The Importance of Industrial Ecology and Design for Environment to AT&T

Braden R. Allenby
Robert A. Laudise

AT&T recognizes that *industrial ecology* and *design for environment* (DFE) are crucial competencies that are vital now, and they will become keys to corporate success in the next century. The importance of these competencies is based on the following three fundamental considerations: the need to control environmental compliance costs; the need to meet customer requirements and demands; and the need to enlarge market access and generate continuous competitive advantage. Over the long term, environmental competence and offerings—especially in services that reduce material and energy consumption—will become increasingly important, and they will ensure that AT&T continues in a leadership position into the next century. Thus, all AT&T stakeholders—including customers, employees, shareowners, and the communities within which AT&T has a presence—attach crucial importance to both industrial ecology and DFE. In short, environmental concerns that once were considered overhead now have assumed strategic importance.

Introduction

Doing business in a global, highly competitive economy is not easy. Successful companies have been driven not just to new techniques, such as total quality management and just-in-time manufacturing, but to completely "reinventing" themselves. As a result, they have become nonhierarchical, project-oriented, flexible, and rapidly responding entities.

Temporary alliances and teams—which are known as *virtual companies*—have become increasingly common, especially in rapidly changing market sectors. The arrogance that unfortunately characterized many successful companies only a few short years ago has vanished. Such arrogance—punished brutally in the marketplace—has been replaced with a dedicated customer focus.

Change—once seen as an occasional challenge or sometimes an annoyance that had to be managed—has become an integral part of daily corporate life and a universal "given." In a fundamental sense, companies are reorienting themselves from concentrating on products and services to focusing on processes, fundamental competencies, and employees. Today, companies understand that if such a focus is nurtured and maintained, timely delivery of output—in a form that will delight customers—almost inevitably will follow. If this focus is not embraced, success will be elusive, even with herculean efforts.

Within the new business environment, the need to adopt yet additional objectives and constraints for operations, products, processes—and eventually, service design and provisioning—must be clearly defined and justified.

Even as companies have changed radically internally, the external world in which they operate has also changed, which in turn drives still more corporate change. The world of the late 20th century is not like the world in which our parents lived, and our children's world will be transformed even more.

One of the biggest engines of change is the profound concern for the environment

Table I. The three principal approaches to the mitigation of environmental issues

Principal approach	Timeframe	Focus of activity	Endpoint	Relationship of environment to economic activity	Underlying conceptual model	Policy leader	Cost of failure to perform
Remediation	Past	Individual site, media, or substance	Reduce local anthropocentric risk	Overhead	Command-and-control intervention in simple systems	United States	Liability, fine
Compliance	Present/past focus	Individual site, media, or substance	Reduce local anthropocentric risk	Overhead	Command-and-control intervention in simple systems	Developed countries	Liability, fine
Industrial ecology and design for environment (DFE)	Present/future focus	Materials, products, services, and operations over life cycle	Global sustainability	Strategic and integral	Guided evolution of complex systems	Northern Europe, especially the Netherlands and Germany	Loss of market access, noncompetitive products and services

now evident in virtually every country and at every level of society. This concern increasingly reflects society's more sophisticated understanding of the myriad links between economic activity and environmental effects.

This fundamental shift, which leads to environmental concerns being viewed as both truly strategic for companies and vital for society, is still underway. These concerns are integral both to the production of value and to the quality of life.

Table I summarizes the major aspects of the three principal approaches to the mitigation of environmental issues. The remediation and compliance approaches share many of the same characteristics. Most importantly, they both treat environmental factors as if they can be managed directly, without the need to address either the underlying causal economic activity or the particular technological system. Moreover, both approaches adopt a localized, media- and substance-specific end-of-pipe approach to environmental mitigation—that is, they are often unsystematic problem remedies. In short, they treat environmental perturbations as overhead to be "fixed."

It is now understood, however, that the truly serious environmental concerns requiring attention—such as stratospheric ozone depletion, loss of arable soil, global climatic change, degradation and depletion of water resources, and extensive loss of habitat and biodiversity—are both global in scope and long term in reach. They are also largely irreversible over the short term, and they involve perturbations of highly complex systems and material cycles.

