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European CEN-CENELEC Standardization on Material Efficiency for longer lifespan within Circular Economy

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Abstract

The European standardization organizations (CEN, CENELEC & ETSI) agreed on the request from the European Commission for drafting a series of horizontal and generic standards in the field of Material Efficiency aspects supporting the Circular Economy. This paper will describe the EU regulation context, the CEN-CENELEC (CEN-CLC) standardization structure and membership, the organization setup for managing the work already started. It will describe the objectives of the 10-standard series that will possibly be for direct use by manufacturers but that are more specifically dedicated to CEN-CLC product Committees in charge of drafting product oriented standards as regards requirements from the EU Ecodesign Directive.

A summary of the expected requirements issued from these draft documents will be presented for the different topics developed for the Material Efficiency of Energy related Products (ErPs), that will apply to equipment and systems.
The general topics are the durability, the ability to re-manufacture, the ability to repair, upgrade and reuse, the recyclability and recoverability, the proportion of re-used components and recycled material, the declaration of critical raw materials, the information on Circular Economy aspects provided to the users of ErPs. Beyond these topics mainly covered by the standards dealing with dependability domain, a focus from functional approaches to durability assessment methods aiming how longer lifespan of products would be assessed will be presented inside this paper.

Based on examples, some additional information will highlight the industries and organizations to prepare the optimization inputs that could be implemented in product oriented Material Efficiency standards that would be derived from the current standardization work in process.

I. Introduction

The European Commission (EC) implemented a decision on a standardization request to the European standardization organizations as regards ecodesign requirements on material efficiency aspects for energy-related products in support of the implementation of Directive 2009/125/EC of the European Parliament and of the Council. This paper aims to summarize, the standardization works in progress within the CEN-CENELEC Joint Technical Committee 10 (CEN-CLC/JTC 10), the European Commission requests and the existing standardization framework which enabled for several decades the integration of a circular model in the economy such as the electrical distribution and industrial equipment expected to be in operation more than 30 years aiming a greener planet.

For that purpose, the CEN-CLC/JTC 10 gathered 310 standardization experts from 18 National Committees, and established some liaisons with 13 European Business to Customer (B2C) and Business to Business (B2B) professional associations. JTC 10 members are committed from the industry, the consumer organizations, NGOs Laboratories, European Commission including its Joint Research Centre, and ETSI in order to get a large panel of expertise to succeed the ambition.

All reports and standards are intended to be used and referenced by product technical committees when preparing their own of product-specific or product family standards. That standard series is not expected to be applied directly.

As the EC aims to reach longer lifespan for products, a special focus will be done on durability assessment covered by the dedicated group CEN-CLC/JTC 10/WG 2. The standardization work is in progress and could be modified and updated before the expected publication in early 2020.

II. Prerequisite

1. Standardization

Criteria for relevance, acceptability, credibility easiness and robustness are described in policy of several standardization bodies while European commission aims a longer lifespan of product. However, a crucial capability for a standard is the verifiability, as specified with the ISO/IEC Directives part 2. Stability, reliability or lifetime of a product shall not be specified if no testing method is available and known for use that can verify the claim within a reasonably short time. The product guarantee provided by manufacturers is not a substitute for such requirements. Guarantee conditions shall not be included inside a standard, because they are a commercial or contractual concept, not a technical one.

The European Commission asks for consistency between Ecodesign implementing measures and other relevant Union legislations. However, the standardization is usually referred for providing tools and methods on how the regulation is implemented and how any loophole or overlap between standardization and regulation must be avoided. As an example, the Waste EU Regulation, as part of circular economy, is not considered. It is implemented, based on subsidiarity, as a national competence and is not supported by CEN-CLC standards.

A non-exhaustive list, but relevant bibliography, to better understand how circular economy concept might be controlled is based on the EN 12973[2] and EN 16271[3] for the functional approaches [1], the IEC 60300-1[4] and IEC 62347[5] for the dependability management, the IEC 62308 [6] for the durability assessment and the ISO 14044[22] and ISO 14025[23] for lifecycle assessment.

2. Circular Economy

Circular economy is not a new concept as reminded by the British Standard BS 8001[24]. A prerequisite is to use material from clean material cycles (REACH). This concept is a dynamic socio-technical ecosystem involving a lot of stakeholders, where the trade-off is linked to a relevant digital transformation with the Internet of Things (IoT). This concept, to transform a linear economy into a circular economy is very broad and can be relevant only if an optimization of the global approach is carried out, driven by the final criterion: a reduced environmental footprint of the full lifecycle of both the product and the system in which the product belongs. The complexity to embed both studies limits the Life Cycle Assessment (LCA) to the product, which can be carried out in a separate way for the upper layer of system. The circular economy should cover the life cycles (product & system) showed in Figure 1.

