State of the art of laws and standards in the field of eco-design of electrical and electronic equipment in Europe

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ABSTRACT

Total energy consumption is expected to double by 2050, greenhouse gas emission must be halved in the same time period and generation, transmission and consumption will need to become 4 times more efficient [1]. Beyond the cost, the technical performances of a product are no longer considered as the unique parameter of choice, environmental performances throughout the whole life cycle of the product needs also to be considered. This implies knowledge of environmenl life cycle assessment and regulatory compliance to ensure that products follow the new laws, rules and regulations. In the case of electrical and electronic equipments, European directives and regulation (WEEE, RoHS, EuP, REACh) and IEC standards in the field of environment are the new driving forces of technological developments. This paper attempts to present a synthesis of these new European legislations and international standards in the electrical and electronics industries.

INTRODUCTION

Electrical and electronic equipments (EEE) are energy-using products which account for a large proportion of the consumption of natural resources and energy. Indeed, once placed on the market and/or put into service, it depends on energy input. Therefore special care is given to address environmental aspects such as substance content, energy efficiency or recycling. The aim of this paper is to show how standards and legislations are organized to structure and improve the life cycle of EEE and the different strategies used in the collection and recycling of wastes in this category.

REGULATORY

European regulations concerning the environment throughout the product life cycle have changed since the early 2000s. Figure 1 shows the European directives and similar directives spread worldwide.

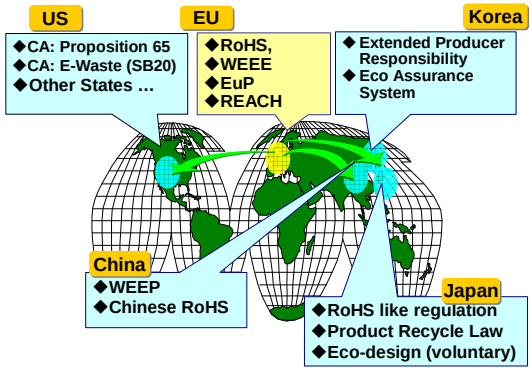

Figure 1. Product policy spreads worldwide [2].

RoHS directive

The RoHS Directive 2002/95/EC - (Restriction of the Use of certain Hazardous Substances in electrical and electronic equipment) was adopted in 2003 by the European Union to promote the restriction of the use of toxic substances [3], [4]. It has been transposed into EC member state by 1 January 2006. The RoHS directive currently limits its scope to final products, mainly consulter goods of the operating voltage not exceeding 1000V AC and 1500V DC. Nevertheless some proactive companies have decided to implement RoHS not only in their low voltage equipments but also in medium and high voltage applications. It shall be noted that its recast is considering an “open scope” that would include all equipments but if explicitly excluded like large fixed installations or industrial tools, and required RC marking.
RoHS restricts the use of four metals in the manufacture of electronic and electrical equipments: lead (Pb), mercury (Hg), cadmium (Cd) and chromium VI (Cr^{VI}) and two flame retardants: Polybrominated biphenyls (PBB) and polybrominated diphenyl ethers (PBDEs), used in various polymers. The prohibition of certain hazardous substances can already facilitate the end of life processing of such equipments and reinforces the WEEE Directive.

WEEE directive

2002/96/EC Directive called WEEE: Waste Electrical and Electronic Equipment Directive [3], [4] is closely related to

the RoHS directive with a similar scope. It aims to improve the management of Waste Electronic and Electrical Equipments. The Directive gives product end of life responsibilities to producers:
- supporting the management of their products at the end of life, i.e. organizing and financing collection and recycling
- product marking
- taking into account the end of life from the design phase to facilitate dismantling, recycling and energy recovering efficiency. Today, the design of a device is no longer restricted to the assembly phase, but must integrate future dismantling. Household producers and distributors are also subject to obligations such as:
- accept customer's existing equipments when they purchase a new product of the same type (an obligation called "one to one")
- inform buyers about the cost of WEEE disposal: the amount of the eco-contribution (or eco-participation) must be indicated on the bill of sale. In France, the producers of EEE gathered and created four eco-organizations approved by the government to fulfill the legal obligations of producers (Eco-systems-SAS (70%$_{wt.}$) [5], Ecologic-SAS [6] (15%$_{wt.}$), ERP-SAS [7] (10%$_{wt.}$) and (Recyclum-SAS [8] (1%$_{wt.}$)). These eco-organizations are in charge of the removal, sorting and treatment of household and professional EEE. They select companies that collect WEEE from local authorities, distributors and not-for-profit organizations.

