parts Access to fasteners
Ability to be disassembled and assembled	Ability to handle parts Number of operators needed for disassembly and assembly Number and type of tools needed for disassembly and assembly Number of (different fasteners) Asymmetry/symmetry of parts Ability to insert a constituent Ability of parts to be secured directly upon insertion without extra operations after the insertion
Wear and damage resistance during the remanufacturing process steps	Materials and fasteners should be sufficiently strong to enable the product to be remanufactured one or more times Materials and marking need to withstand cleaning agents

5.2.3 EN 45554: GENERAL METHODS FOR THE ASSESSMENT OF THE ABILITY TO REPAIR, REUSE AND UPGRADE ENERGY-RELATED PRODUCTS

The standard provides generic methods and criteria that can be used to assess the ability of energy-related products or their parts to be repaired, reused and upgraded. The standard provides one primary assessment method and two additional methods on index and time. The primary assessment method is divided into four tasks described below (Technical Committee CEN-CENELEC/JTC 10 2020c):

- Determine the priority parts that should be included in the assessment,
- Identify criteria and appropriate categories important for the assessment of all priority parts,
- Assign a ranking or classification score to each category of relevant criteria for different priority parts and
- Specify a calculation method to aggregate the results from the three previous steps for each priority part.

A priority part is determined by: (1) its likelihood to need replacement or upgrading, (2) its suitability for reuse or (3) the functionality of the part. The identification of priority parts should also take into account the analysis of EN 45552 standard on durability, where amongst other factors a list of failure parts are identified as part of the analysis.

In the standard, a non-exhaustive list of criteria considered is presented (Technical Committee CEN-CENELEC/JTC 10 2020c):

- Disassembly depth,
- Fasteners and connectors,
- Tools,
- Working environment,
- Skill level,
- Diagnostic support and interface,
- Spare part availability,
- Availability of parts for upgrade,
- Spare parts availability by duration of availability,
- Types and availability of information,
- Return options,
- Data management and
- Password and factory reset for reuse.

5.2.4 EN 45555: GENERAL METHODS FOR ASSESSING THE RECYCLABILITY AND RECOVERABILITY OF ENERGY-RELATED PRODUCTS

The standard provides general principles for assessing the recyclability and recoverability of energy-related products. The standard defines recycling as any recovery operation where waste materials are reprocessed into products, material or substances, whether for the original or other purposes excluding energy recovery (Technical Committee CEN-CENELEC/JTC 10 2019a, 6). Recovery is defined as any operation where the principal result is that waste serves a useful purpose by replacing other materials (Technical Committee CEN-CENELEC/JTC 10 2019a). Hence, recovery can include both material and energy recovery. Furthermore, the standard considers the recyclability of critical raw materials and the ability to remove or to access certain components, assemblies, materials or substances from products to make possible their extraction at the end of life for ease of treatment, recycling and other recovery operations. As such, the standard functions as a method for developing product or product group standards, rather than being directly applicable to products or product groups.

As a first step, one reference end-of-life treatment scenario must be selected, assuming the entire product under assessment undergoes this end-of-life treatment scenario, and that no preparation for reuse takes place in the assessment. When comparing recyclability/recoverability rates of different products, the same reference scenario must be applied. A reference end-of-life scenario describes the combination and sequence of processes and steps required for an end-of-life treatment of a product. The following aspects must be considered when specifying the end-of-life treatment scenario (Technical Committee CEN-CENELEC/JTC 10 2019a, 10):

- Applicable regulations.
- Relevant industry practices and standards allowing efficient recycling and recovery.
- Health, safety and environmental concerns and
- Specific structure and material content.

The reference end-of-life scenario may include the following operations (Technical Committee CEN-CENELEC/JTC 10 2019a, 10):

- Mitigation of hazards and removal of parts for selective treatment.
- Material recovery.
- Energy recovery and
- Disposal.

Criteria at the product level must be defined in order to assess the compatibility of the product with the specified end-of-life treatment. The criteria address the design characteristics of energy-related products, which affect the identification and removal of regulated substances and components that require selective treatment and their recycling or recovery. The criteria may be considered for a qualitative assessment and shall be considered in order to define recyclability/recoverability rates (quantitative assessment) (Technical Committee CEN-CENELEC/JTC 10 2019a, 13):

- Assess the ability to identify the parts of the product containing substances, mixtures or components that shall be removed during depollution;
- Assess the ability to access and to remove the parts that require selective treatment;
- Assess the ability to undo joints;
- In the case of non-separable material combinations, assess the use of materials that are compatible with existing recycling processes;
- Assess the ability to access and to remove parts containing critical raw materials; and
- Assess the ability to access and to remove parts that reduce the recyclability.

The recyclability (R_{cyc}) and recoverability (R_{cov}) rates of energy-related products are calculated in mass percent by the following formulas (Technical Committee CEN-CENELEC/JTC 10 2019a, 14):

$$R_{cyc} = \frac{\sum_{k=1}^{n}\left(m_k \cdot R_{cyc,k}\right)}{m_{tot}} \cdot 100\ \%$$

$$R_{cov} = \frac{\sum_{k=1}^{n}\left(m_k \cdot R_{cov,k}\right)}{m_{tot}} \cdot 100\ \%$$

Where:

n	is the number of parts/materials,
m_k	is the mass of the k^{th} part/material,
$R_{cyc,k}$	is the recyclability factor of the k^{th} part/material,
$R_{cov,k}$	is the recoverability factor of the k^{th} part/material and
M_{tot}	is the mass of the complete product.

Depending on the data available, the assessment can be a detailed or a simplified assessment.

5.2.5 EN 45556: GENERAL METHOD FOR ASSESSING THE PROPORTION OF REUSED COMPONENTS IN ENERGY-RELATED PRODUCTS

This standard provides a general method for assessing the proportion of reused components in an energy-related product. The standard is intended for product technical committees, when developing product or product group standards, but it can also be applied where no product-specific standards exist.

The proportion of reused components can only be determined indirectly because no methods exist to measure this factor directly. The verification is, therefore, by means of documented evidence from manufacturers and suppliers.

The standard presents four different methods to calculate the proportion of reused components in an energy-related product. The calculations can be based on a product level, by assessing each product on its own by mass or by number, or it can be based on a mass balance or number balance over a period of time.

As an example, the following equation applies to calculating the proportion of reused components by number on a product level (Technical Committee CEN-CENELEC/JTC 10 2019b, 6):

$$R_{pn} = \left(\frac{\sum_{k} n_{re\_k}}{n_{tot}}\right) \times 100\ \%$$

Where:

n_{re}	is the number of the used components or groups of components in the assessed product,
n_{tot}	is the total number of components in the product and
R_{pn}	is the proportion of reused components by number of the product.

5.2.6 EN 45557: GENERAL METHOD FOR ASSESSING THE PROPORTION OF RECYCLED MATERIAL CONTENT IN ENERGY-RELATED PRODUCTS

This standard provides a general method for assessing the proportion of recycled material in an energy-related product. The document is not directly applicable to products or product groups; rather, it is intended as a framework for developing the assessment of recycled material content in specific product groups. It is not intended for the generation of publicly available information and comparisons of products in cases where no product-specific standard exists. Furthermore, the standard does not include considerations regarding the quality and physical properties of recycled materials, nor does it comply with the assessment of reused components.

There are currently no reliable, accurate or reproducible methods for directly measuring the recycled content in a product. Therefore, the verification of recycled material content relies purely on documentation provided by the operators in the chain of custody.

As a first step in the assessment of the proportion of the recycled material content, the scope of the assessment must be defined. The assessment can concern the energy-related product or parts of the energy-related product. Furthermore, it is possible to conduct the assessment for all materials, a type of material (e.g. plastic, metal or glass) or individual material (e.g. polypropylene or aluminium). The scope of the assessment shall, furthermore, define whether the recycled material content is based on pre-consumer or post-consumer materials or both. Only these two types of materials count as recycled material.

The standard defines pre-consumer material as material that is not reclaimed and reutilised within the same process that generated it. See Figure 4 for an explanation of the definition.

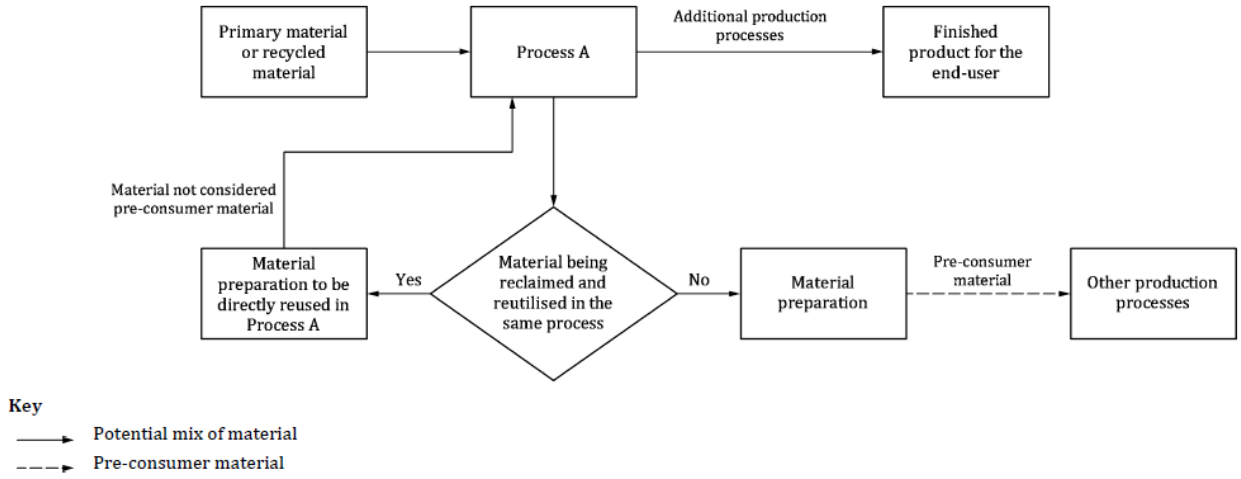

Figure 4: The definition of pre-consumer material (adapted from Technical Committee CEN-CENELEC/JTC 10 2020d, 9)

The standard defines post-consumer material as material from collected waste and treated waste. See Figure 5 for an explanation of the definition.

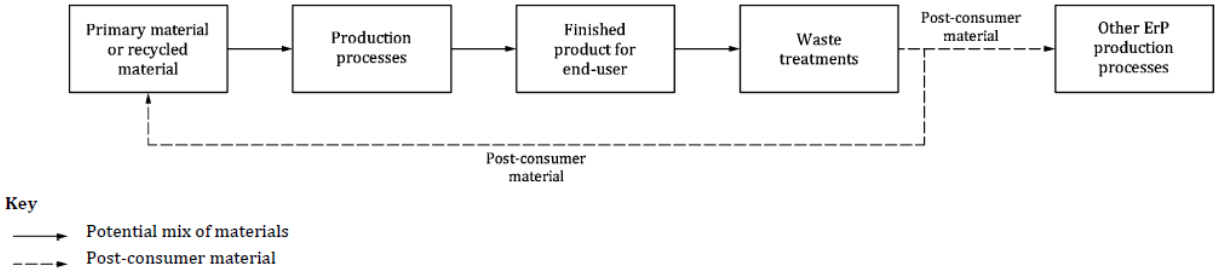

Figure 5: The definition of post-consumer material (adapted from Technical Committee CEN-CENELEC/JTC 10 2020d, 11).

The standard provides a general method for calculating the pre-consumer and post-consumer material content in an energy-using product or parts of it by the following formula (Technical Committee CEN-CENELEC/JTC 10 2020d, 14):

$$R_{pre} = \left(\frac{\sum_k m_{tot,\,k} \times r_{pre,\,k}}{\sum_k m_{tot,\,k}} \right) \times 100\ \% \qquad R_{post} = \left(\frac{\sum_k m_{tot,\,k} \times r_{post,\,k}}{\sum_k m_{tot,\,k}} \right) \times 100\ \%$$

Where:

R_{pre} is the pre-consumer material content of the part/parts or the energy-related product,

R_{post} is the post-consumer material content of the part/parts or the energy-related product and

$m_{tot,k}$ is the total mass of the k^{th} material or part.