Panel 1. Abbreviations, Acronyms, and Terms

AT&T-GIS—the Global Information Solutions business unit of AT&T

CFCs—chemical compounds known as chlorofluorocarbons that are suspected of depleting the stratospheric ozone layer

DFE—design for environment

EPA—the U. S. Environmental Protection Agency

industrial ecology—a study of the interrelationships that exist between the environment and economic activity, especially manufacturing. Special attention is paid to the use and recycling of the products of industry.

ISO—International Organization for Standardization

Even partial mitigation of these serious concerns is impossible without significant changes in current patterns of production and reform of economic activity. Thus, preservation of the environment is a strategic focus for individual companies and crucial to society as a whole.

Companies ignoring these fundamental concerns are in danger of being disadvantaged by regula-

Panel 2. What Is Industrial Ecology?

Industrial ecology may be thought of as "the science of sustainability." The first textbook on the subject, written by two AT&T authorities, provides the following definition:

> Industrial ecology is the means by which humanity can deliberately and rationally approach and maintain a desirable carrying capacity, given continued economic, cultural, and technological evolution. The concept requires that an industrial system be viewed not in isolation from its surrounding systems but in concert with them. It is a systems view in which one seeks to optimize the total materials cycle from virgin material to finished material, to component, to product, to obsolete product, and to ultimate disposal. Factors to be optimized include resources, energy, and capital.[5]

A major current focus of industrial ecology research at AT&T and elsewhere is the elimination or substantial reduction of the environmental effects of manufacturing processes and products over their life cycles—including product remanufacture and reuse—through development and implementation of DFE practices.

Through such research efforts and by the AT&T Foundation sponsorship of related university research, AT&T is playing a seminal role in establishing the field of industrial ecology. Increasing incentives for creating environmentally preferable designs and processes—an important immediate application of industrial ecology—will require changes in legal, economic, and management practices.

Application of industrial ecology will also require an extended body of "green" knowledge in physical science and engineering. Designers need enlarged, verified green databases and design tools for evaluating environmental consequences of design options. Many believe that implementing industrial ecology will be a principal challenge for business and society in the 21st century.

tions, outmaneuvered in the marketplace, and viewed as part of the problem by customers, employees, and fellow citizens. Companies recognizing and accepting the challenges of developing environmentally appropriate operations and offerings will be in a unique position to manage change and prosper into the next century.

Managing this change requires that new conceptual frameworks and tools be developed and deployed. These frameworks and tools include *industrial ecology* (see Panel 2) and its implementation through *design for environment* (DFE) practices, which will drive the evolution to environmental responsibility.

Two other aspects of Table I are worth noting. First, global companies must realize that environmental considerations are international in scope and that the United States is no longer a leader in many areas. For example, northern European countries—especially the Netherlands, Germany, and Scandinavia—are the clear world leaders in establishing regulatory structures based on the new industrial ecology paradigm. Accordingly, adherence only to U. S. practices is not adequate for global commerce.

Second, forward-looking European regulatory structures are not focused primarily on emissions but rather on products in the marketplace. Thus, a company's total cost for its failure to perform lies not just in penalties, as with current U. S. remediation and compliance approaches. A business can also lose market access, as well as product and service competitiveness. For example, the German Blue Angel eco-label is a crucial requirement for winning customers in many European markets.[1] Similarly, the manufacture of computers and telephones having plastic housings containing an incorrect flame retardant can preclude the sale of such products in some European markets.

Compliance Costs

This discussion is intended neither to denigrate the importance of compliance with existing end-of-pipe environmental regulations nor disparage the necessity of

Table II. The three stages of the waste-reduction process

Stage	Primary activities	Effects on productivity	Lead organization	CFC/chlorinated solvent example
Short term	Good housekeeping, emission-control equipment	None to negative	Environment, Health, and Safety (EH&S)	Replace tops on storage containers and scrubbers
Medium term	Minor restructuring of existing processes	None to slightly positive	EH&S and some plant engineering	Eliminate unnecessary cleaning steps
Long term	Product, process, and operation redesign	Potential for substantial increases	Core R&D, concurrent design teams, manufacturing	Design products and processes to use aqueous solvent systems

limiting future liability and clean-up costs. Legal and ethical considerations demand appropriate responses. Indeed, such companies as AT&T spend from 2 to 3 percent of annual revenues meeting environmental requirements. In addition, any global company must concentrate on limiting future liability in developing countries, even though the countries may not yet have sophisticated environmental regulatory programs in place. Operating a business to minimize expenditures for meeting environmental requirements is not only good citizenship but also a necessity if costs are to be reduced.

