Design Chain Solutions for Competitive Advantage: Your Environmental Solutions Resource

Lead-Free: It's Only The Beginning

Where Are We Heading? What Do We Need to Do Differently?

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DCA/OALC/Celestica Webinar

9 December 2010

Agenda

- DCA Introduction
- Where Are We?
- How Did We Get Here?
- Where Are We Going?
- How Do We Get There?

DCA Environmental Compliance Services

- Training/Education
  - Executive Management to Engineering to Production Workers
- Product Portfolio Analysis
  - RoHS/REACH Scope, Impact Assessment, Recommendations
- Business Processes and Supporting Systems
  - GAP Assessment via ECAS™- Environmental Compliance Audit Systems
  - Improvement and Compliance Assurance
- Design for Environment
  - Strategic Roadmap
  - Best Practices
- Environmental Data Collection & Reporting
  - Substances and other
- Legislation/Regulation Tracking Service
  - Keep you aware of current and coming regulations that will have material impact on your products in your markets
- DPIR – The DfE Process Integration Roadmap (w/TFI)
  - 5 year Roadmap
  - Integrating Design for Environment into your Business Processes

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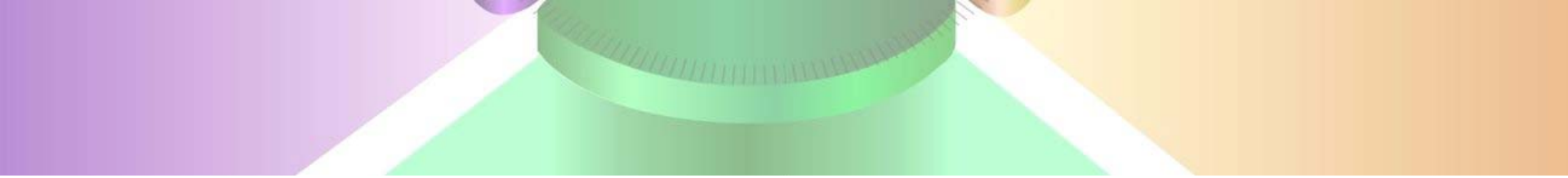
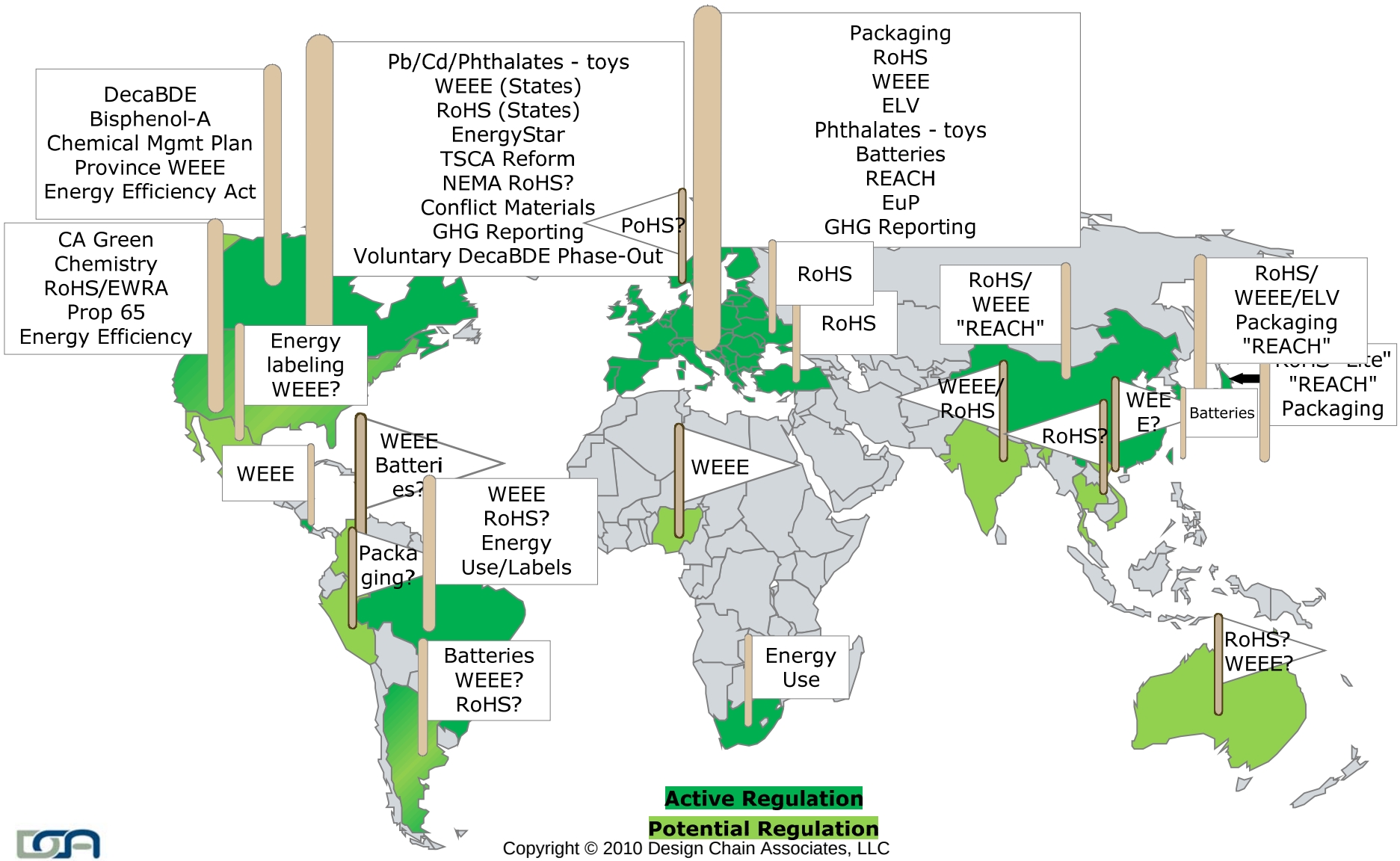