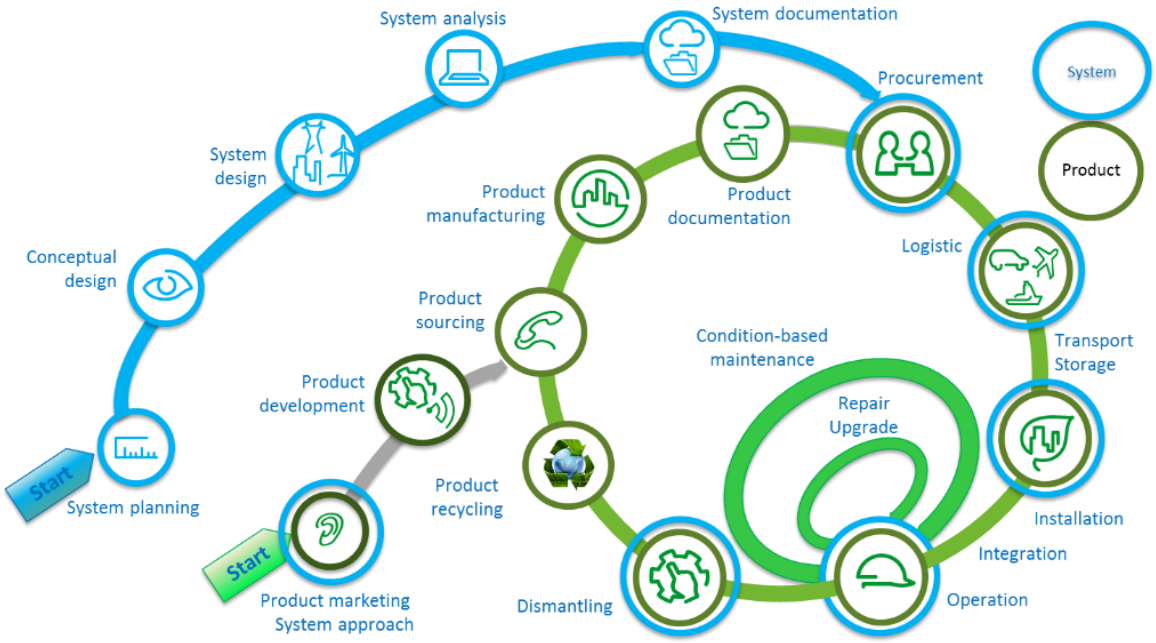

Figure 1 – Life cycles

III. Material efficiency

1. General

The European Commission through the standardization request M/543 provided objectives to the European standardization organizations as regards ecodesign requirements on material efficiency aspects for **energy-related products** (ErP) in support of the implementation of Directive 2009/125/EC. The global objectives of this standardization work are described as follows:

a. Extending product lifetime.
b. Ability to re-use components or recycle materials from products at end-of-life.
c. Use of re-used components and/or recycled materials in products

The CEN-CLC/JTC 10 Committee has created 6 Working Groups that are responsible for the development of the standardization deliverables:

- WG 1 ‘Terminology’
- WG 2 ‘Durability’
- WG 3 ‘Upgradability, Ability to repair, Facilitate Re-Use’
- WG 4 ‘Ability to re-manufacture’
- WG 5 ‘Recyclability, recoverability, RRR index, Recycling, Use of recycled materials’
- WG 6 ‘Documentation and/or marking regarding information relating to material efficiency of the product’, and Critical Raw Material declaration

Each working group works on respective items which are summarized in table I.

TABLE I -

N°	Doc	Title of deliverable	WG	Ref	CEN-CENELEC
1	TR	Definitions related to material efficiency (NWI65684)	1	Pr TR 45550	CENELEC
2	TR	Guide on how to use generic material efficiency standards when writing energy related product specific standardization deliverables	1	Pr TR 45551	CENELEC
3	EN	General method for the assessment of the durability of energy related products (JT010003)	2	Pr EN 45552	CEN
4	EN	General method for the assessment of the ability to repair, reuse and upgrade energy related products (NWI 65685).	3	Pr EN 45554	CENELEC
5	EN	General method for the assessment of the ability to re-manufacture energy related products (NWI 65686).	4	Pr EN 45553	CENELEC
6	EN	Methods for assessing the recyclability and recoverability of energy related products (JT010001).	5	Pr EN 45555	CEN
7	EN	General method for assessing the proportion of re-used components in an energy related product. (NWI 65709).	4	Pr EN 45556	CENELEC
8	EN	General method for assessing the proportion of recycled material content in an energy related product. (JT010002).	5	Pr EN 45557	CEN
9	EN	General method to declare the use of critical raw materials in energy related products. (NWI 65687).	6	Pr EN 45558	CENELEC
10	EN	Methods for providing information relating to material efficiency aspects of energy related products. (NWI 65688).	6	Pr EN 45559	CENELEC
11	TR	Environmental Engineering (EE); Circular Economy (CE) in Information and Communication Technology (ICT); Definition of approaches, concepts and metrics (Published)		TR 103 476 V.1.1.2	ETSI
12	ES or EN	Specific metrics, methods and parameters for assessment of material and resource efficiency aspects of ICT network infrastructure goods in the context of circular economy			ETSI

