

Impact of Environmental Regulations on Electronics Manufacturers

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ABSTRACT

Electronics manufacturers and their supply chains worldwide find themselves dealing with a new type of regulation targeting the environmental performance of their products. While able to comply with these regulations, they are experiencing extraordinary difficulties doing it in an efficient and effective manner so costs are extremely high and the results are not nearly as dramatic as hoped for by the regulators. A key challenge is that, having never before dealt with these sorts of issues, the intellectual and informational framework necessary to support it does not exist. Universities, standards organizations, industries, and governments – even those doing the regulating – do not have as complete an understanding of the true requirements and impacts of this new regulatory paradigm. This paper will describe the regulations, how they target products, how governments, manufacturers, and standards organizations have approached these issues and why, the problems with these approaches, and ultimately propose that the solution to the problem may lie in concerted communication between the stakeholders.

Keywords

Electronics, environmental regulation, impact.

1. INTRODUCTION

Since the early 1990s, a new type of environmental regulation has emerged that is focused more on the actual product being manufactured, than simply its effluent. Since the European Union's packaging directive¹⁰, a swarm of regulations that began in Europe and have been modified and adopted in countries and locales around the world have attempted, whether by design or result, to place controls on how companies define, design, and produce all manner of products. How companies define and manage their "product lifecycle process" has now come under government scrutiny and industry is just starting to understand that they must review and modify the basic concepts long used in that process.

2. INDUSTRY'S CHALLENGE

¹⁰ See directive 94/62/EC - http://ec.europa.eu/environment/waste/packaging_index.htm

2.1 Product-Targeted Environmental Regulations (PTER) and the electronics industry

With the "Restriction on the use of certain hazardous substances in electrical and electronic products" directive (2002/95/EC, "RoHS") and "Waste electrical and electronic equipment" directive (2002/96/EC, "WEEE"¹¹) the EU expanded its scope of environmental control to a broad range of technology products. These directives required the electronics industry to accept two new responsibilities: understand where specific chemicals were used in their products and replace them, and ensure the safe recycling of a product many years after it had been sold.

With these laws the EU had gotten the attention of many other locales, including California, which, lacking oversight from a national electronic waste ("e-waste") regulation like WEEE, decided to work on a state substance restriction and e-waste regulation. While industry lobbying resulted in a narrow scope and no post-consumer responsibility for the products¹², the Electronic Waste Recycling Act¹³ broke ground in 2003 by being the first regulation of its kind in the United States. California has since passed another law that also incorporates, by direct reference, the European Union RoHS directive¹⁴.

Ultimately, these regulations and other imitators in China, South Korea and elsewhere caught the worldwide electronics industry off-guard. Historically, environmental properties of chemicals and substances used by industry to build products were never made available, and were rarely if ever asked for, so were never taken in to account in the product development process. Technical properties such as function or mechanical/electrical/optical/thermal

¹¹ See information on both RoHS and WEEE at http://ec.europa.eu/environment/waste/weee/index_en.htm

¹² Consumers would be required to pay a US\$6 to US\$10 recycling fee when they purchase a product in the scope of the law – this is called "ARF", for Advance Recovery Fee

¹³ California Department of Toxic Substance Control page on the RoHS aspects of EWRA: <http://www.dtsc.ca.gov/HazardousWaste/ewaste/index.cfm>, and the California Integrated Waste Management Board's EWRA site on its recycling aspects at <http://www.ciwm.ca.gov/Electronics/Act2003/>

¹⁴ AB 1109 on lighting efficiency and hazardous waste, http://www.leginfo.ca.gov/pub/07-08/bill/asm/ab_1101-1150/ab_1109_bill_20071012_chaptered.html

characteristics along with business considerations such as availability and cost have been the primary selection determinants. Europe had found a true “blind spot” to regulate industry on, and it has challenged manufacturers worldwide.

The current suite of regulations themselves impact various aspects of the product lifecycle. Table 1, on the next page, shows which classes of PTERs must be reviewed and addressed by phase of the product lifecycle for some specific EU directives and regulations.

