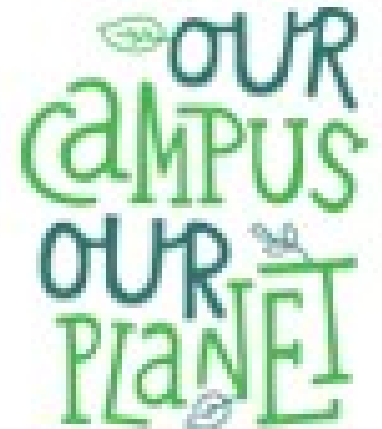


# E-Cycling

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Prepared for  
Our Campus – Our Planet  
August 30, 2010



College of Engineering, Technology, and Architecture  
**UNIVERSITY OF HARTFORD**

# Purpose of this Presentation:

To describe e-cycling

To raise awareness about hazards of just throwing our stuff away

To illustrate that manufacturers are concerned with the end life of products

To show why e-cycling is important to our campus and our planet

# Dorm rooms during my college days:





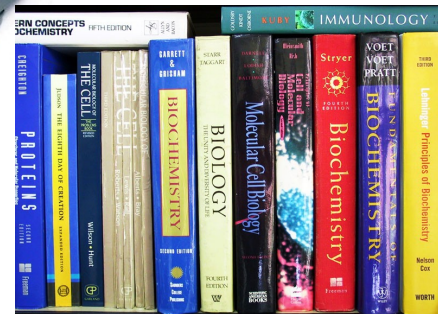


# Today's Dorm Rooms

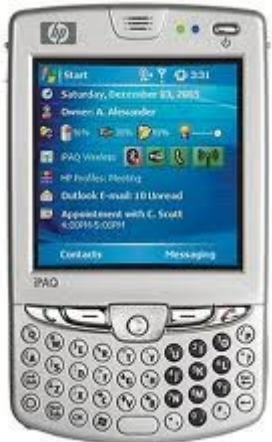




# What my classmates and I brought to College



# What members of the Class of '14 Bring with them to Hartford



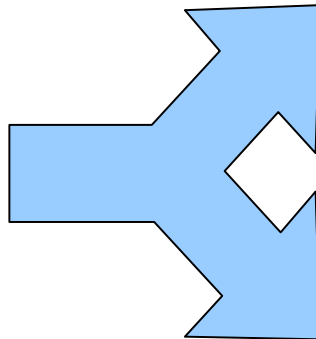


# The problem becomes more complicated

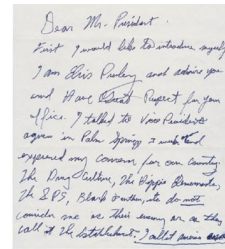


# Recycling was much simpler in my day!

Receive Letter  
from Parents



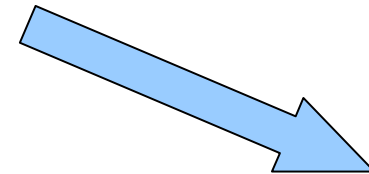
Remove Check



Possibly Read Letter  
Before Discarding



Cash Check  
ASAP





# Recycling is more complicated now!

- Most technology lasts less than 4 years
  - Computers – 2 years
  - Cell Phones – 2 years
  - Video Games – 1 year (or less)
- All technology needs power sources
- Much of our technology uses rechargeable batteries and backup batteries.
- While a University of Hartford undergraduate, a student will recycle several items of technology and numerous batteries.

# Recycling Facts

- In the United States, an estimated 70% of heavy metals in landfills comes from discarded electronics, while electronic waste represents only 2% of America's trash in landfills.
- The EPA states that unwanted electronics totaled 2 million tons in 2005. Discarded electronics represented 5 to 6 times as much weight as recycled electronics.
- The Consumer Electronics Association says that U.S. households spend an average of \$1,400 annually on an average of 24 electronic items, leading to speculations that millions of tons of valuable metals sitting in desk drawers.
- The U.S. National Safety Council estimates that 75% of all personal computers ever sold are now gathering dust as surplus electronics.
- While some recycle, 7% of cellphone owners still throw away their old cellphones.