Where Are We?

INCOMPLETE Environmental Regulatory Landscape "Snapshot"



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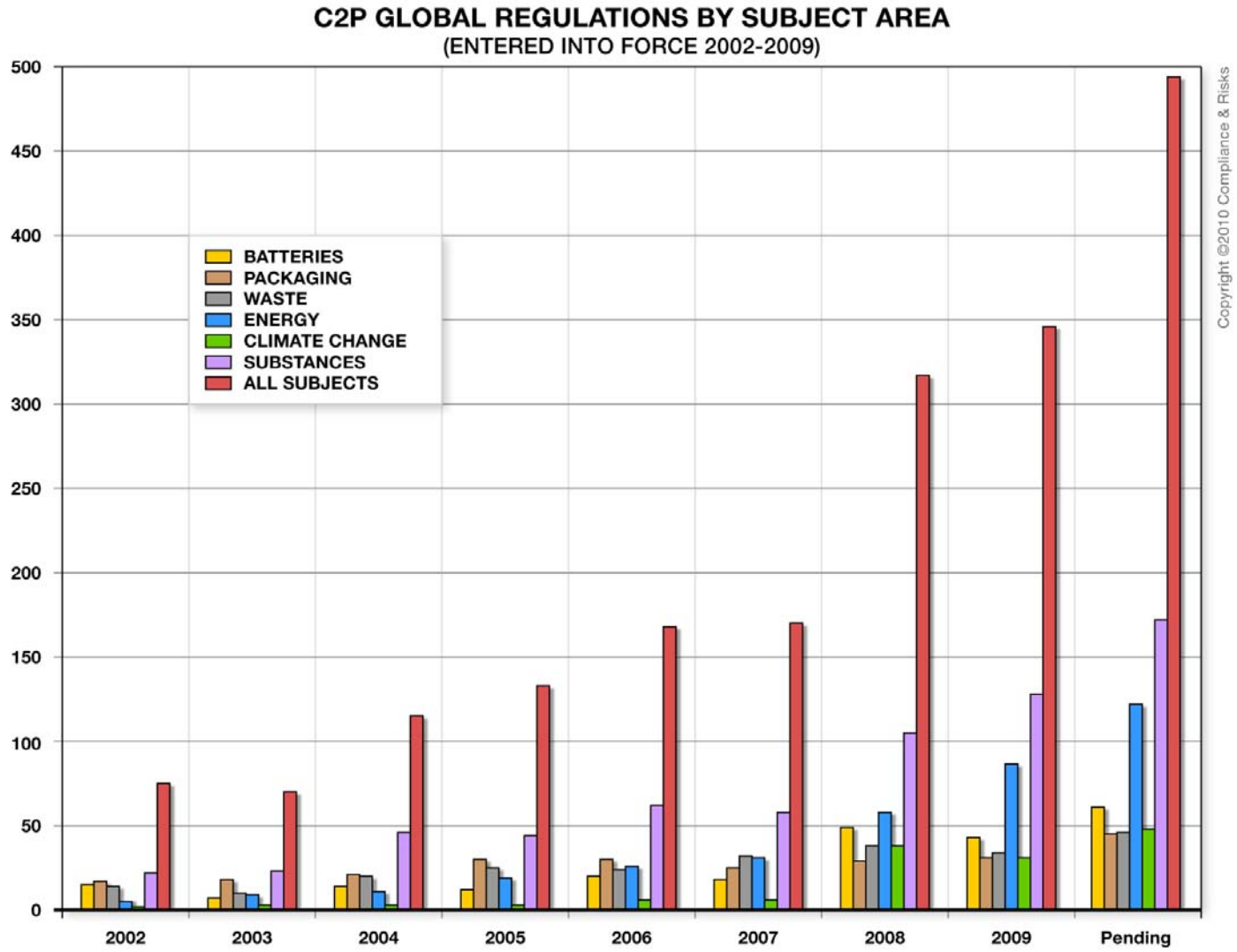
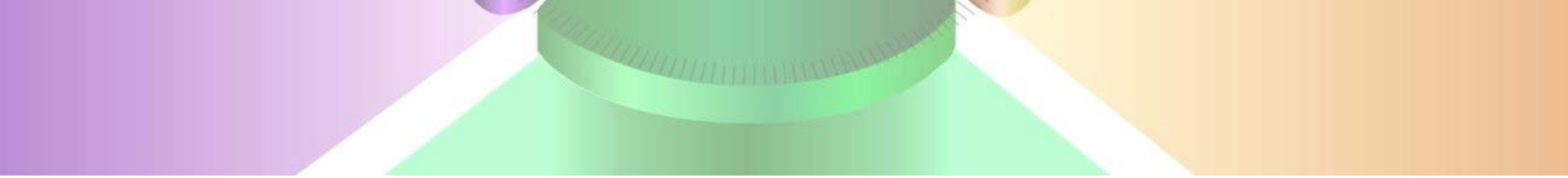
Growth in Environmental Regulations



Statistics reflect C2P content which is indicative of but not 100% equal to the growth in all regulations in the field



Focus on Substances: How Did We Get Here?

Industry Has Occasionally Been Driven to Change Substances

- Disasters
  - Hydrogen for dirigibles
- Regulations