Industry’s response to all these regulations has generally been to do the absolute minimum necessary in the most expedient manner possible to comply. Electronics companies are still challenged to view environmental performance with the same holistic perspective as they do technical and business performance. The result is compliance, of course, but no more and ultimately at a very high cost. In a recent study for the Consumer Electronics Association, the consulting and market research firm Technology Forecasters, supported by DCA, determined that the cost of compliance to the EU’s RoHS directive was US\$32.7B across the entire electronics supply chain, or about 1.1% of one year’s total industry revenue¹⁵.

Table 1. EU Directives & Regulations vs. Primary Lifecycle Phase impacted

	Concept	Design	Prototype	Production	Use	End-of-Life
RoHS		X		X		
WEEE	X	X				X
EuP	X	X		X	X	
REACH		X		X	X	X

The EU does indeed have an overall strategy¹⁶, however it has failed to adequately educate industry (certainly here in the US, at least, and arguably in the EU, since we see a similar approach being taken by European companies) on that strategy, its purpose, and its implementation.

2.2 Industry reaction to RoHS

The reaction to RoHS, the first major new product-targeted environmental regulation that impacted the electronics industry exclusively and directly, was two-fold: first, individual companies had to understand the regulation, how it could affect their products and business, and prepare themselves to comply. Second, as with other regulatory requirements (such as for safety or electromagnetic interference), voluntary standards bodies are driven by member companies to initiate standards development processes where it makes

sense. So knowledgeable people at affected companies had to extrapolate the impact to others in their industry or supply chain and bring forward the potential need to standardize, typically to industry standards bodies and consortia.

This clearly does not happen overnight. In Electronics (as well as other industries), standards only start to become possible when consensus among the larger or more influential companies emerges that they are indeed necessary. Nearly six years have passed since the RoHS directive came in to force and, besides assembly-related standards, industry has created only a handful of relatively narrowly-scoped standards, including JIG-101A, IPC 1752, and J-STD-609; and in the electronics industry none except J-STD-609 appear to be widely used. ASTM only recently issued standard F2617¹⁷, the first industry standard describing how to test materials (albeit only in polymeric materials) for RoHS substances. The consensus on solders to replace standard eutectic tin/lead (63%/37%) with varying mixtures of tin/silver/copper continues to shift even today as challenges occur in a variety of applications.

So why is this the case? In part, it was due to timing and the financial condition of the industry in 2003 when the RoHS directive was passed in to law. Other major factors include

- Prioritization – continued product shipment takes top priority, particularly downturns. Industry cannot afford to allow a regulation to stop production. Standards development usually takes a notoriously long time so companies are forced to solve problems themselves and do so in their own way. This creates inertial resistance to adoption of standards once they are, in fact, available.
- Difficulty – While any standards development process has a degree of difficulty, certain standards require extensive inputs from a variety of different experts and few have broad enough perspective or experience to see the entire picture. IPC 1752 was delayed for six to nine months by a handful of participating companies’ legal departments that apparently had little understanding of supply chain mechanics, for instance.
- Expertise – Manufacturers have lots of expertise in assembly, mechanical and electrical engineering, and material science; they have relatively little in environmental regulation, material disclosure, and design for environment. Since the dawn of the industrial revolution, and perhaps even before, there has been little or no direct requirement for environmental performance in most manufactured products. Therefore, there is no infrastructure (such as university programs, information standards, expert associations,

¹⁵ <http://www.purchasing.com/article/CA6552730.html>

¹⁶ Thematic Strategy on the Sustainable Use of Natural Resources, <http://ec.europa.eu/environment/natres/index.htm>, and the Thematic Strategy on the prevention and recycling of waste, <http://ec.europa.eu/environment/waste/strategy.htm>

¹⁷ ASTM F2617-08, *Standard Test Method for Identification and Quantification of Chromium, Bromine, Cadmium, Mercury, and Lead in Polymeric Material Using Energy Dispersive X-ray Spectrometry*

etc.) or knowledge built in to industry to be able to deal coherently and competently with these issues. There is no place to go for environmental expertise, as there historically has been for manufacturing and design expertise¹⁸.