If needed, the total recycled material content can be calculated by summing R_{pre} and R_{post}. This sum must always be stated alongside the corresponding R_{pre} and R_{post} figures. It is not an obligation to collect all information on all materials, and only verifiable pre-consumer and post-consumer materials with documented chain of custody can be considered recycled content.

5.2.7 EN 45558: GENERAL METHOD TO DECLARE THE USE OF CRITICAL RAW MATERIALS IN ENERGY-RELATED PRODUCTS

This standard specifies a general method for the declaration of critical raw material. This horizontal standard can be applied directly to any energy-related product or product group. Critical raw materials have high economic importance to the EU and are associated with a high supply risk (Technical Committee CEN-CENELEC/JTC 10 2019c, 20). The European Commission has created a list of critical raw materials, which is updated regularly.

The declaration of critical raw materials is based on the standard EN IEC 62474, which includes the following aspects (Technical Committee CEN-CENELEC/JTC 10 2019c, 8):

- A standardised list of declarable substances with standardised names to avoid misspelling and
- A standardised format for declaration to ensure that declarations from different suppliers can easily be understood and exchanged.

The standard differentiates between regulated and non-regulated critical raw materials. A material declaration must be provided for regulated critical raw materials, following the specifications of the applicable legislation. The content of the material declaration shall meet the requirements specified in EN IEC 62474.

The material declaration is voluntary for non-regulated critical raw materials. If companies still need to collect data on a non-regulated critical raw material, EN IEC 62474 can also be applied, but it may be necessary for the companies to create their own substance lists, as the non-regulated critical raw materials are not automatically included in the IEC Declarable Substance List. Specifically, for the non-regulated critical raw materials, the following aspects should be considered in the declaration (Technical Committee CEN-CENELEC/JTC 10 2019c, 18–19):

- Name of the substance or substance group,
- Location of the critical raw material in the product,

- Amount of the substance or substance group and
- Threshold amounts with declaration requirements.

5.2.8 EN 45559: METHODS FOR PROVIDING INFORMATION RELATING TO MATERIAL EFFICIENCY ASPECTS OF ENERGY-RELATED PRODUCTS

The standard provides a general method for communicating material efficiency aspects of energy-related products. The standard is directly related to the above-described standards EN 45552–45558, and it includes two key intensions (Technical Committee CEN-CENELEC/JTC 10 2019d, 5).

- It requires generic or horizontal material efficiency topic publications to include a clause with an overview of the specific topic-related content to be reported.
- It includes a generic method on how to create a communication strategy, which will be used when preparing product-specific or product group–specific publications.

Figure 6 is a graphical representation of the method, with an example concerning the durability/lifetime for certain lamps in accordance with EU/1194/2012, Annex 3.1.2 (European Commission 2012).

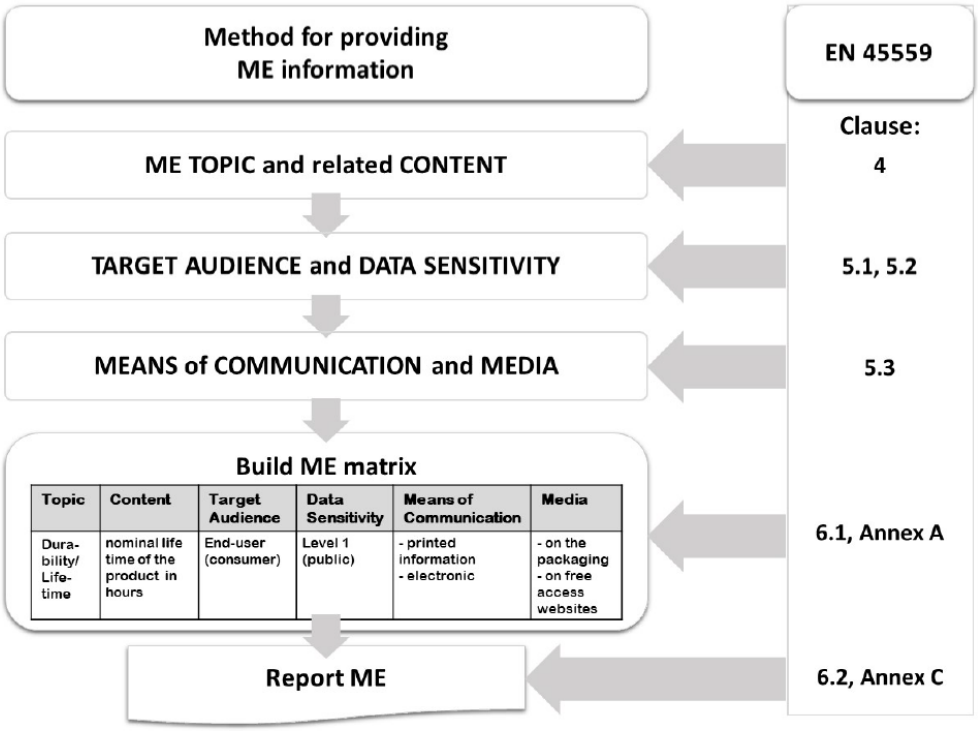

Figure 6: Graphical overview of the method (adapted from Technical Committee CEN-CENELEC/JTC 10 2019d, 6). ME, material efficiency

As Figure 6 shows, it must be determined which of the material efficiency topics as consolidated in the EN standards 45552–45558 are relevant or applicable to the given product. The material efficiency topic may generate different types of information that is communicated to different target groups. This is termed topic-related content; it can be qualitative (e.g. repair information and test reports) or quantitative (e.g. mass, % or hours).

For the communication strategy, the needs and capabilities of the intended target audiences must be addressed. Three key target audiences are defined in the standard (Technical Committee CEN-CENELEC/JTC 10 2019d, 8):

- End-users (including customers),
- Professionals and

- MSA.

Furthermore, the sensitivity of the data must be considered, and the standard specifies that the information can be classified as confidential, restricted or public depending on the sensitivity of the data.

Next, the means of communication and media must be defined. Means of communication refers to the way the information is communicated – for example, through oral, written or graphic formats – whereas media refers to the communicative outlets or tools applied to store or to deliver the information. The latter could include information on the product or product packaging, websites, the point of sale or other (mass) media.

The final step is to build the communication matrix, as shown in Figure 6. The intention is to support product publications in gathering, in a uniform and structured way, all relevant topics. The matrix includes topic, content, target audience, data sensitivity, means of communication and media.

The information on material efficiency topics may be communicated individually or in aggregated form. If communicating aggregated information, the methods for aggregation must be documented and communicated, and what is omitted or included, and how the aggregation was conducted, must be explained.

5.2.9 SUB-CONCLUSION

A main characteristic of the above-mentioned standards is that they are overall horizontal standards that cannot be directly applied to energy-related products or product groups. The only exceptions are the standard on critical raw material (EN 45558) and the standard on methods for providing information (EN 45559), which can be applied directly to product groups. The horizontal standards are therefore intended to provide the framework for developing product-specific or product group–specific standards.

Another characteristic is that there is a considerable overlap between the standards on durability (EN 45552); remanufacturing (EN 45553); and repair, reuse and upgrade (EN 45554), as they cover overlapping and similar aspects. This is an obvious consequence of the fact that, for example, a product's ability to be repaired or upgraded affects its durability and its ability to be remanufactured. In that sense, the three standards can also complement each other in relation to market surveillance.

The standard EN 45554 on repair, reuse and upgrade includes assessment methods, where the different criteria are rated on a scale from A to E. This type of evaluation can embed a subjective interpretation of the criteria, which may not be appropriate for market surveillance purposes, as it can reduce the reliability of the test results. The EN 45554 standard on repair, reuse and upgrade also includes an aggregated score for all relevant criteria. This aggregated score introduces a weighting of each criterion to make the aggregation possible, an approach that again could potentially cause some challenges in terms of market surveillance, as it can decreases the reliability of the test results.

All standards include requirements for documentation. These could provide input to setting information requirements within the framework of the Ecodesign Directive.

5.3 ASSESSMENT OF THE MATURITY LEVEL OF THE EXISTING HORIZONTAL STANDARDS

The standards have different levels of maturity, and some gaps have been identified that need to be addressed in the product-specific or product group–specific standards. The gaps represent actions that need to be taken in the product-specific standards before the assessment methods can be applied.

Table 7 provided an overview of these gaps. In relation to the maturity level, EN 45558 on critical raw materials and EN 45559 on information are the only standards that to some extent can be used directly on specific products or product groups. For all other aspects, product-specific or product group–specific standards and requirements need to be developed.

The concepts are also at different levels of maturity. In terms of durability, it is more likely that specific criteria will be set for the reliability than for the durability of products, because more standards already exist regarding reliability compared with durability. Furthermore, there are already existing ecodesign requirements targeting the reliability of the products, as described in chapter 2.

Table 7: Overview of gaps that need to be addressed in product-specific or product group–specific standards (adapted from Froggatt and Giegerich 2020)

Standards	Gaps that need to be addressed by product-specific or product group–specific standards
EN 45552 Durability	Define product or product group priority functions or parts Define environmental or operating conditions Describe test methods to assess reliability of priority parts Define "limiting states" and potential "end-of-life" states
EN 45553 Remanufacture	Identify product-specific attributes for the product or product group Assess or score relevant parameters that need to be product specific
EN 45554 Repair, reuse and upgrade	The priority parts need to be identified for each product category. Next, the criteria relevant for the specific product category need to be selected. The criteria cover aspects such as disassembly depth, fasteners and connectors, tools, working environment, skill level diagnostic support and interface, spare parts availability, availability of parts for upgrade, types and availability of information, return options, data management and password and factory reset for reuse. Disassembly depth is the only criterion where a calculation can be used for the evaluation. The remaining criteria are evaluated according to classes ranging from A to E. Therefore, it is also necessary to decide whether each class is relevant for the different criteria for that specific product category.
EN 45555 Recyclability	What does the end-of-life scenario look like (relevant design characteristics, qualitative or quantitative scenario)? Product or product group standards need to be created.
EN 45556 Reused components	Calculation methods need to be chosen. Product or product group standards need to be created.
EN 45557 Recycled content	Definition of "same process" Material clustering and unspecified material Traceability chain of custody
EN 45558 Critical raw materials	No gaps: considered to be directly applicable, but reporting thresholds for critical raw materials need to be defined by either product standard or legislation.
EN 45559 Information	No gaps: considered directly applicable depending based on the EN 45552–45558 standards.

5.4 ASSESSMENT OF MISSING CIRCULAR ECONOMY ASPECTS IN THE EXISTING HORIZONTAL STANDARDS ON MATERIAL EFFICIENCY

In the sustainable product policy framework, described in the European Circular Economy Action Plan from 2020, the Ecodesign Directive is assigned an important role to design more sustainable products and to deliver on sustainability. Furthermore, the intention is that in the future the Ecodesign Directive should cover the broadest possible range of products. As a departure point, priority has been given to product groups such as electronics, information and communications technology (ICT), textiles, furniture and high-impact intermediary products.

The Ecodesign Directive has an important and significant role in the transition to a circular economy. However, the directive alone cannot drive the transitions towards a circular economy. First, the directive only targets a small part of the products on the European market and its current scope is only related to energy-related products. Second, and perhaps more importantly, the transition towards a circular economy requires systemic changes that go beyond the single products and look at the overall provision of services and societal infrastructures that the single products are part of. This is also emphasised by one of the participants in the development of the standards under the M/543:

> The circular economy is a systemic change - everything needs to change. […] I think you really have to think big, if you want to have circular economy in place. [...] It is not enough that we are only regulating products, but actually, we also have to regulate the consumers, and we have to regulate the recycler, and we have to regulate the marketing people, and we have to regulate, basically, everything and everybody in the circle.

