The Environmental Juggernaut
How and Why to be Strategic

Agenda

• DCA Introduction
• RoHS – Intro & Impact
• Many RoHSes, Many Differences
  • Key example: China vs. EU RoHS
• WHN: Where Environmental Product Regulation is Going
• A Lifecycle Approach to Environmental Product Regulation
• IEEE 1680-2006: One US Industry Approach
• Final Thoughts
European Union RoHS & WEEE, in Short

- **RoHS**: EU Directive restricting Cadmium, Mercury, Hexavalent Chromium, Lead, Polybrominated Biphenyls, and Polybrominated Diphenyl Ethers from most electronic equipment
  - Figure out what parts contain any of these substances and either have the recipe changed or replace the part
- **WEEE**: Electronics "producers" must extend responsibility for their products to the end of the useful life and provide for the cost and capability of recycling the products
  - Register as a Producer with the government. Identify and work with a recycler. Point your customers to them.

- You had 40 months to do this for RoHS (2/2003 to 7/2006)
  - 29 to 46+ for WEEE...

- Simple, eh?
- Not quite.
“We were unable to ship to meet all of the customer demand which impacted our server brands, most notably Systems i and x. Our unusually high level of unfilled orders were due to end-to-end supply chain complexities which were primarily driven by parts and product transitions to support the RoHS (Removal of Hazardous Materials) [sic] requirement in Europe. This limited our manufacturing and sourcing flexibility.”

http://www.secinfo.com/d11MXs.v1efz.htm

Post Mortem: Why was this so hard to do?

1. RoHS: Material Attributes were never required before
   • No infrastructure (software, supply chain, people) to provide/acquire/interpret/manage data
2. Concise scope guidance was not provided
3. The impact was world-wide but the EU roll-out was not
   • They rolled it out barely adequately in the EU!
4. Adequate time to find/develop reliable replacements was not provided: many exemptions have been requested, & some granted
5. Exemption process takes far too long
   • Some requested Feb. 2005 were granted on June 26, 2006!
6. WEEE: Member state transposition took longer than defined by the directive and significant variations occurred state-to-state
   • Definitions of “Producer” varied; certain member states require registration in the local language; etc.
7. Electronics Industry depression from 2001 in to 2004…
The Result

- Cost of 1.5% to 2.5% of Cost of Goods Sold to comply (per Technology Forecasters research)
- Cost to industry conservatively estimated at a total of $8 billion by TFI’s Pamela Gordon
  - And it keeps growing
- Nobody checked with our Automotive brethren about ELV costs…
  - Original Equipment Suppliers Association (OESA) found that the average cost for inputting data into IMDS was:
    - $75 per simple raw material
    - Up to $2500 per complex assembly
- In 2002, an Automotive Industry Action Group (AIAG) project team used these data and estimated costs to the entire US supply chain for ELV/IMDS in the billions of dollars.

What is the Environmental Payback?

- Slight reduction of dangers to recycling workers
  - Assumes improper recycling to begin with
  - 70% of e-waste goes to China…that’s a different problem
- Slight reduction of PBDEs in our environment
  - Electronics accounted for under 20% of PBDE use in 2001 in US
  - DecaBDE Use fairly widespread in Electronics…not banned!
- Little reduction of Pb in landfills (proper recycling takes care of that)
  - Most is from automobile batteries…

- We probably could have done better for $8B…
What about the other RoHSes?
[What? We’re not done with this yet?]

California EWRA

- Δs include: reporting requirement, subset of scope, subset of substances – in force Jan. 1, 2007

"I recycle more with my pintsy than you do with both hands. Recycle now, thank me later."

RECYCLE HARD

Courtesy California Department of Toxic Substance Control...seriously!
Korea

- Δs include: reporting requirement, subset of RoHS scope + ELV scope

Japan

- Δs include: Marking and disclosure only, narrow subset of RoHS scope
A Couple Other Choice US Locales

• New Jersey – (legislation) Additional substance! (PVC)

• San Francisco – bans Bisphenol A in toys and items for infants/toddlers under 3 years old
  • Effective Dec. 1, 2006
  • BPA critical to FR-4 PCBs and epoxy resin encapsulants
  • ACC Lawsuit prevents enforcement until 1/8/07 hearing

• Etc.