In most instances, managing these expenses requires reducing the amount of waste resulting from a company's daily operations, an area in which AT&T has excelled.[2] Moreover, evaluating how this is done is worth the effort because it shows that meaningful reductions in waste—especially in manufacturing operations—can only be implemented by using DFE principles and tools.

Conceptually, the waste-reduction process can be segmented into three stages, as shown in Table II. In the *short term*, improvements in emissions and waste reduction are achieved primarily by better housekeeping and augmented by emission-control equipment. Note that the latter, while often quite expensive, contributes very little to productivity or long-term shareholder value.

In the *medium term*, progress is achieved by improving existing processes. Such improvement can enhance productivity. Generally, however, the effects are not significant and oftentimes they are marginal at best. Such efforts are worthwhile, but because existing processes are usually well tuned, the resulting improvements ordinarily are not dramatic.

Significant improvements are made and maintained only during the *long term* and only if fundamental product and process reassessment and redesign are involved. While the effort required for such activities often can be substantial, it can lead to significant and enduring productivity gains across the manufacturing system. This strategy must draw on the core R&D and design competencies of a company and incorporate the practice of DFE. The strategy can then effect step-function improvements in the environmental performance of processes, products, and operations.

The process depicted in Table II reflects the experiences of progressive electronics companies, including AT&T, in migrating away from the use of chlorofluorocarbons (CFCs) and more broadly, chlorinated solvents as a class. The crucial first step was definition of the environmental challenge, facilitated in this case by clear scientific evidence of cause and effect (release of CFCs is strongly linked to stratospheric ozone depletion). This scientific evidence led to a vigorous response by the international community (the Montreal Protocol). AT&T responded by being the first electronics company to commit to a complete phaseout of CFCs in manufacturing.

Although regarded by some in the electronics industry as aggressive at the time, AT&T's action enabled its own transition away from CFCs rationally and cost effectively. The first or short-term stage—centering primarily on better housekeeping—could be completed quickly. It included such activities as ensuring that employees replaced tops on storage containers and that they used only the amount of solvent necessary for a given task.

The second or medium-term stage, which generally took a little longer, required re-evaluation of product flows through the manufacturing process. Such re-evaluation determined whether some of the cleaning

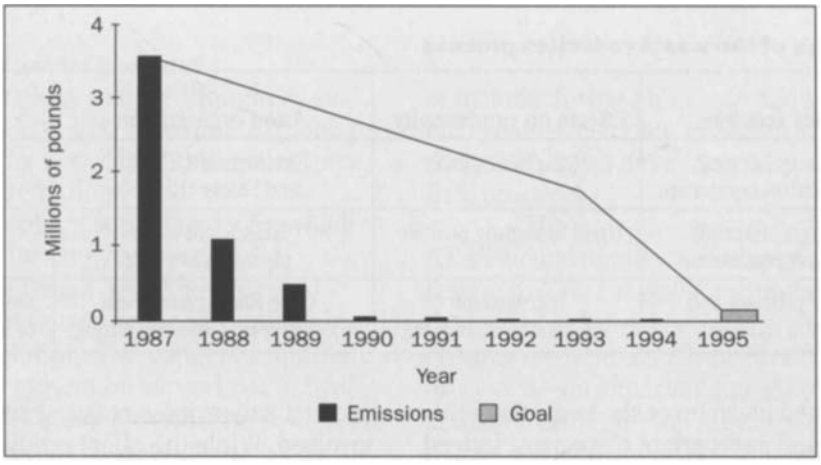

Figure 1. A management-level decision was reached requiring the replacement of all processes emitting CFCs and chlorinated solvent vapors at the AT&T Richmond Works. The reengineering of the plant's manufacturing activities resulted in a dramatic reduction of these and all other airborne emissions, as the bar chart illustrates.

steps being performed were even necessary or whether other steps could be eliminated through changes in product-management procedures.