In essence, the Ecodesign Directive and the mandate on material efficiency is expanding the scope and can get us part of the way towards a circular economy. Further changes are needed and a stronger interaction between the various types of regulatory instruments is necessary for this circular transition to happen. The minimum performance requirements in the implementing measures and voluntary agreements of the Ecodesign Directive ensure a level playing field. However, a transition to a circular economy will require more than minimum performance requirements. The requirements also need to be seen in a broader policy package where different policy instruments push and pull for more sustainable and circular products, as illustrated in Figure 7. This is also the basic idea behind the sustainable product policy framework.

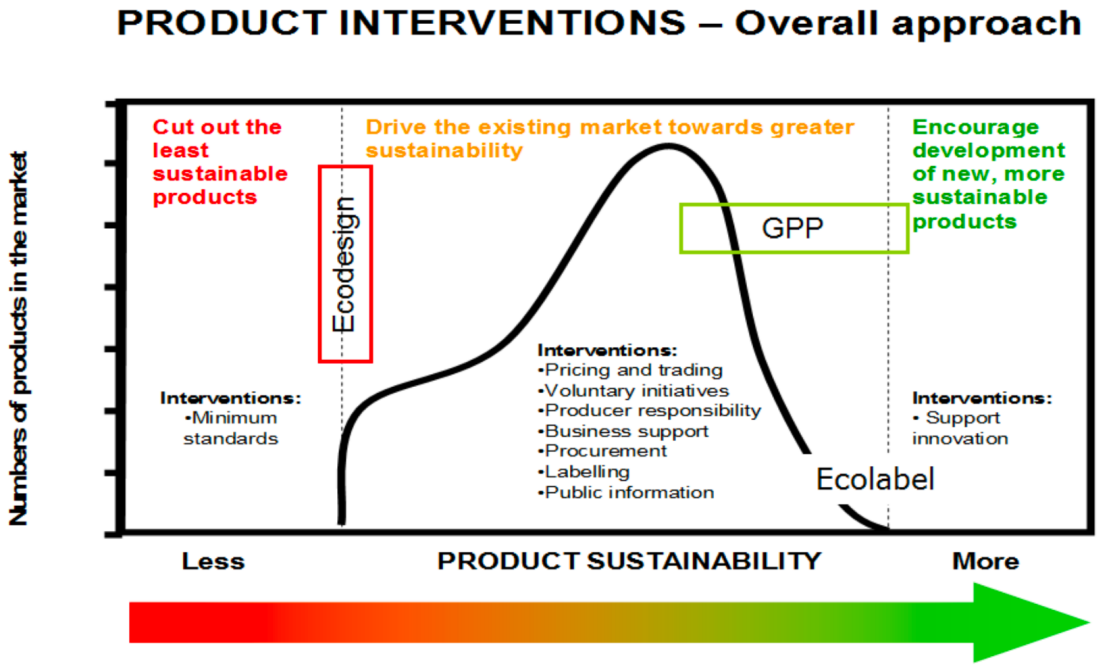

Figure 7: The scope of the different policy instruments (adapted from Galatola 2015)

Equally important is that a transition to a circular economy requires that companies make changes in their business models. Many business models today are related to products and not to services and systems, and this change is imperative for concepts such as repair, reuse and remanufacture to be successful.

Looking at how the horizontal standards are consistent with the applied understanding of material efficiency in Figure 1, there is a clear link between the standards and the concepts of maintenance, repair, reuse, remanufacture and recycling as defined in chapter 1. However, the standards do not include considerations on reducing resources or material consumption, nor are chemicals and restriction thereof part of the standards, despite the importance of this aspect for the reuse and recycling of products, product parts or material, among other aspects.

Chemicals and hazardous substances are partly included in the standard on recycling (EN 45555), but there is not a standard exclusively focused on chemicals or hazardous substances. The regulation of chemicals and hazardous substances is important in a transition to a circular economy to ensure especially recycling of materials, but it can also impact both the reuse and remanufacturing potential of a product or component. The regulation of chemicals and hazardous substances in the Ecodesign Directive has been a topic of much debate, as this topic is also covered by the RoHS directive. So, some stakeholders involved in the ecodesign process have been opposed to also regulating chemicals and hazardous substances in the Ecodesign Directive. However, the advantage of regulating chemicals and hazardous substances in the Ecodesign Directive is that it makes product-specific restrictions possible in cases where a generic restriction of a chemical or hazardous substance does not make sense. Declaration and restriction requirements on chemicals and hazardous substances are already included in the adopted implementing measures and more requirements are included in future implementing measures, such as the one for kettles. It is therefore important that appropriate standards are developed to verify these types of requirements.

The reduction of material consumption throughout the life cycle of a product is also key in a circular economy, as it prevents the use of materials and the generation of waste. The use of resources in the use phase is also an aspect that has been widely covered by existing implementation measures such as energy use (all implementing measures), water consumption in the use phase (washing machines), the use of consumables (printers) and reduction of food waste (refrigerators). Consequently, it is important to ensure that standards are developed to support market surveillance of these types of requirements.

Finally, an interesting subject for further research is the linkage and the relation among the different standards on material efficiency (EN 45552 to EN 45558). The Ellen MacArthur Foundation had already highlighted in 2013 the “power of the inner cycles”, meaning that more value is created in the inner cycles of repair and reuse compared with recycling when it comes to economic, environmental and social value. The “power of circling longer” and extending product lifetime was also highlighted in the same report (Ellen MacArthur Foundation 2013). In other words, the standards on durability and on repair, reuse and upgrade have the potential to create more sustainable value and business opportunities compared with the standard on recyclability. So far, the focus has been on material efficiency: doing things better, but it is worth investigating how to increase the emphasis on material effectiveness, doing the right things and increasing attention to the power of the inner cycles and of circling longer.

6 VERIFIABILITY OF MATERIAL EFFICIENCY REQUIREMENTS

6.1 INTRODUCTION

Enforcement of the Ecodesign Directive and its implementing measures is crucial to ensure that the expected energy and material savings are realised. However, previous reviews have shown that 10%–20% of the products covered by implementing measures are non-compliant (Petersson and Nielsen 2013) and as a result 10% of the total energy savings are lost (Baton et al. 2017). It is therefore crucial that the existing and future material efficiency requirements can be verified by MSA to ensure compliance. This is also specified in the Ecodesign Framework Directive Article 15 section 7 (European Commisssion 2009) "that requirements in the implementing measures shall be formulated in a way that ensures that MSA can verify compliance. Furthermore, the implementing measure shall specify if verification can be achieved directly on the product or based on technical documentation."

According to Article 3 section 2, it is the responsibility of the EU member states to designate authorities responsible for the market surveillance. It is also the responsibility of the EU member states to ensure that the authorities have the necessary power to take the appropriate measures. More specifically, the competent authorities shall (European Commission 2009, Article 3):

- Organise appropriate checks on product compliance, on an adequate scale, and oblige the manufacturer or its authorised representative to recall non-compliant products from the market in accordance with Article 7;
- Require the parties concerned to provide all necessary information, as specified in the implementing measures; and
- Take samples of products and subject them to compliance checks.

As explained in section 2.3, the Danish market surveillance consists of three tasks: (1) control of web-shops, (2) document control and (3) control measurements (product testing), and this is how they comply with the three aforementioned criteria.

6.1.1 THE ORGANISATION OF THE ECODESIGN DIRECTIVE

The Danish Energy Agency is responsible for the Ecodesign Directive and takes part in the policy development. However, since the summer of 2018, the Danish Safety Technology Authority has been responsible for the market surveillance of both the Ecodesign Directive and the EU energy labelling. Before 2018, the responsibility of market surveillance was subcontracted to two private companies (vores bureau and Viegand Maagøe) (Krivosik and Attali 2014; Westphalen 2020). However, as part of the Danish Better Balance reform, market surveillance of a number of policy areas was moved to the Danish Safety Technology Authority.

Part of the idea with the move was to utilise the synergies of different policy areas covering the same products, so that when taking a product out for a test, several policy areas could be tested simultaneously. However, until now it has only been possible to use this synergy in relation to control of web-shops and document control. The contracts with the test laboratories are made in such a way that it is only possible to test products within one policy area. In 2021, the contracts with the test laboratories will be renegotiated, and the plan is to have more dynamic contracts in the future to ensure that more parameters and policy areas can be tested when a product is selected for market control. Thereby, the Danish Safety Technology Authority hopes to be able to utilise the synergies between the different policy areas much better, but also to be able to test for different types of requirements and policy areas at the same test laboratory.

Currently, around 1.5 man-years are allocated to the document control and control measurements (Uldbæk 2020). It is more difficult to assess the man-years allocated to control of web-shops, as these typically look at more than one policy area (Uldbæk 2020). The number of products and the types of products varies from year to year. Typically, around 60 products are tested per year and 150 document controls are made (Krivosik and Attali 2014). In 2020, a total of 193 products were tested. The Danish Safety Technology Authority develops a yearly plan for product testing, including types of products and number of tests (Uldbæk 2020). The products are selected based on market research, past

experience, the introduction of new requirements and high-risk suspicion (Krivosik and Attali 2014; Uldbæk 2020). The yearly plan is then presented to the Danish Energy Agency, and they then have the possibility to come up with suggestions for additional products to cover or data to include (Uldbæk 2020).

6.1.2 NORDIC AND EUROPEAN COLLABORATION

Denmark takes part in both the Nordic and European collaboration regarding the Ecodesign Directive. The Nordic collaboration is organised in the Nordic working group called Nordsyn. The group coordinates the work done by the Nordic regulatory bodies in relation to the Ecodesign Directive and the EU energy labelling. The work group has focused on new policy development (Uldbæk 2020). However, market surveillance is getting more attention, and the Nordic countries have initiated common projects and testing products across the Nordic counties (Uldbæk 2020).

The European collaboration is organised in the administrative cooperation Group (AdCos) and through projects such as EEPLIANT. The purpose of EEPLIANT is to help deliver the intended environmental and economic benefits of the Ecodesign Directive by stringent market surveillance and thereby increase compliance. The EEPLIANT project focuses on developing best practice and making shared product testing across the involved member states. Another resource for the European collaboration is the Information and Communication System for Market Surveillance (ICSMS) (EEPLIANT 2 2019). ICSMS is a market surveillance database maintained by the European Commission, where all EU member states should record information of products that pose a risk (EEPLIANT 2 2019).

6.1.3 ENFORCEMENT OF THE ECODESIGN DIRECTIVE

If a product is non-compliant with the ecodesign requirements, then the manufacturer, importer or authorised representative will receive an enforcement notice requesting them to ensure compliance (Uldbæk 2020; Westphalen 2020). If it is not possible to ensure compliance with the ecodesign requirement, the product should be removed from the market (Uldbæk 2020; Westphalen 2020). Furthermore, the manufacturer, importer or authorised representative will have to pay the cost for product testing at the accredited laboratories held by the Danish Safety Technology Authority. The new EU Market Surveillance Regulation suggests that the Danish implementation of the Ecodesign Directive needs to be adjusted to ensure consistency (Uldbæk 2020). This might imply a more rigorous enforcement of the Ecodesign Directive. A suggestion for the Danish implementation of the EU market Surveillance Regulation is that the police should be notified about all cases of non-compliance with the ecodesign requirements (Uldbæk 2020). If this approach is implemented, the number of police reports related to product non-compliance might increase from around 25 to 125 a year (Uldbæk 2020). The adjustment of the Danish implementation of the Ecodesign Directive also implies that the size of the fine increases from 15,000–20,000 DKK to a minimum of 50,000 DKK depending on the severity of the offence and the size of the company (Uldbæk 2020).