# Why E-cycle Electronics

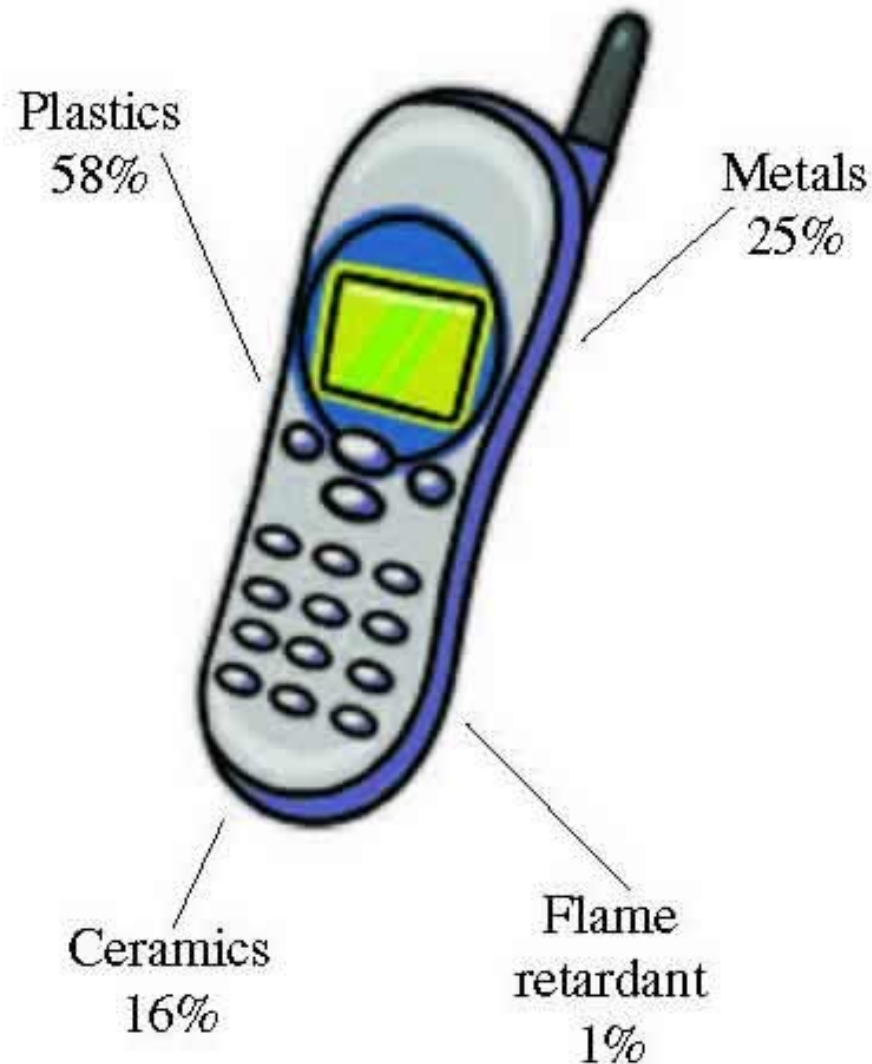
- Electronics consist of many different metals, such as copper, silver, cadmium, gold, silver, brass and tin.
- Almost all of these items include heavy metals.
- Metals, batteries and plastics can be recycled to manufacture new products.
- Such recycling would reduce the need to mine and process new materials.
- The recycled metals can be used in other areas, including plumbing, jewelry and automotive parts.



# Cell Phone Life Cycle



# What's a Cell Phone Made of?



# What's the Value of Heavy Metals in Cell Phones?

| <b>Metal</b> | <b>Metal content and value estimated for a typical cell phone</b> |              | <b>Metal content and value for 180 million cell phones in use in 2004<sup>2</sup></b> |                | <b>Metal content and value for 130 million cell phones retired in 2005<sup>2</sup></b> |               | <b>Metal content and value for 500 million obsolete cell phones in storage in 2005<sup>2</sup></b> |               |
|--------------|---|--------------|---|----------------|--|---------------|--|---------------|
|              | <b>Wt<sup>1</sup> (g)</b>   | <b>Value</b> | <b>Wt<sup>3</sup> (t)</b>   | <b>Value</b>   | <b>Wt<sup>3</sup> (t)</b>  | <b>Value</b>  | <b>Wt<sup>3</sup> (t)</b>  | <b>Value</b>  |
| Copper       | 16  | \$0.03       | 2,900   | \$6.2 million  | 2,100  | \$4.6 million | 7,900  | \$17 million  |
| Silver       | 0.35  | \$0.06       | 64.1  | \$11 million   | 46   | \$7.9 million | 178  | \$31 million  |
| Gold         | 0.034   | \$0.40       | 6.2   | \$72 million   | 3.9  | \$52 million  | 17   | \$199 million |
| Palladium    | 0.015   | \$0.13       | 2.7   | \$22.7 million | 2.0  | \$16 million  | 7.4  | \$63 million  |
| Platinum     | 0.00034   | \$0.01       | 0.06  | \$1.4 million  | 0.04   | \$1 million   | 0.18   | \$3.9 million |
| Total        |   |              | 2,973   | \$113 million  | 2,152  | \$82 million  | 8,102  | \$314 million |