The third or long-term stage, however, was far more fundamental. Unlike the other two preceding stages, it required using core R&D capabilities, redesigning products and processes to use more environmentally acceptable cleaning systems, and investing in new manufacturing equipment. These activities are still in progress, but the suite of technologies involved—for example, semi-aqueous and aqueous cleaning systems and carbon-dioxide pellet and snow cleaning systems—are not only environmentally preferable. For the most part, they are also more economical and frequently result in higher-quality products and lower production costs.

Consider, for example, the case of the AT&T Richmond Works, which produces printed circuit boards. Initial community right-to-know data indicated high emissions of both chlorinated solvents and CFCs. Although perfectly legal, such emissions were unacceptable to plant management. Some initial gains could be achieved by better housekeeping or by slightly modifying existing processes. Richmond Works employees quickly realized, however, that the resulting emission reductions would be relatively minor and difficult to maintain over time.

Accordingly, a management-level decision was reached requiring the replacement of all processes emitting chlorinated solvents and CFCs with environmentally preferable alternatives. This fundamental reengineering of the Richmond Works' manufacturing activities resulted in a dramatic reduction of all airborne emissions, as illustrated in Figure 1. Without such fundamental redesign of product and manufacturing operations, the Richmond plant could not have achieved its remarkable emissions reduction, nor could AT&T have met its environmental waste minimization goals.

What will the factory of the future look like? Perhaps a hint of such a zero-emissions facility is provided by the *molecular beam epitaxy* process invented at AT&T Bell Laboratories and already being used at many AT&T plants.

Originally, molecular beam epitaxy was invented to generate streams of atoms, which are aimed at a semiconductor substrate, to build a structure one atom at a time. This process can be used to produce products ranging from semiconductor lasers to high-speed transistors. It facilitates the production of unique electronic devices not possible using any other method.

Even though molecular beam epitaxy was not developed for environmental purposes, it features ultra-high efficiency and minimum environmental effects. Its principal environmental advantage is that almost every atom becomes part of the device being manufactured. Thus, very little waste goes up the stack or down the

drain. In addition, the use of such poisonous compounds as phosphine and arsine is greatly reduced and in some cases even eliminated.[3,4] Furthermore, molecular beam epitaxy is nearly as efficient as previous manufacturing techniques in its consumption of energy. AT&T's ultimate goal is to have all its factories achieve the same high efficiency that this new technology makes possible.

Delighting Customers

Typically, customers expect high-quality, well-designed products and services at a reasonable price. These attributes, however, no longer are enough in today's highly competitive markets. Thus, the challenges of delighting customers and differentiating one company's products from those of the competition are increasing.

Another technique is emerging, however, by which companies can distinguish their products in such highly competitive markets. This technique is the development of recognizable, world-class *environmental competence*. Such competency not only contributes to the value of a trademark, it also supports and justifies a company's pre-eminent public image.

Furthermore, customers increasingly prefer that the products and services they purchase not harm the environment. Equally important, of course, is that today's consumers do not want to face an environmental problem when disposing of products that have reached the end of their life cycle. Such a problem—now the responsibility of customers—can be solved through implementation of DFE methodologies.

Even though most customers are not yet willing to pay a premium for environmentally favorable products (at least in some countries), it is still important to understand the considerable depth of concern customers have about this issue. For consumers, the question is one of corporate integrity. Customers expect AT&T to be an environmental leader given its excellent reputation and tradition of technological leadership provided by AT&T Bell Laboratories. AT&T recognizes that if it is to continue to earn customers' business and respect, close attention to environmental issues is not optional.

For example, Patagonia—a supplier of outdoor clothing—recently made a decision to switch to AT&T long-distance service specifically because of AT&T's superior record of concern for the environment. AT&T's activities supporting industrial ecology and DFE—combined with its aforementioned reputation for environmental concern—originally led Patagonia to consider AT&T as its preferred long-distance provider. The actual decision to change carriers, however, was not made until Patagonia managers met with members of the AT&T Environmental and Safety organization, who reassured this customer about AT&T's firm commitment to safeguarding the environment and its ongoing implementation of DFE.