6.2 THE VERIFIABILITY OF THE EXISTING MATERIAL EFFICIENCY REQUIREMENTS

As described in chapter 2, various ecodesign requirements targeting material efficiency aspects in the adopted implementing measures already exist. It is assumed that all information requirements can be verified through a simple document control requiring limited resources, expertise and training (ECOS 2018). Therefore, the following section will only look at the verifiability of the specific requirements targeting material efficiency aspects. The existing material efficiency requirements in the implementing measures can be verified if harmonised standards or transitional measures exist, specifying the test methods of the ecodesign specific requirements, or if the requirements can be verified through simple document control. An overview of existing harmonised standards and transitional measures is included in Appendix 2.

6.2.1 WATER CONSUMPTION

The implementing measures covering household washing machines include requirements for water consumption. A harmonised standard, EN 60456:2011 Clothes washing machines for household use – Methods for measuring the performance, specifies how to test the requirements. However, it is difficult to get water-using products tested because very few test laboratories can perform this analysis (Uldbæk 2020).

6.2.2 DURABILITY

Two implementing measures include ecodesign requirements that set minimum requirements for the reliability of the products (vacuum cleaners and electrical lamps and luminaries). In total, four specific ecodesign requirements were identified: lumen maintenance factor, survival factor, reliability of the hose and reliability of the motor (see table 8). For the two requirements covering electrical lamps and luminaries (lumen maintenance factor and lamp survival factor), two transitional measures exist; they can be used to test and to verify the requirements (CIE 97 and EN 60064, 3,5, Annex A). For the two requirements covering vacuum cleaners (hose useability after 40,000 oscillation under strain and operational lifetime of the motor), one harmonised standard exists; it can be used to test and to verify the two requirements (EN 60335-2-69:2012). However, the use of EN 60335-2-69:2012 to test and to verify the reliability requirements for the hose and the motor has been criticised and has created resistance from the industry, as it is a safety standard and not a test and measurement standard. The use of a safety standard instead of a test and measurement standard is not seen elsewhere in the context of the Ecodesign Directive.

The fact that only transitional measures are in place to verify the reliability requirements of electrical lamps and luminaries and that a safety standard is used as a test and measurement standard indicates that standardisation regarding material efficiency aspects is still at its early stage. Even though test standards are available, the experience with control measurements of these types of requirements is limited. Indeed, the Danish Safety Technology Authority has just started getting its first experience with control measurements of these requirements.

In terms of ensuring market surveillance of these aspects, it is also important that the duration of the tests is short, so that the products are not discontinued before the test results are ready. Therefore, accelerated tests can be recommended for some product groups.

Table 8: Overview of the durability requirements and the transitional methods or harmonised standards

Product group	Ecodesign requirement	Standard or transitional measures
Electrical lamps and luminaries	Lumen maintenance factor	CIE 97: 2005 Guide on the Maintenance of indoor electric lighting systems, 2nd edition (transitional measures)
	Survival factor	EN 60064, 3,5 Tungsten filament lamps for domestic and similar general lighting purposes – performance requirements, Annex A (transitional measures)
Vacuum cleaners	The hose shall be useable after 40,000 oscillations under strain	EN 60335-2-69:2012 Household and similar electrical appliances — Safety — Part 2-69: Particular requirements for wet and dry vacuum cleaners, including power brush for commercial use (harmonised standard)
	Operational motor lifetime shall be greater than or equal to 500 hours	EN 60335-2-69:2012 Household and similar electrical appliances — Safety — Part 2-69: Particular requirements for wet and dry vacuum cleaners, including power brush for commercial use (harmonised standard)

6.2.3 DISASSEMBLY FOR REUSE AND REPAIR

Eight implementing measures include ecodesign requirements targeting easier disassembly of spare parts, the light source and separate control gears or certain selected components (Table 3). According to the Danish Safety Technology Authority and the Environmental Coalition on Standards (ECOS), the test laboratories can assess these ecodesign requirements targeting easier disassembly through destructive or non-destructive disassembly tests (ECOS 2018; Uldbæk 2020). Thus, it is important that specific instruction on how the disassembly test should be conducted exists to ensure consistency (ECOS 2018). For six of the ecodesign requirements, it has been specified that the disassembly should be done using commonly available tools. Here, the work conducted in standard EN 45554 on general methods

for the assessment of the ability to repair, reuse and upgrade energy-related products could be relevant in defining commonly available tools. Thus, it may be necessary for some product categories to make product specific adjustments.

6.2.4 SPARE PARTS AVAILABILITY

Six implementing measures include ecodesign requirements on spare parts availability (Appendix 1). These types of requirements are relatively easy to verify, and these measures can be done by the Danish Safety Technology Authority (Uldbæk 2020). The new EU Market Surveillance Regulation, which goes into effect on 16 July 2021, paves the way for "mystery shopping", which means that the authorities can shop using a concealed identity (Uldbæk 2020). This implies that the Danish Safety Technology Authority can check the availability of a spare part availability by opening a fake email account and trying to order the spare part in question (Uldbæk 2020).

A challenge regarding the requirements on spare parts availability is the sanction options towards the manufacturers, importers or authorised representatives. The Ecodesign Directive gives the authorities the possibility to sanction the companies by issuing an enforcement notice that they should ensure compliance with the ecodesign requirements, and if that is not possible, they should withdraw the product from the market (European Commisssion 2009). Furthermore, the company will receive a fine. The requirements regarding spare parts availability cover a period of 7–10 years after the last unit of the model is placed on the market. At that time, it is no longer relevant to have the manufacturers, importers of authorised representative withdraw the product from the market. The only opportunity to sanction the company is therefore a fine. Even though the fine will increase with the revision of the implementation of the Ecodesign Directive into Danish legislation (a consequence of the new EU Market Surveillance Regulation), there is a risk that the size of the fine does not outweigh the cost of ensuring spare parts for the entire period.

6.2.5 FIRMWARE AND SECURITY UPDATES

Two implementing measures include ecodesign requirements on the availability of firmware, covering electronic displays and televisions as well as computers and servers. The ecodesign requirement specifies that the latest available version of the firmware and security updates to the firmware shall be available for 8 years free of charge or at minimal cost. This type of requirement can be verified by checking whether the firmware is available at websites or by requesting the firmware from the manufacturers, importers or authorised representatives. Again, the authority can use the opportunity in the new EU Market Surveillance Regulation of "mystery shopping", requesting the firmware under a concealed identity.

6.2.6 REPAIR AND MAINTENANCE INFORMATION

Four implementing measures include ecodesign requirements that the manufacturers, importers of authorised representatives should provide access to repair and maintenance information for professional repairers under a reasonable and proportionate fee. These types of requirements can be verified by checking whether the manufacturers, importers of authorised representative have information on the website regarding how professional repairers can gain access to repair and maintenance information and by posing as a professional repairer and requesting access to this information.

6.2.7 DATA DELETION

The implementing measure covering computers and computer servers includes requirements to ensure data deletion, stating that a functionality for secure data deletion shall be made available for the deletion of data contained in all data storage devices of the product. It should be possible to check whether such a functionality is available by inspecting the product and user manuals.

6.2.8 DISASSEMBLY FOR RECYCLING

Two implementing measures include requirements targeting disassembly for recycling. Similarly, as with the ecodesign requirements targeting disassembly for reuse and repair, these types of requirements can be verified by the test laboratories through destructive or non-destructive disassembly tests.

6.2.9 MARKING COMPONENTS

The implementing measure covering electronic displays and televisions includes two requirements on marking plastic or material containing flame retardants. These types of requirements should also be possible to verify by the test laboratories using destructive or non-destructive disassembly tests.

6.2.10 HAZARDOUS SUBSTANCES

The implementing measure on electronic displays includes a requirement restricting the use of flame retardants in the enclosure and stand of the display or television. Based on this study, it is not possible to assess how this requirement can be verified. Furthermore, the implementing measures on computers and computer servers includes a requirement on the declaration of mercury content in integrated displays. This requirement could be verified by document control.

6.3 THE VERIFIABILITY OF EXISTING MATERIAL EFFICIENCY REQUIREMENTS IN RELATION TO THE CAPACITY OF THE DANISH SAFETY TECHNOLOGY AUTHORITY

The budget for market surveillance is fixed and the number of products that can be tested each year depends on the budget and the cost of getting the products tested. Previous studies have questioned if sufficient resources are allocated to market surveillance in the EU member states (Petersson and Nielsen 2013). Based on the analysis in this report, the Danish Safety Technology Authority will not have a problem in terms of verifying the information requirements targeting material efficiency aspects through control of web-shops and control of the technical documentation. Indeed, these requirements can be checked at a reasonable price and with limited requirements regarding expertise and training. However, it is questionable as to whether sufficient resources are allocated to this task, especially as more product groups are covered by the Ecodesign Directive and more diverse ecodesign requirements are introduced. Additional studies could evaluate whether the current resources are sufficient.

Laboratory tests can be expensive; the price depends on the type of product and the type of criteria that needs to be tested. A concern could be that the material efficiency requirements could increase the cost of testing products at the laboratories, because more parameters need to be tested and some parameters can be expensive to test. A risk could also be that material requirements, where product testing is associated with high cost, will not be prioritised in a situation with a limited budget. According to the Danish Safety Technology Authority, this is already the case for the requirements covering noise, where control measurements rarely are made due to the high costs (Uldbæk 2020). Work is ongoing by the European Commission with the purpose of ensuring that the ecodesign requirements can be tested within Europe at a reasonable price. However, additional studies are needed to document if this will pose a problem in the future. The way the Ecodesign Directive is implemented in Denmark provides some opportunities for market surveillance. In Denmark, it is possible to charge the cost of acquiring the products to the manufacturers, importer or authorised representative (Uldbæk 2020; Westphalen 2020). Furthermore, if the products are non-compliant with the ecodesign requirements, it is also possible to charge the test costs to the manufacturers, importers or authorised representatives (Uldbæk 2020; Westphalen 2020). This implies that if many products are non-compliant then the cost for product testing is reduced for MSA. The saved cost can then be used to conduct new control measurements.

Regulation and market surveillance of chemicals, such as the RoHS Directive and the REACH Regulation, is the responsibility of the Environmental Protection Agency. Existing and future ecodesign requirements targeting the chemical content of the product could therefore potentially pose a challenge for the Danish Safety Technology Authority, as they have limited experience in these areas. Furthermore, it would be more difficult to utilise the potential synergies between the Ecodesign Directive and the RoHS Directive in terms of market surveillance because the responsibility is divided among several authorities. One possibility could be to develop cross-sectoral working groups between the Environmental Protection Agency and the Danish Safety Technology Authority.

6.4 THE VERIFIABILITY OF NEW MATERIAL EFFICIENCY CRITERIA IN HORIZONTAL STANDARDS

Due to the horizontal nature of the standards, it is still difficult to assess how the new material efficiency criteria can be verified. The material efficiency criteria in the horizontal standards cover many parameters and the possibility to verify these aspects will vary depending on the product type. However, for a number of product categories, the work on developing the product-specific standards has begun (washing machines and servers). Therefore, it could be relevant to look more into the development of these new standards to see how the horizontal standards will be used to develop the product group–specific standards. A few remarks can be made regarding the different assessment methods for which the standards provide the foundation (see Table 9).

For the standard EN 45552 on durability, it will generally be more complex to make reliable and reproducible tests of durability requirements, including both a repair and remanufacturing step, compared with requirements on reliability. Reliability is more mature in its development within standardisation compared with durability, and there are already ecodesign requirements targeting reliability of the product or product components in the adopted implementing measures.