<sup>1</sup>Metal content (wt) calculated from weight of a typical cell phone (Nokia, 2005) and data from Rob Bouma, Falconbridge Ltd., written and oral commun., 2005.

<sup>2</sup>Number of cell phones in use in 2004 from Charny, 2005. Number of cell phones retired in 2005 from U.S. Environmental Protection Agency, 2005. Number of obsolete cell phones projected to be in storage in 2005 from Most, 2003.

<sup>3</sup>Metal content (wt) calculated from data from Rob Bouma, Falconbridge Ltd., written and oral commun., 2005.



# Real quandry nowadays



# What are the recycled materials from the rechargeable batteries and old cell phones made into?

Rechargeable batteries and cell phones can be recycled and used to create other types of materials, including new batteries, stainless steel products and more.

If the recycler is resourceful, none of the material broken down from the recycling of rechargeable batteries and cell phones makes its way into the landfills.

Consumers use an average of six wireless products in their day-to-day lives, and the average cell phone is replaced (or upgraded) every 18 to 24 months. That's a lot of rechargeable batteries and cell phones!!!

# Battery Facts

- Americans purchase nearly 3 billion dry-cell batteries every year to power radios, toys, cellular phones, watches, laptop computers, and portable power tools.
- Inside a battery, heavy metals react with chemical electrolyte to produce the battery's power.
- Wet-cell batteries, which contain a liquid electrolyte, commonly power automobiles, boats, or motorcycles.
- Nearly 99 million wet-cell lead-acid car batteries are manufactured each year.
- Mercury was phased out of certain types of batteries in conjunction with the "Mercury-Containing and Rechargeable Battery Management Act," passed in 1996.
- Recycling batteries keeps heavy metals out of landfills and the air. Recycling saves resources because recovered plastic and metals can be used to make new batteries.
- Batteries contain heavy metals such as mercury, lead, cadmium, and nickel, which can contaminate the environment when batteries are improperly disposed of. When incinerated, certain metals might be released into the air or can concentrate in the ash produced by the combustion process.
- One way to reduce the number of batteries in the waste stream is to purchase rechargeable batteries. Nearly one in five dry-cell batteries purchased in the United States is rechargeable. Over its useful life, each rechargeable battery may substitute for hundreds of single-use batteries.



# Alkaline Manganese Batteries



- Alkaline batteries are used in everything from cameras and flashlights to remote controls.
- In general you may be put alkaline batteries in with your regular trash. This is partly due to the Mercury-Containing and Rechargeable Battery Management Act passed in 1996 that phased out the use of mercury in alkaline batteries, making them less of an issue when disposed in landfills. But this doesn't mean alkalines are not recyclable.
- If you do decide to put alkaline batteries in the trash, you can take extra steps to prevent leaking such as:
  1. Putting multiple batteries in the same plastic bag
  2. Securing the ends of each battery with masking tape
- End Result: Recycling these batteries can recover steel and zinc, two valuable metals. In the case of steel, it can be reprocessed into rebar.



# Nickel-Cadmium (Ni-Cd) Batteries

Ni-Cd batteries are the inexpensive rechargeable form of alkaline batteries. They can be recharged hundreds of times to avoid disposing of batteries and are, for the most, part interchangeable with alkalines.

A cadmium-free alternative to these batteries is Nickel Metal Hydride (NiMH), which you'll now find more often with name brands of rechargeable batteries.

One little known fact about Ni-Cd batteries is that part of the built-in price is to cover proper disposal. Due to the presence of the toxic metal cadmium, these batteries are considered hazardous waste and are not allowed in landfills.