- Breadth of needs – the more companies, countries, and industry segments involved, the more challenging it is to achieve the consensus needed. Consumer product requirements are markedly different from infrastructure and aerospace/defense needs, for instance.
- Failure by the European Union to demand and fund the development of voluntary standards that could be used to meet these regulations. In fact, US industry and standards development organizations (SDOs) initiated most of the voluntary standards mentioned above. US industry has a stronger history of taking voluntary approaches towards potentially regulated areas than does the EU so perhaps this is not as surprising as it otherwise might be.
- Company organizational “silos”: Goals within companies are often not optimized around product lifecycle, but around functional areas. This stems from the fact that different departments often have separate budgets and disconnected objectives. For example,
 - o Safety – “we just define the requirements, engineering must determine how to meet them”
 - o Procurement – Quarterly cost reduction goals result in higher warranty costs due to purchasing cheaper, and ultimately lower quality, parts. Procurement meets their goal while warranty/field service does not.
- Any issue, not just regulatory requirements, that impacts the entire product lifecycle is likely to present difficulties in aligning agendas and goals within a given company.
- No coordinated mechanism to engage the supply chain – companies can deal one-on-one with suppliers quite readily, but when the entire supply chain needs mobilization and engagement there is no way to do that, save repeated email blasts and phone calls. Needless to say there is also no industry-level or cross-industry mechanism to do this when, for example due to REACH, a massive call to action across supply chains (that very much overlap) is required.
- No cross-standards-body oversight and coordination. SDOs are, in fact, often in competition with each other. Oversight

¹⁸ All the key industry research entities (e.g. Bell Labs, etc.) are gone – research is no longer shared for the good of the industry, but is held closely as a competitive weapon. Industry cooperation and information sharing was much better in the ‘80s as we moved from through-hole to surface mount technology than it has been during the transition from lead-based to lead-free solder, for instance.

including definition of standards available, standards needed, standards gaps, and assignments for standards development simply does not exist.

In summary, key challenges to rapidly developing useful voluntary standards for industry use include silos in companies, industries, governments, and standards bodies. Environmental regulations cut across companies and now, with REACH (and soon with EuP, the Energy-using Products directive¹⁹), industries. Mechanisms to improve communication and focus approaches and efforts are needed if industry is to efficiently and effectively comply with these and future requirements.

On the other hand, a partnership between industry and the US EPA produced a voluntary labeling standard called the Electronic Product Environmental Assessment Tool, or EPEAT, in July 2006²⁰. EPEAT was developed for use by government (and other) procurement organizations to assist in purchasing notebook and desktop computers with improved environmental performance, and has been broadly adopted and highly successful. This standard defines mandatory and optional sets of requirements across many aspects of environmental performance, including material selection, energy conservation, packaging, and others. An independent non-governmental organization (NGO) grades submitted products and posts the results on the website. Earlier this year, EPEAT requirements were placed in the federal register, so US federal government agencies are now required to purchase EPEAT-graded computer equipment²¹. Many state and local governments have also adopted EPEAT, as have some large private corporate buyers. As of the end of last year, EPEAT had been used in US\$60 billion of computer purchases²².

2.3 Industry gaps

Dr. Michael Wilson of UC Berkeley identified three “gaps” in his special report for the California Senate in 2006²³. These are gaps between the current and the desired chemical regulatory policies in the US and California. They are

1. **Data gap** – insufficient or unavailable data on toxicity/ecotoxicity for governments and industry to identify hazardous chemicals.

