



**iNEMI**  
International Electronics Manufacturing Initiative

# PVC Alternatives Project

Co-Chairs:  
Scott O'Connell, Cisco  
Jim Arnold, iNEMI

April 2011

Advancing manufacturing technology

# Background


- iNEMI PVC Alternatives project was proposed at the September 2008 iNEMI Sustainability Summit, approved by the Board
  - Project chairs – Scott O’Connell, Cisco & Jim Arnold, iNEMI
- The project is focused on 2 areas:
  - *Phase 1 - Cradle-to-grave Life cycle assessment (LCA) comparing PVC and PVC-free cables - WE ARE HERE TODAY*
  - *Phase 2 - Technical evaluation of PVC alternatives – electrical, mechanical, safety*

# Companies and Organizations Participating in the Project Statement of Work (SOW)

- **OEMs – Alcatel-Lucent, Cisco, Dell, IBM, Intel, Lenovo, HP**
- **Cable Manufacturers – Alpha Gary, BizLink, CordMaster, Hueson Wire, Huntsman, NorthWire, TeknorApex, Tyco, Volex**
- **Resin/Raw Material Manufacturers and Formulators – BASF, Dow, DSM, Dupont, TeknorApex, Exxon Mobil, SABIC**
- **Safety Standards Organizations – UL**
- **LCA Consultants – EarthShift, PE International**
- **Universities, others – Purdue, IST (Integrated Services Technology), ITRI (Industrial Technology Research Institute), The Vinyl Institute**

# PVC Alternatives Project

**Goal:** Perform an Life Cycle Assessment of the electrical and mechanical properties, and safety aspects of PVC alternatives for Power Cord Sets

| Strategy  | Issues   | Graphics  |   |
|---|--|---|---|
| <ul style="list-style-type: none"> <li>Phase 1 – Evaluate differences between PVC with PVC-free compounds in the lifecycle of detachable US desktop power cord sets</li> <li>Phase 2 - Develop and conduct a test to gain a better understanding of the electrical, mechanical and safety aspects of PVC-free alternatives</li> </ul> | <ul style="list-style-type: none"> <li>Industry migration to “PVC-free” materials</li> <li>Sub-team formed to investigate “hot spots” in the life cycle using a screening LCA.</li> <li><b>Current LCA models are limited by lack of data on materials and processes used in the manufacture of power cord sets</b></li> </ul> |  |   |
| <p><b>Project Lead:</b> Scott O’Connell, Cisco Systems<br/><b>Project Co-Lead:</b> Jim Arnold, iNEMI</p>  |  |   |   |
| Tactics   | Milestones and/or Deliverables   | Plan  | Actual                                    |
| <ul style="list-style-type: none"> <li>Phase 1 - Conduct a cradle-to-grave Life Cycle Assessment (LCA) on PVC and PVC-free Alternatives for detachable US desktop power cord sets</li> <li>Phase 2 - Conduct performance testing of different PVC-free alternatives</li> </ul>  | <p>Research Project Information – Define and Collect Data</p> <p>Go / No-Go Decision on LCA Study</p> <p>Investigate LCA models to determine limitations</p> <p>Screening LCA to identify "hot spots"</p> <p>Project Reporting</p>   | <p>Mar-10</p> <p>Aug-10</p> <p>Dec-10</p> <p>Apr-11</p> <p>Jun-11</p>               | <p>Apr-10</p> <p>Sep-10</p> <p>Jan-11</p> |

# PVC Alternatives Project

## Project Team Members



Alcatel-Lucent



Electronic Materials



# What Has Been Done So Far?

- **Vinyl 2010 study on recovery of PVC (2003)**
  - Emphasis on EOL aspects of mixed cable waste
  - [http://www.ecvm.org/img/db/PE\\_Recovery\\_Options\\_final\\_140503.pdf](http://www.ecvm.org/img/db/PE_Recovery_Options_final_140503.pdf)
- **EU Commission study on PVC and replacement materials (2004)**
  - Overview of publicly available LCAs, little information on PVC alternatives in electronic applications
  - [http://ec.europa.eu/enterprise/chemicals/sustdev/pvc\\_en.htm](http://ec.europa.eu/enterprise/chemicals/sustdev/pvc_en.htm)
- **USEPA PVC Alternatives Project (2008)**
  - Focused on building and telecom wire, emphasis on base resins & additives (Pb vs Pb-free)
  - <http://www.epa.gov/dfe/pubs/projects/wire-cable/index.htm>
- **HDPUG Halogen-Free Guideline (2008)**
  - Includes a section on Cables, general information on PVC alternatives
  - [www.hdpug.org](http://www.hdpug.org)
- **HDPUG PVC Alternatives Project (Ongoing)**
  - Emphasis on supply chain readiness for PVC-free cables (all cable types)
- **MIT Life Cycle Analysis of Plastics for Clamshell Packaging: PVC & PET (2010)**

