



Electronic Waste: How Waste Leads to Design Challenges

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HISTORY OF GLOBAL E-WASTE ISSUES

Since the onset of the 21st Century, the electronic sector has experienced a significant increase of environmental regulations. Historically, the majority of regulations affecting this product group has focused on safety and quality requirements. It was not until October 2001, following a large enforcement action taken against Sony for cadmium, that the electronics industry first sensed a looming mandate to restrict substances in electronics. However, calls for waste limitations were made even earlier.

On July 30, 1996, the European Commission began stressing the importance of reducing hazardous substances in electronic waste as a way to enhance the economic profitability of recycling electronic waste and decrease the negative health impacts on workers in recycling plants.

At that time, electronic waste was shipped to third world and developing countries where people and the environment were exposed to toxins as a result of improper treatment and resource reclamation techniques.

Instances of the illegal shipment of waste have been detected by a number of non-profit organizations, including the environmental group, Basel Action Network (BAN). BAN has identified from Hong Kong authorities that an estimated 50-100 containers of electronic waste enters its port each day. As recent as March 2010, Indonesian authorities turned away nine

containers of old CRT monitors from a recycling company based in Massachusetts. In addition, The UK Environment Agency has conducted large-scale raids on sites suspected of shipping electronic waste to Africa. Arrests were made.

Proper treatment of electronic waste is one of the most assured methods of protecting humans and the environment. However, others argue that eliminating the hazardous substances used in electronics altogether would prove just as effective. It is hard to argue against both of these methods, but the latter requires a sufficient social-economic impact assessment to properly quantify impacts caused by substitution of such harmful substances.



Figure 1: Informal e-waste recycling
photo courtesy of StEP-EMPA, © UNEP

RESTRICTION OF HAZARDOUS SUBSTANCES (ROHS) DIRECTIVE (2002/95/EC)

This reasoning led to the promulgation of the European Union’s Restriction of Hazardous Substances (RoHS) Directive (2002/95/EC). This law restricts the use of lead, cadmium, hexavalent chromium, mercury and two brominated flame retardants in electrical and electronic equipment captured within its scope. The majority of its impact has been felt by the manufacturers and distributors due to redesign efforts requiring significant resource allocation in new technology, supplier/customer management, and education. This impact can divert the understanding of where the origin of the RoHS Directive stems.

The reasoning behind restricting these six substances is not solely the human health and environmental concerns during the typical use of the electronics during their functional life,

but the exposure created during end of life (waste) treatment. This reasoning should allow the industry to project future restrictions on electronics.

ROHS AND WEEE DIRECTIVES ARE UNDER REVISION

The RoHS Directive is currently undergoing revision with a number of requested changes stemming from the effects of electronic waste and its treatment.

Jill Evans, Committee on the Environment, Public Health and Food Safety has stated the following as part of the European Commission’s Codecision procedures:

The RoHS recast needs to be put into the context of the EU’s international obligations to reduce total releases of dioxins and furans, with the goal of their continuing

Indicator	Environmental benefit	Number*	Unit
2005 WEEE: Arising: 8.3 Mt Collected: 2.2 Mt			2011 WEEE: Arising: 9.7 Mt Collected: 5.3 Mt
Weight	Growth in WEEE arising	1,359	kt WEEE Arising
Eco-indicator 99 H/A v203**	Total environmental load per year of	643,591	Europeans
Idem, Human Health**	Total environmental load per year of	423,125	Europeans
Idem, Ecosystem Quality**	Total environmental load per year of	46,038	Europeans
Idem, Resource Depletion**	Total environmental load per year of	174,589	Europeans
Cumulative Energy Demand	Equivalent with:	-75	million GJ
Abiotic depletion	Equivalent with:	-40	kt Sb
Global warming (GWPI00)****	Equivalent with:	-36****	Mt CO2
Ozone layer depletion (ODP)	Equivalent with:	-4.8	kt CFC11
Human toxicity	Equivalent with:	-4,047	kt 1,4-DB***
Fresh water aquatic ecotox.	Equivalent with:	-404	kt 1,4-DB***
Marine aquatic ecotoxicity	Equivalent with:	-3,551	Mt 1,4-DB***
Terrestrial ecotoxicity	Equivalent with:	-74	kt 1,4-DB***
Photochemical oxidation	Equivalent with:	-3.0	kt 1,4-DB***
Acidification	Equivalent with:	-50	kt SO2
Eutrophication	Equivalent with:	-1,493	t PO4---

Table ii: Estimated Environmental improvement due to the WEEE Directive 2011 versus 2005

*Negative means avoided environmental impact, ** Meant as a rough illustration only: 1 Pt roughly equals 1/1000 of the environmental load of one European p.year (Goedkoop 1999) ***kg 1,4-dichlorobenzene **** Under the assumption of an unchanged 80% presence of CFC fridges in the WEEE stream over time

Figure 2: Estimated Environmental improvement due to the WEEE Directive 2011 versus 2005

Table ii from the 2008 Review of Directive 2002/96 on Waste Electrical and Electronic Equipment, United Nations University

minimization and, where feasible, ultimate elimination. The final destiny of large quantities of WEEE remains unclear. High-temperature incineration remains the exception. Sub-standard treatment of WEEE – in the EU or in third countries - risks remaining a reality for significant amounts. Emissions of dioxins and furans can only be addressed via material choices at design stage.