¹⁹ See, for instance, http://ec.europa.eu/enterprise/eco_design/index_en.htm for more information

²⁰ See the EPEAT website – <http://www.epeat.net>

²¹ Visit <http://www.gpoaccess.gov/fr/index.html> and search for “EPEAT”

²² See the press release at <http://www.epeat.net/Docs/2007%20Year%20End%20PR.pdf>

²³ See the report at http://coeh.berkeley.edu/docs/news/06_wilson_policy.pdf

2. **Safety gap** – a lack of information on how to identify, prioritize, and mitigate hazards, and
3. **Technology gap** – the lack of data on chemical toxicity results in a lack of market-based (and government) incentive to invent less toxic chemicals to compete against more toxic chemicals currently on the market.

Manufacturers that use chemicals and parts/materials/products that are comprised of chemicals downstream of the chemical manufacturers cannot make the right determinations regarding environmental performance because they, too, have three basic sets of gaps when it comes to addressing product related environmental performance: *knowledge*, *standards*, and *communication*. These can be summarized as follows:

1. Knowledge Gap

- a. Awareness and understanding is not “institutionalized” in industry or academia (or most governments)
- b. Implemented solutions are still suboptimal
- c. Can’t apply partial knowledge to solve a complex problem: optimizing environmental performance of a system of thousands of substances

This gap stems from the “Data Gap”, above - the historic unavailability of toxicity and other environmental data²⁴ on chemicals and chemical applications, as well as the equally historic lack of a market- or regulatory-driven need to use this sort of data for decision-making on chemicals, materials, and technologies for use in product development and manufacturing. With REACH (and perhaps also from voluntary efforts like the US EPA’s Chemical Assessment and Management Program, or ChAMP²⁵) we can expect more of this sort of data, but manufacturing industries will still lack the widespread knowledge required to actually use it to make product environmental performance decisions. Furthermore, the lack of expertise within product industries, particularly those far downstream of the chemical industry (such as electronics, aerospace, automotive, etc.), results in their being vulnerable to misinterpretation of available data or manipulation by agendas from, for example, the chemical industry or NGOs.

2. Standards Gap

- a. Regulation comes in to force before industry standards are in place
- b. SDOs operate in silos; no methodology for identifying gaps
- c. No oversight of SDOs

While REACH is expected to produce a prodigious amount of toxicity/ecotoxicity data on many substances that is currently unavailable, the information will be provided in “dossiers” on the

ECHA REACH-IT system. The information may not be in a machine-readable, mathematically or logically analyzable standardized format. Effectively, humans will have to read it, and render judgments. Standards are therefore necessary to define formats for this sort of information, and enable development of other useful tools for its analysis. These would include, for example, standards on determining weightings and guidance on how and when to apply such weights.

Only by consistent approaches to capturing and interpreting technical information can we even hope to ever have metrics that are useable, for instance, by consumers to compare the environmental performance of two or more competing products. Industry must therefore identify appropriate pre-existing standards, those that need to be developed, and the right SDOs to house their development. There are many other examples.

There is currently a nascent effort at ANSI to put in place a system to integrate SDO silos that would include oversight of, at least, US-based SDOs, assurance of common methodologies, and conformity assessment.

3. Communications Gap

- a. No mechanism for coherent stakeholder communications
 - i. Within companies, within industries, and between industries
- b. All manufacturing industries have to grapple with the same issues but have no platform to share information/approaches/ideas
 - i. Particularly for REACH
- c. This is, in part, due to *knowledge* gap
- d. The ANSI/NAM Manufacturers Network²⁶ is trying to address this, but is entirely volunteer-driven

There is no common and straightforward way to get the surprisingly extensive amount of data that must be communicated to/from the chemical industry, through as many as a dozen or more entities, to the downstream product user. The automotive industry has GADSL and IMDS for ELV, while the Electronics industry has JIG-101A, IPC 1752 and Rosettanet PIP 2A13 for RoHS, and they clearly do not overlap. REACH requires bidirectional communication throughout the supply chain and, outside of the Aerospace industry, which has recently issued TR9535 on substance declaration for REACH²⁷, manufacturers have no way besides email, telephone, fax, postal mail, and face-to-face meetings to achieve that – all of those are time-consuming and produce unorganized, non-computer-readable data that is error-prone. On top of that, except for the ANSI/NAM Manufacturers Network, there is no way for

²⁴ Such as energy used in manufacture, percent post-consumer waste content, etc.