The aim of these standards is to provide methodologies and tools as well as criteria for assessing existing ErP products but not to provide requirements for being circular by design optimization as European Environment Agency highlights [25]. An additional complexity of these tasks is the merging of the B2C and B2B specificities and experiences combined to the objective of European Commission which is to publish the regulations using these standards as support. It is the reason why the standards should not anticipate the regulation and should focus on description of assessment methods for existing ErP product as a toolbox and not to include any requirements which will come from the regulatory framework.

While CEN-CLC JTC10 standards simplified some assessments to be accessible in term of communication for the users, other existing standards contributing to Ecodesign and optimizing the design stages should be specified to help the product TC dealing with the standards for new products.

The following clause will remind the objective of each of CEN-CLC/JTC10 deliverables completed by respective added value from existing standards and by examples if any.

2. Technical topics

This clause aims to describe the objectives of each document followed by the stakes, which will be completed by identified improvable approaches related to new products, as expressed below:

- pr **EN 45550** [10] aims to harmonize the definitions used by the different standards. While lot of definitions exist in IEC 60050-192 [8] standard, it might be beneficial to modify few existing definitions when they are too close to definitions already used or expected to be used in a regulatory framework. As an example, "normal service conditions" is missing from IEC database (Electropedia), and has been replaced by "environmental and operating conditions for normal or intended use" clarifying respective scopes.
- pr **EN 45551** [11] is frozen, because an attempt is to include the guidance inside each respective document.
- pr **EN 45552** [12] aims to describe methods to assess the durability. The durability is mainly covered by existing standards such as the IEC 62308 [6] clause 9.3. However, a reminder of the influencing parameters on product ageing, on how to conduct a functional analysis seemed useful. In addition, the European Commission targeted reliability through durability which are two different concepts, and targeted validation by tests which can be only valid under the test conditions and not the normal use conditions. The user of the pr EN 45552 shall differentiate when durability only focuses on aging, fatigue and wear-out due to environmental and operating conditions, or when the durability assessment also considers maintenance and repair actions, until end of product life. For example, oil-immersed and dry type power transformers are identified to get their ageing mostly affected by thermal aspects. The loading guide for oil immersed power transformers exists since 1984, enabling to assess the expected lifespan of the power transformers related to the use temperature, the load factor. In addition of this fatigue to identify the limit before a failure, the energy efficiency being a requirement of the M548/2014 directive might be a criterion related to the durability. A loading guide existing since 1984 enables to assess the expected lifespan of the power transformers under a defined use temperature, load factor, oil and windings temperature rise.
- pr **EN 45553** [13] deals with the assessment of the ability to re-manufacture energy-related products on a generic level, reminding that neither safety nor performance of the product or part to be remanufactured will be impaired during the remanufacturing process, requiring qualified person, traceability of re-manufactured product and used or expected to be used parts. As example, for power transformers, the amendment of the eco-design directive forecast to deal with material efficiency for circular economy considering the level of the efficiency after the repair, reuse or upgrade (pr EN 45554) and after remanufacturing or refurbishment (pr EN 45553) [26]. In all cases, the legal status and the warrantee of the product after remanufacturing is outside the scope of the standard.
- pr **EN 45554** [14] aims to assess a reparability and reusability to extend the product lifetime when already designed. for the CEN-CLC/JTC 10 Committee the corrective maintenance is so-called repair, while maintenance is kept for preventive and condition based maintenances. The reparability of the product or parts thereof is a benefit for longer lifespan and an optimization process is described with existing guides such as IEC 60300-3-10, 11, 12, 14 where the IEC 60300-3-11[9] describes the relation for reliability centred maintenance (RCM), and shows six different failure patterns which would be useful for the pr EN 45552. The failure identification process and RCM analysis enable the whole range of expected maintenance tasks to be identified and

hence permits support planning to be initiated. The identified maintenance tasks will produce the information needed to analyze support activities such as the provisioning of spare parts, level of repair analysis (LORA), requirements for tools and test equipment, manpower skill levels, and the requirement for facilities necessary to support the derived maintenance concept. Further reliability study, some non-repairable part could get a longer lifespan and higher reliability, integrating cell coin battery when soldered instead of being withdrawable, especially those targeted lifespans over 10 years required for industrial products. It is why only a robust design based on a functional analysis would be able to confirm if the ecodesign perspectives have been achieved.