In addition, the Commission has used information provided by its contracted body, the Öko-Institut, to assess recommendations on other substances to be restricted under the RoHS Directive. The following excerpt is provided based on that contracted findings:

The study commissioned by the Commission on hazardous substances in electrical and electronic equipment highly recommended a phase-out of organobromines and organochlorines due to their potential to form polybrominated and polychlorinated dioxins and furans in waste treatment operations, and gave priority to the phase-out of PVC over selective risk management options to guarantee a reduced release of PVC, of its additives and of hazardous combustion products.

This shows the strength of the waste treatment argument on restricting substances in electronics.

NGOS STRONGLY VOICE THEIR OPINIONS ON E-WASTE

The majority of this reasoning comes from recycling associations, workers unions, and Non-Government Organizations (NGOs) promoting safer substances. One example is the recent joint statement issued in February 2010 by three NGOs: European Environment Bureau (EEB), the Health and Environment Alliance (HEAL), and Women in Europe for a Common Future (WECF).

The main points are as follows:

- *Provide a coherent framework to include all EEE;*
- *Restrict by 2014 hazardous substances and materials in EEE that cause serious concern throughout their lifecycle (production, use, disposal) and hamper recyclability, such*

as halogenated organic substances, to a maximum of 0,1% (weight by weight);

- *Restrict by 2014 the use of nano silver to the detection limit in homogenous EEE parts;*
- *Ensure a specific methodology for future substance restrictions focusing on waste considerations which are in line with the specific aims of the RoHS Directive.*

The above statement is not a law and none of these three NGOs are part of the government of the European Union, but they have a significant voice and are very dedicated to having their considerations addressed in the coming recast of the RoHS Directive. In retrospect, trade associations and government authorities also have a similar standing when it comes to being heard and provide the other ends of the argument.

If any of the substances described in this article, that are not already covered by the existing RoHS Directive, would cause significant impact to the quality or continued function of electronic equipment, then now is the time for manufacturers to voice their reasoning. In a sobering reflection, it may be too late to submit information to support the continued use of these substances if it has not already been done since the timeline for the recast of the RoHS Directive is as follows:

- **9 March:** Deadline for amendments
- **4 May:** Vote in the ENVI committee
- **15-16 June:** Vote in plenary

THE ROHS DIRECTIVE'S FUTURE IMPACT ON THE MEDICAL PRODUCT INDUSTRY

The current RoHS Directive does not include medical equipment or monitor and control equipment within its scope. This will soon change. These categories of electronics will need to adhere to the RoHS Directive's substance restrictions by as early as 2014. The recast of the RoHS Directive does provide an additional annex for application exemptions related to these two product categories, but studies on the availability of substitutes for new substances being recommended for restriction are quite limited.

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Medical Device manufacturers have been significantly alarmed about the restriction of PVC. This material is used significantly within this industry due to its flexibility and endurance. It would be expected that significant studies and research would need to be conducted before restricting such a material in medical devices. This thought can be strengthened by the following statement in the Commission's suggestion regarding the recast of the RoHS Directive:

The placing on the market of medical devices requires a conformity assessment procedure, according to Directives 93/42/EC and 98/79/EC, which could require the involvement of a notified body designated by Competent Authorities of Member States. If such a notified body certifies that the safety of the potential substitute for the intended use in medical devices or in vitro medical devices is not demonstrated, this will be viewed as a clear negative socio-economic, health and consumer safety impact. It should be possible to apply for exemptions of equipment coming under the scope of this Directive from the date of its entry into force, even when that is before the actual inclusion in the scope of that equipment.

INITIAL ELECTRONIC PRODUCT RE-DESIGN CHALLENGES

The conversion to safer alternatives may require a significant initial investment. Once alternatives are established and their production scaled up, costs will be reduced quickly and the benefits will prevail. Socioeconomic considerations should therefore only be used when making a decision on the duration of an exemption. Insufficient availability of substitutes should not be a yes/no criterion for an exemption, but should have an effect on the time until a prohibition is fully enacted. There is no need to introduce "reliability" as a separate criterion, as it is already covered by the safety consideration.



