CAUSE 2003: From Industrial Revolution to...

Industrial Ecology

with Amish, Eric, and Lauren
History of IE

• A system that "would maximize the economical use of waste materials and of products at the ends of their lives as inputs to other processes and industries."
  - Frosch, 1992

• Essentially mimics natural systems
Types of Industrial Ecosystems

• Local, Regional, National, Global

• Industrial Symbiosis

• The Eco-Industrial Park
An Eco-Industrial Park in Devens, Massachusetts

“We should leave to the next generation a stock of ‘quality of life’ assets no less than those we have inherited.”

- Devens Enterprise Commission

- Local opinion

- Government action
View of Devens, Massachusetts
Major Characteristics of the Devens Eco-Industrial Park

• Material, water, and energy flows
• Companies within close proximity
• Strong informal ties between plant managers
• Minor retrofitting of existing infrastructure
• One or more anchor tenants.
Examples of IE

Common Sense IE:

Saving resources
Recycling
Be efficient when possible

Why?

Fewer resources consumed
  → lower operational costs

Less waste/trash
  → lower disposal costs
Examples

• Liberal plans
• Using renewable resources
• Wastes become new resources
• Efficient production
• Long-lasting design of systems
PSU Dining Commons

- Computer software
- Batch Cooking
- Napkins
Kalundborg, Denmark

- Industries exchange wastes
- Companies made agreements 70s - 90s
- Asnaes – Coal-fired power plant
- Statoil – Oil Refinery
- Gyproc – plasterboard company
- Novo Nordisk – biotechnology company
## Coal Power Plant

<table>
<thead>
<tr>
<th>Inputs:</th>
<th>Products:</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Coal</td>
<td>• Electricity</td>
</tr>
<tr>
<td>• Surplus gas from nearby refinery</td>
<td>• Steam + Heat</td>
</tr>
<tr>
<td>• Cool Salt Water</td>
<td>• Hot Salt Water</td>
</tr>
<tr>
<td></td>
<td>• Ash</td>
</tr>
<tr>
<td></td>
<td>• Gypsum</td>
</tr>
</tbody>
</table>

Coal Power Plant

- Waste Gas
- Gypsum
Oil Refinery

- Petroleum
- Steam
- Gas
- Sulfur
- Fuels
Industrial Ecology in Kalundborg

• Saves resources:
  - 30% better utilization of fuel using combined heat + power than producing separate
  - Reduced oil consumption
  - 3500 less oil-burning heaters in homes
  - Does not drain fresh water supplies

• New source of raw materials
  - Gypsum, sulfuric acid, fertilizer, fish farm

http://www.symbiosis.dk
Lead

Atomic Number: 82
Atomic Mass: 207.20
FIGURE 7  Simplified model of the industrial ecology of lead (amounts in tons per year).
Analysis of Lead, 1989, USA

• % Lead consumed for batteries = 78%
• In lead-acid batteries 700,000 tons out of 800,000 tons recycled, were re-processed and reused ~ (87%)
Figure 3. U.S. lead consumption, by end use, nonbattery uses, 1978-98.


~ 360,000
~ 130,000
~ 90,000
Figure 2. U.S. lead consumption in batteries, 1978-98.
Lead, 1998

- % Lead consumed for batteries = 88%
- 95% recycling efficiency
Automobile IE

- 65% of an automobile is comprised of iron and steel
- In 2001, 15 million tons of iron and steel were recycled from automobiles
- Can be used to produce 48 million steel utility poles

http://www.recycle-steel.org/cars/main.html
From the Junkyard

- Useable engines, tires, batteries, fluids, and other parts are removed for resale
- The body is shipped to a scrap yard
- Magnets separate iron/steels
- Scrap metal is sent to steel mills
- New car bodies are made with at least 25% recycled steel
- Other parts such as tires can be shredded and reused