- pr **EN 45555** [15] This document provides a general methodology to assess the recyclability, the recoverability of energy-related products and the recyclability of critical raw materials from energy-related products. In addition, this document considers the ability to access or remove certain components, assemblies, materials or substances from products to facilitate their extraction at the end-of-life to optimize ease of treatment, recycling and other recovery operations. It includes description of horizontal criteria and clarifies the quantitative measurement of recyclability using a full or simplified process. It makes the link with environmental benefits and considers the end of life treatment scenario, considering the representativeness and the different sources of relevant data. As example the power transformers are reparable and recyclable enabling to valorize the materials even if power transformers are excluded from the WEEE directive,
- pr **EN 45556** [16] General method for assessing the proportion of re-used components in energy-related products. Two calculation methods based on mass of re-used components and the number of re-used components are presented. While writing product specific standards on assessing the proportion of re-used components product specific technical committees should apply the most suitable methods for their product group.
- pr **EN 45557** [17] provides general method for assessing the proportion of recycled material content in energy related products. This standard describes the "pre-consumer material". It makes distinction with new scrap, it provides the way to calculate the recyclability and recoverability of ErP and gives the principle for the mass-balanced recycled material. It gives specific guidelines for material consideration and deals with the traceability.
- pr **EN 45558** [18] provides general method to declare the use of critical raw materials in energy related products in the way these information could be exchanged between stakeholders along the supply chain in a well-known formalized format issued from IEC 62474 standard [21]. The EN 45558 defines Critical Raw Material (CRM) as the CRM listed in the annex 1 of the EU Commission document COM(2017)490 final [x].
- pr **EN 45559** [19] provides methods for providing information relating to material efficiency aspects of energy related products. all documents previously mentioned describes different methods of assessment. The result of the assessment methods will be communicated to the user. In addition, the conditions for which the assessments are valid shall also be communicated. Example: A power transformer is expected to be operated by a user under defined conditions for 20 years. If one condition is the yearly average temperature at 20°C with a load factor near 1, while a second user would like to use the same power transformer in a warmer area such as 25°C with a different load factor. The Figure 1 shows how a user is informed and how he can verify the influence of a temperature of use and the load factor changes keeping a same ageing rate. The second user shall limit its load factor at 0.95 for a same ageing rate.

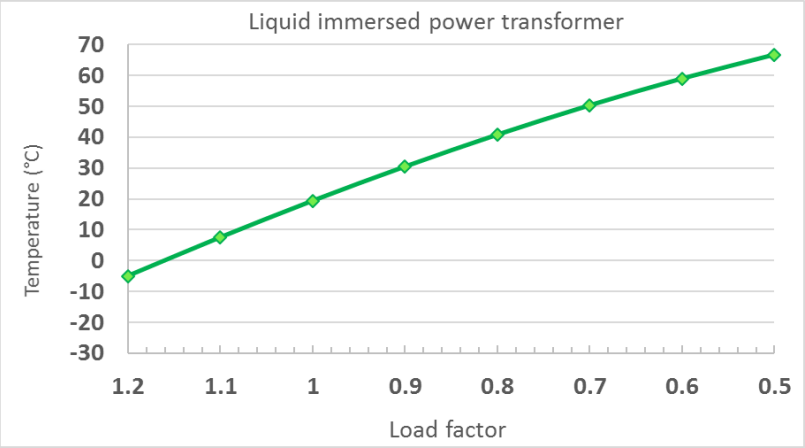

Figure 1 – Example for liquid immersed power transformer for a constant ageing rate.

- **ETSI TR 103 476** [20]: This technical report aims to provide an overview of the most important existing aspects, parameters, indicators, metrics, results, and business models used for estimating the resource efficiency and circular economy characteristics of Information Communication Technologies (ICT) infrastructure goods as input for further standardization. All topics mentioned in Table 1, requiring metrics, are covered by the ETSI 103 476 report, mentioning the respective trade-off based on a wide bibliography analysis. As example in a durability analysis, a trade-off is required between OPEX and CAPEX while the innovations are expected to bring energy savings. So optimization is the heart of any durability analysis, where functional durability shall complete the technical durability [25].