²⁵ See <http://www.epa.gov/champ/>

²⁶ <http://www.ansi.org/chemicals>

²⁷ See the press release at

<http://www.asd-europe.org/Content/Default.asp?PageID=67>

different manufacturing industries to identify and resolve common problems and issues in a mutually acceptable, and hopefully beneficial, way.

3. Addressing These Challenges

So as the EU government rolls out new PTERs²⁸ and other governments follow, and new environmental challenges such as measurement and reduction of greenhouse gases loom on the electronics industry's horizon, it remains unclear whether

- The regulations are actually addressing the most important and compelling issues,
- The goals of these regulations are being met as efficiently and effectively as possible, and
- The local or global environment is really being improved.

Implementation of these regulations has been and will continue to be extremely expensive for industry (despite estimates to the contrary from the European government, particularly for REACH²⁹). Governments, from the industry perspective, do not really seem to understand just how deep the impact of these regulations is, nor how unprepared for them industry really is. In fact, manufacturing industries like electronics do not understand this either. If it were well understood, the energy and funding for education, standards development, and a competitive approach to compliance would be far higher, as it is for new technologies, for instance. Nevertheless, as described above, industry has historically viewed environmental regulation as something to simply comply with rather than to compete on. This is an enormous inertia that government can and must help industry overcome. Some of the keys to success include the following:

- Standards to support regulation must be considered for feasibility and implementation as regulation is defined.
- Today the European Union, and most other countries, produces regulations in this space without producing concomitant supporting standards. The Chinese Ministry of Information Industry produced supporting "standards" for their RoHS-like regulation after it was published, but more to support the lack of clarity and completeness in it than to help manufacturers to comply (but it had that effect as well, of course).
- Transparency amongst all stakeholders in the industry standards development process may

²⁸ See, for instance, the "Sustainable Production and Consumption and Sustainable Industrial Policy Action Plan" at http://www.euractiv.com/29/images/SCP%20draft%20404_tcm29-171962.doc and http://ec.europa.eu/environment/eussd/escp_en.htm

²⁹ Total costs were estimated between €2.8 and 5.2 billion over 11 and 15 years respectively. See http://ec.europa.eu/environment/chemicals/reach/background/i_a_en.htm#env_benefits for more information.

require NGO oversight to achieve. The European Commission already funds ECOS – the European Environmental Citizens Organisation for Standardisation.³⁰ There is no equivalent entity outside the EU.

- Governments would be well advised to be less "sovereign" when adopting and modifying regulations that already exist in other parts of the world and impact global manufacturers, as well as consider international impacts when new regulations are adopted.
- Companies (electronics, in particular) often try to build one configurable product for distribution around the world in order to achieve economies of scale, driving costs down and (with proper oversight) quality up. Since the EU first promulgated the RoHS directive, for instance, China, South Korea, Japan, California and several other nations and locales have either implemented a similar regulation or are currently considering it. Not one of the implemented regulations is 100% common and consistent with the EU RoHS directive. Different implementations and requirements of laws that are otherwise attempting to accomplish the same thing add complexity and cost, not value.
- A recent study determined that the top risk to business for 2008 is regulatory and compliance risk: "This is being driven by an escalating regulatory burden in many markets, as well as numerous compliance challenges as companies extend their value chains well beyond Europe, North America, and the BRICs (Brazil, Russia, India and China)."³¹ While not exclusively environmental, the issue is nevertheless the same. An international process to vet and align regulatory requirements would, if potentially complicated by nationalist agendas and desires (such as improving domestic competitiveness at the price of international market access, or simply to prove prowess at regulation), enable the possibility of optimization of both the regulation and its implementation.
- Educate users (engineers and scientists) at downstream companies on how to understand and use environmental properties in decision-making and problem solving.
- The multidisciplinary nature of the challenge of environmental performance of manufactured products is not currently being addressed at the university level in any significant manner. Engineers need basic education and guidance on how to think about this area, while universities need to graduate a greater number of green chemists/chemical

³⁰ See <http://www.ecostandard.org>

³¹ Ernst & Young, *Strategic Business Risk 2008 – the Top 10 Risks for Business*, P.8

engineers and toxicologists with awareness of how chemicals are used in products and the tradeoffs and considerations thereof. Areas of cross-fertilization and specialization include electronics/electrical engineering, mechanical engineering, material science, physics, chemistry, chemical engineering, business management, global studies, environmental science, and many others. Courses and seminars for working engineering and scientists also need to be developed.

