



Industrial Ecology and “Getting the Prices Right”

by *Allen V. Kneese*

Industrial ecologists are employing innovative technologies and other inducements to curb environmental degradation. Fixing the markets could accelerate—and simplify—progress toward their goal.

During the 1990s, the term “industrial ecology” has emerged from academia into corporate and public policy. The term reflects a conviction that modern industrial activity must account for its environmental impacts (see Jesse Ausubel’s story on page 14). Some nations and firms are paying serious attention to the ultimate goal of industrial ecology, which is to minimize harmful wastes and to use and reuse to the greatest extent both industrial products themselves and their wastes. As yet, though, such interest is very isolated.

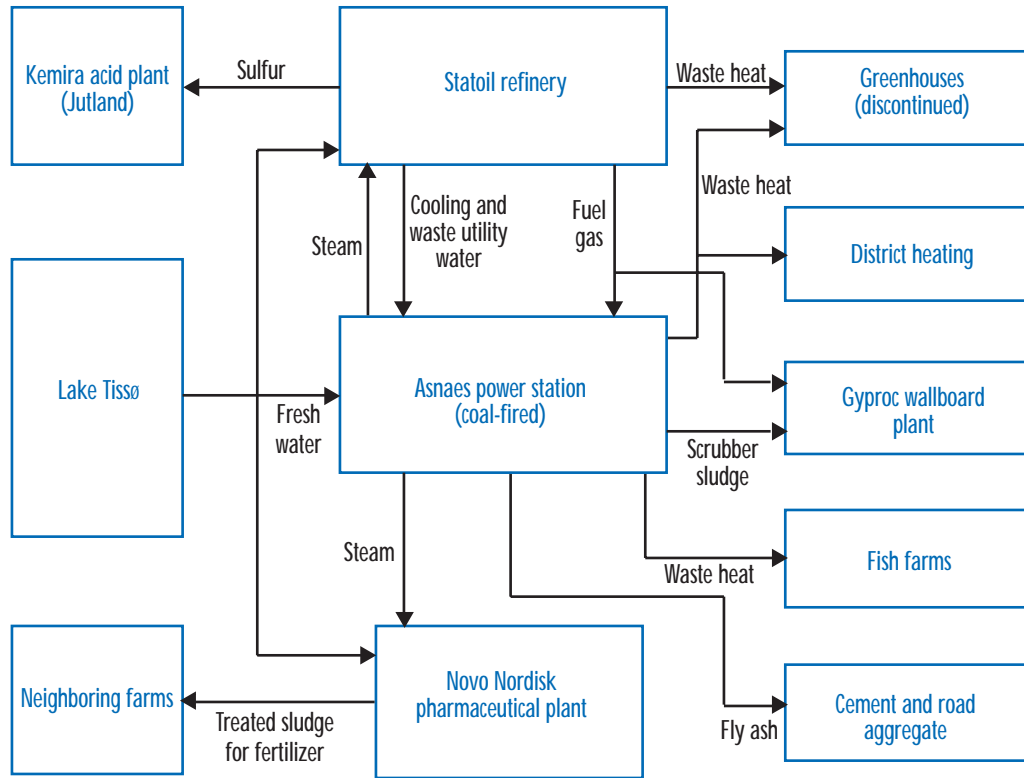
Why is interest not more widespread in achieving the benefits seen by industrial ecologists? To an economist, the question is why markets are failing to incorporate on their own the objectives of industrial ecology. The answer is that markets need to be fundamentally restructured so that prices reflect the full social costs of production. Reconfigured markets, combined with proper incentives such as emissions and effluent fees, could persuade more firms to act in environmentally beneficial ways. To achieve this fix, however, policymakers—particularly in the United States—would have to abandon their impulse for central planning and direct regulation.

The Roots of Industrial Ecology

Like all serious ideas, industrial ecology has origins in earlier work. Much of this research took place at RFF in the 1960s and 1970s, where early work in environmental economics supported the development of integrated policies and practices in environmental and natural resources management. One research topic being addressed here at that time was residuals management in specific industries and regions. That is,

RFF researchers were examining economic activity based primarily on a simple fact: the sum-total of materials and energy flowing through the economy must be accounted for, either as part of a process, product, or service, or as “leftovers.” Residuals—waste materials and the energy not fully used in either production or consumption—must go somewhere, according to the first (materials balance) law of thermodynamics. They can simply be returned to the environment in the water, land, or air; alternatively, wastes from one plant or industry can become the material or energy resources for other processes, plants, or industries. Environmental pollution illustrates the former; the well-known “ecoindustrial” complex in Kalundborg, Denmark is one example of the latter.