And then there’s China....
EU-China “RoHS” Comparison

<table>
<thead>
<tr>
<th>Issue</th>
<th>EU</th>
<th>China</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material Targets</td>
<td>Common</td>
<td></td>
</tr>
<tr>
<td>Date Law Passed</td>
<td>23-Feb-03</td>
<td>28-Feb-06</td>
</tr>
<tr>
<td>Effective Date</td>
<td>1-Jul-06</td>
<td>1-Mar-07</td>
</tr>
<tr>
<td>Materials Restricted?</td>
<td>Yes</td>
<td>Not Yet</td>
</tr>
<tr>
<td>Marking &amp; Disclosure</td>
<td>None</td>
<td>Four Requirements:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1) Disclose Hazardous</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Materials and Locations</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2) Environment-Friendly</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Use Period Label</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3) Packaging Materials</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mark</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4) Date of Manufacture</td>
</tr>
<tr>
<td>Scope</td>
<td>10 Categories, Very Broad</td>
<td>MIL’s Scope of “Electronic</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Information Products”:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>EU RoHS Scope + ELV,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Medical, Radar, Components,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Materials - most</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Household Appliances, Toys,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Tools...</td>
</tr>
<tr>
<td>Exemptions</td>
<td>Material Application</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>Exemptions Defined; Can be</td>
<td>&quot;Key Administrative Catalog&quot;</td>
</tr>
<tr>
<td></td>
<td>petitioned</td>
<td>defines included</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Products; may also define</td>
</tr>
<tr>
<td></td>
<td></td>
<td>material application</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&quot;exemptions&quot;; no formal</td>
</tr>
<tr>
<td></td>
<td></td>
<td>petition process yet</td>
</tr>
<tr>
<td>Packaging Materials</td>
<td>Out of Scope (Packaging</td>
<td>Non-toxic/Recyclable,</td>
</tr>
<tr>
<td></td>
<td>Directive)</td>
<td>Disclosed in mark</td>
</tr>
<tr>
<td>Production Materials</td>
<td>Out of Scope</td>
<td>Restricted per material</td>
</tr>
<tr>
<td></td>
<td></td>
<td>restrictions</td>
</tr>
<tr>
<td>Implementation/</td>
<td>By Each Member State’s</td>
<td>Direct national regulation</td>
</tr>
<tr>
<td>Clarification</td>
<td>local law/ Through</td>
<td>“Industry Standards”</td>
</tr>
<tr>
<td></td>
<td>Commission Decisions</td>
<td></td>
</tr>
<tr>
<td>Put On The Market</td>
<td>Confused and inconsistent</td>
<td>Just Announced: March 1</td>
</tr>
<tr>
<td></td>
<td>definition across member</td>
<td>2007 is Date of</td>
</tr>
<tr>
<td></td>
<td>states. Basically allows</td>
<td>manufacture</td>
</tr>
<tr>
<td></td>
<td>limited channel stuffing</td>
<td></td>
</tr>
<tr>
<td>Testing/Certification</td>
<td>Not a prerequisite</td>
<td>Is a prerequisite (Chinese</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Lab test results only) for</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Catalog items</td>
</tr>
</tbody>
</table>

Bottom Line

1. Companies with national and international markets can not simply address EU RoHS and think they are done
2. Reacting to each regulation as it comes up is costly, unbelievably inefficient, and dangerous
WHYN?
Where is this all going? And WHY???

The EU’s Integrated Product Policy

• Purpose: Drive Sustainable Development
  • Defined as “meeting the needs of the present generation without compromising those of future generations”
  • All Products (not just Electronics) have an impact on the environment during
    • Production
    • Use
    • End Of Life
• Proposes a specific approach to development of products to balance markets and economies with environmental concerns and impacts
IPP: Based on Five Principles

- Life-Cycle Thinking
  - Consider the Environmental Impact of the Product Over its Entire Lifecycle
- Working With The Market
  - Motivate the Market to Drive Desired Improvements
- Stakeholder Involvement
  - Encourage Involvement & Cooperation In The Decision Process
- Continuous Improvement
  - Rather than Setting Thresholds
- A Variety of Policy Instruments
  - Voluntary Initiatives, Regulations, Tax Incentives, Etc.

- EU Product-Focused Environmental Directives all play a part in IPP

How Directives Relate to the Product/Equipment Lifecycle
Can It Happen Again? Yes...