End Result: For both Ni-Cd and NiMH batteries, recycling involves using heat to separate the high temperature metals, such as nickel and iron, from the low temperature ones, like zinc and cadmium. Some of the metals solidify after they melt, while others are reprocessed as metal oxides. These metals all have value.

# Lithium-Ion (Li-ion) Batteries



- Li-ion batteries are one of the newest forms of rechargeable technology. They are commonly found in cellular phones and consumer electronics. These batteries are also being introduced as the power source for electric vehicles.
- It's likely that you'll be disposing a Li-ion battery along with an electronic device, such as upgrading a cell phone or selling a laptop. In most cases, the company that handles your electronic device will accept the battery as well.
- End Result: These batteries are recycled in the same way as Ni-Cd batteries and produce valuable metals.
- One reason to not store Li-ion batteries or put them in a landfill is that they have the potential to overheat and explode when exposed to hot temperatures. If you're starting to collect Li-ion batteries before you recycle them, it's a good idea to store them in a cool location.

# Silver Oxide Batteries



- This is the most common form of the button cell battery, which are usually find in calculators, cameras, and wristwatches. In addition to their small size, button cells are known for a long storage life and the ability to work well in low temperatures.
- Silver oxide and other button cell batteries also contain mercury, which makes recycling a must. Luckily, you'll have fewer button cells to recycle since they aren't as common and last longer.
- In many cases, a professional will replace these batteries, so ask the business if it will recycle the battery for you. If not, often times these batteries are accepted as part of household hazardous waste programs. Button cells have an alphanumeric code, and the first letter indicates what type you have ("L" for manganese dioxide, "S" for silver oxide).
- End Result: Silver oxide batteries are typically shredded during the recycling process to recover the valuable heavy metals.

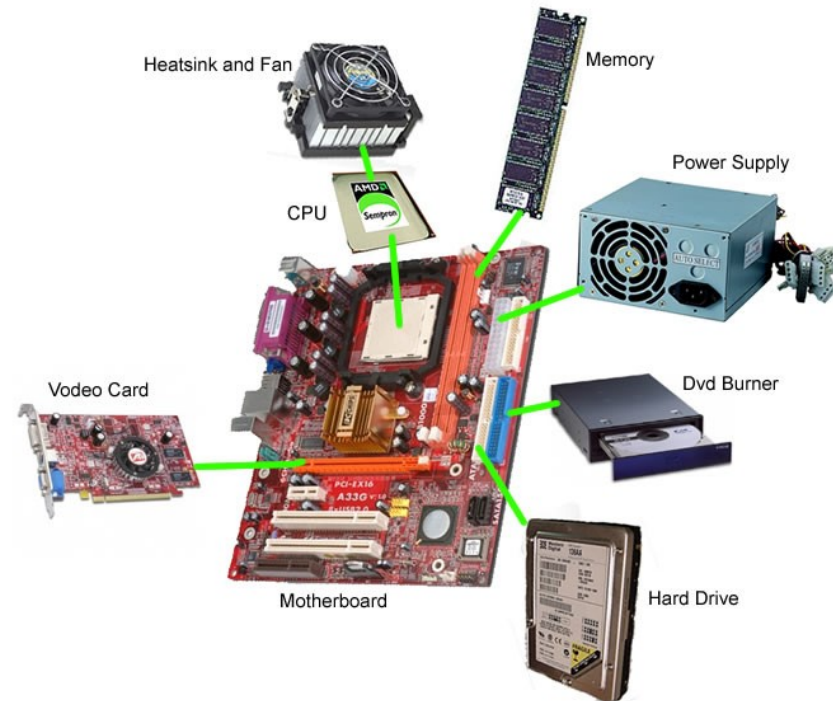
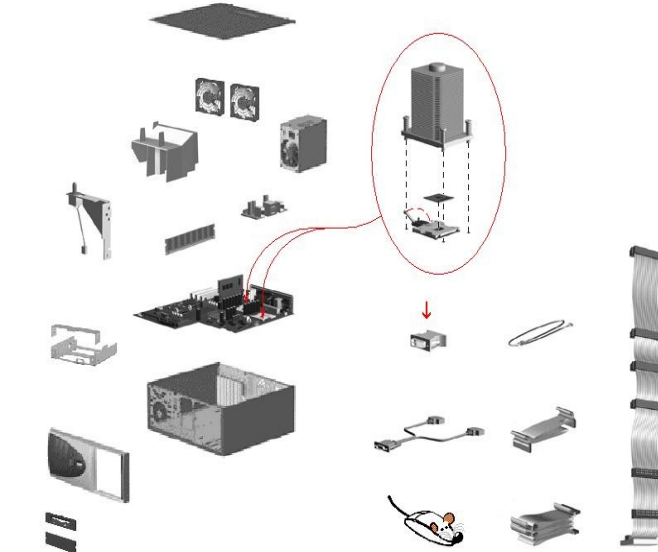
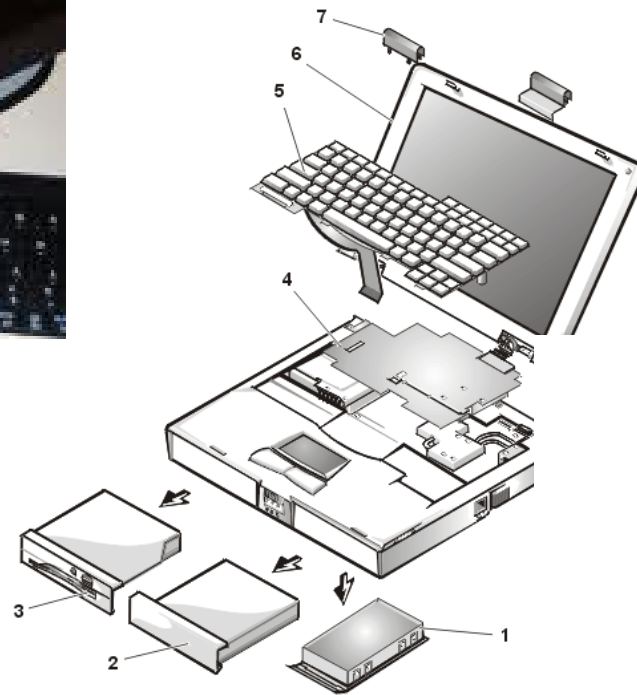