***Significant historical data on PVC (and additives); however little data exists on non-PVC alternatives & additives***

# Typical Uses of PVC In Electronic Cables



PVC alternatives developing for all cable applications:

**Jacketing**  
**Insulation**  
**Strain Relief**  
**Plugs**

# PHASE 1 – LIFE CYCLE ASSESSMENT (LCA)



# Phase 1 - LCA Project

**Goal: Conduct a cradle-to-grave life cycle assessment on PVC and PVC alternatives, emphasis on US desktop power cords. The project should take into account the needs of electronic product sectors represented by iNEMI membership.**

- 1. Identify market segment & cable design/BOM requirements**
- 2. Review & assess existing LCA studies for relevance in the electronics sector**
- 3. Identify candidate materials and develop life cycle inventory (LCI) – base resins + additives**
- 4. Identify LCA parameters and LCA tool of choice (SimaPro, GaBi, etc.)**
- 5. Conduct the LCA – may begin with a high-level screening assessment to identify “hot spots” across the life cycle**

# Current Resin Alternatives Identified for LCA

The goal of the LCAs is to represent the variety of environmental specifications used across the industry for US desktop power cords:

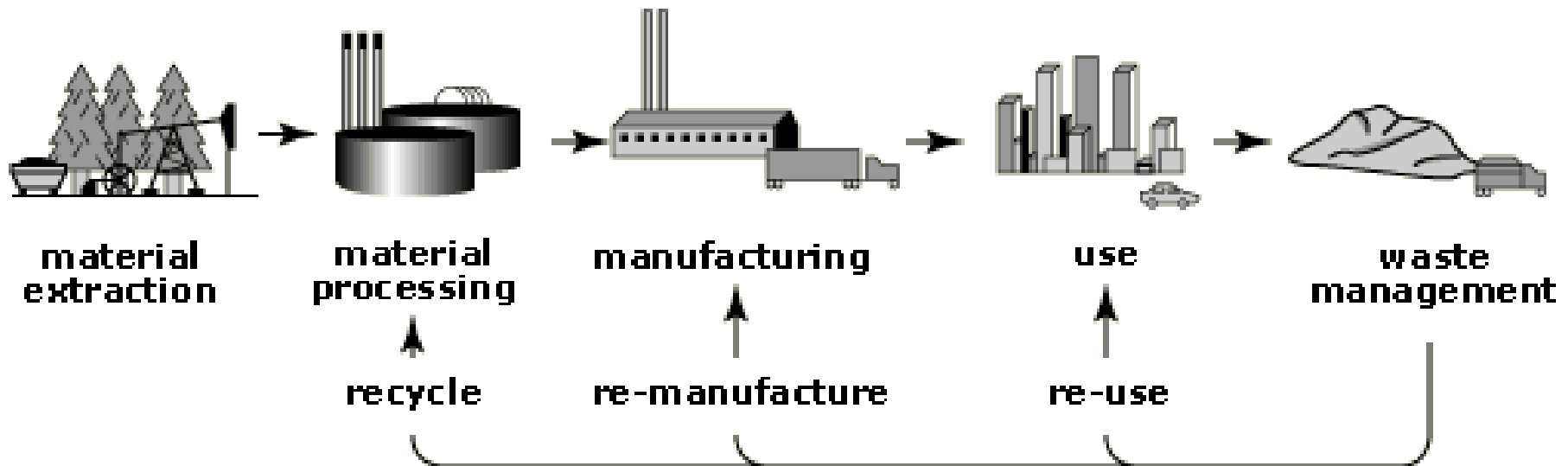
- **PVC #1 - “Standard” RoHS-compliant**
- **PVC #2 - RoHS-compliant, phthalate-free (renewable or non-renewable plasticizers)**
- **Low Halogen - RoHS-compliant, phthalate-free, HFR & PVC-free (TPE, TPU)**

# Phase I LCA Project

- **Goal** – conduct a pilot LCA within GaBi comparing PVC, TPE and TPU resins for use in RoHS-compliant US desktop power cords. Use the pilot results to develop a model for assessing different cord sets either independently and/or within the iNEMI PVC Alternatives project.
- **Pilot LCA Details**
  - **Functional unit:** RoHS-compliant US desktop power **cord** (6ft cable) made of PVC, TPE and TPU resins
  - **Scope:** Raw material extraction thru end-of-life phases
  - **Participants:** Cisco, Alcatel-Lucent, Dow
  - **Key assumptions:**
    - Utilize existing data within GaBi
    - Utilize key assumptions developed by the iNEMI project team (cut off criteria, life span, etc)
  - **Expected results:** produce an LCA model for the iNEMI PVC Alternatives project team that identifies “hot spots” across the life cycle as well as data gaps for future work by the NEMI project team