- REACH, EuP have different requirements, but are also environmental
- Require more/different attributes to flow up/down the Supply Chain and be analyzed and understood
- REACH: Authorization of up to 2K and potential withdrawal of ~1K substances based on adequate control & socio-economic impact
- EuP: "Energy-using Products" Directive
  - Energy vs. Material Type
  - Limited industry knowledge and no infrastructure to support either today
- REACH hits the fan in 2 years…China and California are reviewing it

REACH Webcast - for more info...

- DCA Oct. 18, 2006 Webcast with Robert Donkers, EU Delegation to the USA
  - One of the original authors of REACH
- Archived and available to view for FREE
- Visit
- Send me comments/questions!
  - mike@designchainassociates.com
Design for Environment
A Strategy for Product Companies to Address Environmental Requirements

Product Design Today

- Technical Product Design fundamentally focuses on 4 or 5 (or so) attribute classes:
  - Functional
    - Including quality/reliability attributes
  - Mechanical
  - Thermal
  - Electrical
  - (Optical)
- Over the past 2 decades we’ve incorporated business attributes
  - Cost
  - Leadtime
  - Roadmap
  - Ramp capability
  - Etc.
The Industry Blind Spot

- Environmental Attributes
  - Impact of products on the environment

- Including
  - Material Attributes
  - Energy Attributes
  - Waste Attributes

- Only rarely considered – for example “how does this product achieve this thermal capability at this price point?” “lead die attach, dude” “kewl”

The Four Main DfE Elements

<table>
<thead>
<tr>
<th>Material Utilization</th>
<th>Energy Utilization</th>
</tr>
</thead>
<tbody>
<tr>
<td>type &amp; amount</td>
<td>extraction &amp; processing</td>
</tr>
<tr>
<td>virgin/recycled/recyclable</td>
<td>use/recovery</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Lifecycle Extension</th>
<th>Waste Minimization</th>
</tr>
</thead>
<tbody>
<tr>
<td>extraction &amp; processing</td>
<td>manufacturing, transport</td>
</tr>
<tr>
<td>use, recycling</td>
<td>use, recycling</td>
</tr>
</tbody>
</table>
Lifecycle Thinking for Electronics: A Product Strategy For & Beyond EuP

- Consider the impact of each resource category on each product lifecycle phase
  - During development of the MRD (Market Requirement Document) or before
- Measure values of current and competitive products
  - Measure over time, too
- Develop an “ecological profile” of your product
  - Whether or not covered by EuP Directive
  - “Green Procurement” is spreading regardless of legislation
- Make the requisite changes to your product definition and development business processes
  - This simply becomes part of how you do business
- Gil Friend, CEO of Natural Logic: “Achieve Regulatory Insulation”

IEEE 1680-2006 - it’s a good start...

- Specifies required and/or optional targets for
  4.1 Reduction/elimination of environmentally sensitive materials
  4.2 Materials selection
  4.3 Design for end of life
  4.4 Product longevity/life cycle extension
  4.5 Energy conservation
  4.6 End of life management
  4.7 Corporate performance
  4.8 Packaging
1680 Pluses

• Touches on most of the important environmental requirements
• Independent entity (NGO) grades products and posts results
  • See www.epeat.net
• Sets three levels of compliance:
  • Bronze: Meets all required criteria
  • Silver: Bronze + 50% or more of optional criteria
  • Gold: Bronze + 75% or more of optional criteria

1680 Issues

• Voluntary, but gaining traction? See next two slides
• Narrow scope
• Little that is a stretch for technology today
  • Yet there are zero systems that are GOLD!
    • Primary challenges include
      • Use of biobased materials and postconsumer recycled plastic
      • Minimizing use of different types of plastic
      • Options for powering via renewable energy sources
    • Needs a real roadmap
• Criteria for lifecycle extension and modular design are weak
  • Just about all desktops get high marks!
Recent DCA/TFI Survey: Have Features for Extended Life in New Designs

Yes 57%
No 43%
n=79
Much improved since 4Q 2005.

