

# **Industrial Ecology: Design with Nature**

**SESHA/DTSC**

**Joint Pollution Prevention Mini-Conference**

**5 November 2003**

**Gil Friend, President & CEO**

**Natural Logic, Inc.**



# 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

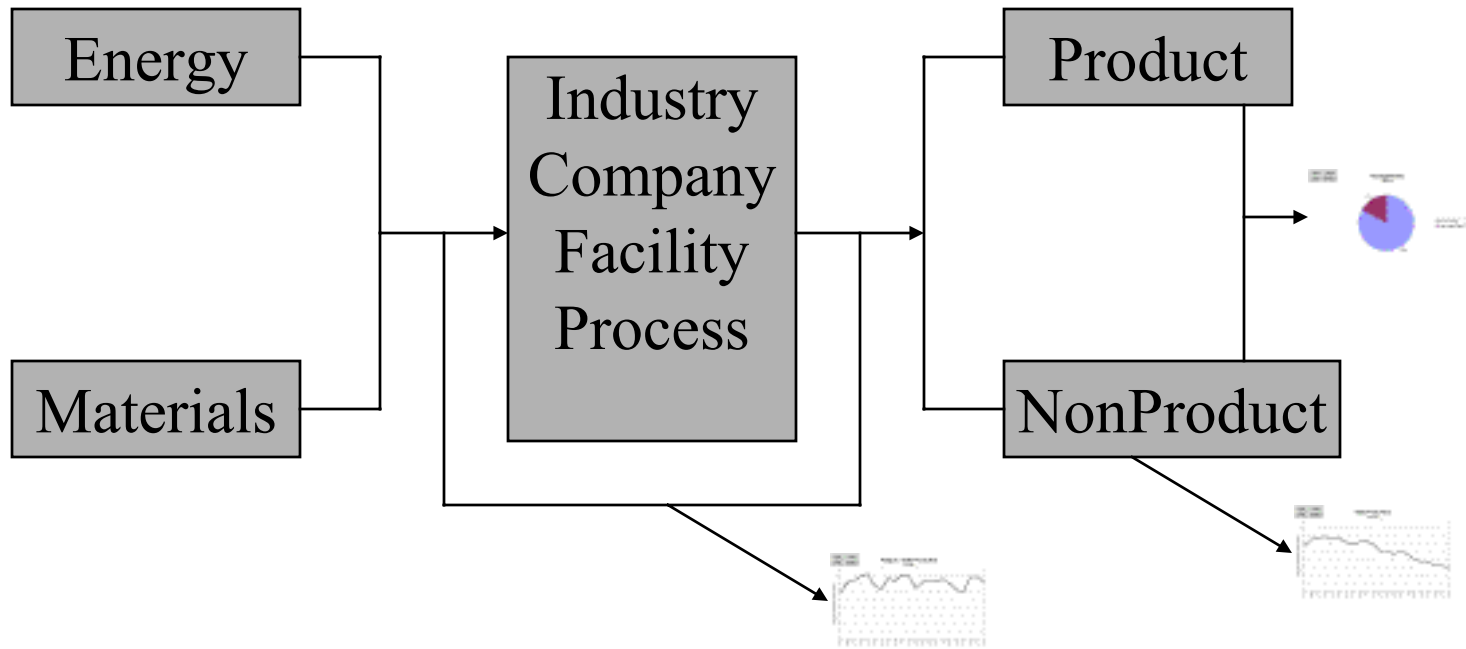


# Materials “down the drain”

- **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...



