What's Next on the Environmental Front

By Joe Johnson and Bob Pfahl

Saturday, 01 July 2006

New priorities must be defined and industry must proactively drive for harmonized regulatory standards.

The RoHS Directive goes into effect in the EU this month. Last month's column demonstrated that industry, for the most part, is ready. However, much work remains to be done to reduce the ongoing costs of maintaining RoHS compliance, address additional legislation and changing regulations around the world, and complete and optimize the conversion from eutectic solder. This month, we focus what is ahead, and the alternative directions that industry could take. The thrust of our argument is that industry should take a proactive approach, work with stakeholders and direct activities where there is technical/ecological evidence we could and should be doing a better job to protect the environment. We should involve stakeholders in the process of evaluating alternative technologies to determine tradeoffs between product functionality, environmental impact, reliability, safety and cost. We will give an example of the model we recommend for working with stakeholders and discuss areas that warrant attention.

iNEMI's 2004 *Environmentally Conscious Electronics* roadmap emphasized the concept of "sustainability," the impact of European legislation on the entire supply chain and the R&D needs to support environmentally conscious design. This approach reflects a more forward-looking posture and relates to developing a sound scientific basis for environmental considerations. Specific findings/needs identified by the roadmap included:

> Development and implementation of appropriate scientific methodologies to assess true environmental impacts of materials and potential tradeoffs of alternatives.
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> Development of cost-effective, energy-efficient power supplies.
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> Development of a common, meaningful, straightforward definition of sustainability that is relevant to the electronics industry and its supply chain, can be applied quantitatively at the business level, can be easily communicated to stakeholders, can be used to set targets and that encourages an integrated lifecycle sustainability strategy.

Even as industry adapts to the long-anticipated, well-advertised challenges of European WEEE and RoHS laws, an unprecedented expansion of legislative initiatives is underway. To some degree, this next wave of product-based environmental regulations represents the globalization of WEEE/RoHS requirements; however, it also introduces additional labeling, eco-design, energy efficiency and certification mandates. Legislation such as EuP (Energy using Products Directive), REACH (Registration, Evaluation, Authorisation and Restriction of Chemicals) and the updated Batteries Directive will keep a certain focus on Europe. Going forward, drivers may come from any region of the world.

Table 1 is an overview of four primary categories of product-based legislation across the globe. Although not inclusive of all legislative activity, there is a clear trend of increasing regulatory complexity - without much time for industry to catch its breath from WEEE and RoHS. The state/provincial-level legislative activities in the U.S. and Canada are particularly problematic due to the diversity of regulatory approaches. Such diversity runs counter to the theme of harmonization, which industry must promote to permit efficient and effective adoption of worldwide requirements. When coupled with ongoing activities in China, Japan, Australia, Mexico and South America, industry may be put in a position of allocating greater-than-anticipated resources to deal with the inherent inefficiency of non-harmonized requirements. Broader participation in trade associations and standards bodies can help promote stakeholder approaches and improve worldwide harmonization of product-based requirements.

Table 1. Key Legislation on the Horizon

Region	Substance Bans	Recycling	Eco-Design	Energy Efficiency
Europe	RoHS REACH	WEEE	EuP	EuP Codes of Conduct (Voluntary)
North America	35 states 5 provinces	35 states 5 provinces	Referenced in some state legislation	Power supplies in CA, other states pending
China	Management methods (China RoHS)	China WEEE	Management methods	Labeling
Japan	RoHS Labeling	Japan WEEE		METI Standars/ labeling

The following sections discuss how industry might proactively address substance concerns, energy usage and design restrictions.

Halogen-Free: Alternative Technologies

We propose a proactive model involving stakeholders in the process of evaluating alternative technologies to determine tradeoffs between product functionality, environmental impact, reliability, safety and cost. Two linked projects - a technical evaluation project organized by iNEMI, and an environmental and human health assessment project organized by the U.S. EPA - have been created to evaluate alternatives to the brominated flame retardants currently used in epoxy resin PCBs. The RoHS Directive prohibits the use of polybrominated biphenyls (PBBs) and polybrominated diphenyl ethers (PBDEs) in nonexempt electronic equipment (note an exemption is granted for deca-BDE in polymeric applications). These compounds are typically used as flame retardants and some have been shown to have cumulative exposure potential in humans and adverse health effects on laboratory rodents. Although PBBs and PBDEs are not used in circuit board materials, stakeholders are

beginning to urge a precautionary stance on the use of other non-regulated halogenated organic substances, such as brominated epoxies for PCB applications.