For the standard EN 45553 on remanufacturing, the assessment methods are not as developed as for some of the other standards. It primarily identifies product attributes and criteria that are important for remanufacturing along with a few examples on assessment methods. The assessment methods cover aspects such as the ability to be accessible and disassembly sequence and disassembly depth. Furthermore, there is a considerable overlap between the product attributes and criteria included in the EN 45553 standard on remanufacturing and those included in the EN 45554 standard on repair, reuse and upgrade.

The standard EN 45554 on repair, reuse and upgrade also identifies a number of criteria along with assessment methods regarding how to evaluate each individual criterion. Only one of the assessment methods is based on a calculation (disassembly depth); the rest are based on a classification of the different aspects according to a scale ranging from A to E. Five of the criteria are already included in existing implementing measures. This evaluation of the criteria on a scale ranging from A to E can, for some of the criteria, embed a qualitative interpretation of the criteria. This factor can provide some challenges in relation to market surveillance, as it is important that there is consistency among test facilities so that they arrive at the same conclusion. It is therefore important that the different levels are well described to ensure that there will be no differences in the way the products are assessed. Consequently, further research has to be carried out to understand how this type of qualitative criteria can be set in a way that uncertainties and subjective understandings are reduced, so these criteria are also trustworthy and can contribute to the overall improvements of the material efficiency of products.

Rating of the criteria on a scale from A to E also differs from the way repair, reuse and upgrade have been targeted in already adopted implementing measures, where it is more a question of setting a minimum requirement for each criterion. As an example, a specific minimum number of years is set for the availability of spare parts and not an assessment of whether spare parts are available for the short, mid or long term or whether information on spare parts availability is provided (Figure 8). A question is whether rating these requirements is necessary, when setting minimum requirement in the Ecodesign Directive, and whether these are more suitable for policy tools that provide information to the end consumers, such as the EU energy labels and ecolabels. However, it should be mentioned that these assessments methods are only included in the annexes of the standards and only as examples of how the assessment methods could appear.

The EN 45554 standard on repair, reuse and upgrade also provides an example of an aggregated score for all relevant criteria. When a numeric value is attributed to each of the classes (A to E), each criterion must be weighted to achieve an aggregated score. This aggregation makes the assessment more complicated and more inscrutable because it will be difficult to establish in which way(s) the product is more repairable or reusable based on the aggregated assessment. Again, it is unknown whether this action is necessary with an aggregated score when setting minimum performance requirements or if it is more suitable for policy tools targeting the end consumer.

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Figure 8: Classification of spare parts availability by duration of availability (adapted fromTechnical Committee CEN-CENELEC/JTC 10 2020c)

Category Description	Class
Long-term availability	A
Mid-term availability	B
Short-term availability	C
No information on duration of availability	D

The EN 45555 standard on recyclability and recoverability provides methods for how to calculate a product's recyclability and recoverability, defined by mass in percentage. The recyclability and recoverability rate is based on the selected end-of-life treatment scenario, which will therefore have a large impact on the recyclability or recoverability rate. In market surveillance, the reliability of the assessment is essential, as it should be possible to arrive at the same result every time a product is assessed. To ensure that conclusion, the end-of-life treatment scenario has to be well-defined and the same for the specific product category. In addition to the two calculation methods, the standard also identifies design criteria regarding the importance of the end-of-life scenario of the product. A number of these design criteria have already been included in adopted implementing measures. Furthermore, the draft implementing measures for kettles include a recyclability requirement, stating that the recyclability rate of a kettle shall be greater than 75% (European Commisssion 2021). It might be difficult to document the actual end-of-life scenario for a specific product in a specific setting. Therefore, these types of future requirements may mainly be verified by review of technical documentation provided by the manufacturer or producer.

The EN 45556 standard on the proportion of reused components provides four assessment methods based on the number of reused components or the mass of reused components on the product level or the number or mass of reused component by mass balance. One of the challenges, in terms of market surveillance, is that it is not possible to determine whether a component is reused based on control measurements through product testing, as no methods exist to measure this factor directly. The verification and market surveillance can therefore primarily be based on review of technical documentation provided by the manufacturers, importers or authorised representatives.

The EN 45557 standard on the proportion of recycled content provides two calculation methods for the pre-consumer and post-consumer recycled material content. Again, one of the challenges in terms of market surveillance is that it is not possible to verify the recycled material content through product testing because no methods exist. Therefore, verification and market surveillance need to be based on a review of the technical documentation provided by the manufacturers, importers or authorised representatives.

EN 45558 on general methods to declare the use of critical raw material and EN 45559 on information are the only standards that have the potential to be used directly, and where the development of product or product category specific standards are not needed. Furthermore, these types of requirements could be checked by document control and theoretically not pose a problem in relation to verification and market surveillance.

Table 9. Overview of aspects and/or criteria covered by the standards and the proposed assessment methods or examples of assessment methods

	Aspects/criteria covered	Assessment method	Comment
EN 45552: Durability	Durability	Set up generic methods on how to conduct the durability analysis, including potential repair and remanufacturing steps. The specific assessment methods will be highly dependent on the product or product group.	Durability is not a well-developed concept within standardisation.
	Reliability	Set up generic methods on how to conduct the reliability analysis.	Requirements are already included in the implementing measures.
EN 45553: Remanufacture	Ability to be identified Ability to locate access points and fasteners Accessibility of parts Ability to be disassembled and assembled Wear and damage resistance during the remanufacturing process steps	The standard only provides a few examples of quantitative methods to assess the different product attribute listed such as the ability to be accessible and disassembly sequence and disassembly depth.	The assessment methods need to be further developed for most product attributes and related criteria.
EN 45554: Repair, reuse and upgrade	Aggregation of criteria scores	A numeric value is attributed to each of the classes below.	Introduces a weighting of the different aspects Might be more relevant for policy tools targeting consumers
	Disassembly depth	Assessment based on a calculation	
	Fasteners and connectors	Assessment is based on a classification if the fastener types are reusable, removable or neither removable nor reusable.	
	Tools	Assessment is based on a classification of the necessary tools according to a scale from A to E.	Requirements already included in the implementing measures.
	Working environment	Assessment is based on a classification of the working environment from A to C.	
	Skill level	Assessment is based on a classification of skill level from A to E.	
	Diagnostic support and interface	Assessment is based on a classification of diagnostic support and interface from A to E.	
	Spare parts availability	Assessment is based on a classification of spare part availability from A to E.	Requirements already included in the implementing measures.
	Availability of parts for upgrade	Assessment is based on a classification of spare part interface from A to C.	Requirements already included in the implementing measures.
	Spare parts availability by duration of availability	Assessment is based on a classification of spare parts availability by duration of availability from A to D.	Requirements already included in the implementing measures.

	Types and availability of information	Assessment is based on a classification of information availability by comprehensiveness from A to C and on a classification of information availability by target groups from A to D.	Requirements already included in the implementing measures.
	Return options	Assessment is based on a classification of return option from A to C.	
	Data management	Assessment is based on a classification of data management from A to C.	
	Password and factory reset for reuse	Assessment is based on a classification of possibilities to password and factory reset from A to D.	Requirements already included in the implementing measures.
EN 45555 Recyclability and recoverability	Recyclability	The calculation method is defined by mass (per cent). The calculation is based on the end-of-life reference scenario.	Requirements on this is included in the draft requirements for kettles. Verification is based on a review of technical documentation.
	Recoverability	The calculation method is defined by mass (per cent).	Verification is based on a review of technical documentation.
EN 45556 Proportion of reused components	Proportion of reused component by number on product level	Calculation method defined	The verification can be based primarily on review of technical documentation.
	Proportion of reused component by mass on product level	Calculation method defined	The verification can be based primarily on review of technical documentation.
	Proportion of reused component by mass balance	Calculation method defined	The verification can be based primarily on review of technical documentation.
	Proportion of reused component by number balance	Calculation method defined	The verification can be based primarily on review of technical documentation.
EN 45557 Proportion of recycled material	Pre-consumer material content	Calculation method defined	The verification can be based primarily on review of technical documentation.
	Post-consumer material content	Calculation method defined	The verification can primarily be based on review of technical documentation.
EN 45558 Declare the use of Critical raw materials	General method for the declaration of critical raw materials	Based on IEC 62474	If there is a high maturity level, it can be used directly. Verification is by review of technical documentation.

6.5 HOW TO ENSURE VERIFIABILITY OF FUTURE MATERIAL EFFICIENCY CRITERIA

Generally, requirements that can be verified through control of information on websites and document control do not pose a huge problem in terms of verification and market surveillance (Uldbæk 2020). Thus, it is important to emphasise that around 1.5 people a year plus some extra resources are set aside for control of websites. Hence, the human resources allocated for this task are limited. Still, the product testing and control measures can pose a challenge regarding the new material efficiency requirements. It is therefore essential to ensure that harmonised standards are published specifying methods on how to test and to verify these new requirements. Furthermore, there needs to be accredited laboratories that can test the material efficiency requirements also at a reasonable cost. To avoid additional costs, these accredited test laboratories should be able to perform tests of all the ecodesign requirements to avoid the purchase of additional products or shipping the same product between different test facilities.

Other member states have identified the availability of accredited test laboratories as a barrier for control measurements through product testing. However, according to the Danish Safety Technology Authority, it is not a problem in Denmark, as the Danish Technological Institute has been able to perform many of the control measurements through product testing (Uldbæk 2020). However, there have still been problems getting products tested. As an example, the laboratory conducting the test of lighting equipment lost their accreditation during the contract period and the Danish Safety Technology Authority has not been able to do control measurements of lighting equipment during this period (Uldbæk 2020). In addition, it is difficult to find laboratories that can test water-using products (Uldbæk 2020). Therefore, to ensure that future material efficiency requirements can be verified, it is important that there are accredited laboratory facilities within the EU that can conduct the required tests at a reasonable cost.

Regarding testing the future material efficiency requirement, it will be key to ensure the dynamic contracts with the laboratories or test facilities to ensure that the laboratories have the possibility to test all potential requirements and not only the energy requirements. This could potentially also strengthen synergies among the different policy areas for which the Danish Safety Technology Authority is responsible for the market surveillance.

For a number of the criteria covered by the horizontal standards such as recyclability and recoverability rate, the proportion of reused components and the proportion of recycled material content, there are currently no methods available to verify the requirements by taking products and subjecting them to compliance checks. Hence, these future requirements can primarily be verified by review of the technical documentation showing compliance with the ecodesign requirements provided by the manufacturers, importers or authorised representatives. Regarding market surveillance and verification procedures, it is also important that the future material efficiency requirements do not provide room for a subjective interpretation in the assessment.

The introduction of new and more diverse requirements can make product testing more complex and potentially also more expensive. Therefore, it is important to develop further both the Nordic and the European collaboration and to conduct more cross-country product testing. It is also important that the ICSMS database is used more actively to ensure that products that are banned from the Danish market are also removed from other EU member states. However, currently the ICSMS data base is primarily used in connection with the EEPLIANT projects.

7 CONCLUSIONS

The review of the 28 adopted implementing measures shows that nine of these include specific ecodesign requirements targeting material efficiency aspects and 22 of the adopted implementing measures include information requirements related to material efficiency.

The information requirements target end consumers, recyclers and professional repairers. They cover aspects such as how to use and to maintain the products with the aim of minimising environmental impacts and to ensure product life expectancy, the period of availability and installation of spare parts and instructions on how to disassemble and to recycle or to dispose of the product at its end of life. The specific requirements cover aspects such as durability (or reliability using the definition from EN 45552), availability of firmware, easy disassembly, spare parts availability, access to repair and maintenance information for professional repairers, data deletion options, disassembly for recyclability and marking plastic and hazardous substances.