Why does industry fail to incorporate recovery and recycling practices more routinely into its operations? In large part, business practices, the laws and regulations that govern them, and the markets in which they operate, all conform to conventional economic conceptions of production and consumption processes. Unfortunately, economists have by and large ignored the important flows of materials through the economy and the physical laws governing them. Goods and services in the marketplace are made out of something, but classical models generally fail to consider where that something comes from and where it goes. (Even the term consumption as commonly used by economists is apt to be misleading, since what in fact is consumed in market transactions is not a physical mass but a flow of services from that physical mass that are involved in production and consumption.)



The industrial ecosystem at Kalundborg, Denmark

Working at Resources for the Future, Robert Ayres, Ralph d'Arge, and I borrowed the ideas of mass conservation and materials balance from the physical sciences in order to model and analyze the flows of materials through the economy. While the model that resulted is somewhat technical, its basic ideas are simple: the environment can be viewed as a large shell (see page 12 illustration) surrounding the economic system, providing sustenance and carrying away wastes. Broadly stated, the mass of residuals returned to the natural environment must be equal to the mass of basic fuels, food, minerals, and other raw materials entering the processing and production system, plus atmospheric gases. This principle must hold true for each sector of the economy taken separately and for economic systems taken as a whole.

Resource use, production, and consumption, seen from this perspective, could be aptly described as processes of materials and energy throughput and balanced materials flows. More importantly, these

processes are intimately bound together with the problems of residuals disposal, and hence with the pollution of air, land, and water that occurs when the capability of the environment to absorb and assimilate the returning materials is overwhelmed. Considering problems of air, water, and solid waste in isolation from each other is thus insupportable, even though our laws and regulations, then as now, treat each environmental medium separately and as the locus of largely isolated problems.

The powerful incentives and price-setting effects of markets now operate in the economy for natural resources (such as oil, minerals, and agricultural land) that serve as commodities. In contrast, markets exist only highly imperfectly or not at all for the environmental resources to which most residuals are usually returned, such as regional or global airsheds and watercourses. Instead, these are seen as "common property" that falls outside normal market exchange. Thus their price is effectively set as zero. Such

resources tend to be used for the disposal of residuals as though for other purposes they are valueless. Unfortunately, laws meant to control such use rely upon efforts to regulate their use directly, not to correct the faulty price signals given by the market concerning the use of common property resources. Thus they are fighting the price system rather than working with it.

Applying the Research

Research at RFF evolved over time toward establishing quantitative estimates for relationships that the theoretical work suggested might be important. Robert Ayres went on from RFF to continue this work, helping it to grow into a discipline now widely known as industrial metabolism. (A significant underpinning of industrial ecology, industrial metabolism can be defined as the integrated set of all

physical processes that convert raw materials, energy, and labor into products and waste byproducts.)

Work within RFF on residuals management continued along two main lines. Clifford Russell, William Vaughan, Blair Bower, and others focused on the individual plant level, examining materials balances and flows and how they related to prices, including both prices for "normal" inputs and outputs and (experimentally) for residuals discharges (services of common property resources or emissions fees). Quantitative studies examined the petroleum and steel industries, among others, embodying materials balance concepts and other innovative procedures.

A second line of RFF research applied these ideas on a regional basis, specifically to the heavily industrialized and populated lower Delaware River valley. Bower, Russell, and Walter Spofford developed an environmental quality model accounting for materials flows and balances to test the significant linkages, including costs, among the management of different types of residuals in a regional context. Later studies

(with an amended version of the model) examined how incentive (pricing) approaches can be made to yield such desired results as meeting regional environmental standards at the least cost to the region.