Currently, the UL 94 V0 fire safety standard is achieved in epoxy resin PCBs by covalently reacting TBBPA (Tetrabromo bisphenol A) with the epoxy resin backbone. After the reaction TBBPA ceases to exist as a chemical entity. Approximately 96% of printed wiring boards utilize TBBPA. One of the reasons cited for using alternative materials is to eliminate the potential for dioxin/furan formation during certain end-of-life scenarios for FR-4 boards. However, the environmental and human health profile of a material is not solely defined by impacts at the end-of-life. Environmental impacts occur throughout the lifecycle of a material, from development and manufacture through product use and finally at end-of-life of the material or product.

iNEMI Halogen-Free Project. iNEMI is organizing a technical project on halogen-free electronics, focusing on PWBs. The thrust of the project is to characterize and encourage the supply base for alternate materials. It will evaluate key electrical, mechanical and reliability requirements of PWBs for various market segments. The first phase of the project will identify the market segment requirements, identify candidate materials and key performance characteristics, and design test vehicles and test methodologies. The second phase will construct test vehicles and perform mechanical and reliability tests on the candidate materials. The third phase will evaluate test results and compare them with the requirements. Technical risks will be identified.

U.S. EPA Assessment of Alternative Flame Retardants. Industry is engaging in a multi-stakeholder partnership with the EPA to better understand the full range of options for achieving the UL 94 V0 fire safety standard for PCBs. This partnership will develop information to improve understanding of the environmental and human health impacts of new and current materials that meet the fire safety requirements for circuit boards. This information will be presented to permit industry to consider environmental and human health impacts along with cost and performance of PCBs (as identified in the iNEMI project) as they review alternative materials and technologies. The participation of all relevant stakeholders is critical to understanding flame retardant formulations and developing scientifically sound information. The partnership will incorporate lifecycle thinking into the project as it explores the hazards associated with flame retardants and potential exposures throughout the lifecycle of flame retardants as used in FR-4 PCBs. As appropriate, the scope will include aspects of the lifecycle where public and occupational exposures could occur. For example, consideration of exposures from incineration or burning at the end of life will be included, as will exposures from manufacturing and use. The partnership will focus the study on the candidate materials selected by the iNEMI project. The outcome of the project will be a report that outlines the environmental and human health hazards associated with flame retardants in FR-4 boards.

Lessons learned. The iNEMI and EPA projects have revealed that NGOs, regulators and concerned citizens do not have an understanding of the complex tradeoffs that industry faces when it makes major changes in materials and manufacturing processes. The process of defining the two projects has made stakeholders aware of the many levels of the supply chain that must be engaged to evaluate and introduce alternative technologies. It has also made them aware that there are technical risks as well as environmental, health and safety risks that must be balanced.

A Systems Approach

The industry must take a systems approach to DfE and should engage stakeholders in the process. Regulations frequently do not take a systems approach but, rather, a tactical approach focusing on the current concern. An example is the reduction of energy use. Energy use is of concern to everyone. Often a significant fraction of energy use is determined by the system architecture at the beginning of the design process. Industry needs to be proactive in making stakeholders aware of the energy savings that we are constantly achieving through new technology. It is important for industry to show, at a systems level, the gains we are achieving.

Design processes are unique to each firm and are often the key to their market success. Design is a creative process and needs broad input, not regulatory oversight. Many firms have integrated DfE criteria into their extensive design processes. Firms need to make stakeholders aware of their processes and seek input from environmental stakeholders in those processes.

For the past decade, industry worked to develop alternatives to eutectic solder in anticipation of legislative restrictions. While the impacted segments of industry have adapted to comply with these restrictions, much work remains to be done to optimize the process. In particular, we need to adopt harmonized models that permit efficient and effective integration of the worldwide regulatory and market access requirements evolving under the environmental banner.

The experience of this decade has demonstrated that legislators and other stakeholders were not fully aware of the potential for "unintended consequences" of regulations to cause significant and unproductive disruptions in the global supply chain. These effects can hinder progress toward the fundamental regulatory goals of reducing overall environmental impacts of electronic products. We are about to enter a new phase, where the spectrum of stakeholders must work together to proactively identify and resolve potential areas of environmental risk and develop rational risk reduction alternatives. Priorities must be defined and industry must proactively drive for harmonized regulatory standards to support two mutually beneficial outcomes: Protecting the global environment while promoting an efficient means for business to comply on a global basis.

Ed.: This is the last in an 18-month series on the environmental mandates generally falling under WEEE and RoHS. We heartily thank the International Electronics Manufacturing Initiative (**inemi.org**) and its members for their contributions. For additional information about the U.S. EPA Design for the Environment Program's Assessment of Flame Retardants for the Electronics Industry, contact Kathleen Vokes at **vokes.kathleen@epa.gov** or visit **epa.gov/dfe/**.

Joe Johnson is senior manager for Regulatory Affairs at Cisco Systems (**cisco.com**), chair of iNEMI's Environmentally Conscious Electronics Technology Integration Group and co-chair of the ECE Technology Working Group for the iNEMI Roadmap; **joejohn2@cisco.com**. **Bob Pfahl** is vice president of operations for iNEMI (**inemi.org**); **bob.pfahl@inemi.org**.