  - Lead, Cadmium, Mercury, Asbestos, PBDEs, Phthalates (coming)
- Voluntary Replacements
  - Beryllium Oxide in Packaging => Head Spreaders in Plastic
- NGO and Peer Pressure
  - Brominated Flame Retardants, PVC
- Business Strategy/CEO Awareness
  - Cost Reduction (e.g., reduce regulatory cost burden)
  - Attract/Retain Employees
  - Opportunity to Expand Market-Share

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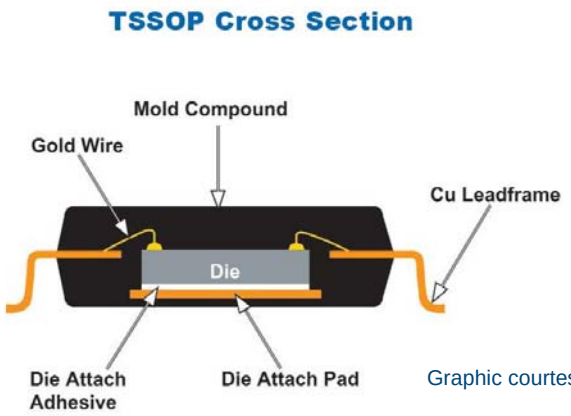
What Does It Take To Add or Change A Substance?

