CHAPTER 19

Potential Municipal–Industrial Complexes

Introduction

For many years, municipalities have been cooperating with industries by permitting them to use their public plants to dispose of local factory wastes. Your author first wrote about this "joint treatment" in 1963. These systems allowed participating industries to contract with their municipal sewer service agencies to accept certain amounts and types of wastes into their systems with and without payment provision. Thus, precedent has been established, provisions made, and experiences gained from these prior associations of city and industry. Some of the past arrangements of combined treatment turned out to be a boon to both parties, whereas others resulted in a bane to both. The reader is urged to read mine and other discussions of joint treatment to aid in comprehending the problems of the past and the rationale for optimism for what we now recommend for the future.

For the present and the future, I am recommending the municipal–industrial complex concept similar to what was reviewed in Chapter 18. To accomplish this type of "pollution solution," the industrial plant must be located at the site of the municipal wastewater treatment plant. This should really not be a great burden to the industry because it would find it advantageous to operate at the lower elevation and secluded location usually selected by cities.

We will consider in Chapter 19 only one of many potential municipal–industrial complexes in which municipal solid wastes are recovered and reused within the complex by two industrial plants.

Municipal Solid Wastes–Industrial Complexes

Municipal wastewaters typically contain approximately 5–10% settleable suspended solids. In addition, some of these solids are grease-like in nature and will separate from the denser settleable solids. Usually cities use large settling tanks to remove both types of solids—one by the process of sedimentation and the other by flotation. Both types of solids are eventually usually wasted into the environment or treated extensively before some type of ultimate disposal is used. Both the treatment and discharge into the environment are costly and damaging.

In Figure 19.1, I present a schematic concept of one municipal–industrial complex in which both types of solids are recovered and used by industries in the complex to make additional products. In this complex, the municipal sewage's settled solids are rotary-dried to produce a 5–10% cake, which is conveyed to the agricultural growing area to enhance the growth of selected fruits and vegetables. These food crops are then harvested and sold to outside canners or canned, if possible, on-site of the complex.

The lighter than water solids (grease) are skimmed from the settling tank surface and conveyed directly to the on-site renderer, which concentrates and converts these solids by enclosed heating to an edible animal food additive, natural animal glue, or a soap base for sale as products. Transportation of the solids to distant industrial factories is avoided, as is the importation of raw materials for industrial production. No municipal solids are released to the air, water, or land environments before or after costly treatments.

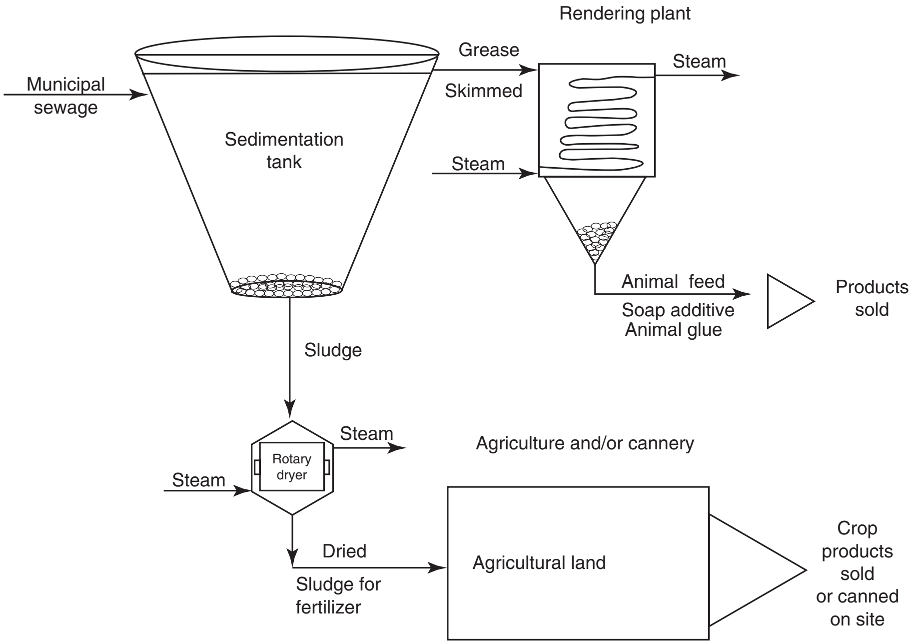

FIGURE 19.1. Schematic diagram of one type of municipal-industrial complex.

