Future Initiatives for Sustainability

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Abstract

From 2000 to 2007 most electronic manufacturers focused their environmental initiatives on eliminating lead and other banned materials from their products. This activity took far more time, manpower and resources than anyone imagined at the beginning. As the industry began to emerge from this intense effort, it identified a number of important issues that had to be put on the "back burner." The 2007 iNEMI Environmentally Conscious Electronics (ECE) Roadmap identified a number of important areas for research including:

- Accepted and sound scientific methods to evaluate environmental impact of materials that are also accepted by regulators, NGOs and industry.
- New innovative energy sources.
- R&D to develop a sustainable electronics infrastructure.

This paper highlights some of the R&D initiatives identified by industry to meet their social responsibility objectives. It also discusses industrial initiatives that are currently under way or proposed to lead the electronics industry on its journey towards a more sustainable world. Since the 2009 ECE Roadmap is currently under development, the presentation at the conference will update the discussion in this paper.

1 Introduction

1.1 Scientific Methods

The 2009 ECE Roadmap is currently being developed by participants around the globe. This roadmap is developed every two years and takes a ten-year long view of the industry. The three important areas identified in the 2007 ECE Roadmap are even more critical two years later. The first of these is the requirement for sound scientific methods to evaluate the environmental impact of materials that are acceptable to industry, regulators, and NGOs alike.

During the last two years we have seen two major examples where Federal legislation in the United States was not preceded by scientific analysis. Firstly, the recent re-evaluation of current Federal mandates requiring the use of corn based ethanol in automotive fuels is one example. Studies by the German EPA had already identified the negative environmental impact from this application of corn; current commodity market conditions also have revealed the negative economic impact on food cost and availability. The second example is the Clean Energy Act of 2007 [1] which bans the use of incandescent lamps by 2014 in favor of solutions such as compact fluorescent lamps. However, the legislation did not address the establishment of a recycling infrastructure for the mercury containing fluorescent lamps.

1.2 Innovative Energy

During the past two years there has been a strong growth in both production and research and development of alternative energy sources, particularly wind and solar. Semiconductor based solar cells are now in volume production for applications in countries such as Germany and Spain that offer tax incentives and for firms like Google and WalMart that want to establish a green image. In addition R&D in thin film photovoltaic cells is now receiving significant funding from venture capitalists particularly in California. Because of this increased activity, iNEMI is preparing its first photovoltaic roadmap.

1.3 Sustainability

Research to develop an infrastructure for sustainable electronics includes a number of growing energy efficient technologies such as solid state illumination using LEDs and other devices. Again, because of this increased interest, iNEMI is preparing a 2009 Solid State Illumination Roadmap.

1.4 2009 ECE Roadmap

The 2009 ECE roadmap will again be subdivided into four sections as in 2007:

- Materials
- Energy
- Recycling
- Design

In addition we will reintroduce a chapter on Sustainability that will focus on short term issues, such as how you rationally evaluate alternative technologies and their advantages and disadvantages (e.g., the ethanol based fuel example or the compact fluorescent light example) as well as more strategic concepts such as the use of information technology to reduce man's environmental impact.

The following five sections give brief highlights of the issues being addressed in the 2009 roadmap, followed by a section on a sustainability summit that iNEMI will be holding on September 22-23 to develop an action plan for the electronics industry to focus on key collaborative activities that could reduce the industries' environmental impact.

We will also focus on the future: what's 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 our activities (based on technical/ecological evidence) where we could and should be doing a better job to protect the environment. In addition, we will recommend a proactive approach that involves stakeholders in the process of evaluating alternative technologies to determine trade-offs between product functionality, environmental impact, reliability, safety, and cost.

2 Materials

2.1 The Pb-Free Challenge

The most significant impact and challenge of the European RoHS regulation was the directive to eliminate all use of lead (Pb) in electronics. High-reliability hardware companies were relieved to understand that exemptions would be granted for continued use of tin-lead (SnPb) materials in their products; however, the rapid transition of the supply chain to meet the high-volume needs of non-exempt consumer electronics created an availability problem for critical components (new and existing) in traditional surface finish configurations. Many suppliers have elected to convert all of their components over to Pb-free finishes. In a number of cases, this presents compatibility issues and reliability concerns (especially with BGAs) for those users who BGAs) for those users who are allowed to continue to use SnPb assembly processes.

For companies that sell high-reliability/long-service-life products, the rationale for staying with SnPb assembly is very clear: in many cases Pb-free technology has not demonstrated the required level of reliable performance for long-life, mission-critical applications. In some cases the ability to move to Pb-free assembly is impeded by the non-availability of Pb-free parts for older, low-volume or out-of-production BGA components. While it is increasingly obvious that virtually all electronics products will be Pb-free over time, there are a number of knowledge gaps that still must be closed before Pb-free reliability can be predicted with the same certainty that SnPb assembly can deliver.