This statement shows that restrictions will be applied to all electronics under the scope of the new RoHS Directive and applied exemptions are clearly noted to be held within a determinate timeline, not an exclusion from scope of the law.

REACH REGULATION (EC1907/2006) VS ROHS DIRECTIVE (2002/95/EC)

Another hot topic surrounding substance restrictions and electronics is the European Union's REACH (Registration, Evaluation and Authorization of Chemical Substances) Regulation. This chemical safety law enacts an incredible amount of information disclosure on the identity and safe use of chemicals. When it comes to the scope of electronics, this disclosure requirement narrows to identifying Substances of Very High Concern (SVHC) if found in concentrations of 0.1% (w/w). Since having this requirement applied to all Articles (includes electronics), it has been argued that the RoHS Directive should no longer be necessary since the REACH Regulation mandates substance control in its own manner.

This argument has been quashed because of the waste treatment aspect surrounding electronics. The REACH Regulation does not address the safety issues regarding products when they become waste and some substances are not properly taken into account (i.e. polymers). The European Commission's justification below is clear:

It should be stated specifically that RoHS supplements REACH. RoHS and REACH have different objectives, scope, timelines, and outreach. RoHS was created to address the specific problems of a fast-growing waste stream, REACH addresses chemical substances at a general level, with no special focus on waste. REACH is a regional law still in its infancy, RoHS is already setting a global standard. Key problems with WEEE are due to polymers, which are exempted from REACH. RoHS should be further developed to address the specific problems of the recovery and disposal of WEEE at the origin.

EU ROHS - A PIONEERING "GLOBAL STANDARD"

The interesting portion of this statement is defining the RoHS Directive as a "global standard." This is quite true, as we have now seen the implementation of laws placing the same restrictions on electronics in California, South Korea, China, Japan, and Turkey. Plus many other jurisdictions are investigating the application of an RoHS law or standard. The justification for the majority of these movements outside the European Union is the need to reduce toxic substances entering the waste stream. These substances not only have the potential to cause adverse effects to humans and the environment, they also reduce the feasibility of resource reclamation in the form of recovery processes in lieu of a landfill.

To this date, over two thirds of the world have enacted electronic waste laws or are in the process of enacting such laws requiring diversion to environmentally sound management and disposal. This will lead to a significant increase in studies and visibility as to what effects this new recycling stream will pose to human health and environment. Older studies lead to the creation of the RoHS Directive, but with a new focus on identifying toxicity of substances (REACH, TSCA, CEPA 1999, etc.) there will be many available references in justifying further restrictions to electronics (and many other products).

THE COSTS OF E-WASTE REGULATIONS

The electronics industry needs to be aware of developments stemming from the waste laws to avoid costly redesign efforts and negative customer satisfaction responding to the unavailability of compliant products.

This is punctuated by a Consumer Electronics Association (CEA) survey that stated the following:

About 29% of companies surveyed reported lost sales due to RoHS with the average loss being \$1.84 million. Sales losses were due to delay in new product sales and discontinued business in the EU.

Another example of costs arising from electronic waste laws is the approach some systems are taking in France. The implementation of France's Waste Electrical Electronic Equipment (WEEE) Directive mandates that "producers" finance the collection and treatment of their market share's worth of electronic waste. To fulfill this requirement, producers are offloading this responsibility to producer compliance organizations that will fulfill the collection and treatment on their behalf. These compliance organizations will be introducing a two tiered cost model (July 2010) for their members. Costs for collection and treatment will be more expensive for products that do not have a good lifespan, are not recyclable and/or contain hazardous substances.

To avoid this type of monetary loss, environmentally conscious design aspects must be initiated at the outset of product introduction or concept. This should include programs for substance management, recyclability, energy efficiency, and reusability. Not only will this avoid loss of sales due to product availability, but will strengthen internal system efficiencies and reduce excess waste in processes.

POTENTIAL SOLUTIONS FOR COST-EFFECTIVE E-WASTE COMPLIANCE

Businesses have options when they address compliance. The process they follow can include:

- Identification of applicable requirements

- Compliance Assurance Process implementation and certification
- Employee and vendor communication and training
- Supplier data collection
- GAP Analysis and Risk Assessment
- Product re-engineering (if required)
- Product screening and testing based upon GAP/Risk Assessment
- Green claims verification/certification, product labeling, and marketing launch

The decision depends upon a business, the target market, legislative requirements, and customer requirements. Further, which of the process steps can be completed using internal resources or is there a need to fill the gaps by partnering with a third party? Third parties can assist in understanding the requirements, developing corporate or product strategy, providing education and training to employees and suppliers, conducting inventory assessments, testing, verifying, auditing, and ensuring ongoing compliance. ■

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