In addition, other advantages may exist for such a complex. For example, the wastewater effluent from the municipal system may be reused to irrigate the agricultural area rather than discharging it to a nearby watercourse.

Municipal Wastewater–Industrial Complex

Municipal wastewaters also contain about 1,000 parts per million (ppm) of dissolved and colloidal solids, most of which are organic. These solids are costly to remove by effective treatment (usually biological). Hence, some, if not all, of these solids are discharged into the environment, causing degradation of water courses.

An ideal solution to this problem is to incorporate the municipal treatment plant into a complex with other industries that can use these solids to evolve a product for commercial use. One such complex is shown in Figure 19.2.

In this complex illustration, two industries and the municipality are involved: fishery food, agriculture crop food, and municipal sewage. The sewage is first treated by sedimentation. The supernatant wastewater is directed to an algal production pond. Here, algae grow aided by natural sunlight and minerals and other nutrients remaining in the sewage.

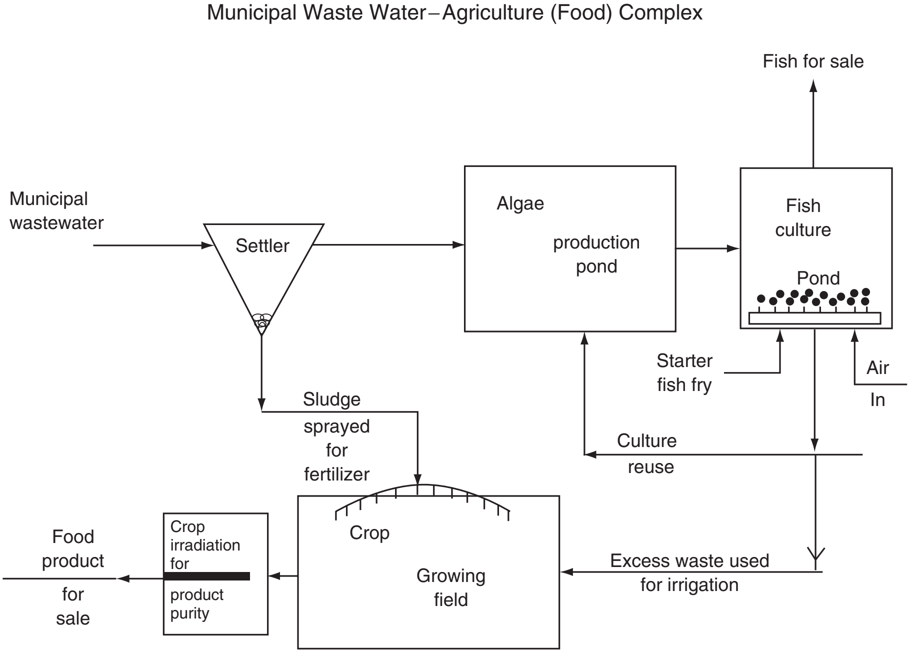

FIGURE 19.2. Municipal waste water–agriculture (food) complex.

After sufficient detention time, the algae-laden overflow is discharged to the fish culture pond. Starter fish fry and air are introduced into this pond to enhance the growth of fish such as Tilappia for sale as animal and human food. The fish growth is enhanced by the amount and nature of algae fed to the culture pond. Some fish pond culture is recirculated to the algae production pond to stimulate the growth of more algae.

Excess culture pond effluent is distributed in a crop-growing area. Crops such as corn, beans, and tomatoes can be grown in this field. The crop growth is also aided by applying (spraying) settled sewage sludge from the sedimentation basin. After harvesting and crop irradiation, the food products can be sold again for animal and human consumption.