- Nothing is easy…

Case Study 1: TBBPA in IC Packaging



Graphic courtesy Amkor Technology

- Bromine added to mold compound in early ’80s
- Reliability testing results: increased Au/Al intermetallic growth at high temp (175°C – 200°C)
  - Increased bond wire resistance → open circuit
  - Proportional to bromine concentration
- Solutions: increase Tg of mold compound; add antimony oxides

Sources: Blish, et. al., “Effect of Bromine Concentration in Molding compound on Gold Ball Bonds to Aluminum Bonding Pads”, IEEE 1986 Electronics Conf; National Semiconductor “Package Reliability – August 1999”

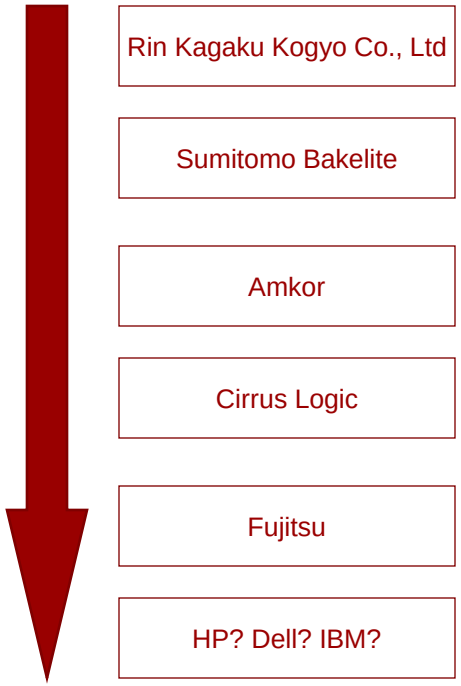
Case Study 2: Red Phosphorus

- Sumitomo Bakelite replaced bromine with “red phosphorus” in mold compound
  - “Environmentally Friendly”: no Br or Sb
  - Similar flowability, curability and electrical properties
  - Better reliability in high temperature operating/storage life (no Br or Sb!)
- Early field failure rate increased
  - Fujitsu saw a 0.8% failure rate in 6-12 months
  - High temp/humidity environment → shorts in ICs

Sources: Deng & Pacht: FAILURES IN SEMICONDUCTOR DEVICE ENCAPSULATED WITH RED PHOSPHORUS FLAME RETARDANT - http://www.glue.umd.edu/~yuliangd/publications/C2005-SMTA-RP.pdf'.Nakao, Fujitsu HDD (Hard Disk Drive) Defect http://shippai.jst.go.jp/en/Detail?fn=2&id=CA1000624

Case Study 2: Red Phosphorus

- Root Cause: Red phosphorus was “sealed” in $Al(OH)_3$, but seals were poor/inconsistent
  - Created phosphoric acid in temp/humidity
  - Dissolved Cu and/or Ag, which flowed and caused internal pin-to-pin shorts
- Sumitomo stops making the product
  - After 1000 tons is produced
  - Lawsuits ensue…
- Root cause:
  - Poor process control
  - Inadequate reliability testing regimen and control thru multiple levels of supply chain

