CHAPTER 20

Naturally Evolving Industrial Complexes

In the 1900s, industrial plants located in the general vicinity of one another began to use wastes discharged by one another. The necessity to dispose of wastes and to import raw materials has led each plant to search for both buyers of wastes and suppliers of raw materials. The search sometimes resulted in finding these industrial plants relatively nearby, because for some time manufacturers were located in the same geographical area. These areas were sometimes referred to as "industrial zones" or "industrial parks." The original purpose of these zones or parks was to confine manufacturing to certain physical places in the overall community. This freed the area from transgressing traditional residential needs (quiet, clean air, less street traffic, etc.). Earlier, the purpose of these industrial areas was certainly not to avoid pollution of the environment. In fact, just the opposite resulted, as it allowed more environmental degradation. However, this polluted area was at least partially segregated from the rest of the community that served the people: residences, schools, hospitals, and recreational facilities such as parks. The philosophy was similar to that used early by state stream pollution agencies: to classify streams from A to F according to their best usages. For example, historically an F classification allowed a stream to be used for the discharge of all industrial wastes as its best usage. The stream zone in this case was segregated and allowed to deteriorate to its lowest level of water quality. It wasn't long, however, before these agencies realized that such classification, and indeed stream usage, was detrimental to industry and the whole society. "F" and other lower stream usages were soon abandoned. We discovered that we could not afford to degrade any one area to avoid contaminating another.

This same realization may already be taking hold in the so-called *naturally evolving industrial complexes,* and hence, the need to promote closer working relationships between industrial plants in order to avoid or at least minimize environmental pollution.

Ehrenfeld and Gertler (1997) reported on a naturally evolving industrial ecosystem in Kalundborg, Denmark. The ecosystem slowly evolved over a 25-year period and contains 11 physical linkages (shown in schematic form by Ehrenfeld and Gertler and reproduced here in Figure 20.1). They reported that four main industries comprise the "heart" of the ecosystem: (1) the coal-fired Asnaes Power Station, (2) Statoil oil refinery, (3) NovoNordisk Pharmaceutical and enzyme manufacturer, and (4) Gropoc Plasterboard Manufacturer. They also reported that several users in Kalundborg "trade and make use" of wastes and energy produced, as well as "turn byproducts into products." In addition, firms outside the city also receive byproducts as raw materials. The authors reported that this symbiotic relationship between the ecosystem industries developed slowly and quite naturally.

Over a 25-year period, they claim that the ever-increasing need for energy and the availability and use of byproducts as feed was "fundamental to this approach." They maintain that "entropy-minimizing states in stable biological systems are accompanied by increases in the interdependence among the entities." This infers that old systems of independent industrial location and production results in entropy-increasing processes (a wasteful system). Naturally, as the authors point out, entropy is a measure of disorder in any system and will increase as plants operate independently to generate products and wastes.

The authors describe this slowly evolving industrial ecosystem as an attempt to make "economic use of their byproducts and to minimize the cost of compliance with new ever-stricter environmental regulations." Also, it remains inferred or at least implied that this system will ultimately result in lower industrial production costs.

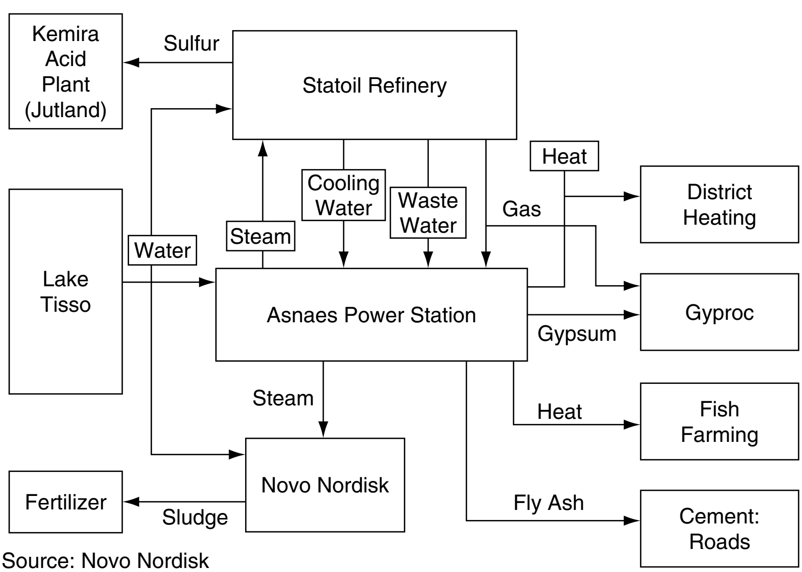

FIGURE 20.1. The Industrial Ecosystem at Kalundborg, Denmark.