By using a complex system such as this one, neither municipal sludge solids nor contaminated liquid effluent reaches the land, air, or water environment outside the complex. This complex represents just one of several that can accomplish the same objective while evolving other industrial products.

Lake Industry–Villagers Complex

Lakes can serve as valuable industries for their users. For example, some lakes can be used by boaters, fishermen, and even bathers and swimmers. If, at the same time, these lakes are used by downstream owners for generating electricity and for irrigation water by farmers, conflicts over the lakes' use and operation may exist.

We are just beginning to amass information about ways and means of using and operating such multipurpose lakes. Your author has proposed economic methods for allocating water usage in lakes as far back as 1970 and repeated in summarized form in this book in Chapter 21. However, until now, administrative decisions largely determine which water use gets priority. Administrative decisions are usually made by political pressures rather than by rational economic values.

For example, downstream water users may sometimes exert enough influence on upstream lake property owners to release (or lower) water levels in the lake, thus interfering with lake-industry uses. I suggest one technical (or nonadministrative and noneconomic) method whereby such situations can be ameliorated.

Usually lakes are surrounded by nearby villages or even cities whose residents use the lake for recreation, as mentioned in the first paragraph. When lake levels are lowered because of release of water for downstream users, village lake users lose some or all of the recreational benefits available to them. One way of overcoming, to some extent, this dilemma is to treat and discharge its domestic wastewater (sewage) at the headwaters of the lake.

This will add about 100 gallons of water per person per day to the lake instead of sending the sewage water immediately downstream as an eventual waste. A village of only 1,000 people, for example, could increase the water volume of the lake by about 6.35 million gallons each year (1,000 × 100 × 365). This may, by itself, be enough to preserve boating and fishing activities in the lake. In a manner of speaking, this is a form of municipal wastewater reuse that may not be as objectionable to the public as other uses, such as irrigating edible crops and street cleaning.

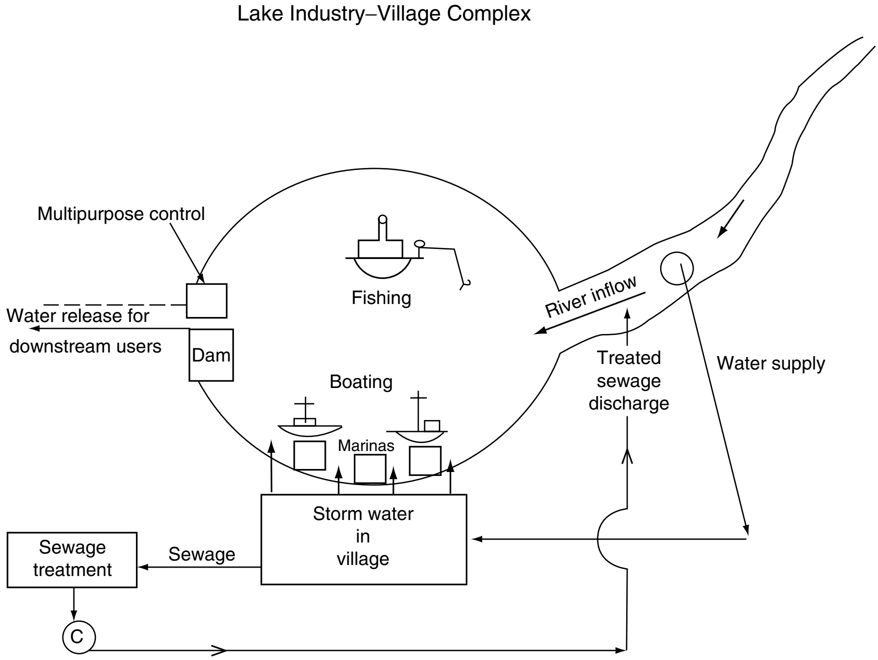

FIGURE 19.3A. Lake industry–village complex.