In 2003 iNEMI formed a High-Reliability RoHS Task Force, made up of firms that were either taking the Pb exemption or were out of scope for EU RoHS. The efforts of this group focused on ways to work with the BGA component supply base (integrated circuit as well as packaging firms) to support SnPb-compatible BGAs, assist with questions of long-term reliability, and/or other solutions to address concerns. The group has published four position papers dealing with issues related to the conversion to Pb-free solders and components.

Based on recommendations from the iNEMI High-Reliability RoHS Task Force and results from a workshop on BGAs, iNEMI has started a new round of projects addressing the needs of high reliability applications. Included are three new projects:

- *Evaluation of Pb-Free Component & Board Finish Reliability.* This project will evaluate the effects of alternative surface finishes for circuit boards and package substrates on Pb-free solder joint reliability during mechanical and thermal stress testing.
- *Pb-Free Early Failure Project.* This new iNEMI effort will be working to determine whether a large sample size will reveal Pb-free early failures in accelerated thermal fatigue testing of Pb-free solder joints. All components for the test vehicle are on order and many have been received. The test vehicle board design is complete.
- BFR-Free High-Reliability PCB. This project is a follow-on to iNEMI's current BFR-Free PCB Project. Proposed project objectives include:
  - Build on industry knowledge and capability and on results of the iNEMI BFR-Free Project: Test Phase (Phase II)

- Consider unique market segment requirements
- Identify technology readiness and gaps
- Stimulate supply capability
- Determine BFR-free board-level reliability for various components

The challenge of converting the high-reliability segment of the industry to Pb-Free technologies has demonstrated that in the future industry needs to better coordinate its response to mandated change. It also serves as a case study on the impact of introducing material changes in our global industry.

2.2 Identifying and Removing Select Brominated Compounds

2.2.1 Overview

iNEMI has adopted the policy of explicitly identifying what material is being eliminated rather than generic labels such as bromine-free or halogen-free. Not all uses of bromine and halogen containing molecules present a risk. We believe that we need to provide more explicit information to the public on what is being eliminated and why it presents a risk. The following sections describe efforts to address several brominated flame retardants.

2.2.2 Brominated Flame Retardant (BFR) Free: Proactive Evaluation of Alternative Technologies

In the introduction we proposed a proactive model involving stakeholders in the process of evaluating alternative technologies to determine trade-offs between product functionality, environmental impact, reliability, safety and cost. Two linked projects, a technical evaluation project organized by iNEMI, and two environmental and human health assessment projects organized by the US Environmental Protection Agency (EPA), have been created to evaluate alternatives to the brominated flame retardants currently used in epoxy resin circuit boards. The RoHS Directive prohibits the use of polybrominated biphenyls (PBBs) and polybrominated diphenyl ethers (PBDEs) in nonexempt electronic equipment (note an exemption is allowed 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 the electronics industry to take a precautionary stance on the use of other non-regulated halogenated organic substances, such as the use of brominated epoxies for circuit board applications.

Currently, the UL 94 V0 fire safety standard is achieved in epoxy resin circuit boards 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.

2.2.2.1 iNEMI BFR-Free Test Project

iNEMI is completing one project on BFR-Free PWBs. The thrust of the project has been to characterize and encourage the supply base for alternate materials. The project is determining key electrical, mechanical and reliability requirements of PWBs for various market segments. The first phase of the project identified the market segment requirements, candidate materials and key performance characteristics, and designed test vehicles and test methodologies. The second phase constructed test vehicles and performed mechanical and reliability tests on the candidate materials. A new project is being established to evaluate BFR-Free PWBs for high reliability applications. Most development to date has focused on thinner PWBs for consumer applications. The project will focus on high wiring density boards for commercial applications. Many manufacturers in this market segment are considering introducing BFR-Free PWBs when they switch to Pb-Free solders, thus avoiding an extra round of reliability testing at the product level.

2.2.2.2 US EPA Assessment of Alternative Flame Retardants

The electronics industry is engaged in a multi-stakeholder partnership with EPA's Design for the Environment Program to better understand the full range of options for achieving the UL 94 V0 fire safety standard for printed circuit boards. This multi-stakeholder partnership has developed information to improve everyone's 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 allow industry to consider environmental and human health impacts along with cost and performance of circuit boards (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 incorporates 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 electronic FR-4 printed circuit boards. The scope includes 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 has focused 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.

2.2.3 Results

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

3 Energy

Demand for energy, including electricity, continues to be a major topic around the world. As governments consider programs and policies that support the efficient use of energy, the electronics industry must guard against ill-conceived regulations and mandatory standards imposed by governments that could stifle innovation and have adverse impacts for consumers and manufacturers. Regulations should specify requirements, not select technology. Governments must recognize and support innovation, and the pursuit of voluntary initiatives, which are the keys to energy efficiency progress in the electronics industry. Realistic solutions and initiatives for energy efficiency in the electronics industry can best be reached through a government-industry partnership that thoroughly analyzes the facts, to determine what is best for energy conservation, innovation, consumers and high tech manufacturers. A strong push for enhanced energy efficiency – that has until now been satisfied primarily by voluntary initiatives – is increasingly becoming regulated as well. Harmonization through international standardization is essential.

