13.6: The Kalundborg Industrial Ecosystem

Industrial ecosystems of various degrees of sophistication have existed ever since the first industries were established, although they were not called industrial ecosystems or even recognized as such until the latter 1980s. The system most commonly cited as a fully developed industrial ecosystem is the one that developed spontaneously in Kalundborg, Denmark. This system is centered around two very large energy enterprises. The first of these is the ASNAES electrical plant fired by coal and with a capacity of 1,500 megawatts. The second enterprise is the Statoil petroleum refinery, processing 4–5 million tons per year. The initial relationships in the Kalundborg system consisted of exchanges between these two enterprises. The power plant sold steam to the refinery to use in processing, and the refinery provided the power plant with fuel gas and cooling water. Both enterprises produce low-level energy in the form of steam that is used for district heating of homes and commercial buildings. The heat is also used in a large greenhouse operation, as well as in a fish-farming enterprise. Another big player in the Kalundborg industrial ecosystem is the Novo Nordisk pharmaceutical plant, which receives steam from the energy suppliers. This huge enterprise makes 40% of the world's supply of insulin as well as industrial enzymes. Fermentation processes in this plant generate excess yeast, which is used as protein supplement for swine. The plant produces large quantities of biological sludge, which, along with wastewater treatment sludge from the waste and wastewater treatment plant associated with the fish farm, is used as fertilizer and soil conditioner in area farms.

The Kalundborg industrial ecosystem is often cited for the spontaneous way in which it developed, beginning in the 1960s with steam and electricity provided to the petroleum refinery from the power plant then branching out to a large variety of other enterprises in the vicinity. Some of the enterprises were driven by required measures to lower pollution. As a result of the requirement for lime scrubbing of the stack gas from the power plant, large quantities of calcium sulfate were produced, which were used to manufacture gypsum wallboard for buildings. Air pollution control measures resulted in the substitution of clean burning hydrocarbons from the petroleum refinery in place of some of the coal to generate electricity in the power plant. The requirement to remove sulfur from petroleum led to the construction of a sulfuric acid plant.

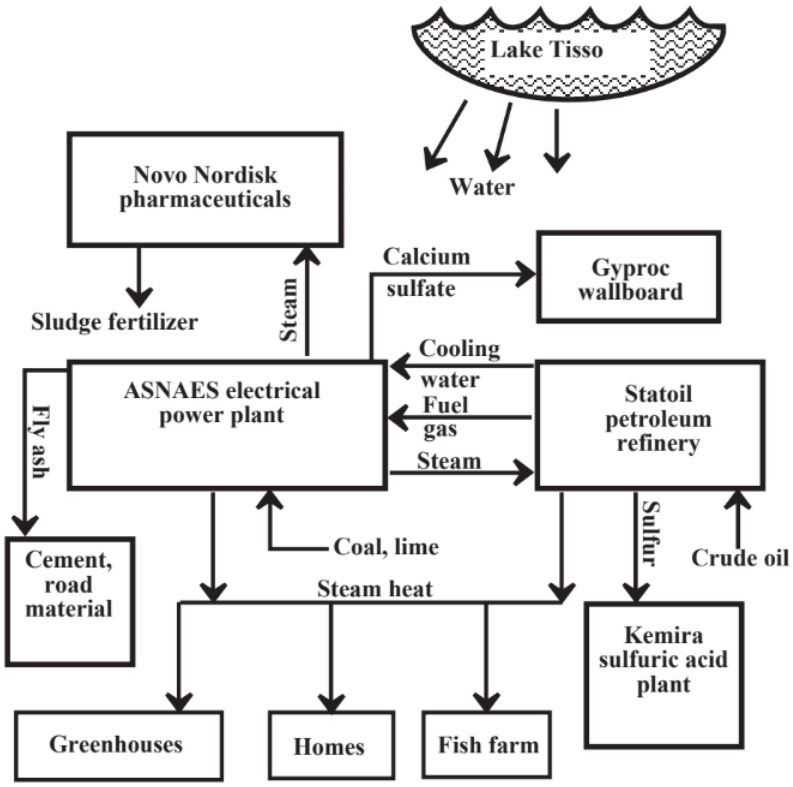

Figure 13.3. The industrial ecosystem in Kalundborg, Denmark, is commonly cited as an example of a functioning system of industrial ecology. The figure shows the numerous mutually advantageous operations in this system. It developed spontaneously beginning with exchanges of materials and energy between the electrical power plant and the petroleum refinery.

It is interesting to consider the conditions that lead to such a well developed industrial ecosystem at Kalundborg. First of all, the Kalundborg industrial ecosystem did not develop from directives from any centralized authority mandating cooperation. Instead it

arose from agreements between various entities acting in their own corporate self-interests. A rather close social system that promoted contact between individuals was helpful. The relatively small geographic area involved has been helpful in enabling facile communication and the transfer of materials and energy among the various enterprises. This is especially so in that several of the main commodities involved — steam, water, waste treatment sludge — cannot be shipped economically for any great distances.