I have depicted such a complex in Figure 19.3. In this complex, the lake-bordering village treats and pumps its sewage to the upper part of the lake instead of discharging it below the lake dam to downstream river users. This in no way affects the villages' upstream drinking water quality or quantity. The fishing, boating, and recreation industry existing in the lake will be enhanced, especially when downstream water users are lowering dam overflows to serve their interests.

Thus, we have a type of complex in which the lake industry is aided by the wastes of the villagers. An illustration of a situation in which this complex solution might be used is Detroit, Oregon (Gavin 2001). In Detroit Lake, boating businesses disappeared because of competition for water prompted by the Northeast's near-record drought. This caused the Army Corps of Engineers to decide against bringing the water level high enough to support recreational lake activities.

The Ultimate Natural Resource Conservation and Resource Preservation Plant

This section is for those whose imagination has been stimulated sufficiently to envision the ultimate in this concept. Why not use all liquid and solid wastes of a municipality to produce some of the products that municipality needs to survive and grow such as food, electricity, and water? It can be done, and again with no wastage of material to harm the surrounding environment.

If you doubt that it is possible, I refer you to Figure 19.3 as proof of the concept. In this depiction of an ultimate environmentally balanced industrial complex (EBIC), all municipal wastewater and combustible refuse represent the EBIC plant inputs.

The wastewater is settled to produce grease and sludge, which are fed to the fermenter to produce methane gas for burning and steam formation in the power plant for electrical energy.

The burnable refuse is also fed directly to the power plant for burning, steam formation, and power plant electricity.

The settling basin effluent after chlorination is fed to an algae growth pond fortified with tricalcium phosphate fertilizer and carbon dioxide from the power plant stack gas.

The algae are introduced into the fish growth pond to produce an edible fish product for sale after irradiation.

The entire fish pond effluent is used to irrigate a crop-growing field. The field is also supplemented with waste-digested sludge from the fermenter. The agricultural product is periodically harvested, irradiated, and sold to the city folk.

Meanwhile, all the excess wastewater overflow that was fed to the growth field for irrigation is filtered through the underground soil and becomes a source of reusable groundwater for reuse by the municipality. In summary, all municipal wastewater and burnable refuse have been treated and reused as a source of water, electricity, and food for the same municipality.

A current example of an intended ultimate waste treatment facility is located in Fallbrook, California. A proposed joint project by Fallbrook and Camp Pendleton would reuse wastewater that now flows out to the ocean (2003). Following four sequences of treatment—preliminary, primary, secondary, and tertiary—the clean wastewater would then flow through a wetland into the Santa Margarita River, and then finally into various recharge ponds where the water would percolate into an underground aquifer. Later, water from the underground aquifer would be reclaimed with nitrogen compounds removed and stored in an open surface reservoir. From this reservoir, the water would overflow into the Santa Margarita River where it would be partly diverted into recharge ponds. Groundwater from these ponds would be pumped into the water-treatment plant, stored, and used for a domestic water supply for the Camp and Fallbrook.

The developers of this plan recognize that “Fallbrook’s proposal to recycle waste water to make it safe for drinking must overcome negative sentiment.” They counter with the fact that “treated waste water would spend six months percolating into the ground and mixing with naturally occurring water before it would be treated again and reused.” In this instance, I would add that “dilution—with treatment—would provide the solution to pollution.”