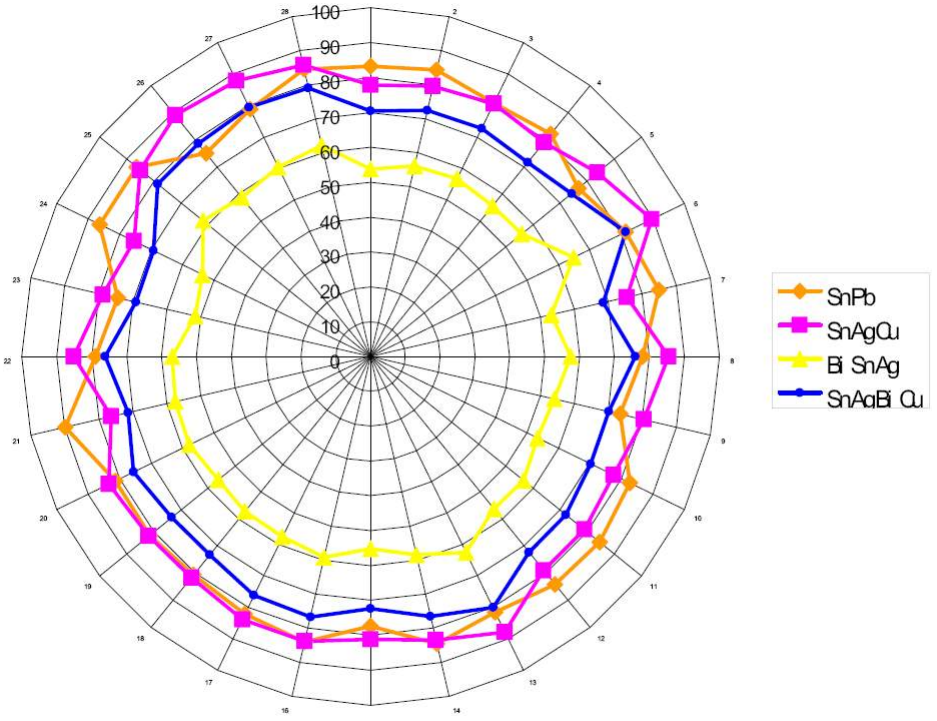


Case Study #3: SnPb to SAC

1. EU Restricts 6 substances classes from Electronic products
   - Impacting ~150 substances
   - Out of a universe of 140,000 substances
   - Maybe 3000-5000 used across vast majority of EEE?

2. Cost of EU RoHS Implementation to the *global* Electronics Industry:
   - $32.7B (+11%/year)*

3. How did we do?**



Higher value indicates higher environmental impact
SAC: SnAgCu; BSA: BiSnAg, SABC: SnAgBiCu

* TFI 2007 Cost of RoHS Study for CEA

** Julie Schoenung, "Green Electronics: Life Cycle Assessment", Feb 19, 2009 DTSC RoHS Symposium

Regrettable Solutions: We're Not Alone

- Brake Pad: Asbestos replaced by Copper
  - Carcinogen replaced by Aquatic Toxin
  - Washington state now regulates Cu in brake pads!
- Gasoline: Lead replaced by MTBE
  - Air pollutant replaced by water pollutant
- Pesticides: A Litany of Problematic Replacements

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Moral of the Story

- In an existing, holistic, functioning system, changing one seemingly minor material in a seemingly minor way can and will have unforeseen consequences

Or…

If Anything Can Go Wrong, It Will

Murphy's Law

"It Should Be Easy for the Electronics Industry to Change Materials!"

- So Says Greenpeace, based on superficial observation…
- Can RAPIDLY improve products/performance ONLY BECAUSE we understand the materials we use so well
- Changing a substance = a whole new learning curve

For Example…	
❖ Lead in solder ➢ 60+ years of experience ➢ Excellent reliability models ➢ Well-understood performance	❖ Pb-Free solder ➢ ~10 years of experience ➢ Incomplete reliability models ➢ Adequate(?) performance ➢ Mandated by the EU RoHS Directive

- *without impacting other technical performance properties*
  - Not a holistic approach…

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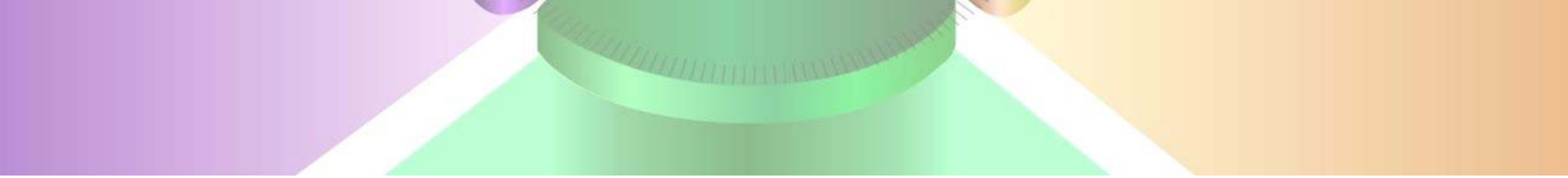

Where Are We Going?