# **“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

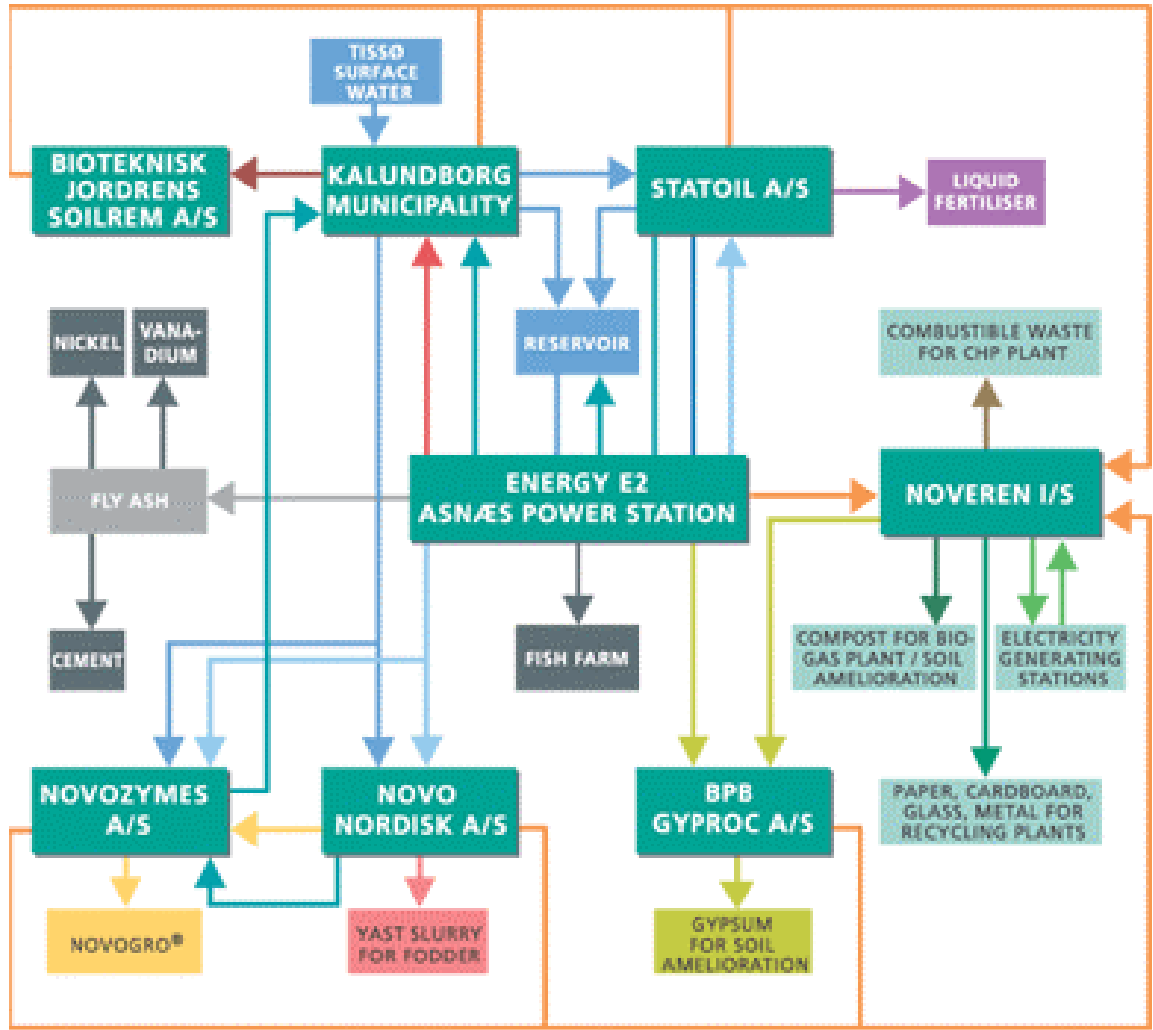
- **Kalundborg**
- **EcoIndustrial Parks**
- **EcoIndustrial Estates**
- **EcoIndustrial Networks**
- **Zero Waste strategies**



# 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)





ASH	WATER	STEAM	COOLING WATER	WASTE-WATER	GYPSUM	LIQUID FERTILISER	RESIDUAL HEAT	YEAST SLURRY
NOVOGRO®	SLUDGE	OTHER	OTHER WASTE	PAPER, CARDBOARD, GLASS, METALS	ELECTRICITY	COMBUSTIBLE WASTE	COMPOST BIO-MATERIAL	