Types of Features for Extending Useful Life of Products

Modular design
Easier upgradability
Quantitatively more robust design
Easier refurbishment
Other

n = 99
Industry Challenges

- Much of the data needed is unavailable
- Little understanding of what lifecycle data is needed
  - And how to compare/weigh/trade-off, e.g. eutrophication, global warming, etc. properties of different plastics
  - Standards will be needed
- No process for inter-industry collaboration
  - This is a cross-industry challenge
- No coherent process to inject science in to policy and government deliberations…

Lifecycle Thinking for Electronics: DCA’s DfE Planning Matrix

<table>
<thead>
<tr>
<th>Material Type</th>
<th>Material Amount</th>
<th>Energy Use</th>
<th>Lifecycle Extension</th>
<th>Waste Streams</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concept</td>
<td>Target Materials, Resources</td>
<td>Target Material Reduction</td>
<td>Overall material metric</td>
<td>Modular design, Materials</td>
</tr>
<tr>
<td>Design</td>
<td>Reusability, Recyclability, Hazardous Mat'l</td>
<td>mass/item</td>
<td>DM, Design for Disassembly, During Component Mfg</td>
<td>Upgradeable</td>
</tr>
<tr>
<td>Prototype</td>
<td>Target reduced Energy Materials: lower melting temp solder, recyclable</td>
<td>Fewer solder joints=less solder, serial channels=fewer wires/traces</td>
<td>Transportation (mass, distance); forecasting accuracy; expediting</td>
<td>Reusable</td>
</tr>
<tr>
<td>Production</td>
<td>Target reduced Energy Materials: lower melting temp solder, recyclable</td>
<td>Fewer solder joints=less solder, serial channels=fewer wires/traces</td>
<td>Transportation (mass, distance); forecasting accuracy; expediting</td>
<td>Reusable</td>
</tr>
<tr>
<td>EOL/Support</td>
<td>Failure rate, transportation, Logistics</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Take-Back</td>
<td>Recycling Ease</td>
<td>Recycling Value/Infrastructure</td>
<td>Infrastructure Development, Prep.</td>
<td>Transportation</td>
</tr>
<tr>
<td>Use</td>
<td>Intentional/unintentional release?</td>
<td>Total use life</td>
<td>Infrastructure Convenience: upgrades, Effluence</td>
<td>Reuse vs. Recovery vs. Landfill</td>
</tr>
<tr>
<td>Disposal</td>
<td>Precautions? Scrubbing? Extra steps?</td>
<td>Enough volume for special recycling steps (e.g. tagging)?</td>
<td>Infrastructure Convenience</td>
<td>Reuse vs. Recovery vs. Landfill</td>
</tr>
</tbody>
</table>
Concluding Observations

• Toxicity/ecotoxicity, energy use throughout the lifecycle, & lifecycle extension have typically not been attributes considered in
  • The material selection process
  • Supply Chain Design process
    • Supplier Selection
    • Component/item selection
• Suddenly they are critical/primary
  • Supply Chain was not designed with environmental attributes in mind
• The trajectory of product-focused environmental regulation is becoming clear:
  • ALL chemicals that are toxic/ecotoxic OR where toxicity is unknown risk being restricted
  • Energy use through the entire lifecycle, including during manufacturing and stand-by/off state, is of growing concern
  • Keeping products out of the waste stream as long as possible is becoming a requirement

Recommendations 1: Management

• Get a budget!
• Understand the trajectory of regulation
  • How could it impact your business?
  • What are others doing?
• Identify strategies/tactics for competitive advantage
  • Standards
  • “Green Procurement” in your markets
  • Benchmark your competitors
  • What is the supply base doing/not doing?
  • Fund research and industry activities
• Approach this Proactively and Strategically
  • There is OPPORTUNITY here...
  • Otherwise there is just cost and risk
Recommendations 2: Engineering

- ACTION: Start identifying and collecting environmental attributes on ALL the substances used in your products
  - Including consumables
  - Material composition, energy
  - What is available, what is not, why
- Materials, e.g.
  - Rethink standard form factors
  - Rethink virgin vs. recycled
- Lifecycle extension – think creatively
  - What can be modularized? What standards are needed?
- Product development expertise is needed for industry standard development
  - Join!

Near Term Activities

- First Emerging Chemical Issues Workshop held in September 2006
  - Will be annual
- Monthly Conference Calls
  - Multi-industry
- ANSI Member Forum
  - Expected to establish an Emerging Chemical Issues Forum
- Contact me for more information
  - Mike@DesignChainAssociates.com
  - 866-DCA-7676 x2