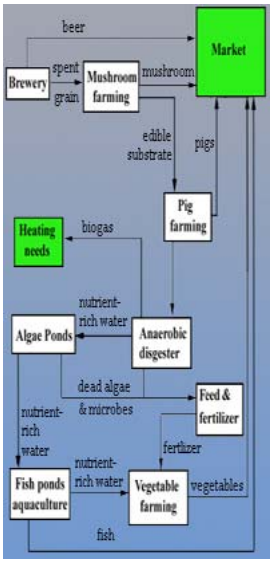


A first tool of Industrial Ecology:

ECO-INDUSTRIAL PARKS

How do they work – What do they accomplish
Examples – Case studies

Main goal:
SUSTAINABILITY
(responsibility toward future generations)

↓

Basic approach:
INDUSTRIAL ECOLOGY
(imitation of nature)

Imitation of ecosystem:
ECO-INDUSTRIAL PARKS
(closing material loops, energy efficiency)

In addition:
GREEN TECHNOLOGIES
(pollution avoidance rather than pollution treatment)

↑

This lecture

Eco-Industrial Parks:
A Foundation for Sustainable Communities?
by Ernest Lowe, Indigo Development

What exactly do we mean by "sustainable community development"? How do we begin implementing principles of sustainability in our communities? The concept of eco-industrial parks (EIPs) offers one starting point for addressing these questions.

In order to be economically viable, most communities attempting to move toward sustainability will need to include an industrial sector in their economic mix. But to involve industry in strategies for sustainability requires fundamental improvements in industrial environmental performance and resource efficiency, as well as better integration of companies into their host communities.

In these remarks, note the following elements:
- Link between sustainability and industrial activities,
- Necessity to seek environmental performance,
- Integration of companies in their host communities.

Brief historical perspective

The Eco-Industrial Park (EIP) concept was first formalized in 1992-93 by Indigo Development, a team of people from Dalhousie University in Nova Scotia, and Cornell University's Work and Environment Initiative.

In 1994, the U.S. Environmental Protection Agency (EPA) awarded a contract to Research Triangle Institute and Indigo to flesh out the concept and undertake a case study.

By the fall of 1996, 17 projects declaring themselves eco-industrial parks were on the drawing boards in the United States. At least two had recruited their first tenants.

At the current time, activities have slowed in the United States while China has enthusiastically embraced the concept with 15 EIP demonstration projects and 45 national trial EIPs since 2001.

What is an EIP?

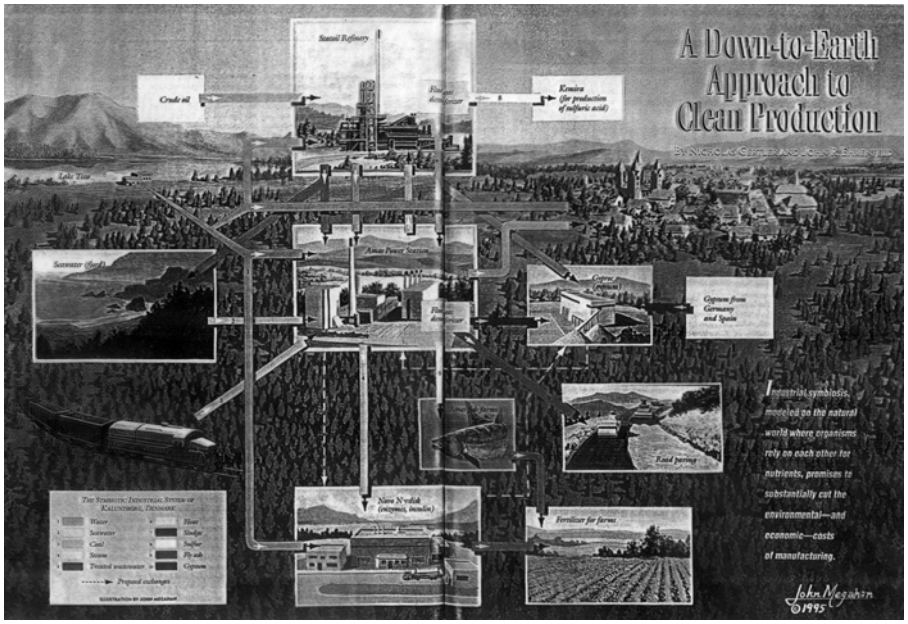
An eco-industrial park involves a **network of firms and organizations**, working together to improve their environmental and economic performance. Some planners and researchers of EIPs have used the team "industrial ecosystem" to describe the type of **symbiotic relationships** that develop amongst participating firms.