4 Recycling

Electronics recycling systems are now in effect in many regions and countries across the globe. For other jurisdictions, it is not a question of if (but when) a coordinated effort of industry and/or the public sector will take some form of responsibility for its products at the end of their useful life. The push for this responsibility stems from three public policy motivations: (1) the perception that electronic products pose a danger to the environment when disposed of in landfills and incinerators, (2) the desire to relieve government of the cost to recycle these products, and (3) the opportunity to recover resources that otherwise would be disposed of. However, governments and industry have not settled on a single model to manage these costs or impose responsibility on the electronics industry. Whether in the form of surcharges on the price of new products, obligations to pay for a company's branded products collected in the recycling system, requirements to collect and recycle a certain volume of returned products based on a share allocation system, or paying a flat fee for the right to sell within a jurisdiction, end-of-life legislation is having an impact on the costs of business for manufacturers of electronic products.

5 Design

Impacts on the design of EEE (Electronic & Electrical Equipment) in recent years have included material changes (geographic RoHS directives), recycling (WEEE initiatives), voluntary eco-labels (E-star, TCO) and regional laws (mercury legislations). While these material choices and recycling initiatives do, and will continue to affect the design of EEE, the focus of the Design portion for the 2009 iNEMI ECE roadmap will be on those design impacts not covered in other areas of the roadmap. Design changes due to materials, recycling and energy will not primarily be covered in this section.

Those design initiatives that have taken a more direct focus on design changes, wherein only a portion of the requirements are considerations of material choice or energy use, will be primarily addressed here. Green Procurement initiatives like the US-EPA sponsored Electronic Product Environmental Assessment Tool (EPEAT); the non-material, non-recycling updates to TCO and Blue Angel for various IT products; the general proliferation of Eco-labels around the world; the future of LCA/LCT (Life Cycle Analysis/Thinking) and the effects expected from the Eco-Design of Energy using Products (EuP) directive will be examined.

6 Sustainability

The concept of sustainability is being widely adopted and promoted by companies throughout the electronics supply chain as a core tenet and measure of performance of their business operations, largely in response to heightened interest by stakeholders in corporate social and environmental responsibility. Increasingly, companies are publishing what they refer to as sustainability reports or corporate social responsibility (CSR) reports, in place of traditional environmental reports, although the general nature and content of the reports has changed little, with the possible exception of additional emphasis on social considerations.

While "sustainability" is being treated as a standalone topic on the ECE TWG matrix, it is perhaps better viewed as cutting across all the existing ECE Roadmap topic areas – materials, energy, recycling and design – both as an inherent reason for further examination of these and other areas, as well as a framework for measuring industry progress in meeting environmental and social goals.

At the tactical level this chapter will illustrate that impact trade-offs must always be evaluated when making "environmental improvements." At the strategic level this chapter will discuss the positive environmental impact that electronic systems (IT) can have in displacing existing processes (e.g., video conferencing replacing face-to-face meetings).

7 Plan for Action

iNEMI will hold an Industry/Academic "Sustainable Summit." The motivation for the workshop was recognition by the iNEMI Board of Directors that the electronics industry should act more strategically on environmental issues. The summit will:

- Invite Industry and Academic Speakers to speak.
- Establish Breakout Groups to brainstorm options and priorities.
- Establish Action Groups on selected topics based on outcome of meeting.

The goal of the workshop is:

- To evaluate opportunities for industry collaborative action on proactive environmental programs.
- To define academic research needs to support these programs.
- To stimulate funding for the necessary research.
- To form and execute the required industrial collaborative programs.

iNEMI will hold the workshop in the United States on September 22-23 on the Motorola Campus in Schaumburg, Illinois. Further details will be provided at Electronics Goes Green 2008 and on the iNEMI website.

8 Summary and Conclusions

The 2009 iNEMI Roadmap will help define needed initiatives in the electronics industry to create a more sustainable world. The iNEMI Sustainability Summit will serve to define areas in which industry can take action to make our products more sustainable. Underlying these activities is a belief that industry must take a proactive stance, must with work with stakeholders both to educate them on the complexity of making changes to our products, but also to understand their concerns about our products. When we make changes we must provide more explicit information to the public on what is being eliminated and why it presents a risk; otherwise we face the risk of changes being demanded when there is no environmental risk.

9 Bibliography

[1] http://frwebgate.access.gpo.gov/cgi-bin/getdoc.cgi?dbname=110_cong_public_laws&docid=f:publ140.110