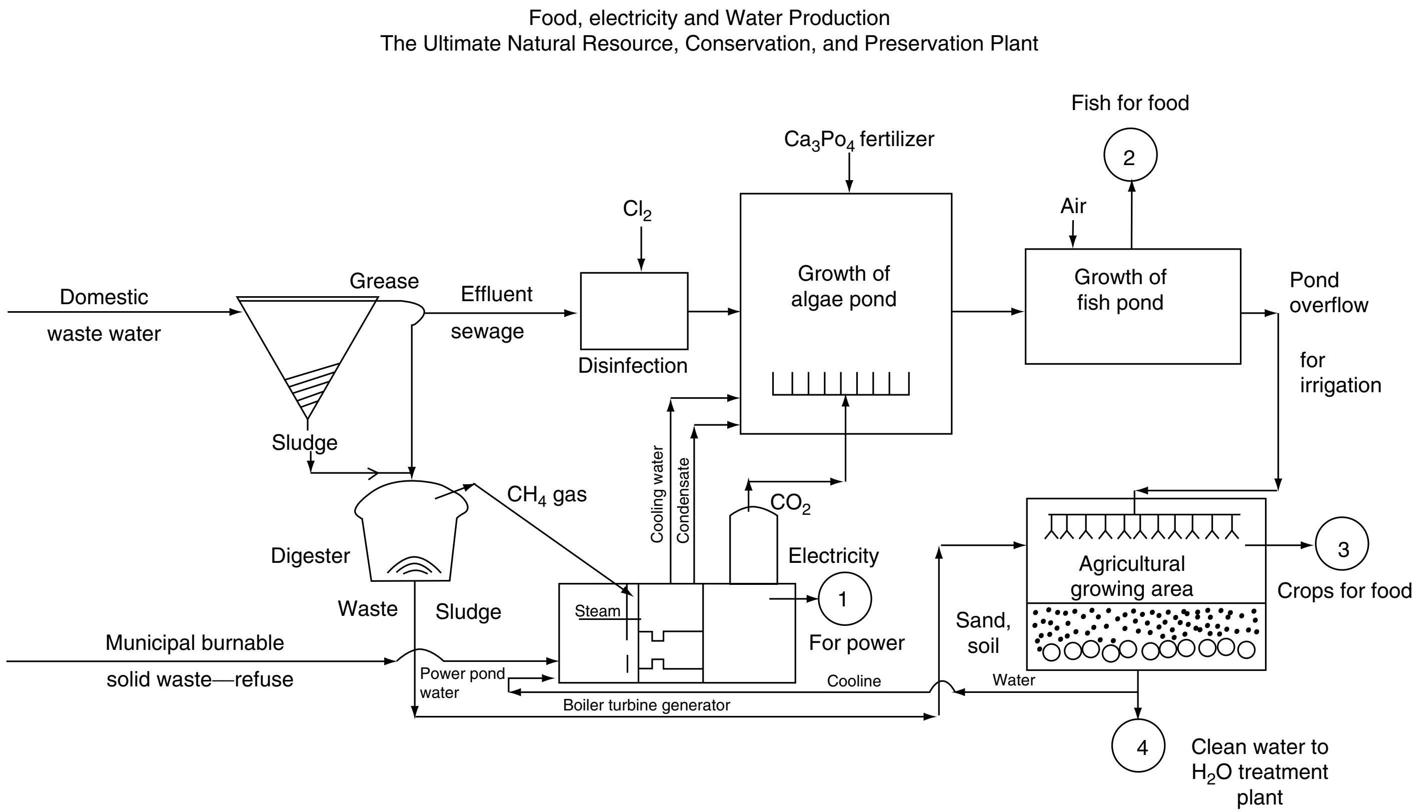

FIGURE 19.3B. Food–electricity and water production plant.

Byproduct Synergy

The U.S. Business Council for Sustainable Development (2003) has proposed the principle of byproduct synergy as "one industry waste stream can be used by another as a primary resource." It is "as a simple idea, but one which has enormous potential for reducing waste volumes and toxic emissions to air and water, as well as cutting operating costs." To facilitate the system, the U.S. Business Council for Sustainable Development states that "businesses need to work together to determine what unwanted by-products exist, and what their potential applications are. The resources can then be exchanged, sold, or passed free of charge between sites, creating a by-product synergy." The Environmental Protection Agency (EPA) and the World Business Council for Sustainable Development have defined this system as "the synergy among diverse industries, agriculture, and communities resulting in profitable conversion of by-products and wastes to resources promoting sustainability." They claim that it is the principle that "underpins the concept of industrial ecology—a holistic view of industry in which organizations exchange energy and material between one another, rather than operating as isolated units. Industrial ecology promotes a shift away from traditional open linear systems towards closed loops and interdependent relationships of the kind found in nature."

