Analytic Tools for Industrial Ecology

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Analytic Tools

• Case studies aren’t enough….YOU NEED TOOLS

• When dealing with Industrial Ecology, case studies need to be complimented with quantifiable analysis in order to ensure better decision-making
Analytic Tools

- Material Input per unit of Service (MIPS)
- Environmental Risk Assessment (ERA)
- Material Flow Accounting (MFA)
- Cumulative Energy requirements Analysis (CERA)
- Environmental Input-Output Analysis (IOA)
- Life Cycle Costing (LCC)
- Total Cost Accounting (TCA)
- Cost Benefit Analysis (CBA)
- Cost-Effectiveness Analysis (CEA)
- Multi-Criteria Analysis (MCA)
- Total Quality Management (TQM)
Life-Cycle Assessment

“The life-cycle assessment is an objective process to evaluate the environmental burdens associated with a product, process, or activity by identifying and quantifying energy and material usage and environmental releases, to assess the impact of those energy and material uses and releases on the environment, and to evaluate and implement opportunities to effect environmental improvements. The assessment includes the entire life cycle of the product, process or activity, encompassing extracting and processing raw materials; manufacturing, transportation, and distribution; use/reuse/maintenance; recycling, and final disposal (SETAC 1993).”
Life-Cycle Assessment

• Measuring the “cradle-to-grave” impact of a product on the environment.
• Most comprehensive approach to assessing environmental impact
Life-Cycle Assessment

- Evolved to a standardized and general method
- Society of Environmental Toxicology and Chemistry (SETAC) published widely accepted series of guidelines and principles in “Life-Cycle Assessment Code of Practice”
- International Standard Organization established 14040 for LCA methods
Life-Cycle Assessment

- **Goal Definition (ISO 14040)** – basis and scope of evaluation defined
- **Inventory Analysis (ISO 14041)** – create process tree to map out inputs and outputs connected with product
- **Impact Assessment (ISO 14042)** – emissions and consumptions are translated into environmental effect.
  - Impact categories: extraction of abiotic & biotic resources, land use, climate change ozone depletion, human toxicity, eco-toxicity, eutrophication, acidification etc.
    - Data is categorized, weighted, and normalized.
- **Improvement Assessment/Interpretation (ISO 14043)** – Areas for improvement are identified.
Life cycle analysis in Practice
McDonalds Corporation
Largest food service organization in the world
18 million customers daily
Unpaid external environmental costs resulting from:
  Industrial beef production
  Use of Polystyrene in packaging
Life cycle inventory for beef
260 million acres overgrazed

40% of world grain

25% of Central American Forests

Fertilizers, pesticides, habitat loss, CO₂

EXHIBIT 4: WATER USED IN PRODUCTION

- Beef
- Butter
- Almonds
- Chicken Meat
- Soybeans
- Eggs
- White Rice
- Sugar
- Brown Rice
- Barley
- Oats
- Corn
- Orange Juice
- Broccoli
- Melon
- Tomatoes
- Lettuce

Gallons of Water Used per Pound of Food

Source: Water Education Foundation
EXHIBIT 5: SOURCES OF METHANE

- Wetlands
- Rice Paddies
- Cattle
- Burning of Vegetation
- Gas Drilling
- Termites
- Landfills
- Coal Mining
- Other Animals
- Oceans
- Fresh Water

Source: Cicerone Oremland, Biogeochemical Aspects of Atmospheric Methane
Life Cycle Improvement Analysis
Reduce individual beef consumption by 50%

Replace with organic grains, legumes, veggies and fruit

Reform current cattle-industry practices

Polluting and Depleting our Water—Cattle produce a billion tons of organic waste each year. Waste from livestock, and the pesticides and fertilizers used to grow feed, are the number one non-point source of water pollution in the U.S. Almost half the water used in the U.S. each year goes to grow feed and provide drinking water for cattle and other livestock. It takes 29 gallons of water to produce a pound of tomatoes, 139 gallons to produce a pound of bread, but 2,464 gallons to produce a pound of beef.

Animal Suffering—Each and every day, 100,000 cattle are slaughtered in the U.S. Their deaths are cruel and horrible—a shocked with electric prods, beaten and kicked, shot with a stun-gun, hung by their feet, their throats cut.

Global Warming—Cattle are a major source of greenhouse gases.

But… “there’s nothing wrong with eating beef—its American”

More than 8,500 McDonald’s restaurants in America—and thousands more around the world—proudly advertise more than 85 billion hamburgers sold. What’s the real cost of these? For starters:

- tens of millions of cows slaughtered;
- trillions of gallons of water used to grow their feed;
- millions of tons of methane, a greenhouse gas, released;
- millions of acres of public land eroded and destroyed;
- enough grain fed to cows to provide millions of hungry families with a daily meal.

Most McDonald’s patrons are unaware of how their individual decisions as consumers add up to create such a devastating global impact.