# Lead-Acid Batteries



- These are the batteries that primarily power automotive units, such as cars, boats, golf carts, motorcycles and even lawn mowers.
- Lead-acid batteries have a 97 percent recycling rate, the highest of any consumer product in the U.S., which is good because they're one of the most harmful products in a landfill with a mixture of lead and sulfuric acid.
- End Result: Lead-acid batteries are recycled by separating the battery into its three main components: Plastic, lead and sulfuric acid.
  - The polypropylene plastic is reprocessed into new battery cases
  - Lead pieces are cleaned and also reprocessed for use in new batteries
  - The battery acid is either neutralized and sent through a waste water treatment plant to be cleaned for human consumption, or it's converted into sodium sulfate that's used in laundry detergent

# What about our Computers!



According to the Carnegie Mellon University Green Design Initiative Technical Report #97-10, there are three classes of hazardous materials in computers.

Class I - Materials not necessary for operation

Class II - Materials necessary for operation, but expensive to replace.

Class III - Materials necessary but with no easy replacement.

# Class I materials

- Primarily Lead shielding for CPU cases.
- Manufacturers have switched to cases which use more plastic for shielding, as well as using metals other than Lead.

# Class II materials

- Include
  - PCP in capacitors
  - Cadmium in batteries
  - Lead Solder on circuit boards
  - Mercury in batteries and switches.
- Cadmium is still present in rechargeable portable computer batteries, as are traces of Mercury, but each in lower quantities.
- Nickel-Cadmium (NiCd) technology continues to be the most widespread choice in the industry, although other options such as Nickel-metal-hydride (NiMH) exist.
- Lead solder is still a standard part of circuit board fabrication, but again, less is being used due to technology advances.



# Class III materials

- Include
  - Phosphorous in monitors
  - Copper-plastic interface cables
  - Silicon and Arsenic in integrated circuits
- Little progress has been made in removing these materials from design other than through reduction.
- An interesting side-effect of the continued use of metals in the design of computers is that they account for a high percentage of the end-of-life value of products. The more metals present (e.g. Aluminum), the higher the reclamation value for a recycling firm. Ironically, as metals are successfully replaced, there will be less incentive for recycling to occur. Metals account for over 70% of the residual value of computers.