# 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**
  - [Friend 1978, Hodges 1978]



# 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

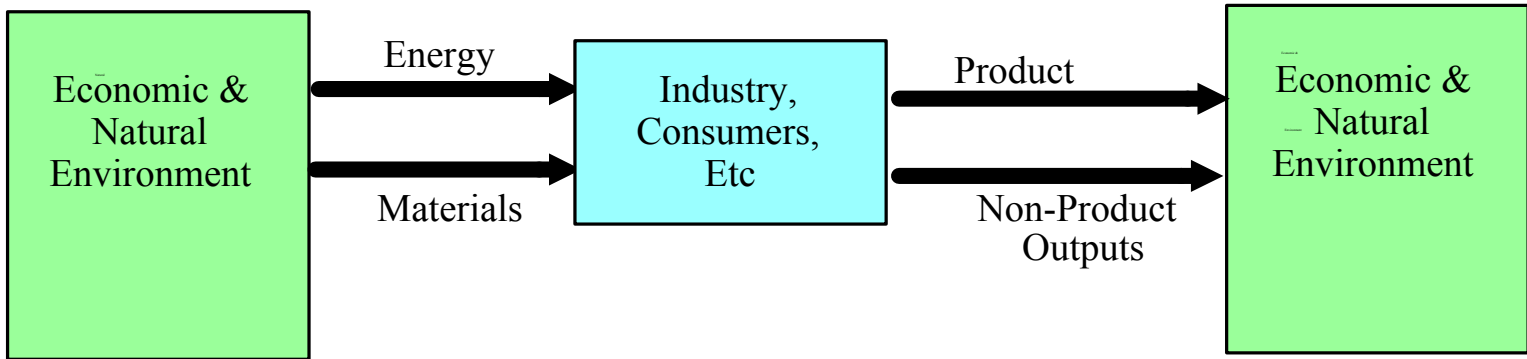


# Design principles & Key Indicators

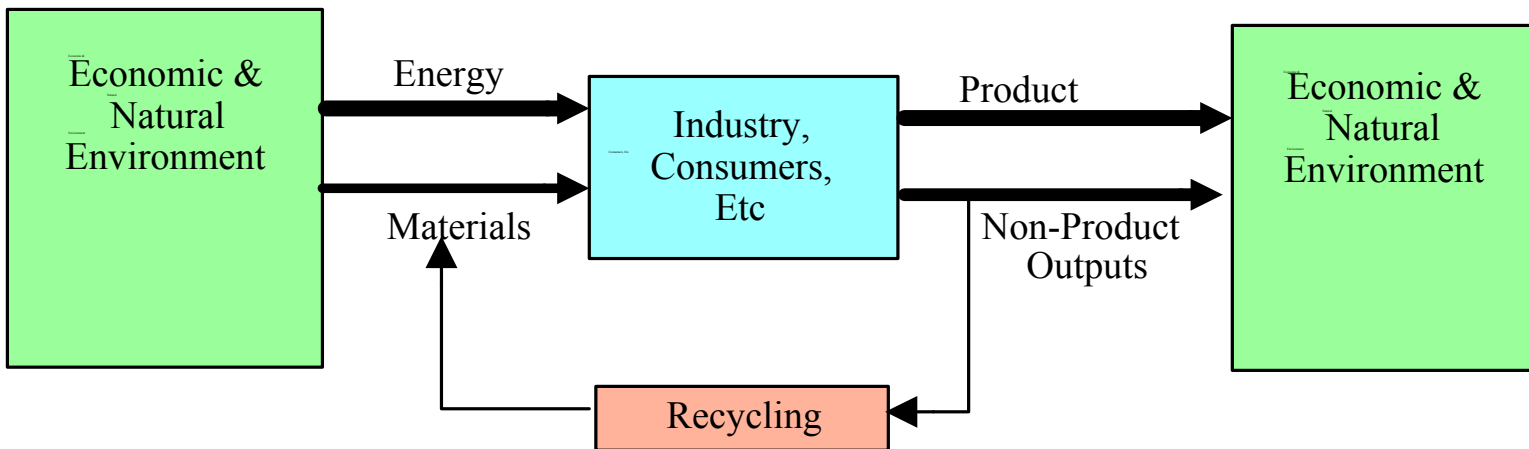
- **Low throughput**
- **Minimize extraction**
- **Minimize energy use**
- **Close - and shorten - material loops**
- **Rich interconnections**
- **Reduce**
  - adverse effects to natural environment
  - non-renewable energy
  - human health effects
- **Long lasting products**



