Industrial Ecology: Design with Nature

SESHA/DTSC
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Natural Logic
Building profit and competitive advantage through exceptional environmental performance

Strategy:
Value generation
Strategic Sustainability™ Consulting
Strategic Supply Chain Partnerships™
Marketing and product development
CSR reporting as strategic business tool
Sustainable economic development
Life cycle thinking

Design:
Collaborative Innovation
Integrative design process / charrettes
Green / High performance buildings
LEED training and process management
Green materials research / specification
Permaculture systems: design with nature
Building / Site / Natural system integration

Tools:
Metrics, Dashboards, Reporting
Business Metabolics™ benchmarking software
Key Performance Indicators development
CSR Reporting Power Tools
EcoAudit Toolkit
EQE Checklist

Operations:
Advanced resource productivity
Integrated EcoAudits: process efficiency
Environmental Management Systems
Evaluation & implementation
Green building operation protocols
Profit Discovery processes
Industrial Ecology:
What it is, what it isn't, and why

• The industrial ecology concept has deep practical and intellectual roots, stretching far earlier than the oft-cited Kalundborg example.
• Considerable promise for improving economic performance while reducing industry's environmental footprint.
• Considerable challenges -- technical, entrepreneurial, some of them perhaps intrinsic to the current Eco-Industrial Development model itself -- to realizing that promise.
• Eco-Industrial Development -- the application of industrial ecology principles to industrial development and regional economic development
• Idea has captured the imagination of countless analysts and some 60 North American communities.
Context
Something has shifted

- **Sustainability:**
  Moving from gleam to mainstream

- **More significant than the shift from**
  “pollution prevention” to “pollution control”

- **Transforming “environment” from a**
  financial burden to a source of strategic
  business advantage
  - Process efficiency
  - Design revolution

- **Transforming role of business**
Why should we care?

• Resource depletion
• Pollution, health, productivity
• Life support systems: Air / Water / Food / Biodiversity / Climate
• Balance of payments
• License to operate
• Competition
• Social equity & social stability
Massive economic impacts

- Money down the drain
- Profit margins squeezed
  - uncontrolled yet avoidable resource costs
  - inefficient production processes
- Risk management diverts critical resources
- High cost & value
  - customer and employee loyalty
  - brand erosion
Energy “down the drain”

• US manufacturing
  – $64 billion on fuels and electric energy

• US trade
  – 1999 energy imports $44.6 billion
  – 1999 trade deficit $218.2 billion

• US energy budget
  – $200 billion/year national savings if we just match Japan
Materials “down the drain”

- US manufacturing
  - $1.9 trillion on materials

- “Waste” treatment & remediation:
  - $81.9 billion annual expenditures

- Pollution abatement:
  - $8.4 billion capital investment for manufacturers
    - (7.5% of total capital investment)
  - $19.2 billion operating costs

- “Total Cost of Waste” (Steven Rice)
  - 4-10 times direct (disposal) costs
Only two things...

Energy

Materials

Industry
Company
Facility
Process

Product

NonProduct
“Waste”? No such thing!

- Contextual - like weeds - yet significant
- No “waste” in nature
- “Non-Product Output” adds no value to a company’s customers or shareholders
- The U.S. economy’s physical output?
  - 94% “waste”
- Accounting systems miss full costs
Enter: Industrial Ecology
Industrial Ecology: Design with Nature

- Nature's ecosystems have more than 3.5 billion years of experience evolving efficient, complex, adaptive, resilient systems.
- Why should companies reinvent the wheel, when the R&D has already been done?
  - Gil Friend, 1991
History

- Benyus, Biomimicry, 1997
- Friend, EcoMimesis 1996
  - http://www.natlogic.com/resources/nbl/v05/n04.html
- Tibbs, Industrial Ecology 1992
- Various, sustainable agriculture 1970s-80s
- McHarg, Design with Nature 1972
- Van Dresser, Landscape for Humans 1940s
- Howard, An Agricultural Testament 1890s
- Indigenous agriculture
Trajectory

- Kalundborg
- EcoIndustrial Parks
- EcoIndustrial Estates
- EcoIndustrial Networks
- Zero Waste strategies
Kalundborg

• **Collaboration between five industrial businesses for mutual economic and environmental benefit**
  – Power plant
  – Fish farm
  – Pharmaceutical company
  – Agricultural farms

• **Projects**
  – recycling water:
  – exchanging energy at different levels: waste steam, district heat
  – waste products to inputs (e.g. sludge to fertilizer)
Zero waste

- Dupont reduced pollutants 80% in five years.
- "It was actually easier to motivate the 80 top managers to commit to zero emissions than it was five years ago to motivate them to commit to reduce 80% waste."
  - Edward Woolard, Chairman & CEO
Principles
(or, The Story of 0)
Industrial Ecosystems: Modeling on natural ecosystems

• No waste (the output of one process becomes the input for another);
• Concentrated toxins are not stored, but synthesized as needed;
• "Elegant" cycles of materials and energy weave among the companies;
• Systems are dynamic, and information driven;
• Independent participants in coordinated action.