3. Durability concept

The durability is the ability to function as required, under defined conditions of use, maintenance and repair, until a final limiting state is reached. The limiting state is reached after an event limiting a function. This event could be a failure or a wear-out failure or a fatigue when a digital or an analog function is no longer delivered, as shown Figure 2. Each function should be classified by importance, to identify where the function associated to eco-design should be identifiable. The maintenance and repair strategies influence the functional durability when the technical durability met a limitation. A durability assessment should take a differentiation when durability only focuses on aging, fatigue and wear-out due to environmental and operating conditions, or when the durability assessment also considers maintenance and repair actions, until end of product life.

In accordance with the IEC, the durability corresponds to the end of the useful life, which means a unit associated to a duration (time, cycle, distance…) from the first use until user requirements are no longer met, due to economics of operation and maintenance, or obsolescence. The CEN-CLC/JTC 10 could not integrate predictive limitation(s) inside the proposed methods to assess the durability, due to the economic and obsolescence reasons.

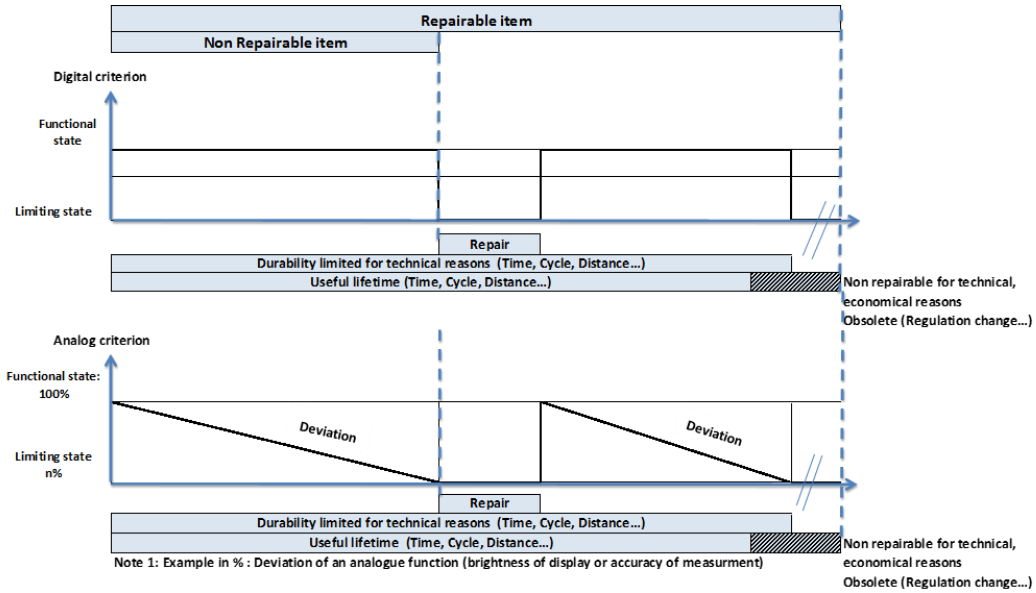

Figure 2 – Durability limitation and actions to recover a use phase.

When a repair aims to recover a rating assessed by an analog criterion, it could be necessary to identify an acceptable threshold defining a tolerance. However, the critical functions such as those linked to health and safety must reach 100% after repair.

The durability analysis should be carried out in accordance with to IEC 62308:2006 [6], subclause 9.3, as follows:

1) identify applicable environmental and operating conditions (see IEC 60721 serie of standards and the product standard) being part of the mission profile.
2) identify stresses related to the conditions previously defined (see IEC 62308 [6])
3) identify transfer functions (EN 12973) [2]
4) identify magnitude and locations of stresses combining conditions and simulation tool such as finite element (FE) other.
5) identify likely failure sites, mechanisms and modes (FE tool or other)
6) identify the most appropriate damage model (Experience, Accelerated test (see IEC 62506 [7])
7) identify the durability using appropriate damage model(s) and acceleration factors

The durability of any ErP product is a crucial information used for any life cycle assessment or a reliability analysis, however the durability is not a reliability of an ErP.

IV. Conclusion

As a first step the assessed criteria and deliverables to be issued in 2019/2020 by the CEN-CLC/JTC 10 should be a relevant methodology to assess different topics for Circular Economy, while the IEC should engage the whole approach aiming to optimize the material efficiency through a design approach aiming a lowest environmental footprint.

In a second step, the presumption of conformity with particular Material Efficiency requirement from the EU Regulation will be possible by using dedicated product-oriented CEN-CLC standards. These standards should be derived from the horizontal deliverables issued from JTC 10 Committee but drafted by TCs in charge of particular ErP.

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