ErP directive

The ErP (Energy-Related Products directive (2009/125/EC) formerly Eup: Energy using Products (2005/32/EC)) is an eco-design European Directive establishing a framework for setting requirements for eco-design of energy-using and related products such as double glazing windows, taps and showerheads [4]. Products that transport people or goods are excluded. The directive calls for actions at the design stage to reduce pollution at source of products throughout their entire life cycle (including materials use, water use, polluting emissions, waste issues and recyclability), with a particular focus on energy. Indeed, 70% of the costs of environmental impacts are determined at that stage, and most of the costs involved are committed then. The ErP directive should promote sustainable development through a harmonised level of environmental protection and consequently cross-border transportation of energy using products, environmental protection and increased security of energy supply. ErP is set up to improve particularly energy efficiency of any goods having an impact on energy consumption during use, *i.e.* mainly energy consumption during the use phase by reducing for instance the stand-by of such equipments or the water consumption and therefore the amount of energy needed to heat water, but may also consider objectives for other impacts.
ErP concerns electrical and electronic equipments which:
- represent a significant volume of sales and trade, indicatively more than 200,000 units a year within the community according to most available figures.
- have a significant environmental impact within the community
- present significant potential for improvement in terms of its environmental impact without excessive costs.

The ErP Directive is a directive that evolves over time. It intends a first series of products with specific targets for environmental improvement (9 implementing measures have already been adopted and several preparatory studies are completed or ongoing). Both new goals and sets of products are in preparation and will be announced through the working plan of the European commission. In practice, all non-compliant products are banned from being sold in the 27 European member states. This was for example the case of incandescent lamps, for which a gradual phase-out started in the EU in 2009 under this Directive.
The CE marking (European conformity) is a mandatory conformance mark. But the manufacturer, on its sole responsibility, draws up a declaration of conformity in which he attests that its products meet essential requirements set out in European Directives. Public authorities in each member states may control if products really meets EU consumer safety, health or environmental requirements.
The energy consumption is expected to double by 2050, greenhouse gas emission must be halved in the same time period and generation, transmission and consumption will need to become 4 times more efficient [1]. This is tremendous but this can be achieved: thanks to directive such as ErP.

REACh

The REACh regulation means Registration, Evaluation and Authorization of Chemicals [3], [4]. It establishes a single integrated system of registration, evaluation and authorization of chemicals marketed in the European Union. REACh requires a registration process and environmental and toxicological evaluation from all producers and/or importers of substances or preparation put on the European market. In addition, it sets up the principle of traceability of Substances of Very High Concerns (SVHC) when used in articles. All European companies (manufacturers, importers, distributors and/or downstream users) may be concerned by REACh.
The main purpose of REACh is to improve the protection of human health and the environment through the better and earlier identification of the intrinsic properties of chemical substances. Many substances are already subject to restrictions on their use within the European Union. However, it is found that the current restrictions on use are insufficient.
It gives greater responsibility to industry including downstream users to manage the risks from chemicals (users must use Safety Data Sheet and Chemical Safety Report (CSR) to control risks and must communicate with supplier if use is not covered by CSR).

A substance may be listed as a SVHC if it meets one or more of the following criteria: carcinogenic, mutagenic, repro-toxic, **P**ersistent, **B**ioaccumulative, **T**oxic for the Environment (**PBT**) or **v**ery **p**ersistent, **v**ery **b**io-accumulative (**vPvB).** By November 2010, the European Chemicals Agency (ECHA) has included 38 substances in the candidate list of SVHC for authorization [9]. The list is published on ECHA website.

Suppliers of SVHCs must provide their customers with a Safety Data Sheet (SDS). Suppliers of mixtures of substances which contain more than 0.1%$_{wt.}$ of any SVHC must provide their customers with a SDS *on request*. Manufacturers or importers of *articles* containing more than 0.1%$_{wt.}$ of any SVHC must provide their customers, and consumers on request, with adequate information on the safe use and disposal of the article, including the name of the SVHC(s) concerned. From 1 June 2011, manufacturers and importers of articles will also have to notify the European Chemicals Agency of the quantities of SVHCs used in their articles [9]. (An *article* as defined in REACh is defined as an object which is given during the manufacturing process a form, a special surface that are more critical for its manufacture than its chemical composition.)

STANDARDS

Concerning standardization, several documents were published or are under development within ISO and IEC organizations. In practice, they address regulated aspects as listed above and provide industry with reference document to ensure legislation requirement fulfillment.

The mains ones are:

Figure 2. Structure of IEC (TC 111) [2]

In the field of eco-design there are a number of international standards of reference developed by the IEC (International Electrotechnical Commission) and ISO (International Standardization Organization). Specific attentions are required for the standard IEC TR 62476**,** IEC 62 430 and ISO 14 044 which are the most used in the field of EEE.

IEC TR 62476:

Guidance for evaluation of products with respect to substance-use restrictions in electrical and electronic products IEC/TR, which is a technical report, provides a framework for the use of internationally accepted standards, tools and practices to evaluate electrical and electronic products with respect to restricted substances. This technical report can also be applied to declarable substances which are not restricted in electrical and electronic products. This technical report provides guidance on how technical documentation and relevant evaluation and control methods should be selected and applied for restricted or declarable substances of any producer's product. [12]

IEC 62430:

Environmentally conscious design for electrical and electronic products IEC International Standard is intended to be used for all parties involved in the design and development of electrical and electronic products, and products and materials they contain. It is divided into two separate parts, as shown in Figure 3: the foundation and process elements ECD (Environmentally Conscious Design) consisting of three actions (plan, do and check / act).