– Hardin Tibbs
Program for Industrial Ecology

• Creation of industrial ecosystems
• Balancing industrial output to natural ecosystem capacity
• Dematerialization
• Improving metabolic pathways
• Systemic patterns of energy use
• Policy alignment with long-term perspective of industrial system evolution

— Hardin Tibbs
Design Principles

• Understand ecosystem dynamics, and the competitive pressure for optimal efficiency of both organism and ecosystem
• Model metabolism—flows of energy and cycles of materials
• Watch boundaries and interactions
• Do more with less
• Reduce dissipative uses
• Stack functions—multi-purpose processes and components
• Shift from capital-energy to income-energy

– Hardin Tibbs
Design Principles

• Long term optimization, rather than short-term maximization
• Maintaining and enhancing regenerative capacity
• Diversified system
  – components linked in complementary functioning (to minimize outside inputs/exports)
  – diversity of many kinds: species, spatial, structural, temporal, and trophic (Hollings)
• Multi-functional biological components minimize need for industrial inputs
• Turn “waste” into nutrients/feedstocks
• Careful attention to rates and cycles
• Match flows to needs

Design Principles

- Diverse, modular production units
- Renewable energy sources
- Variety of raw materials, multiple sources
- Leverage of Aggregate Efficiencies
- Optimal rates
- Synergism and Symbiosis

— Holmes/Todd 1995
Design Principles

• Current solar income
• Waste equals food
• Respect diversity
  – Bill McDonough
Design Principles: Resilience criteria

- dispersion
- numerical redundancy
- functional redundancy
- optional interconnection
- flexibility
- modularity
- internal buffering
- technical simplicity and forgivingness
- easily reproducible

— Hollings 1978
Design Principles

• Material flows
  – Close material loops
  – Shorten loops
  – Use "waste" streams
  – Rich interconnections

• Minimize:
  – throughput
  – extraction of virgin materials
  – non-renewable energy
  – adverse environment impacts
  – persistent bioaccumulative toxics (PBTs)
  – human health effects
  – transport distances
Design Principles

• **Products**
  – Long lasting products
  – More service, less product

• **Maximize**
  – Product life
  – Diversity and interconnection
  – Closed material loops
  – Resource Efficiency
  – Added value
Design principles & Key Indicators

- Low throughput
- Minimize extraction
- Minimize energy use
- Close - and shorten - material loops
- Rich interconnections
- Reduce
  - adverse effects to natural environment
  - non-renewable energy
  - human health effects
- Long lasting products
Metabolic Efficiency Strategies

Economic & Natural Environment

Industry, Consumers, Etc

Energy

Materials

Product

Non-Product Outputs

Economic & Natural Environment
Metabolic Efficiency Strategies: Recycling?
Metabolic Efficiency Strategies: Reduce NPO

Economic & Natural Environment → Energy → Industry, Consumers, Etc → Product → Non-Product Outputs → Economic & Natural Environment
Metabolic Efficiency Strategies: Cascading
Metabolic Efficiency Strategies: Parameters

- Networks
- Closed “technical” cycles
- Renewables
System Conditions for Sustainability

• Substances from the earth's crust must not systematically increase in the ecosphere.

• Substances produced by society must not systematically increase in the ecosphere.

• The physical basis for the productivity and diversity of Nature must not be systematically deteriorated.

• Resources must be used efficiently and fairly with respect to meeting human needs.

– The Natural Step
Business Metabolics™

- Resource productivity trends
- Key ratios
- Throughput Pie™

- Internal+External Benchmarks
- Link “environmental” & business factors
The Challenge Ahead
“New industrial revolution”

- Products, services and whole businesses that reduce, eliminate or reverse impact on the environment… profitably!
- Cars that clean the air
- Factories that clean the water
- Buildings—and cities—with “zero ecological footprint”
- Companies that make more money selling less “stuff”
- “Making the world work for 100% of humanity”
Challenges: Industrial Ecology

• **Business issues**
  – Matching resource flows
  – Reliability of supplies
  – Contract design

• **Development issues**
  – Evolved vs purposive systems
  – Entrepreneur vs public authority initiated

• **Regulatory and legal issues**
  – Waste or resource - RCRA
  – Incentives / Disincentives: pollution, waste disposal, virgin materials
  – Technology standards -> performance standards
  – High-leverage, non-lethal control variables
  – Zero emissions zoning
Challenges: High Tech

Issues
• Supply chain
• Ecological footprint
• Digital divide

Innovative business responses:
• HP+Noranda: Mining the “waste” stream
• HP: eInclusion
• Various: selling service
• Still waiting: the modular endless upgradeable PC
Challenges: Your customers

Innovative business responses:

- Cargill-Dow: crop-based polymer feedstocks
- DuPont: zero waste, chemical management systems
- Millennium Chemicals: new market in fuel cell production for its zirconia, use of efficient CHP
- ASG Transport: “petroleum is a strategic dead end”

The key strategic question:

“What business are we really in?”
Getting From Here to There

Asking the right questions

Not “Can we?”
“How can we?”

It’s all about design
Natural Logic, Inc.


Helping companies and communities prosper by embedding the laws of nature at the heart of enterprise.

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