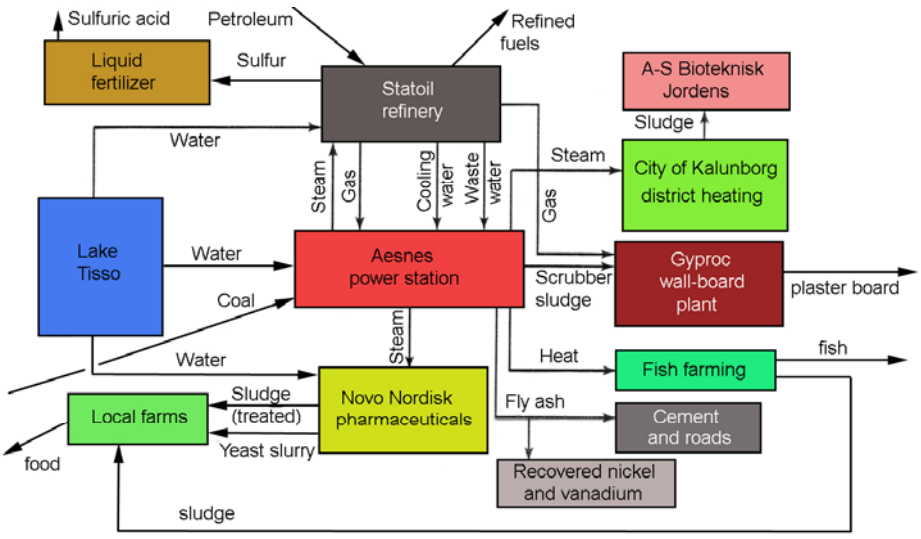
Specifically, Indigo's EPA research project defined eco-industrial parks as follows:

"*An eco-industrial park is a community of manufacturing and service businesses seeking enhanced environmental and economic performance through collaboration in managing environmental and resource issues, including energy, water, and materials. By working together, the community of businesses seeks a collective benefit that is greater than the sum of the individual benefits each company would realize if it optimized its individual performance only.*

The goal of an EIP is to improve the economic performance of the participating companies while minimizing their environmental impact."

Town of Kalundborg in Denmark – A historical first and canonical example





Flows of resources in the eco-industrial system at Kalundborg, Denmark

Kalundborg Savings & Profits:

Water
The companies have reduced the overall consumption by 25% by recycling the water and by letting it circulate between the individual partners. A total of 1.9 million m^3 of groundwater and 1 million m^3 of surface water are saved on a yearly basis.

Oil
The partners have reduced their oil consumption by 20,000 tons per year, corresponding to a 380-tonne reduction of sulfur dioxide emission on a yearly basis. The major reductions have been achieved by Novozymes A/S, Novo Nordisk A/S and Statoil that have used process steam from the production at Asnæs Power Station.

Ash
The combustion of coal and orimulsion® (bitumen-based fuel) at Asnæs Power Station results in approximately 80,000 tons of ash, which are used in the construction and cement industries for the manufacturing of cement or the extraction of nickel and vanadium.

Gypsum
Every year BPB Gyproc A/S receives up to 200,000 tons of gypsum from Asnæs Power Station. This figure corresponds to the large majority of the company's annual consumption. The gypsum substitutes the natural gypsum used in the production of plasterboards.

NovoGro®
NovoGro® from Novozymes A/S substitutes the use of lime and part of the commercial fertilizer on approximately 20,000 hectares of farmland.

Kalundborg Savings & Profits:

Wastewater
The collaboration of Novozymes A/S, Asnæs Power Station and Kalundborg Municipality, in the area of wastewater treatment, reduces the environmental impact on Jammerland Bugt considerably.

Sludge
The recycling of sludge stemming from the treatment plant brings about a reduction in production time at A/S Bio-teknisk Jordrens Soilrem, synonymous with expenditure cuts and improved economy.