The market surveillance comprises three tasks: (1) control of web-shops, (2) document control and (3) control measurements through product testing. The information requirements are primarily verified through control of web-shops and websites, and this also applies to the information requirements targeting material efficiency. The specific requirements are verified through document control and control measurements through product testing. The control measurement through product testing is conducted by accredited test laboratories. The Danish experience is still limited regarding control measurements through product testing of the specific material efficiency. However, through a project running within the framework of Nordsyn, Denmark is gaining experience with control measurements of the material efficiency requirements for lighting equipment. As Denmark is considered one of the EU member states dedicating the most resources to market surveillance, a conclusion is that the experience is limited with control measurements of the specific material efficiency requirements in the EU. A recommendation is to use future EU projects such as the EEPLIANT to gain more experience with testing the material efficiency requirements of products.

All standards developed under standardisation mandate M/543 are horizontal and cannot be applied directly to energy-related products or product groups. Instead, the standards should be used as guidance to develop vertical product-specific standards. The only exceptions are the standard on critical raw material (EN 45558) and the standard on methods for providing information (EN 45559), which can be used directly on product groups. There is also a considerable overlap between the durability standard (EN 45552); the standard on remanufacturing (EN 45553); and the standard on repair, reuse and upgrade (EN 45554). However, durability, remanufacturing, repair, reuse and upgrade are also related concepts that will influence one another. Finally, all standards also include information on how the requirements should be documented.

The standards are at different maturity levels and an overview of the gaps that need to be addressed in the product-specific standards are provided in Table 7. Again, the only exceptions are EN 45558 on critical raw materials and EN 45559 on information, which to some extent can be used directly on specific product groups. The specific concepts in the addressed standards are also at different maturity levels.

In the sustainable product policy framework, the Ecodesign Directive has been assigned an important role in driving a circular economy. However, the Ecodesign Directive sets minimum performance requirements for products and thereby removes the worst performing products on the market. The directive can therefore not drive a circular economy alone; rather, it should be considered in a broader policy framework. While the standardisation mandate M/543 covers many relevant circular economy aspects regarding energy-related products, one central aspect is missing, namely chemicals and the restriction of chemicals and the reduction of materials and resources going into the products.

Even though the experience of Danish authorities with control measurements of the existing material efficiency requirements is limited, it has been possible to identify potential ways to verify the requirements (Table 10). The possible verification method only relates to the specific ecodesign requirements provided in the implementing measure and can therefore not be used in general to show compliance with the theme.

Table 10: Overview of how the existing material efficiency requirements in the implementing measures can be verified

Material efficiency requirements	Possible verification
Water consumption	Performance test (harmonised standard EN 60456:2021)
Durability (reliability)	Use tests or accelerated use tests (transitional measures: CIE 97 and EN 60064, 3,5: Annex A, harmonised standards: EN 60335-2-69: 2012)
Disassembly for reuse and repair	Destructive or non-destructive disassembly test
Spare parts availability	Ordering spare parts using a concealed identity
Firmware and security controls	Checking availability (websites or requesting the firmware using a concealed identity)
Repair and maintenance information	Checking availability (websites or requesting the information using a concealed identity)
Data deletion	Inspection of the product and user manuals
Disassembly for recycling	Destructive or non-destructive disassembly test
Marking plastic	Destructive or non-destructive disassembly test
Restriction of chemicals in certain parts	Not possible to identify how this can be verified because there is no experience with testing these requirements.
Declaration of mercury content	Document control

The budget for market surveillance is fixed and previous studies have questioned whether sufficient resources have been allocated to market surveillance in the EU member states. It is concluded that the information requirements targeting material efficiency aspects can be verified by the Danish Safety Technology Authority. However, limited resources are available for this task and it could be questioned whether the resources are sufficient. A prominent challenge is the specific requirements targeting material efficiency can pose a challenge. A concern is the additional cost of testing more requirements and more diverse requirements within a confined budget. Another concern regards whether accredited test laboratories are in place, which can confirm compliance through product testing of the new requirements at a reasonable cost. However, the fact that the Danish Authorities can charge the cost of product testing and purchasing the product to the manufacturers, importers or authorised representative, if the products are non-compliant with the ecodesign requirements, provides the opportunity to perform additional testing within the budget in case many products are non-compliant.

It has not been possible to identify how the existing requirements on chemical restriction were verified because there is no experience with product testing of these types of requirements within the Danish Safety Technology Authority. The market surveillance of chemicals is the responsibility of the Danish Environmental Protection Agency. Consequently, the experience of the Danish Safety Technology Authority with these types of requirements is limited. A recommendation could therefore be to set up a cross-sectoral working group between the Danish Safety Technology Authority and the Danish Environmental Protection Agency.

Due to the horizontal nature of the standards, it is difficult to assess how the new material efficiency requirements can be verified, except for EN 45558 on general methods for declaration the use of critical raw materials, where it is possible to verify the requirements through document control because it is merely a declaration requirement. However, for two product categories (washing machines and servers) the work of developing the product specific standards have begun. It could therefore be relevant to follow this work more closely.

A general comment is also that it will be potentially more complex to verify future durability requirements (covering both repair and remanufacturing steps) compared with future reliability requirements. For the standard EN 45554 on remanufacturing, the assessment methods have not been very developed because it primarily identifies important product attributes and criteria for remanufacturing processes, along with a few examples of assessment methods. The

standard on reuse, repair and upgrade (EN 45554) covers a number of aspects that can improve reuse, repair and upgradability alongside an approach to calculate an aggregated score. One of the assessment methods is based on a calculation, but the remaining criteria are evaluated based on a classification of the different aspects according to a scale ranging from A to E. This classification of the different criteria can embed a qualitative interpretation. This outcome can potentially exert challenges in terms of verification if the reliability and consistency of the assessment is not ensured. Therefore, additional research is needed on how this type of qualitative criteria can be set in such a way that uncertainties and subjective understandings are reduced. Another question is whether a scoring system is necessary, as six of the criteria are already covered in adopted implementing measures, but without a scoring system. Furthermore, an aggregated repair, reuse and upgrade score is also suggested, including a weighing of the different criteria. Another question is whether this aggregated score is needed in a Ecodesign context, or if it is more suitable for direct consumer information. Regarding verification and market surveillance, another challenge might be that the EN 45556 standard on the proportion of reused components and the EN 45557 standard on recycled content can only be determined indirectly, as no methods exist to measure this directly. The verification is, therefore, by means of documented evidence from manufacturers and suppliers.

To ensure that future material efficiency requirements can be verified, harmonised standards have to be developed specifying the tests methods, which can be used to test product compliance. Furthermore, accredited test laboratories that can test the material efficiency requirements should be available. It is also important that the contracts with the laboratories are dynamic, so that it is possible to test for all the different requirements and if possible, also different policy areas to ensure that potential synergies are utilised. Furthermore, the European and Nordic collaboration could be strengthened to utilise the resources for market surveillance in Europe more efficiently.

This study provides a number of recommendations and suggestions for further studies.

- Perform an analysis and assessment of the resources allocated to market surveillance of the Ecodesign Directive and the EU Energy Label and to what extent it is sufficient to ensure an efficient market surveillance. This endeavour will become more important with the possible increase in the scope of the Ecodesign Directive and more diverse ecodesign requirements.
- Further analyse and evaluate the criteria covered in the harmonised standards with a specific focus on those criteria where a qualitative interpretation might be necessary.
- The enforcement strategy of the Ecodesign Directive is currently under revision and future studies could therefore examine different enforcement strategies including a more dialogue-based method.
- Follow and analyse the product-specific standards under implementation based on the standardisation mandate M/543.
- Examine the availability and cost of testing new and future material efficiency requirements at accredited test laboratories. This endeavour could also include an analysis of other organisational models such as the one applied by the Swedish Energy Agency with in-house test facilities.

This study provides the following recommendations:

- More collaboration between the Nordic countries and the other EU member states on market surveillance, including using resources such as the ICSMS databased and the EPREL database;
- Set up a cross-sectoral working group between the Danish Safety Technology Authority and the Danish Environmental Protection Agency checking compliance with the requirements targeting chemicals and hazardous substances;
- Make use of a future European projects, such as EEPLIANT, to gain more experience with market surveillance of the material efficiency requirements across the member states; and
- Ensure that contracts with accredited test laboratories are dynamic so that all requirements and policy areas can be tested simultaneously to utilise the synergies of consolidating the market surveillance of various policy areas at the Danish Safety Technology Authority.

8 PERSPECTIVES: THE SWEDISH EXPERIENCE

As documented in this report, the experience with market surveillance of the already adopted ecodesign requirements targeting material efficiency is still limited; this is a natural consequence because some of the ecodesign requirements have just recently been adopted. However, the study has also documented that the experience with market surveillance and verification of the older ecodesign requirements targeting material efficiency for vacuum cleaners and lighting is also limited. An exception is the Swedish Energy Agency, which has some experience with product testing of the already adopted material efficiency requirements. This chapter will synthesise the most important experiences of the Swedish Energy Agency with verification and market surveillance of the material efficiency requirements in already adopted implementing measures. The section is based on an interview with Emma Olsson from the Swedish Energy Agency.

8.1 ORGANISATION OF THE SWEDISH MARKET SURVEILLANCE

The Swedish market surveillance is organised differently than the Danish market surveillance, as both policy development and market surveillance is placed in the Swedish Energy Agency. Furthermore, the Swedish Energy Agency also has in-house testing facilities for a number of product categories including lighting, electronics (including computers and TVs) and some white goods. For some product categories, the product testing is conducted by external laboratories. The laboratory is quite small, and therefore they use it more strategically than for bigger volumes. This set-up with in-house test facilities implies that more resources are allocated in-house to market surveillance and the policy area in general than in the Danish context. In 2021, around 3–5 people are working on market surveillance; 10 people are working in the laboratories; 3–4 people are working on policy development; and a few are working on communication, management and associated areas. Hence, in total 20–25 people are working on the entire policy area of the Ecodesign Directive and the EU energy labelling.

The in-house test facilities provide some rather unique opportunities for the Swedish Energy Agency to develop competency and knowledge in-house on the more technical aspects of the products and product testing. This competency and knowledge are used in the policy development process to challenge, for example, claims and concerns from the producers and manufacturers. Furthermore, the close collaboration between the employees working on policy development and the employees working with market surveillance provides unique opportunities to use more actively the learnings from product testing in the policy making process.

8.2 EXPERIENCE WITH MARKET SURVEILLANCE OF ADOPTED ECODESIGN REQUIREMENTS TARGETING MATERIAL EFFICIENCY

An essential aspect in terms of product testing of any requirements, be it material or energy efficiency, is that standards are available at the time when the requirements take effect. Therefore, a key initiative to ensure market surveillance of existing and future material efficiency requirements is that standards specifying test methods are developed and harmonised. It is therefore important that the work on developing the product-specific standards proceed on material efficiency.

8.2.1 WATER CONSUMPTION OF HOUSEHOLD WASHING MACHINES

Household washing machines represent one product category that the Swedish Energy Agency has been testing in-house; they have tested water consumption alongside additional functionality requirements such as cleaning and drying efficiency. It is labour intensive to test household washing machines because they need to have the machine running for many hours. Therefore, they have only tested a limited number of products. They do not plan to continue to do in-house testing of household washing machines in the future. However, they have been a bit reluctant to close this part of the laboratory because there are limited external test facilities available within the EU.

8.2.2 DURABILITY REQUIREMENTS FOR ELECTRICAL LAMPS AND LUMINARIES AND VACUUM CLEANERS

Electrical lamps and luminaries represent another product category with which the Swedish Energy Agency has experience with testing the specific requirements targeting durability from the now revised implementing measures (lamp lumen maintenance factor, lamp survival factor, number of switching cycles before failure, premature failure rate and rated lamp lifetime). They have also tested light-emitting diode (LED) lamps according to the endurance test method defined in the new ecodesign regulation. For lighting products, test standards are quite well developed, and the Swedish Energy Agency is also involved in a sub-group under the International Energy Agency (IEA) focused on lighting and the development of standards. The experience with vacuum cleaners is still limited, but they have done some testing in relation to the now withdrawn energy labelling requirements for vacuum cleaners and the ecodesign regulation covering vacuum cleaners. The tests included energy consumption, energy efficiency, rated power, dust pick-up, particles and noise, but the durability requirements for the engine and the hose were not included in the test.