The byproduct synergy system is really an advanced stage of marketing and exchanging wastes. Previously, the older waste exchanges did not flourish for several reasons (discussed more fully in Chapter 13 of this book). However, this system is a new attempt to list wastes and target industries' needs much more directly and completely. For these reasons, and for the timeliness of its inception, as well as the advanced education of industries, it has a better chance for success.

The Industrial Ecosystem Development Project (International Institute for Sustainable Development, 2002)

The EPA instigated a 2-year project "to identify potential by-product partnerships in an industrialized area of North Carolina, encompassing Raleigh, Durham and Chapel Hill." It was modeled after or inspired by the Kalundborg, Denmark, system (which is described in Chapter 20) with the exception that the area is much larger with a larger population and dominated by pharmaceutical, computer, and telecommunications equipment manufacturers. A brief description of their findings is in order here to illustrate how the system works.

Of the 343 facilities (industrial), 182 agreed to take part in the study. It is important to realize that this again is a project system "after the fact." That is, all the industrial plants had already been built and were in operation in the area. It had not been any kind of planned complex. They used a geographic information system (GIS) to ascertain the byproducts arising there and the inputs they required. Its goal was to ascertain with "matches" among nearby plants. About half the sites yielded 49 different byproducts, of which 12 were deemed "viable" for short-term partnerships, namely acetone, carbon, desiccant, hydrochloric acid, methanol, packaging, plastic bags, sawdust, sodium hydroxide, wood ash, wood chips, and wood fluff. In addition, 24 byproducts were found for which partnerships could be developed with more effort, including copper, electricity, floppy disks, glass fibers, ink, plastic, and wire.

They give as examples that in "one instance, a company which used vermiculite as a packaging material realized that it could use waste sawdust from a furniture shop directly across the street—waste material that would otherwise have been landfilled." In another case, they found that one plant could save 5,000 truck transportation miles a year by taking leftover acetone to a local business that could use it, rather than haul it to a hazardous waste facility 150 miles away.

The report of this study concludes that "the main obstacle to industrial ecology is the absence of a 'champion' to bring the various industries together." In addition, "what is lacking in most communities is an agent to promote the vision of a web of materials, water and energy flowing between neighbours, and to gather the local information about by-products available or raw material requirements needed to build this web."

The U.S. Business Council for Sustainable Development (2003) has taken on the responsibility of furthering the implementation of this system. It repeats the purpose of byproduct synergy as the "practice of matching under-valued waste or by-product streams with potential users, helping to create new revenues or savings for the organizations involved while simultaneously addressing social and environmental impacts."

The Council lists the following benefits of the process:

1. Reduced operating expense
2. Reduced energy use
3. Reduced emissions
4. Waste transformed into product
5. Surpassed regulatory targets
6. Improved community
7. Improved productivity
8. Improved profitability

It also admits the following barriers:

1. Technical barriers
2. Economic barriers
3. Regulatory barriers and liability
4. Perception and reputation
5. Lack of incentives

Examples of Byproduct Synergies

The Counsil explains that each regional project involves getting 10–20 unlike companies to pay a fee and engage local, state, and federal governments to support the study. It gives as an example one of the earliest companies to adopt byproduct synergy, the Chaparral Steel Company. As one of its first synergies, it discovered the "potential for steel slag to be used as a raw material for the cement manufactured by nearby Texas Industries." The steel slag contained Ca_2SiO_3, formed by the high temperatures of the steel-making process and a building block of Portland cement. By using the steel slag instead of purchased lime, which would then have to be heated to calcination, Texas Industries reduced the energy requirements and related emissions of CO_2, NOx, and SO_2 of the cement-making process. The company found that profits for both companies also increased.

In Table 19.1, the byproduct synergy presents a large opportunity for reducing raw material consumption, energy use, and emissions and waste generation, along with associated cost savings.

The Business Council for Sustainable Development and its Byproduct Synergy Production unit, Applied Sustainability (AS), launched new projects in the United States, Mexico, and Canada starting in 1997. "In each of these projects synergies emerged with potential for measurable financial, social and environmental values." I summarize some of the interesting byproduct synergies here for illustrative purposes.