Other Waste
On a yearly basis, Noveren I/S receives:
13,000 tons of newspaper / cardboard which after a quality check are sold to cardboard and paper consuming industries in Denmark, Sweden and Germany producing new paper, new cardboard, egg boxes and trays for e.g. the health sector.
7,000 tons of rubble and concrete that are used for different surfaces after crushing and sorting.
15,000 tons of garden / park refuse delivered as soil amelioration in the area.
4,000 tons of bio waste from households and company canteens. The bio waste is used in the compost and biogas production.
4,000 tons of iron and metal, which is resold after cleaning for recycling.
1,800 tons of glass and bottles that are sold to producers of new glass.

Results at Kalundborg:

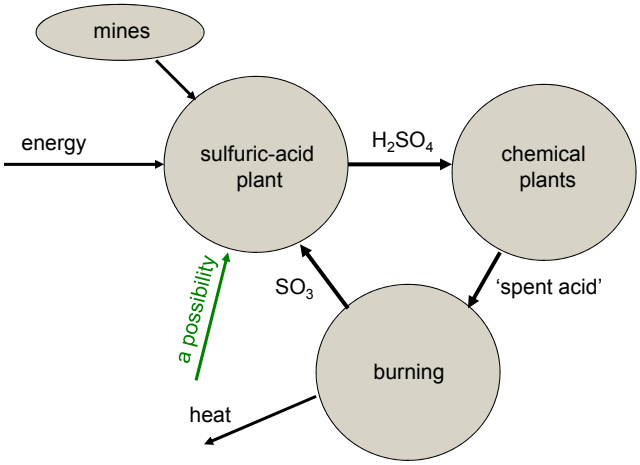
Economic
Total investment of about US$60 million
Annual revenues of about US$12 million
Average payback time of 5 years
Accumulated revenues as of 1993: over US$120 million

Environmental savings
19 thousand tons of oil
30 thousand tons of coal
600 thousand m^3 of water (out 3 million)

Reduced emissions
130 thousand tons of CO_2 (out of 4 million tons)
3700 tons of SO_2 (out of 29000 tons)

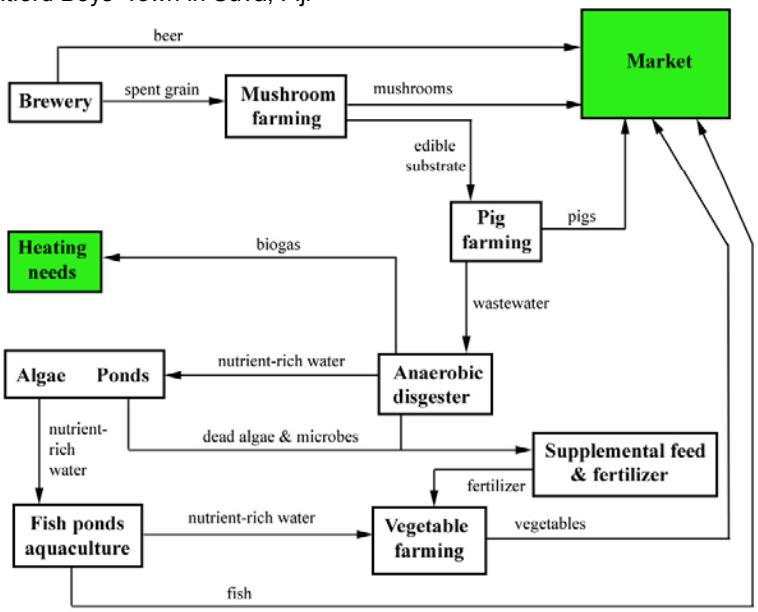
Reuse of waste products
135 tons of fly ash
2800 tons of sulfur
80000 tons of gypsum
800 thousand tons of nitrogen in sludge

A simple but effective arrangement in the so-called Houston Ship Canal



(From O'Rourke, Connelly & Koshland, 1996)

Flow resources in the integrated biosystem of Montford Boys' Town in Suva, Fiji



U.S. EPA (http://www.epa.gov/jtr/topics/eipex.htm)
Eco-Industrial and Resource Recovery Parks

1. Resource Recovery Park

A group of reuse, recycling, and composting processing, manufacturing, and retail businesses receiving and selling materials and products in one location.