8.2.3 REQUIREMENTS FOR THE AVAILABILITY OF FIRMWARE AND SECURITY UPDATES FOR FIRMWARE

The Swedish Energy Agency does not yet have a method for testing the new requirements on availability of firmware and security updates for firmware. However, they have come across these aspects when testing for the energy use of different appliances, as they have experienced that the appliance changes behaviour when firmware and security updates for firmware are updated. Hence, it is a well-known aspect for the Swedish Energy Agency and something they have also used as input to the policy process.

The Swedish Energy Agency has had no experience with the new requirements on easy disassembly of certain parts; it is something they need to work on in the future. These new requirements differ from the existing requirements and thus necessitate a different set of skills for the laboratories and MSA. However, inspiration and experience might be collected from other authorities responsible for the Toy Safety Directive or electrical safety, as these also include destructive tests.

8.2.4 SPARE PARTS AVAILABILITY

The Swedish Energy Agency has no experience with product testing and market surveillance of the ecodesign requirement on spare parts availability. However, as the Danish Safety Technology Authority plans to do, the idea is to check the availability by requesting the spare parts using a concealed identity – acting like a consumer. A challenge for some of the requirements is the long time span from the adoption of the requirements until the market surveillance steps take effect.

8.2.5 INFORMATION FOR PROFESSIONAL REPAIRERS

Regarding the requirement on repair information available to professional repairers, there is still uncertainty on how the specific requirements will be integrated at the national level. Hence, the first step before actual market surveillance can begin is to develop and to implement a system for sharing repair information with professional repairers at a national level.

8.2.6 HAZARDOUS SUBSTANCES

The Swedish Energy Agency also has had limited experience with market surveillance and testing requirements targeting hazardous substances in products, such as restrictions, declarations and marking certain substances, because these requirements have been more related to legislation such as RoHS and REACH and thereby falls under the responsibility of the Swedish Chemical Agency. Therefore, the Swedish Energy Agency works in close collaboration with the Swedish Chemical Agency regarding these types of requirements.

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10 APPENDIX 1

This appendix includes the full review of the 28 implementing measures and voluntary agreements adopted under the Ecodesign Directive. The aim is to identify all adopted ecodesign requirements targeting resource efficiency. Green colour indicates that there are requirements and red colour indicates that there are no resource efficiency requirements.

	Commission Regulation Number	Resource efficiency (RE) requirements	Information requirements targeting resource efficiency
Air conditioners	No 206/2012		
Domestic ovens	(EU) No 66/2014		Information relevant for non-destructive disassembly for maintenance purpose and information relevant for dismantling, in particular in relation to the motor, if applicable, and any batteries, recycling, recovery and disposal at end-of-life. Domestic ovens: mass of the appliance

	Commission Regulation Number	Resource efficiency (RE) requirements	Information requirements targeting resource efficiency
Electrical lamps and luminaires	(EU) 2019/2020	Lumen maintenance factor and survival factor (from September 2021). The light sources and separate control gears shall be replaceable with the use of common available tools and without permanent damage to the containing product.	The technical documentation shall provide instructions on how light sources and separate control gears can be removed without being permanently damaged for verification purposes by market surveillance authorities. Manufacturers, importers or authorised representatives shall provide information about the replaceability or non-replaceability of light sources and control gears by end-users or qualified persons without permanent damage to the containing product. Such information shall be available on a free-access website. For products sold directly to end-users, this information shall be on the packaging, at least in the form of a pictogram, and in the user instructions. light sources and separate control gears can be dismantled from containing products at end of life. Dismantling instructions shall be available on a free access website. A warning if the light source cannot be dimmed or can be dimmed only with specific dimmers or with specific wired or wireless dimming methods. In the latter cases a list of compatible dimmers and/or methods shall be provided on the manufacturer's website. A if the light source contains mercury: a warning of this, including the mercury content in mg rounded to the first decimal place; A warning that it shall not be disposed of as unsorted municipal waste. Information about lifetime

	Commission Regulation Number	Resource efficiency (RE) requirements	Information requirements targeting resource efficiency
Household dishwashers	(EU) 2019/2022	From March 2021 Availability of spare parts for a minimum period of seven years after placing the last unit of the model on the market. The spare parts can be replaced with the use of commonly available tools and without permanent damage to the appliance	The booklet of instructions provided by the manufacturer shall provide: The power consumption of the off mode and of the left-on mode. Indicative information on the programme time, energy and water consumption for the main cleaning programmes. Specify that it is suitable to clean normally soiled tableware and that it is the most efficient programme in term of its combined energy and water consumption for that type of tableware. The list of spare parts and the procedure for ordering them shall be publicly available on the free access website of the manufacturer, importer or authorised representative, at the latest two years after the placing on the market of the first unit of a model and until the end if the period of availability of theses spare parts. The manufacturer's, importer's or authorised representative's website shall indicate the process for professional repairers to register for access to information; the available repair and maintenance information shall include: the unequivocal appliance identification; a disassembly map or exploded view; 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 dishwasher (where applicable).

	Commission Regulation Number	Resource efficiency (RE) requirements	Information requirements targeting resource efficiency
Household refrigerating appliances	(EU) 2019/2019	From March 2021: Availability of spare parts for a minimum of 7 years after placing the las unit of the model on the market (thermostats, temp. sensors, printed circuit boards & light sources). For a minimum period of 10 years (door handles, door hinges, trays and baskets) Manufacturers shall ensure that these spare parts can be replaced with the use of commonly available tools and without permanent damage of the appliance. Requirements for dismantling for material recovery and recycling while avoiding pollution according to WEEE (ensuring that refrigerating appliances are designed in such a way that the materials and components can be removed with commonly available tools). Access to repair and maintenance information for professional repairer under a reasonable and proportionate fee . This information includes appliance identification, disassembly map, list of repair and test equipment, wiring and connection diagrams, diagnostic fault and error codes. The instruction manual for users and installers and free access websites shall include: the combination of drawers, baskets and shelves that result in the most efficient use of energy for the refrigerating appliance;	From March 2021: Clear guidance about where and how to store foodstuffs in a refrigerating appliance for best preservation over the longest period, to avoid food waste; the recommended setting of temperatures in each compartment for optimum food preservation; an estimation of the impact of temperature settings on food waste; instructions for the correct installation and end-user maintenance, including cleaning, of the refrigerating appliance; access to professional repair, such as internet webpages, addresses, contact details. Relevant information for ordering spare parts, directly or through other channels provided by the manufacturer, importer or authorised representative; the minimum period during which spare parts, necessary for the repair of the appliance, are available; the minimum duration of the guarantee of the refrigerating appliance offered by the manufacturer, importer or authorised representative;
Household tumble dryer	(EU) No 932/2012		

	Commission Regulation Number	Resource efficiency (RE) requirements	Information requirements targeting resource efficiency
Household washing machines	(EU) 2019/2023	Measure of water consumption Availability of spare parts, for a minimum period of 10 years after placing the last unit of the model on the market. The spare parts can be replaced with the use of commonly available tools and without permanent damage to the household washing machine or household washer-dryer. The manufacturer or representative shall ensure the delivery of the spare parts within 15 working days after having received the order. After two years after the placing on the market of the first unit of a model and until the parts are available, the manufacturer, importer or authorised representative shall provide access to the repair and maintenance information (over a reasonable fee 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). The information shall contain the unequivocal identification, a disassembly map, technical manual of instructions for repair, list of necessary repair and test equipment, wiring and connection diagrams, diagnostic fault and error codes, instructions for installation of relevant software, firmware including reset software ; and information on how to access data records of reported failure incidents.	The list of spare parts shall be publicly available on the free access website until the end of the of the period of availability of these spare parts. Indicated by the manufacturer for the respective programmes will contribute to energy and water savings; recommendations on the type of detergents suitable for the various washing temperatures and washing programmes; indicative information on the programme time, remaining moisture content, energy and water consumption for the main washing programmes at full or partial load, or both;
Local space heaters	(EU) 2015/1188		Information relevant to disassembly, recycling and/or disposal at end-of-life;

	Commission Regulation Number	Resource efficiency (RE) requirements	Information requirements targeting resource efficiency
Professional refrigerated storage cabinets	(EU) 2015/1095		A section of the free access websites of manufacturers for installers and other professionals, their authorised representatives, or importers shall be provided, containing information relevant for: (i) installation in order to optimise energy efficiency of the appliances; (ii) non-destructive disassembly for maintenance purposes; (iii) disassembly and dismantling for disposal at end-of life.
Residential ventilation units	(EU) No 1253/2014		The manufacturer's free access website shall make available detailed instructions, inter alia, identifying the required tools for the manual disassembly of permanent magnet motors, and of electronics parts (printed wiring boards/ printed circuit boards and displays > 10 g or > 10 cm2), batteries and larger plastic parts (> 100 g) for the purpose of efficient materials recycling, except for models of which less than 5 units per year are produced
Solid fuel boilers and packages of a solid fuel boiler, supplementary heaters, temperature controls and solar devices	(EU) 2015/1189		Any specific precautions to be taken when the solid fuel boiler is assembled, installed or maintained; .information relevant to disassembly, recycling and disposal at end-of-life shall be available on free access website and in the instruction manuals for installers. Manufacturers should provide information on disassembly, recycling and disposal
Space heaters, combination heaters, packages of space heater, temperature control and solar device and packages of combination heater, temperature control and solar device	(EU) No 813/2013		Information relevant to disassembly, recycling and disposal at end-of-life shall be available on free access website and in the instruction manuals for installers

	Commission Regulation Number	Resource efficiency (RE) requirements	Information requirements targeting resource efficiency
Electronic displays and televisions	(EU) 2019/2021	Shall ensure that joining, fastening or sealing techniques do not prevent the removal, using commonly available tools, of the components indicated in point 1 of Annex VII of Directive 2012/19/EU on WEEE or in Article 11 of Directive 2006/66/EC of the European Parliament and of the Council on batteries and accumulators and waste batteries and accumulators, when present. Plastic components heavier than 50 g shall be marked by specifying the type of polymer with the appropriate standard symbols or abbreviated terms. Components containing flame retardants shall additionally be marked. Electronic displays with a screen panel in which concentration values of Cadmium (Cd) by weight in homogeneous materials exceed 0,01% shall be labelled with the 'Cadmium inside' logo. The logo shall be clearly visible durable, legible and indelible. The use of halogenated flame retardants is not allowed in the enclosure and stand of electronic displays. The following spare parts shall be made available to professional repairers: internal power supply, connectors to connect external equipment (cable, antenna, USB, DVD and Blue-Ray), capacitors, batteries and accumulators, DVD/Blue-Ray module if applicable and HD/SSD module if applicable for a minimum period of seven years after placing the last unit of the model on the market. The following spare parts shall be available to professional repairers and end-users: external power supply and remote	Shall make available, on a free-access website, the dismantling information needed to access any of the products components referred to in point 1 of Annex VII of Directive 2012/19/EU. This dismantling information shall include the sequence of dismantling steps, tools or technologies needed to access the targeted components. The end of life information shall be available until at least 15 years after the placing on the market of the last unit of a product model. The list of spare parts concerned and the procedure for ordering them shall be publicly available on the free access website of the manufacturer, importer or authorised representative, at the latest two 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 Information on the minimum guaranteed availability of software and firmware updates, availability of spare parts and product support shall be indicated in the product information sheet as from Annex V of Regulation (EU) 2019/2013.