- Incorporation of environmental performance metrics in final product specifications.

A primary challenge is how to ensure a market-driven incentive for improvements in environmental performance. Standards are, of course, needed to ensure consistency and limit “greenwashing”, well-written regulation is necessary to provide the proper incentives and drive the proper behavior, and consumer education campaigns on how to interpret and compare environmental performance of one item over another are critical to enabling consumers to make intelligent product choices. Public media campaigns/educational websites/etc., and buy-in and participation from the retail sector are critical for this to succeed.

4. The Biggest Challenge

All of the above are the “whats” to be done. The biggest issue, though, is the “How” – how can all of this be accomplished? American industry, in particular, has turned in the past to public/private partnerships to address major challenges. The tension between industry and government – the regulated and the regulator – however, makes this difficult. People from one have a poor understanding of what the other understands, is trying to accomplish, and needs. And in an area that is new to both, like PTER, the challenge is compounded.

But the fact is that we have one planet and its resources are clearly not unlimited. Working together in partnership to address enormous international challenges may be the only viable way to deal with issues larger than any one person, company, industry, or government. The breadth and depth of impact of environmental challenges on society and the planet requires what may turn out to be the largest global public-private partnership to date. We envision five categories of participants³²:

1. Manufacturing industry – representation is ultimately required across a great breadth of product sectors
2. Governments – federal, regional, as well as international (i.e. European Union)
3. Environmental NGOs – local, national, and international all have roles to play and have

been key thought leaders and drivers of regulatory requirements as well as voluntary industry actions

4. Academia – at and above (and perhaps below) university level: ensuring that we produce people with the critical thinking skills necessary to span and include multiple disciplines and deal with this global challenge is a key to success.
5. Standards Development Organizations – because they produce the international embodiments of knowledge that can be distilled into practice to insure interoperability and efficiency

5. Conclusion

In this paper we have endeavored to show how the combination of a new type of environmental regulation, lack of industry awareness and comprehension, and poor or non-existent communication paths between and within governments, industries, standards bodies, companies, NGOs, and educational institutions has resulted in very tenuous, costly, and ineffective mechanisms for industry to comply with said regulations. Governments responsible for these regulations should understand that industry is surprisingly ignorant of the big-picture frameworks that incorporate the individual environmental regulations with which they must comply. Moreover, industry should take a far more considered approach to environmental performance improvement if they are ever to achieve truly competitive performance in the environmental arena and reduce the antagonism and frustration with governments and NGOs in this area. To fill the fundamental gaps that industry has requires cooperation with governments, between different manufacturing industries and disciplines, with and within SDOs, with NGOs, and with the educational system. Fundamental infrastructures are required that are missing today. By addressing these issues, we can enable the move from simple compliance to true and meaningful competition. This will incentivize and enable the drive for real environmental performance improvement of products from all manufacturing industries and their supply chains worldwide.

If the electronics industry has proven anything, it is that when humans understand something extremely well, then we can constantly improve it. Electronics technology has improved along technical performance and cost measures faster and further than any other industry in history. It is now time to apply the same drive for improvement to environmental performance.

6. ACKNOWLEDGEMENTS

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³² Similar, though less extensive, concepts are covered in Gerencser, M., et. al., *Megacommunities*, 2008 Palgrave MacMillan

environmental regulations”³³.

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<http://igov.berkeley.edu/workingpapers/series4/Kirchner.Final.pdf>

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