2. Zero-Emission Park

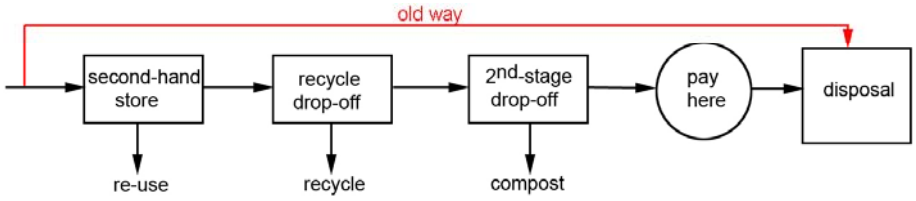
A group of co-located businesses working together to reduce or eliminate emissions and wastes.

3. Virtual Eco-Park

A group of businesses that are geographically separate, but still working together to minimize their impact on the environment.

Example of a Resource Recovery Park:
Monterey Regional Waste Management District Regional Environmental Park in Marina, California

Participating establishments:
- Permitted sanitary landfill
- Public drop-off recycling station
- "Last Chance Mercantile" resale facility
- Landfill gas power project
- Materials recovery facility (MRF)
- C&D recycling operation
- Composting operations
- Soils blending facility



Zero-Emission Park: Example
Chaparral Steel-TXI, in Midlothian TX

Participating Establishments:
- Steel mill
- TXI Cement Division (Texas Industries, Inc.)
- Automobile shredding facility

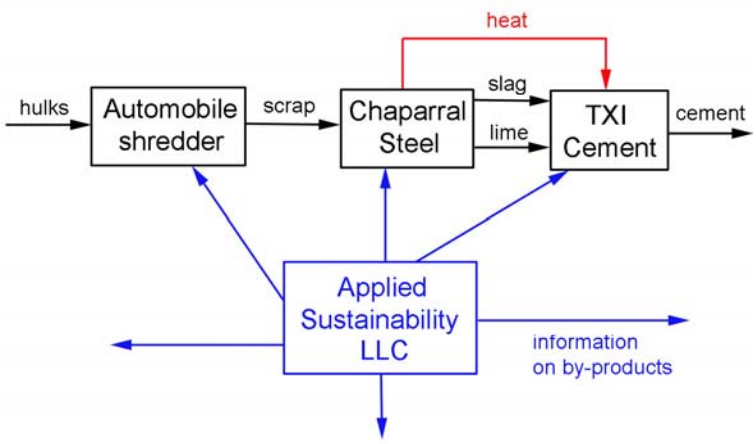
Chaparral Steel and TXI Cement Division, two Midlothian, Texas manufacturing facilities owned by the same company, established the foundation of a zero-emissions park by forming a partnership to use Chaparral's steel slag in the cement kiln to produce high-quality Portland cement.

The process allows the cement company to skip two energy-intensive steps. First, the process uses steel slag that has already been subjected to the high temperatures of the steel furnace, supplying the heat of formation of the slag's principal compound, dicalcium silicate, the building block for Portland cement. Second, by using lime that has already been calcined by Chaparral, TXI is able to skip a step that would have expended considerable energy and generated carbon dioxide.

This by-product sharing arrangement aims to eliminate waste by developing links between Chaparral, TXI Cement, and a nearby automobile shredding facility that provides scrap steel to Chaparral for new production. The end goal is to create enough linkages such that everything the steel mill produces will, in synergy with adjacent enterprises, be a useful product.

The Chapparal-TXI partnership also spurred the creation of a new company, **Applied Sustainability LLC, which assists businesses in identifying by-product sharing opportunities**.

Here is how Chapparral Steel and TXI Cement work together thanks to Applied Sustainability, LLC



By adding slag to the cement manufacturing process, cement production has jumped 10% and energy consumption has dropped 10%, accompanied by a comparable reduction in greenhouse gas emissions.

Virtual Eco-Park: Example
The Brownsville Project, in Brownsville, Texas

Potential Participating Establishments:
To be determined

The Brownsville Project takes a regional approach to exchanging materials and byproducts. As currently envisioned, the project will include not only industrial facilities, but also small businesses and agricultural partners.

A database of companies in Brownsville and neighboring **Matamoros, Mexico**, has been developed and analyzed to identify potential materials exchange opportunities among companies. Cost-based data was added to the database, and a marketing plan will be developed to evaluate and recruit participants.

The Texas Department of Commerce and the Brownsville community have provided initial funding, and project leaders are working to secure long-term support. In particular, state officials will be working closely with project leaders to ensure that permitting procedures do not become a barrier to development.

Components of EIP design

EIPs have a rich menu of design options, including site design, park infrastructure, individual facilities, and shared support services.