	Commission Regulation Number	Resource efficiency (RE) requirements	Information requirements targeting resource efficiency
		control for a minimum period of seven years after placing the last unit of the model on the market. Spare parts shall be replaceable with the use of commonly available tools and without permanent damage to the appliance The latest available version of the firmware shall be made available for a minimum period of eight years after the placing on the market of the last unit of a certain product model, free of charge or at a fair, transparent and non- discriminatory cost. The latest available security update to the firmware shall be made available until at least eight years after the placing on the market of the last product of a certain product model, free of charge. After two years after the placing on the market of the first unit of a model and until the parts are available, the manufacturer, importer or authorised representative shall provide access to the repair and maintenance information (over a reasonable fee 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). The information shall contain the unequivocal identification, a disassembly map, technical manual of instructions for repair, list of necessary repair and test equipment, wiring and connection diagrams, diagnostic fault and error codes, instructions for installation of relevant software, firmware including reset software ; and information on how to access data records of reported failure incidents.	

	Commission Regulation Number	Resource efficiency (RE) requirements	Information requirements targeting resource efficiency
Vacuum cleaners	(EU) No 666/2013	The hose, if any, shall be durable so that it is still useable after 40 000 oscillations under strain. Operational motor lifetime shall be greater than or equal to 500 hours.	The technical documentation and a part for professionals of the free access websites of manufacturers, their authorised representatives, or importers shall contain the following elements: information relevant for non-destructive disassembly for maintenance purposes, in particular in relation to the hose, suction inlet, motor, casing and cable, information relevant for dismantling, in particular in relation to the motor and any batteries, recycling, recovery and disposal at end-of-life.
Water heaters, hot water storage tanks and packages of water heater and solar device	(EU) No 814/2013		Information relevant for disassembly, recycling and/or disposal at end-of-life.
Household combined washer-drier	N/A		
Air heating products, cooling products, high temperature process chillers and fan coil units	(EU) 2016/2281		The instruction manuals for installers and end-users, and a part for professionals of the free-access websites shall provide information relevant for disassembly, recycling and/or disposal at end-of-life.
Circulators (glandless standalone circulators and glandless circulators integrated in products)	(EU) No 622/2012		Information concerning disassembly, recycling, or disposal at end-of-life of components and materials, shall be made available for treatment facilities on standalone circulators and on circulators integrated in products. Manufacturers shall provide information on how to install, use and maintain the circulator in order to minimise its impact on the environment

	Commission Regulation Number	Resource efficiency (RE) requirements	Information requirements targeting resource efficiency
Computers and computer servers	(EU) 2019/424	From 1 March 2020, manufacturers shall ensure that joining, fastening or sealing techniques do not prevent the disassembly for repair or reuse purposes of the following components, when present: (a) data storage devices; (b) memory; (c) processor (CPU); (d) motherboard; (e) expansion card/graphic card; (f) PSU; (g) chassis; (h) batteries. L 74/56 EN Official Journal of the European Union 18.3.2019. From 1 March 2020, a functionality for secure data deletion shall be made available for the deletion of data contained in all data storage devices of the product. From 1 March 2021, the latest available version of the firmware shall be made available from two years after the placing on the market of the first product of a certain product model for a minimum period of eight years after the placing on the market of the last product of a certain product model, free of charge or at a fair, transparent and non-discriminatory cost. The latest available security update to the firmware shall be made available from the time a product model is placed on the market until at least eight years after the placing on the market of the last product of a certain product model, free of charge. For products with an integrated display containing mercury, the total content of mercury as X,X mg shall be declared	Manufacturers shall provide in the technical documentation and make publicly available on free-access websites: the minimum number of loading cycles that the batteries can withstand (applies only to notebook computers); If a notebook computer is operated by battery/ies that cannot be accessed and replaced by a non-professional user, the manufacturer shall provide the following information n 'The battery[ies] in this product cannot be easily replaced by users themselves'. The information provided on the external packaging of the notebook computer shall be clearly visible and legible and it shall be provided in all the official languages of the country where the product is marketed
Electric motors	(EU) 2019/1781		Manufacturers should provide relevant information on disassembly, recycling or disposal at end-of-life. information on the range of operating conditions for which the motor is designed: (a) altitudes above sea-level; (b) minimum and maximum ambient air temperatures including for motors

	Commission Regulation Number	Resource efficiency (RE) requirements	Information requirements targeting resource efficiency
			with air cooling; (d) maximum operating temperature; (e) potentially explosive atmosphere
External power supplies (no-load condition electric power consumption and average active efficiency of external power supplies)	(EU) 2019/1782		
Fans driven by motors with an electric input power between (EU) No 327/2011125 W and 500 kW	(EU) No 327/2011		Manufacturers should provide relevant information on disassembly, recycling or disposal at end-of-life of such fans. Manufacturers shall provide information in the manual of instruction on specific precautions to be taken when fans are assembled, installed or maintained. If provision 2(5) of the product information requirements indicates that a VSD must be installed with the fan, manufacturers shall provide details on the characteristics of the VSD to ensure optimal use after assembly.
Simple set-top boxes	(EC) No 107/2009		
Small, medium and large power transformers	(EU) No 548/2014		Information on the weight of all the main components of a power transformer (including at least the conductor, the nature of the conductor and the core material). The study showed that energy in the use phase is the most significant environmental aspect that can be addressed through product design. Significant amounts of raw materials (copper, iron, resin, aluminium) are used in the manufacturing of transformers, but market mechanisms seem to be ensuring an adequate end-of-life treatment, and therefore it is not necessary to establish related ecodesign requirements.

	Commission Regulation Number	Resource efficiency (RE) requirements	Information requirements targeting resource efficiency
Standby and off mode electric power consumption of electrical and electronic household and office equipment	(EU) No 801/2013		
Water pumps	(EU) No 547/2012		Information relevant for disassembly, recycling or disposal at end-of-life;

	Commission Regulation Number	Resource efficiency (RE) requirements	Information requirements targeting resource efficiency
Welding equipment	(EU) 2019/1784	From 1 January 2021: Availability of spare parts for a minimum period of 10 years after the production of the last unit including control panel; power source(s); equipment housing; battery(ies); welding torch; gas supply hose(s); gas supply regulator(s); welding wire or filler material drive; fan(s); electricity supply cable; software and firmware including reset software. Manufacturers shall ensure that these spare parts can be replaced with the use of commonly available tools and without permanent damage to the equipment and the part. The delivery to professional repairers of spare parts shall be ensured within 15 working days after having received the order. Manufacturers shall ensure that welding equipment are designed in such a way that the materials and components can be removed with the use of commonly available tools. Access to repair and maintenance information no later than two years after the placing on the market of the first unit of a model. The available repair and maintenance information shall include: a disassembly map or exploded view, a list of necessary repair and test equipment, component and diagnosis information (such as minimum and maximum theoretical values for measurement), wiring and connection diagrams, diagnostic fault and error codes (including manufacturer-specific codes where applicable), data records of reported failure incidents stored in the welding equipment (where applicable), and instructions for installation of relevant software and firmware including reset software. Manufacturers, authorised representatives or importers may charge reasonable and proportionate fees for access to the repair and maintenance information or for receiving	Information on a list of equivalent models; information relevant to recycling and disposal at end-of-life; the year of manufacture. Information on the display of welding equipment: Where a display is provided for a welding equipment it shall provide indication of the use of welding wire or filler material in grams per minute or equivalent standardised units of measurement. The list of the spare parts and the procedure for ordering them shall be publicly available on the free access website of the manufacturer, authorised representative or importer, at the latest two years after placing on the market of the first unit of a model and until the end of the availability of these spare parts.

	Commission Regulation Number	Resource efficiency (RE) requirements	Information requirements targeting resource efficiency
		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.	

	Commission Regulation Number	Resource efficiency (RE) requirements	Information requirements targeting resource efficiency
Refrigerating appliances with a direct sales function	(EU) 2019/2024	Availability of spare parts: thermostats; starting relays; no-frost heating resistors; temperature sensors; software and firmware including reset software; printed circuit boards; light sources; door handles and door hinges; knobs, dials and buttons; door gaskets; and peripheral trays, baskets and racks for storage; for a minimum period of eight years after placing the last unit of the model on the market. The spare parts can be replaced with the use of commonly available tools without permanent damages to the appliance. The maximum delivery time for spare parts is within 15 working days	The available repair and maintenance information shall include: the unequivocal appliance identification; a disassembly map or exploded view; technical manual 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 refrigerating appliance with a direct sales function (where applicable), instruction manuals for installers and end-users shall include instructions for the correct installation and end-user maintenance, including cleaning, of the refrigerating appliance with a direct sales function; the recommended setting of temperatures in each compartment for optimum food preservation; an estimation of the impact of temperature settings on food waste; relevant information for ordering spare parts, directly or through other channels provided by the manufacturer, importer or authorised representative such as internet webpages, addresses, contact details; the minimum period during which spare parts, necessary for the repair of the refrigerating appliance with a direct sales function, are available; the minimum duration of the guarantee of the refrigerating appliance with a direct sales function offered by the manufacturer, importer or authorised representative.

11 APPENDIX 2

This appendix provides an overview of existing harmonised standards and transitional measures.

Product group	Mandate	Harmonised standards	Type of standard	Measured parameter
Circulators	M/469	3	Measurement and test standards (3)	Energy (EEI) (3)
Computers	M/545	0	Transitional methods of measurement	
Household dishwashers	M/481	1	Measurement and test standards (1)	Performance including energy
Domestic ovens, hobs and range hoods		5	Measurement and test standards (4), performance standard and measurement and test standard (1)	Energy (2), Performance including energy (2), Performance (1)
Electric motors	M/470	2	Measurement and test standards (1), performance standard (1)	Energy (2)
Fans	M/500	0	No harmonised standards	
Air conditioners and comfort fans	M/488	9	Performance standard and measurement and test standard (1), measurement and test standards (7), compatibility standard (1)	Noise (2), performance including energy (4), energy (2), rating conditions, tolerances and data presentation (1)
Hot-water boilers		0	No harmonised standards	
Water heaters and hot water storage tanks	M/534	0	Transitional methods of measurement	
Space heaters	M/535	0	Transitional methods of measurement	
Local space heaters, solid fuel local space heaters	M/550	0	Transitional methods of measurement	
Solid fuel boilers	M/551	0	Transitional methods of measurement	
Air heating products, cooling products, high temperature process chillers and fan coil units	M/560	0	Transitional methods of measurement	

Lamps (directional and LED)		0	Transitional methods of measurement	
Lamps (non-directional)		0	Transitional methods of measurement	
Lamps (fluorescent and professional)	M/485	0	Transitional methods of measurement	
Power supplies	M/450	1	Measurement and test standard (1)	Energy (1)
Professional refrigerated storage cabinets		0	Transitional methods of measurement	
Household Refrigerating appliances	M/459	1	Measurement and test standard	Performance including energy
Set-top boxes	M/451	0	No harmonised standards	
Standby and off mode	M/439, M/544	4	Measurement and test standard (4)	Performance including energy (3), energy (1)
Electronic displays and Television	M/477	0	Transitional methods of measurement	
Transformers	M/495, M/495 Am1, Am2, Am3	2	Performance standard (2)	Electrical characteristics and design (1), energy (1)
Household tumble driers		2	Performance standard and measurement and test standard (1), measurement and test standard (1)	Performance including energy, noise (5)
Vacuum cleaners	M/540	4	Measurement and test standard (2), performance standard (2)	Performance including energy, safety (durability) (2), noise (1)
Residential ventilation units	M/537	0	Transitional methods of measurement	
Household washing machines	M/458		Measurement and test standards (2)	Performance including energy (1), noise (1)
Water pumps	M/498	0	Transitional methods of measurement	
Welding equipment	M/559	0	No harmonised standards	
Refrigerating appliances with a direct sales function		0	No harmonised standards	

ICT	M/462	0	No harmonised standards	
Special motor and variable speed drives	M476	0	No harmonised standards	
Non-household washing machines, dryers and dishwashers	M/537	0	No harmonised standards	
Material efficiency	M/543	8	Measurement and test standards	Material efficiency