INDUSTRIAL ECOLOGY

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Contents

Summary

Industrial Ecology (IE) is critically reviewed, discussed and analyzed. The subject matter includes: IE definitions, goals, roles, objectives, approach, applications, implementation framework, implementation levels, industrial ecologists qualifications, ways & means for analysis and design, sustainable agriculture, sustainable industry, sustainable environment, zero emission, zero discharge, hazardous wastes, cleaner production, waste minimization, pollution prevention, design for environment, material substitution, dematerialization, de-carbonation, greenhouse gas, process substitution, environmental restoration, site remediation, etc. Several case histories, which have been gathered by the United Nations Industrial Development Organization (UNIDO) for the development of sustainable agriculture and industry using the industrial ecology

concept, are also presented.

1. Introduction and Definitions of Industrial Ecology

Industry, according to the Oxford English dictionary, is “intelligent or clever working” as well as the particular branches of productive labor. Ecology is the branch of biology that deals with the mutual relations between organisms and their environment. Ecology implies more the webs of natural forces and organisms, their competition and cooperation, and how they live off one another.

The recent diffusion of the term “Industrial Ecology” stems from its use by Frosch and Gallopolous (1989) in a paper on environmentally favorable strategies for manufacturing. Industrial ecology (IE) is now a branch of systems science for sustainability or a framework for designing and operating industrial systems as sustainable systems inter-dependent with natural systems. It seeks to balance environmental and economic performance within the emerging understanding of local and global ecological constraints.

A system is a set of elements inter-relating in a structured way. The elements are perceived as a whole with a purpose. A system’s behavior cannot be predicted by analysis of its individual elements. The properties of a system emerge from the interaction of its elements and are distinct from their properties as separate pieces. The behavior of the system results from the interaction of the elements and between the system and its environment (system + environment = a larger system). The definition of the elements and the setting of system boundaries are “subjective” actions.

In this context, industrial systems apply not just to private sector manufacturing and service but also to government operations, including provision of infrastructure. A full definition of industrial systems will include service, agricultural, manufacturing, military and civil operations, as well as infrastructure such as landfills, recycling facilities, energy utility plants, water transmission facilities, water treatment plants, sewer systems, wastewater treatment facilities, incinerators, nuclear waste storage facilities and transportation systems.

An Industrial Ecologist is an expert who takes a systems view, seeking to integrate and balance the environmental, business and economic development interests of industrial systems. He/she will treat “sustainability” as a complex, whole system challenge, and will work to create comprehensive solutions, often simply integrating separate proven components into holistic design concepts for possible implementation by his/her clients.

A typical Industrial Ecology Team includes IE partners, associates and strategic allies qualified in the areas of industrial ecology, eco-industrial parks, economic development, real estate development, finance, urban planning, architecture, engineering, ecology, sustainable agriculture, sustainable industry systems, organizational design, etc. The core capability of an IE Team is the ability to integrate the contributions of these diverse fields into whole systems solutions for business, government agencies, communities and nations.

2. Goal, Role and Objectives

An industrial ecologist's tasks are to interpret and adapt an understanding of the natural system and to apply this to the design of the man-made system in order to achieve a pattern of industrialization that is not only more efficient, but which is intrinsically adjusted to the tolerances and characteristics of the natural system. In this way, it will have built-in insurance against further environmental surprises because their essential cause will have been designed out.

A practical goal of industrial ecology is to lighten the environmental impact per person and per dollar of economic activity, and the role of industrial ecology is to find the leverage and opportunities for considerable improvement from practical effort. Industrial ecology can search for leverage wherever it may lie in the chain from extraction and primary production through final consumption, i.e. from cradle to rebirth. In this regard, a performing industrial ecologist should aim to become a preserver when endless re-incarnations of materials can be achieved.

An overarching goal of IE is the establishment of an industrial system that cycles virtually all materials. It uses and releases a minimal amount of waste to the environment. The industrial systems' developmental path to such an end state follows an orderly progression from Type I to Type II and finally to Type III industrial systems, as follows:

1. Type I industrial systems represent an initial stage requiring a high throughput of energy and materials to function and exhibit little or no resource recovery; it is a once flow-through system with rudimentary end-of-pipe pollution controls.
2. Type II industrial systems represent a transitional stage where resource recovery becomes more integral to the workings of the industrial systems but does not satisfy its requirements for resources; manufacturing processes and environmental processes are integrated at least partially, and whole facility planning is at least partially implemented.
3. Type III industrial systems represent the final ideal stage in which the industrial systems recycle all of the material outputs of production, though still relying on external energy inputs.

A Type III industrial ecosystem can become almost self-sustaining, requiring little input to maintain basic functions and to provide a habitat to thousands of different species. Reaching Type III final stage is the goal of IE. Eventually, the communities, cities, regions and nations should become sustainable in terms of natural resource use and environmental impact.

According to Frosch (1996), "The idea of industrial ecology is that former waste materials, rather than being automatically sent for disposal, should be regarded as raw materials—useful sources of materials and energy for other processes and products…

The overall idea is to consider how the industrial system might evolve in the direction of an interconnected food web, analogous to the natural system, so that waste minimization becomes a property of the industrial system even when it is not completely a property of an individual process, plant, or industry."

IE provides a foundation for sustainable industrialization, not just incremental improvement in environmental management.

The objectives of IE suggest a potential for reindustrialization in economies that have lost major components of their industrial base. Specifically, the objective of industrial ecology is not merely to reduce pollution and waste as traditionally conceived; it is to reduce throughput of all kinds of materials and fuels, whether they leave a site as products, emissions or waste.

The above objectives of IE have shown a new path for both industrial and developing countries. Central objectives of an industrial ecology based development strategy are making economies profoundly more efficient in resource use, less dependent upon non-renewable resources, and less polluting.

A corollary objective is repair of past environmental damage and restoration of ecosystems. Developing countries that recognize the enormous opportunity opened by this transformation can leapfrog over the errors of past industrialization. They will have more competitive and less polluting businesses.

3. Approach and Applications

The Industrial Ecology (IE) approach involves (1) application of systems science to industrial systems, (2) defining the system boundary to incorporate the natural world, and (3) seeking to optimize that system.

IE is applied to the management of human activity on a sustainable basis by: (1) minimizing energy and materials usage; (2) ensuring acceptable quality of life for people; (3) minimizing the ecological impact of human activity to levels natural systems can sustain; (4) conserving and restoring ecosystem health and maintaining biodiversity; (5) maintaining the economic viability of systems for industry, trade and commerce; (6) coordinating design over the life cycle of products and processes; and (7) enabling creation of short-term innovations with awareness of their long-term impacts.

For small industrial systems applications, IE helps companies become more competitive by improving their environmental performance and strategic planning. For medium-sized industrial systems, IE helps communities develop and maintain a sound industrial base and infrastructure without sacrificing the quality of their environments.

For the large industrial systems, IE helps government agencies design policies and regulations that improve environmental protection while building business competitiveness.

Application of IE will improve the planning and performance of industrial systems of all sizes, and will help design local and community solutions that contribute to national and global solutions.

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