Natural Systems – An industrial park should fit into its natural setting in a way that minimizes environmental impacts while cutting operating costs.

Example: The Herman Miller design plant in Phoenix illustrates the use of native plant reforestation and the creation of wetlands to minimize landscape maintenance, purify storm water run-off, and provide climate protection for the building.

Example: Use of local solar and/or wind energy

Energy – More efficient use of energy is a major strategy for cutting costs and reducing burdens on the environment.

Example: Steam or heated water flowing from one plant to another (energy cascading), or to homes in the area.

Material Flows – In an eco-park, companies perceive wastes as lost opportunities that ideally are potential products to be re-used internally or marketed to someone else.

The park infrastructure may include the means for moving by-products from one plant to another, warehousing by-products for shipment to external customers, and common toxic waste processing facilities. One emerging strategy for EIP planning involves anchoring the park around resource recovery companies that are recruited to the location or started from scratch.

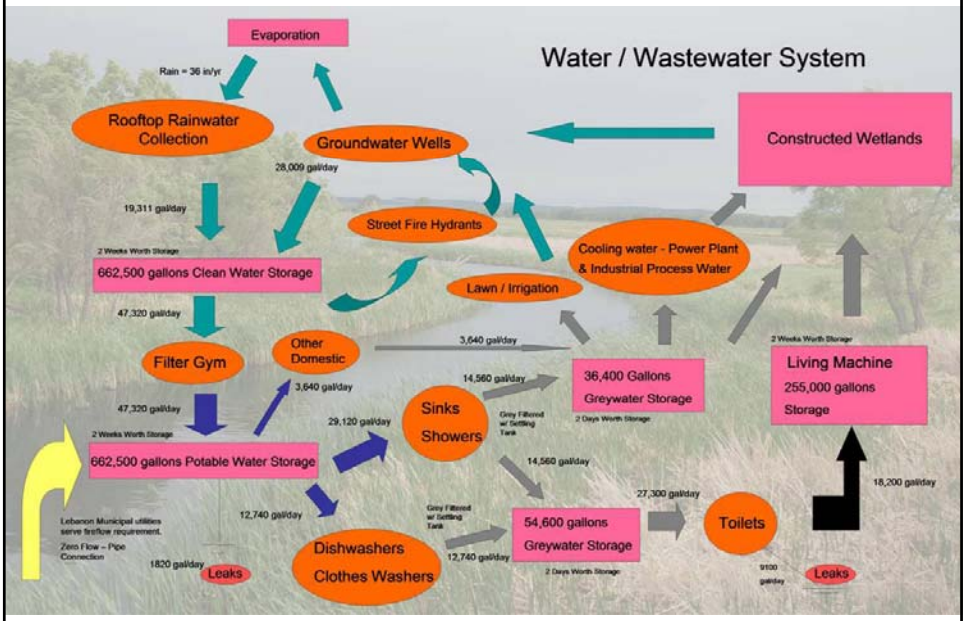
Example: Brewery, mushroom farming, pig raising and vegetable farming in Fiji

Water Flows – Processed water from one plant may be re-used by another (water cascading), passing through a pre-treatment plant as needed. The park infrastructure may include mains for several grades of water (depending on the needs of the companies) and provisions for collecting and using storm water run off.

Park Management and Support Services – Management supports the exchange of by-products among companies and helps them adapt to changes in the mix of companies (such as a supplier or customer moving out) through its recruitment responsibility. It may maintain links into regional by-product exchanges and a site-wide telecommunications system.

The park may also include shared support services such as a training center, cafeteria, day care center, office for purchasing common supplies, or a transportation logistics office.

Water cascading and recycling in an eco-community



Benefits of Eco-Industrial Parks

1. *Monetary benefits to companies*:

↓ Production costs (purchasing unwanted by-products form others at bargain prices; selling its own by-products)
↓ Energy consumption (less transportation)
↓ Waste management (on-site, or even being able to sell what would otherwise be waste)
↓ Costs of compliance
↓ Cost of some R&D (shared with other companies)

2. *Environmental benefits*:

↓ Demand on natural resources
↓ Waste (in all forms: solid waste, air emissions, wastewater)
↓ Chances of accidents in transportation (pipes instead of trucks)

3. *Societal benefits*:

Better economy → more jobs
Cheap heating (in both park and residential neighborhoods)
Cleaner air, cleaner water → better health
↓ Demand on sewer system, landfill *etc*.