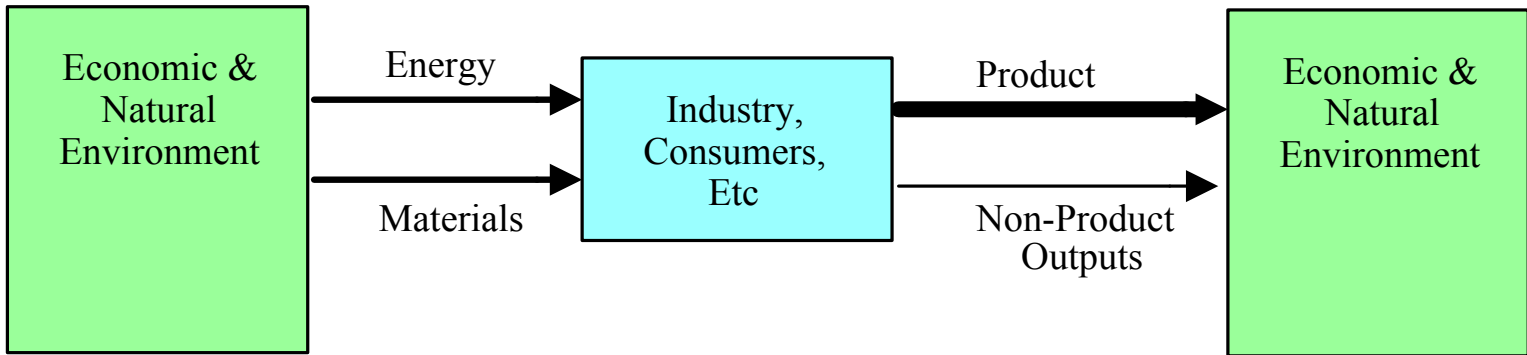
# Metabolic Efficiency Strategies



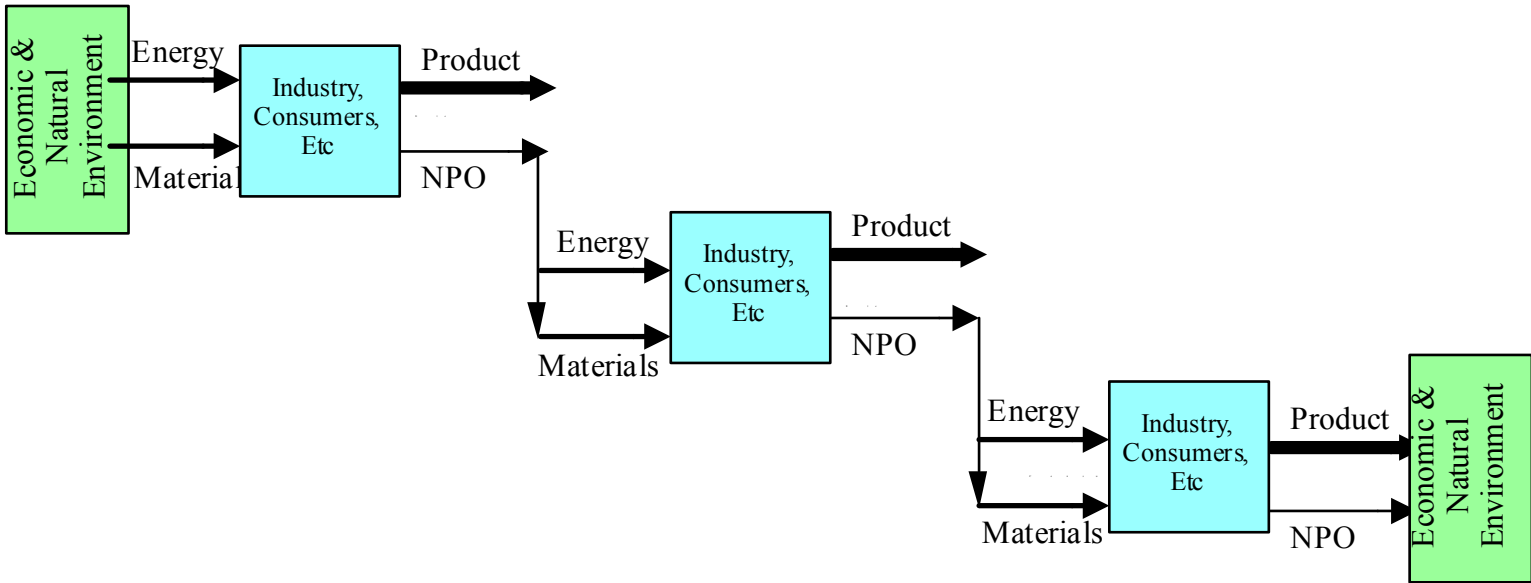
# Metabolic Efficiency Strategies: Recycling?



# Metabolic Efficiency Strategies: Reduce NPO



# 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™

The screenshot shows the Business Metabolics™ web application interface. The browser address bar displays the URL <http://www.businessmetabolics.com>. The page features a navigation sidebar on the left with links such as "Biz Meta Home", "My Biz Meta", "Make Current My Biz Meta", "Administration", "Help", and "Log Out". The main content area displays a flow diagram with input fields for "Energy", "Materials", "Select Location(s)", "Select Ratios", "Products", and "Non Product". Each input field has a "Clear" button. Dashed arrows indicate the flow from the input fields to a central black box, which then branches out to the output fields. At the bottom, there are buttons for "Clear", "Refresh", "Options", "Graph Now!", and a dropdown menu for "Key Indicators".

- 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.**

**Strategy. Systems. Software.**

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

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**1-877-NatLogic**