http://www.recycle-steel.org
# Material used in cars

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>ca. 1950s</th>
<th>ca. 1990s</th>
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</thead>
<tbody>
<tr>
<td>Plastics</td>
<td>0</td>
<td>101</td>
</tr>
<tr>
<td>Aluminum</td>
<td>0</td>
<td>68</td>
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<tr>
<td>Copper</td>
<td>25</td>
<td>22</td>
</tr>
<tr>
<td>Lead</td>
<td>23</td>
<td>15</td>
</tr>
<tr>
<td>Zinc</td>
<td>25</td>
<td>10</td>
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<tr>
<td>Iron</td>
<td>220</td>
<td>207</td>
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<tr>
<td>Steels</td>
<td>1290</td>
<td>793</td>
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<tr>
<td>Glass</td>
<td>54</td>
<td>38</td>
</tr>
<tr>
<td>Rubber</td>
<td>85</td>
<td>61</td>
</tr>
<tr>
<td>Fluids</td>
<td>96</td>
<td>81</td>
</tr>
<tr>
<td>Other</td>
<td>83</td>
<td>38</td>
</tr>
<tr>
<td><strong>Total Weight</strong></td>
<td><strong>1901</strong></td>
<td><strong>1434</strong></td>
</tr>
</tbody>
</table>

http://www.fes.uwaterloo.ca/u/jjkay/pubs/IE/

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Why Aluminum?

- Can replace steel
- Less dense than steel
- Increased fuel economy due to lighter automobiles
- Less emissions
- Rusting
European Aluminum Association
Aluminum Production

• Aluminum requires large amounts of energy to extract ~ 6 – 8 times more than steel

• However, recyclable without much loss
Aluminum Cans

- In 1998 879,000 metric tons of Aluminum cans were recycled (63% of all Al cans)
- Cans comprise less than 30% of Al products
- In 1998, 3.4 million metric tons of Aluminum were processed from recycled Aluminum (37%).

http://www.aluminum.org/Template.cfm?Section=Recycling
Summary of Autos

• Recycling steel and aluminum
• Replacing steel with aluminum
• Buying longer lasting automobiles with better fuel economy
• Using alternate means of transportation
IT'S INTERMISSION TIME, FOLKS!
The Economics of Ecology
(or...covering your bottom line)

Pictures courtesy of http://pubs.wri.org/pubs_description.cfm?PubID=3786
and http://www.kbnp.com/bl.htm respectively.
Monterey Regional Waste Management District Regional Environmental Park

- “Reduce, Reuse and Recycle”
- Hazardous Waste Mitigation
- Reselling materials instead of dumping
- Landfill Gas Power Project
Cape Charles Sustainable Technology Park

Create 400 Jobs in first stage of development for Local Area
  * 27% below poverty line

Redevelop Brownfields
Government Subsidy
Natural Habitat and Infrastructure
Solar Building Systems, Inc.
Energy Recovery
Market Failure
Negative Externalities

• Harm proportionate with output produced
• Harm increases at an increasing rate with output produced (synergistic effect)
• Harm significant initially, increases at decreasing rate with output produced

![Negative Externalities Graph]
Market Failure Correction: Subsidies
Economic Benefits of IE

• Hidden Resource Productivity Gains
  – **Within Firm**: eliminating waste
    • Making plant more efficient
  – **Within Value Chain**: reducing costs
    • Synergies between production and distribution
  – **Beyond Production Chain**: closed loop
    • Eco-Industrial Parks and inter-firm relations
Benefits of IE to Corporation

• Revenue Generation
• Cost Savings
• Reduced Liabilities
• Competitive Edge of Regulatory Flexibility
• Enhanced Public Image
• Market Leader
Barriers to Development

• Suitability of materials to reuse
• High cost of recycling (internalize negative externalities)
• Information Barriers (must set up reciprocal relationships between sectors)
• Organizational Obstacles
• Institutional Barriers (need fiscal and regulatory government intervention)
Macro to Micro Scale of IE

- Macro: Industrial Processes as a whole
- Meso: Sector Interrelationships
- Micro: Individual Consumer/Producer Behavior
- “Conspicuous Consumption” and Conspicuous Waste

Photo courtesy of: http://www.cpm.ehime-u.ac.jp/AkamicHomePage/Akamic_E-text_Links/Veblen.html
Jobs, Jobs, Jobs

• "President Bush is committed to increasing the productivity and wealth of the American economy and to ensure that all regions, states, and communities share in economic opportunity." ~ David A. Sampson, Assistant Secretary of Commerce for Economic Development
IE: Other Examples
The Future of IE
That One Guy
References

- http://www.is4ie.org/history.html
- http://www.devensec.com/sustain.html