Regulations and Customer/NGO Requirements are Inconsistent

- And Individually Unpredictable
- But *the trend is clear…*
- The *direction* these are taking is knowable
  - So you can plan for it
    - At both corporate and industry-wide levels
  - So you can develop strategies to address it in a general sense
  - And you can develop tactics to deal with specific requirements
  - Thereby minimizing reactive, unbudgeted, and sub-optimal responses

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Regulatory Trajectories are Predictable

Chemicals (e.g. RoHS, ELV, REACH)

From: A few bad actors in specific applications
To: All chemical substances in all applications

Energy Use (e.g. Energy Star®, ErP)

From: Use phase only
To: All lifecycle phases from extraction thru manufacture thru disposal

Waste/Reuse/Recycling (e.g. Producer Responsibility/WEEE)

From: Basic recycling of bottles/cans
To: Full responsibility for all products through their entire lifecycle

Carbon Footprint

From: Voluntary corporate reporting
To: Products and Supply Chains with regulatory caps & taxes

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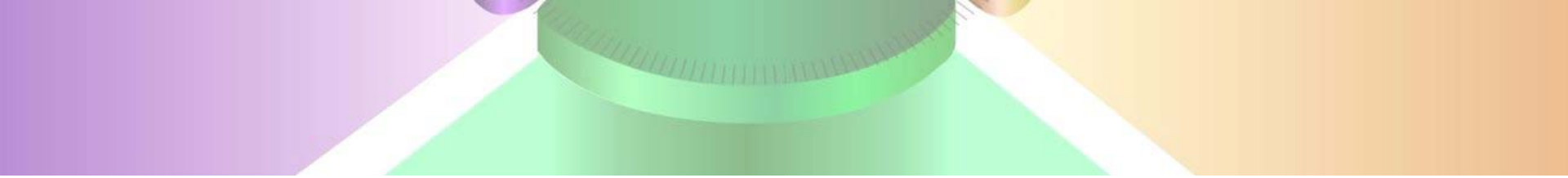
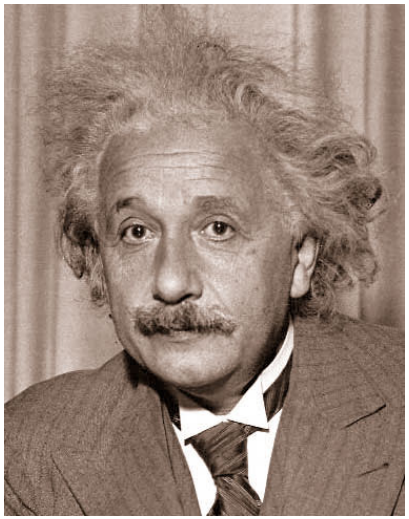


How Do We Get There?

The significant problems we face cannot be solved at the same level of thinking we were at when we created them.

- Albert Einstein



Think at a Different Level

- Develop and KEEP IMPROVING Standards that will enable quantitative (or at least qualitative) comparisons
  - For Engineering Use
  - For Marketing Use
  - NSF/GCI 355, IEEE-1680.n, etc.
- Work with Academia on identifying educational needs and defining certificate and degree programs to fill knowledge gaps
- Incorporate Environmental Parameters into decisions about substances, technologies, components, materials
  - New data leads to new tools, techniques, and knowledge

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Concluding Observations

- Environmental attributes have *typically* not been considered during material selection or performance requirement setting processes
- Suddenly they are critical/primary
- Changing materials piecemeal and reactively is extremely difficult
  - Prone to failure: functionally or environmentally
- The trajectory of product-focused environmental regulation is quite clear
- Industry needs to take a holistic, standards-based approach to achieve an effective and efficient result

- We CANNOT afford to continue to allow a series of hastily done substance replacements like SnPb to SAC to impact the industry!
  - We must be proactive and drive positive, measurable, and VISIBLE environmental performance change ourselves, or else governments and NGOs will drive it

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Thank You For Your Attention

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