But this April and May, through the Adopt-A-McDonald’s Campaign—at more than 1,000 McDonald’s across the nation—more than 1,000,000 customers will get the facts about the real cost of buying a fast-food burger.
Life Cycle Inventory for Polystyrene
EXHIBIT 6: PRODUCTION OF POLYSTYRENE PACKAGING

Disposal

Cru Production

Roundwood Harvesting

Wood Residue

Corrugated Liner and Medium Manufacture

Corrugated Box Fabrication

Shaded boxes indicate primary packaging; other boxes indicate secondary packaging.
Life Cycle Improvement analysis
On November 2, 1990, McDonald’s announced its decision to replace the polystyrene clamshell sandwich packaging with a paper-based “quilt-wrap” that was expected to reduce the volume of its packaging by 90 percent. Representatives also stated that the production process used to make the new wraps would result in reduction of energy consumption, air emissions, and water pollution. Burger King and Wendy’s do not use polystyrene for their sandwich wraps; Burger King uses polystyrene only for coffee cups and has even begun to phase out this use.
Use of organic paper

Reduction of chemicals when using non-bleached paper

Easiest to recycle

Efforts toward sustainable wood harvest

Use of air pollution controls

But… Large water and wood requirement, requires transport
Implications

• Major problem of LCA is the complexity and effort required to quantify the effects of ONE product or function.
• Incomplete data leads to uncertainty – however at least there is some kind of foundation for a more informed decision.
• Streamlining
• Life-cycle thinking
Information Systems

• Traditional information systems
  – Consolidate data
    • Economic
    • Technical
  – Turn data into information useful to firms and shareholders

• Environmental information systems
  – Consolidate data
    • Environmental
    • Regulatory
    • Economic
    • Technical
  – Turn data into information useful to firms, the public, government, and planners
  – E.g. Toxic Release Inventory

• Inter-organizational information systems
Eco-industrial parks (EIPs)

• EIPs convert waste by-products into inputs
  – Materials, water, energy
  – Industrial symbiosis
  – Industrial ecosystem

• Obstacles
  – Requires exchange of large amounts of information about industrial inputs and outputs
  – Most information not publicly available in U.S.
Eco-Industrial Park Management

- Inter-organizational information system
  - Support intercompany communication
  - Inform member firms of local environmental conditions
  - Provide feedback on EIP performance
  - Publicly accessible
Shortcomings of information systems

• Data is flawed
  – Uncertainty of environmental information
    • Difficult to quantify
    • Difficult/time-consuming to obtain
    • Temporal variability and seasonality
    • Spatial heterogeneity
  – Accuracy and precision of data usually not reported

• Data is manipulated
  – “Sweetheart reporting”
  – Aggregation/oversimplification
  – Category definition and naming
  – System boundaries
Risks in EIPs

• By-products exchange requires reliable supply
  – Agriculture is seasonal
  – Standby supply source
• Constant demand
  – Unwanted by-products must be disposed of as waste
FaST, DIET, & REaLiTy

- Decision support tools designed by EPA to aid development of EIPs
- FaST: Facility Synergy Tool
- DIET: Designing Industrial Ecosystems Tool
- REaLiTy: Regulatory, Economic, and Logistics Tool
The Burlington EIP

- Proposed EIP would be a 10-acre site in the Intervale
- Site currently contains 4 facilities:
  - McNeil wood-burning power plant
  - Private/community farms
  - Composting facility
  - Waste Wood Depot
FaST

- Planners analyze industry profiles of the input/output flows:

*Note that the compost facility generates revenue by charging to accept certain input streams.*
FaST

- FaST compiles these facility profiles
- Planner searches for input/output matches…

Search for Facility Synergies
DIET

- Planner exports FaST data to DIET
- Select the desired weights:
  1. Environmental Benefits
  2. Cost Savings
  3. Job Creation

Based on these weights, DIET suggests:
- Certain facilities
- Linkages
- Facility size
- Number of jobs
### The Size of Facilities Locating at the Park

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The total amount of land required for the facilities at the park:

- Land Used: **10.0**

The total amount of land available at the EIP site:

- **SIZE: 10.0**
REaLiTy

• An updated database
• Planner checks the EIP Model developed by FaST and DIET for potential Regulatory, Economic and Logistic constraints:
  – Future regulation on waste management
  – Unprofitable facilities
  – Seasonal and temporal fluctuations
  – Specific input/process requirements
Limitations of FaST, DIET, and REaLiTy

• “Scoping models,” NOT detailed systems
• Quantitative estimates only a framework
• Relies on incomplete information
• FaST is not user friendly
• EPA canceled funding for tools in 2000
• “Very unlikely that the software will be updated in the foreseeable future”
  – Suzanne Giannini-Spohn, EPA program manager
Closing Thoughts

• Analytic tools are vital for Industrial Ecology
• Provide opportunity for being proactive
• Need to develop better incentives to promote use and further development
  – User friendly
  – Cost/Time efficient
Thank You!