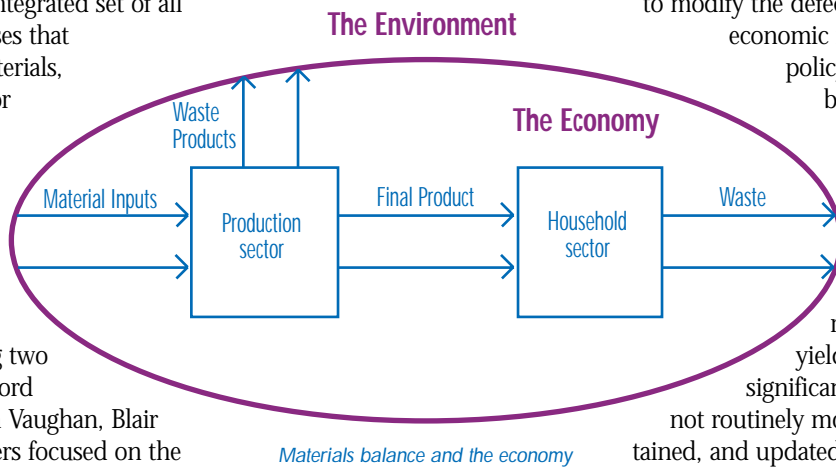
Implications for Policymaking

These early RFF studies are of more than archival interest; in the intervening years, policies based on command and control have changed hardly at all. A number of other countries regard environmental degradation to result largely from a failure in the system of economic incentives, much as I have argued here, and attempt to remedy it through emissions fees policies (more popularly referred to as "green taxes"). The United States, however, continues with a policy approach that is fragmented and grossly overdependent on direct regulation rather than one that attempts

to modify the defective system of economic incentives. A new policy departure could benefit from the comprehensive RFF models. While these studies have been highly useful as research tools, yielding a number of significant insights, they are not routinely modified, maintained, and updated broadly for the regions across the country.

Such systematic attention would be required for these models to support rigorously justifiable pricing systems for environmental resources. But the gains thought to be achievable through industrial ecology could not in any case be reaped through central planning and direct regulation. The futility, or worse, of this approach is revealed in the disastrous results it has produced in economies all across the world where it has been tried as a tool of industrial development and management. In contrast, correcting the pricing systems may reveal the apparent gains touted by industrial ecology to be little more than artifacts of a distorted system of economic incentives.

An alternative policy approach that allows for more flexible, decentralized, and dynamic adjustments



invites serious consideration. A plan to “get the prices right” by correcting incentives currently distorted by the price system and misguided public policies should proceed on two fronts, involving subsidies and fees.

Subsidies—First, the subsidies that have historically been built into our economic system to aid rapid and large-scale exploitation of natural resources ought to be re-examined. They have encouraged excessive use of materials in general and attached false economic advantages to the use of virgin rather than recycled materials. These incentives reinforce the failure to price common-property resources by increasing throughput of materials and energy in the economy. Removing them will mean higher prices (for energy, for example), but these changes should be carefully distinguished from inflationary increases. They reflect the embedding in prices of the newly unsubsidized costs of particular goods and services.

One means for adjusting these incentives would be to scrutinize depletion allowances and other tax policies that favor more rapid exploitation of natural resources. Producers of most mineral and energy products, such as petroleum, lead, zinc, copper, and bauxite, receive special treatment that effectively reduces their tax rates. This practice keeps their prices lower than they would otherwise be, and thus encourages the use of virgin materials vis à vis recycled ones. Other examples are the remaining agricultural subsidies embedded in our farm policies and the extremely low prices for government-supplied water in the arid west. Such subsidies, while often entirely inappropriate to current circumstances, are so embedded in our overall economic system that phasing them out might in given cases require some form of adjustment assistance.

Fees—A second policy initiative to combat perverse incentives would involve directly and systematically encouraging the conservation of environmental (common property) media through the use of effluent and emissions fees—“green taxes.” Creating and maintaining a fully coherent, organized set of effluent taxes based on economic modeling analyses is not possible at this time due to excessive information requirements. However, levying such taxes across a broad front of

activities that affect common property resources would recognize the interdependencies among environmental media and provide incentives for continuing development of processes that consume fewer materials or that are more conducive to recycling or treatment of residual materials.

Conclusion

America’s legal and regulatory systems address issues related to resource conservation and environmental improvement almost entirely through direct regulation of particular environmental media. Such an orientation continues to produce the familiar field days for lawyers, heavy costs, a huge bureaucracy, ad-hoc and capricious impacts, and far-reaching intrusion by government into decisions about the design of industrial processes.

An incentive-oriented (emissions fee) approach could not by itself deal with all of the sticky problems that arise in achieving environmental management objectives. For example, the discharge of highly toxic or persistent substances might still have to be prohibited by law and prevented through regulation. Schedules of effluent and emissions taxes that truly minimized the costs of achieving pollution control objectives would be too complex for practical application, and the necessarily more simplified schedules would inevitably introduce some inefficiencies into the system.

The advantage that can be claimed for the incentives approach, therefore, is not that it is free of administrative problems, for it is not. Nor can it fully replicate a theoretical least-cost solution in achieving environmental objectives, such as that yielded in principle by the Delaware study. An incentives-based policy would, however, be based upon a sound conception—that prices should reflect all costs—and upon experience that shows the tremendous power of prices and markets as signals to improve the allocation of natural resources.

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