In their paper, Ehrenfeld and Gertler (1997) tabulate in chronological order from 1959 to 1993 the evolution of this entire ecosystem. They place the Asnaes Power Station, the largest in Denmark, as the "heart of this system," and they further report that by altering its operation of wasting energy, it improved its energy efficiency to about 90% from about 40% when used as a free-standing plant.

The authors report some of these energy-efficiency improvements as follows:

1. Distributing heat from the power plant through a network of underground pipes.
2. Delivering steam to two of its industries. The 2-mile-long steam pipeline paid for itself in 2 years and eliminated thermal pollution of the nearby fjord at the same time.
3. Providing gypsum-containing byproduct to the wallboard manufacturer for incorporation into its product. The gypsum resulted from the power plants sulfur dioxide scrubber.
4. Selling fly-ash and clinker from the power plant for road building and cement production.
5. Piping gas from the refinery to fire the wallboard manufacturing plants' drying ovens.
6. Trucking desulfurizing plants' sour gas to a conversion plant to make sulfuric acid. The remaining sour gas is reburned in the power plant.
7. Piping the refineries' cooling water to the power plant where it is purified and reused as boiler feed water.
8. Piping the refiners' biologically treated wastewater to the power plant for cleaning uses.
9. Distributing the pharmaceutical waste sludge to nearby farms for fertilizer.

Ehrenfeld and Gertler (1997) also present a table itemizing the "resource savings through interchanges," as well as brief descriptions of some other potential partial ecological complexes that they refer to as *symbiotic ecosystems*. They discuss the subject of "barriers and limits" of symbiotic ecological systems. One significant presentation by the authors is the statement that "it would take some form of public intervention in imposing large disposal costs or subsidies to the recovery firms to create the favorable economics that led to the evolution of Kalundborg." As a practical matter, this is the direction to which the public has been moving. The references in the authors' paper are recommended for reading for the serious pursuer of originating "industrial ecosystems."

Woodard (2002) reported on the operation of this complex. Per the manager of Asnaes, "we're all making money from this" (referring to the city's system of turning waste into raw resources). "We have a bit of difficulty understanding why the rest of the world isn't doing it."

Lowe et al. (2000) wrote a handbook for local development teams entitled *Eco-Industrial Parks*. This comprehensive treatise included topics such as the benefits, costs, risks, challenges, and foundations of eco-industrial parks (EIPs). They also describe how to begin setting up a team to evolve the EIP and to design, plan, construct, and manage it. An important contribution of this report is the section in the Appendix titled

"Cases." These cases include the Burnside Industrial Park in Nova Scotia, the Chattanooga, Tennessee Parks, the Brownsville, Texas Park, the Baltimore Empowerment Zone Eco-Industrial Park, the Port of Cape Charles Sustainable Technologies Industrial Park, the Zero Emissions Research Institute (ZERI) in Tokyo, Japan, the Rotterdam Harbour Industrial Ecosystem Project (ENIS), the Haymouth and Virginia sustainable mixed use developments. The reader of this book is urged to review the entire report to obtain a historical view of EIPs, as well as the authors' views of their utility in today's industrial development.

Lowe (2000) created a paper on industrial ecosystems and byproduct exchanges from a document originally prepared for the Philippine Board of Investments. He expands on the Kalundborg case (described earlier in this chapter) to illustrate potential byproduct exchanges of Philippine industries. This reference provides evidence that the EIP system is moving ahead and receiving increased attention of not only environmental engineers, but also environmentalists in the broadest sense.

References

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