# What about our LCD Displays?



- LCD Displays contain a fluorescent back-lamp that contains Mercury and Cadmium.
- Should be properly recycled
- Recently it was found that a process of heating, then cooling and dehydrating the PVA (polyvinyl-alcohol, the key component of LCDs) with ethanol produces a surface area of mesoporous material with great potential for use in biomedicine. The resultant product's anti-microbial properties can now be enhanced by adding silver nanoparticles, producing something which is anti-bacterial and can kill things like E.coli. (However this will be well in the future.)

# What Happens to Recycled Electronics?

- Ideally the recycling processor will remove the reusable items, extract the re-processable metals and plastics, and environmentally soundly discard the rest.
- On the other hand...

- Often the materials are shipped in bulk to countries where environmental regulations are not as strict as in the US and EU countries.
- There people working under hazardous conditions remove parts and disassemble the systems often using techniques that are not environmentally friendly or, even worse, safe.



## Third World “Recycling”



Photos from the NY  
Times



# What about Compact Fluorescent Lamps?



# Compact Fluorescent Lamps



Don't dump your dead CFL's in the trash.

- CFL's contain a small amount of mercury; approximately 3-5 milligrams. It's a tiny amount, about the size of the very tip a ballpoint pen and far less than what is present in a watch battery. Still, a hundred million of these small amounts does become a significant issue.
- However, while there has been quite a bit of panic about mercury in CFL's, coal fired electricity production generates mercury in the form of emissions that go straight into the atmosphere. Most likely, CFL mercury levels are far less than the additional mercury emissions involved in powering a comparable incandescent globe over the same period of a CFL's lifespan.

- Additionally, at the end of a CFL bulb's life, little of the mercury remains in its most toxic form.
- Regardless, given the fragility of the bulbs; caution is necessary and mercury shouldn't wind up in landfill at any time and at any level. Mercury is a powerful toxin that contaminates earth, air and water and accumulates in animal tissue.

# What if you break a CFL?



- Open windows in the room to air out for 15 minutes before cleaning up
- Don't use a vacuum as this will spread mercury into the air
- Wear gloves when cleaning up
- Use a disposable brush to gently sweep up fragments
- Use a moist paper towel to help pick up remaining tiny fragments
- Wrap the pieces up in layers of newspaper and place in a sturdy sealable bag or container along with anything used to clean up the mess.

Then to place the container or bag in your rubbish bin, but I feel that perhaps it should be treated as hazardous chemical waste; i.e. stored safely until such time that it can be taken to a hazardous chemical disposal facility.

It pays to be extra careful when handling a CFL bulb :).

# What Industry has done

- ROHS
- Design for Recycling.
- Mandatory recycling for some products, especially in the EU
- Made recycling easy
- Understand the the supply chain for a product includes e-cycling



# Restriction of Hazardous Substances - RoHS

- Directive of the European Union
- Products made anywhere in the world, if they are to be sold and used within the EU are required to conform to ROHS regulations
- Materials banned -
  - Lead (Pb)
  - Mercury (Hg)
  - Cadmium (Cd)
  - Hexavalent chromium (CrVI)
  - Polybrominated biphenyls (PBB)
  - Polybrominated diphenyl ethers (PBDE).

# Design for the Environment (DfE)



Look for the label!

Program of U.S. EPA

Design Products that are safe for the environment

<http://www.epa.gov/opptintr/dfe/index.htm>

# DfE Areas Related to Electronics

## Electronics

- Computer Display Partnership
- Flame Retardants in Printed Circuit Boards
- Lead-Free Solder Partnership
- Printed Wiring Board Partnership