# Identified GaBi Data Gaps



## Materials Data Gaps

- PVC resin does not include additives (plasticizers, fillers)
- TPU and TPE resins are not included (only PE, PU)

## Cable Manufacturing Data Gaps

- No plastic extrusion process (only injection molding)
- Extrusion process is included in Eco-Invent database
- Different extrusion & drying processes for non-PVC resins

# Key Inputs from Power Cord Manufacturers

- **Similarities Between PVC and Non-PVC**

- Specific gravity and mass/thickness are similar for PVC and non-PVC resins used in power cord cable jacketing
- Cable jacketing extrusion process for PVC and non-PVC is done in the same factory location
- Recycled content % and production waste generation

- **Differences Between PVC and Non-PVC**

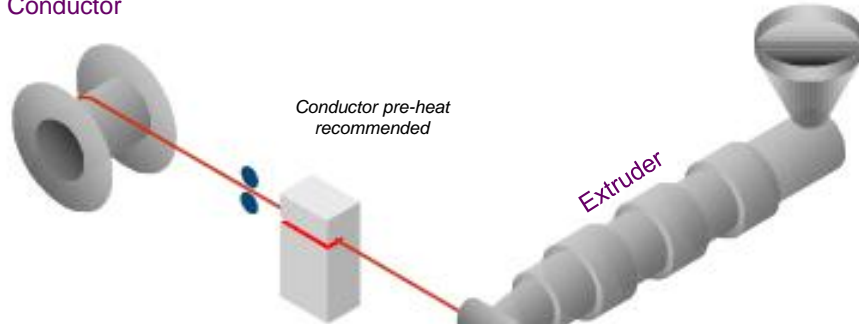
- Sourcing of resins for cable manufacturing
  - For PVC, most source of resins are from China
  - For TPE, source of resins are from China and from USA
  - For TPU, source of resins are from Europe and from USA
- Resin moisture content must be controlled for non-PVC (<0.02%) as too much moisture will affect the mechanical & electrical properties of the cable after the extrusion process
- Different parameters for extrusion and drying of PVC and non-PVC cable jacketing:

| Resin        | Extrusion Temp | Drying Conditions |
|--------------|----------------|-------------------|
| PVC          | 120-180C       | 80C for 2H        |
| TPU - glossy | 140-230C       | 100C for 6H       |
| TPU - matte  | 140-180C       | 90C for 3H        |
| TPE          | 140-180C       | 90C for 3H        |

# Dow SUSTAIN Processing Guide



Conductor



Barrel Temp:

- PVC: 160-190°C
- Non-PVC: 180-200°C

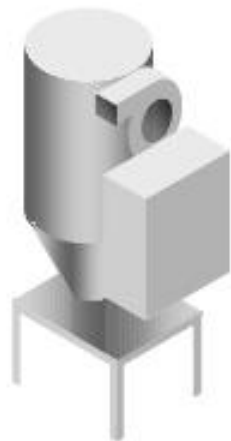
Extruder

Line Speed

- PVC: 80-100m/min
- Non-PVC: 60-100 m/min

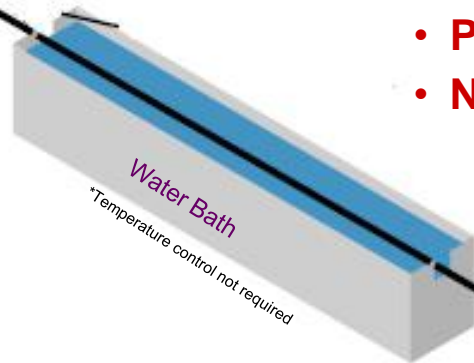


Desiccant drier



Drying Conditions:

- PVC: 110°C @ 1hr
- Non-PVC: 100-110°C @ 2hrs



\* All data based on extrusion of SVE type cable on a 75mm extruder with screw CR 3:1 and L/D 25:1



# Phase I LCA Project – Next Steps

- **March 2011 - develop a screening LCA to identify “hot spots” across the US desktop power cord life cycle**
- **April 2011 - document the screening LCA results and determine if a more detailed LCA is appropriate**
- **May/June 2011 - produce Phase I project report**
- **June 2011 - begin Phase II project**

# Phase 2 - Technical Evaluation of PVC Alternatives

**Goal:** Understand the electrical, mechanical and safety aspects of PVC alternatives. Develop, manage, and execute performance testing.

1. Develop an evaluation test matrix for PVC alternatives
2. Create a PVC alternatives global safety standards matrix, emphasis on power cords
3. Manufacture PVC-free power cords (test samples) using commercially-available resins
4. Assign teams to carry out completion of the testing per agreed-up test matrix
5. Roll-up results for final report



Questions?  
Comments?

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