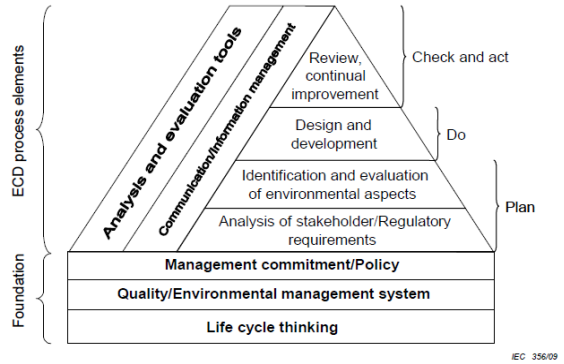

Figure 3. Overview of the EDC process according to Annex A of IEC 62430 [13]

The IEC 62430 standard helps to establish, document, implement and maintain the process of eco-design as a full part in the design. It contains the following steps:

- Analysis of regulatory and environmental expectations of stakeholders
- Identification and evaluation of environmental aspects and impacts consist in:
  - Establishing a procedure for identifying incoming flows (materials, energy, resources ...) and outgoing (products, waste, emissions ...).
  - Identification of key environmental aspects for assessment and prioritization according to their contribution to the overall impact. The quantitative approach is encouraged
- Design and Development
  - Find a balance between environmental and other criteria: function, technical, quality, performance, cost...
- Review and Continuous Improvement

A procedure must be established for the process of eco-design, implemented and maintained. For example: by

conducting design reviews.
- Sharing information / communication
It is advisable to integrate this process into the management system as the system of quality management. Implementation of eco-design inside a company should not be limited to the design department but means to mobilize every department and install a culture inside of the organization.

ISO 14044

The ISO 14044 is an environmental management standard that specifies requirements and provides guidelines for conducting Life Cycle Impact Assessment. LCIA aims at quantifying the emissions, resources consumed and environmental and health impacts that are associated with goods and services ("products"). ISO 14044 includes four steps (Figure 4).

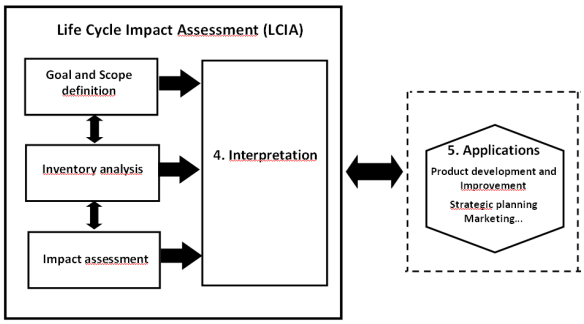

Figure 4. Life Cycle Analysis framework according to ISO 14044 (the step 5 is not mandatory) [14]

Standards comparison: CEI62430 and ISO 14044

Both standards are complementary as shown in Table I. Indeed, both go hand in hand: the ISO 14044 standard makes an assessment of environmental impacts of the product when it is finished, while the standard IEC 62430 conducts regular reviews by considering all environmental liabilities or stakeholders in the phase of design and product development. The latter is continuously optimized by the standard IEC 62430, and is subject to a presentable and transparent review to the customer through the ISO 14044. The IEC 62430 standard is well suited for R & D which must now develop products always better not only on the technical and economic terms but also in terms of environmental impacts.

	ISO 14044 standard	CEI 62430 standard
GOAL	Life cycle analysis methodology	**Minimize the environmental impacts**
TYPE	**Declarative**	**Managerial**
	Passive : document review	**Active** : continuous improvement, regularly reviews
UTILIZATION	Adapted when the product is finished *Life cycle analysis*	Adapted to the stage of conception and development **(R&D)**: *Eco-design*
METHOD	Mandatory	Free but chosen method has to be done and demonstrate
ACHIEVEMENT	**Difficult to apply because application of the standard is required without exception**	**Require top management attention**
HOW TO CHOOSE	COMPLEMENTARY	

Table I. Comparative table of standards ISO 14044 and IEC 62430

CONCLUSION

Regulations and standards are essential tools to coordinate the efforts of industrials and urging the implementation of eco-design inside companies. They can play both the role of a driving force and support. Europe in recent years has shown its willingness to be a pioneer in this area and was responsible for numerous regulations relating to environmental improvement product. The electrical and electronic sector is affected by a large portion of these texts including RoHS, WEEE, ErP and REACH Regulation.

These texts are difficult to read and often lend to interpretation. However, they are intertwined in such ways that they complement each other. Furthermore, some countries such as China, Japan, Canada and Australia, have adopted similar regulations and others are under investigation. The generalization of such a regulatory framework and the use of IEC standards should eventually reduce the environmental impact of electrical and electronic equipment throughout their life cycle. It is therefore essential to develop a monitoring tool prescriptive and reliable to follow the evolution of these texts and anticipate future changes.

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