## Lithium-ion Batteries and Nanotechnology Partnership

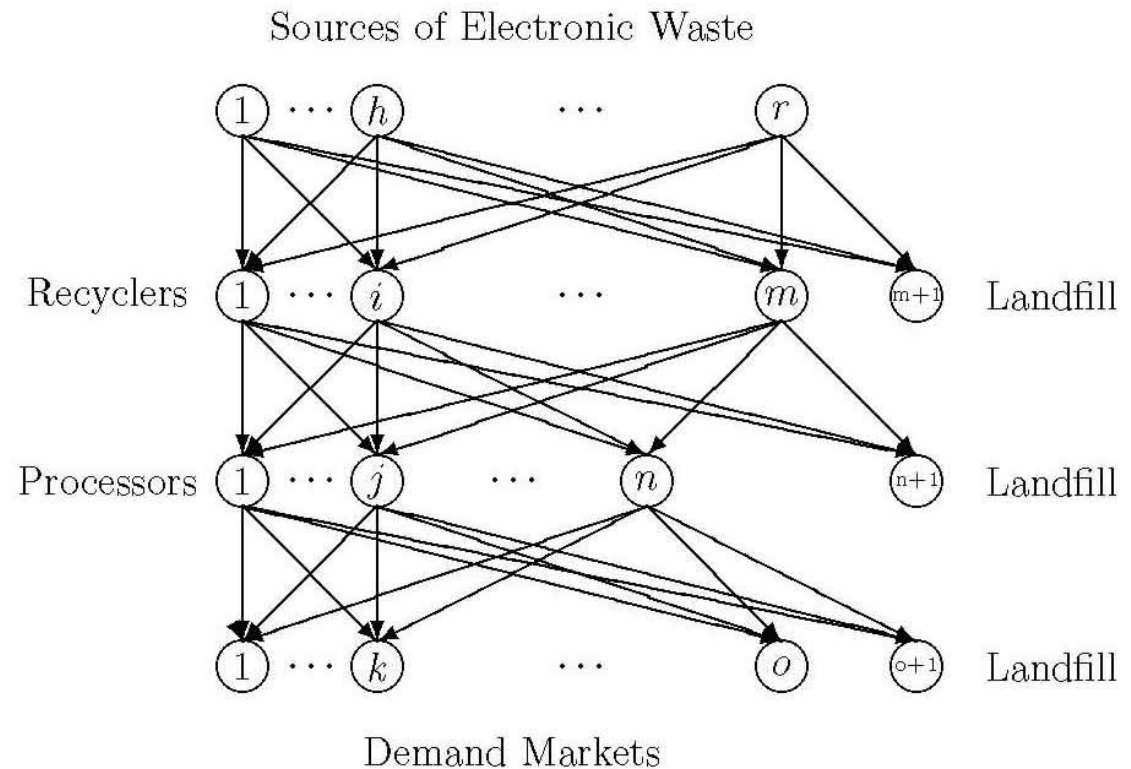
## Wire & Cable Partnership

More info - <http://www.epa.gov/opptintr/dfe/pubs/index.htm>

# Mathematical Models of Supply Chain and E-cycling

Companies have realized that recycling is an important part of the Supply Chain.

One can formulate the complex reverse supply chain network of electronic waste management and recycling to obtain the endogenous equilibrium prices and material flows between tiers.



# Trash at the University of Hartford

According to John Michalewicz from O&M -

- The residential side of campus (Less the Commons) historically generates 30 tons of trash per week (about 1000 tons of trash per academic year).
- It is impossible for use to calculate or otherwise determine how much of it is junk electronics.
- As a rule, O&M staff who find electronics left behind or damaged/discarded handle it as electronic waste. This waste is not included in the 1000 ton number.
- When the University's hauler dumps our material at the burn plant, if even a small percentage of electronic waste is found, O&M would hear about it – O&M has had no reports in the last 5 years.



# What we can do at Hartford?

- Ensure all batteries are recycled properly and not just thrown into the trash.
- Keep larger electronic articles for electronic waste recycling at the end of the academic year.
- Learn which plastics can be recycled and put into the appropriate bins.
- Recycle Ink and Toner cartridges.

## DO NOT THROW IN THE TRASH



- Batteries

- Fluorescent Tubes



- CRTs



- Hazmat containers (even empty)



- Electronic items



These items are hazardous waste (HW).

It is illegal to throw them in the trash. The Navy can be fined by the local or state regulators if HW from the installation is found at unauthorized landfills. Electronic items are also regulated for recycling or disposal.

For disposal option: Coordinate with the Installation Environmental Office



## DO NOT THROW IN THE TRASH (ONE MORE TIME!)



- Appliances



- Tires



- Wood \*note that treated wood is a hazardous waste



These items can be recycled.

For disposal of these items, check with the installation Environmental office or get information from the Hazardous Waste Management Plan.

Thanks for coming  
and  
Have a Great 4 Years at Hartford!  
And remember to  
Reduce  
Reuse  
Respect  
Recycle



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