In Tampico, Mexico

PVC residuals were converted into shoe soles.
Excess acetonitrile was substituted for a more expensive solvent.
CO_2 was recovered and used in a new manufacturing CO_2 plant.
Plastic polymers were recovered and pulverized with liquid nitrogen to homogenize these scrap wastes for reuse.
Waste plastic residuals were reused in construction.
Plastic packaging bags were used in construction of platforms for ship loading.
Waste hydrocarbons and municipal waste were used in a waste-to-energy project.

Alberta, Canada

Spent caustic (NaOH with contaminants) from a Kraft paper mill and a refinery was reused in the Kraft process to make up for Na losses.

North Texas

Wood waste from tree trimming was used for a biomass-fueled electricity generation unit.
Copper cooling wastewater was used to recover copper.
Electrostatic dust from a precipitator was recovered for use as a fertilizer because of its high concentration of boron.

Montreal, Canada

Reprocessing of lead smelter baghouse dust for metal reuse.
Reuse of a relatively pure supply of hydrogen gas if it can be transported economically.
Reuse of auto-shredder fluff for energy production.

TABLE 19.1
Annual Cost and Environmental Benefits of Successful Synergies

Implemented Synergies	*Ecological/Biological*	*Energy Savings*	*Residue Reduction*	*Cost Savings*
CemStar® 130,000 tons of steel slag used in place of lime (single plant operation)	Reduced SO_2 (acid rain) through coal displacement	Displacement of 11,800 tons of coal used to calcine lime (3.5 billion Btu)	130,000 tons of steel slag not land-filled Emission reductions from coal displacement: 65,000 tons CO_2, 800 tons of NOx, 33 tons of hydrocarbons	*Steel producer:* Reduced/eliminated steel slag treatment/disposal costs *Cement producer:* Less costly raw material Calcination is not required; energy consumption and associated emissions for cement production are reduced
Auto shredder residue (ASR) 120,000 tons of ASR mined for metal reclamation, and ASR remaining after metal recovery used for power generation	Reduced SO_2 (acid rain) through coal displacement	18,000 tons of metals (Al, Cu, Mg, Sn) recovered from ASR and not mined 98,000 tons of carbon-based ASR displaces 66,000 tons of coal for power generation (20 billion Btu)	120,000 tons of ASR not landfilled Energy savings associated with metal recovery vs. mining prevent 151,000 tons of CO_2 emissions SO_2 emissions reduced by substitution of ASR for coal	*ASR producer:* Reduction/elimination of ASR disposal fees Increased revenue from recovered metals Revenue from sale of ASR as alternative fuel *ASR consumers:* Lower-cost, less energy-intensive method of obtaining metals Lower-cost fuel
Graphite/copper sludge 37,500 lb of sludge saved from landfills and municipal water systems	Landfill biota not exposed to toxicity of copper waste	18,750 lb of copper recovered and not mined (5.6 million Btu)	37,500 lb of graphite/copper sludge not landfilled 412,500 gallons of graphite/copper-tainted wastewater not released to municipal wastewater treatment	*Sludge producer:* Reduced/eliminated waste disposal fees Revenue from sale of sludge to copper extraction company *Metal recovery company:* Lower-cost source of copper

New Jersey

> Dow Chemical Company plants are pursuing the use of three wastes: (1) a latex emulsion stream from paint production for reuse in road construction and in agricultural operations to control dust, (2) an off-grade, or scraps of polyethylene, for possible use in making shoe soles, and (3) reusing rigid polyurethane scraps for potting soils to increase aerability.

Once again, all of these studies are aimed at reducing wastes of industrial plants that are already in operation. Although this is an admirable and important step in the elimination of industrial wastes and in potentially reducing production costs, ultimately we must design new facilities right from the beginning to include so-called byproduct synergy. That task may be even more difficult to implement because of the inertia it must overcome at the beginning.

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