A decision by the Danish government to purchase AT&T Global Information Solutions (AT&T-GIS) PCs is yet another example of brand preference being driven—at least in part—by concern for the environment.[1] AT&T-GIS eventually won the contract because its PC product family was one of only a few available in Europe to meet the requirements of the German Blue Angel eco-label.

It is interesting to note that the Blue Angel directive requiring producers to take back products when consumers are finished with them shifts any risk of potential liability on ultimate disposal from the consumer (the Danish government) to the supplier (AT&T-GIS).

Of course, customers are not the only stakeholders having an interest in safeguarding the environment. For example, conscientious employees want to work for responsible companies. They want to be associated with a company of which they can be proud and about which their children can freely talk in school. AT&T's environmental program—driven increasingly by its empowered employees—contributes significantly to the company's ability to attract highly qualified people and to support a desirable and fulfilling work environment.

Market Definition and Access

Arguably, compliance could be maintained—albeit at greater expense and with some loss of productivity—through the intensive use of end-of-pipe technologies. The same cannot be said about the new generation of product-related environmental regulations. This situation can be demonstrated simply by referring to the standards established by the German Blue Angel eco-labeling requirements for PCs.[1] By no stretch of the imagination could requirements for modular design, limited variety of plastics, or product takeback by suppliers when customers are done with the products be met by any conceivable end-of-pipe approach.

A similar example is offered by the U. S. Environmental Protection Agency (EPA) Energy Star eco-label for computers, which can be obtained only by meeting minimum energy-efficiency requirements. In practice, this program has defined industry standards, and it is now in the process of being adopted worldwide (the EPA Energy Star eco-label is already a requirement in many state and national government requests-for-proposals). Such new product-related environmental regulations can only be met by involving the whole manufacturing enterprise—in short, by accepting such requirements as strategic necessities and not as overhead.

It is helpful to conceptualize the issue of market access and definition. A market may be visualized as having many requirements for success. Usually, however, only a few requirements are viewed as crucial—for example, time to market, price, quality, and user-friendly interfaces. Until recently, it has generally been true that the environmental characteristics of products or services have not been crucial for success, with the exception of markets for compliance or remediation technologies. Thus, manufacturers in most sectors had little market pressure to adopt environmentally preferable practices.

The first notable exception to the rule involving core manufacturing operations for the electronics industry is, of course, the successful elimination of CFCs by most leading companies. Shortly, international law and the EPA will no longer permit manufacturers to use CFCs to clean electronic components. Despite this fact, however, many high-technology manufacturing companies have yet to understand the extent to which environmental considerations are becoming an important, sometimes critical dimension of many markets.

Such importance will become apparent as the environmental management and environmentally related product standards and methodologies take effect. These governing factors, currently under discussion at the International Organization for Standardization (ISO), will be known as *ISO 14000*.

Covering not only corporate environmental management systems (in a manner analogous to ISO 9000 quality requirements), ISO 14000 will also influence, for example, the uniform methodologies used for determining the life-cycle effects of materials and products. It will also provide environmental standards and requirements broadly applicable to products. Additionally, standards for the eco-labeling of products will be established, attaching more importance and "legitimization" to these already significant programs.

An interesting example of a market being established essentially from scratch by government environmental regulation arises from the amended U. S. Clean Air Act. In one noteworthy section, it required that employers implement plans to reduce commuting by its employees in locales having poor air quality, thus presenting a substantial challenge to many employers. This situation represents an extension of employers' accountability to an activity not traditionally regarded as their responsibility.

Viewed another way, however, the government created by fiat a substantial market for teleworking platforms and related services. Industry response to this potentially significant opportunity has been slow and sporadic, in part because product managers and business planners in the electronics industry are not used to markets being defined or created along environmental dimensions. The opportunity already exists, however, and the penalty for not embracing it is relinquishing the market to more nimble and aggressive competitors.

Although the historic motivation has not been environmentally related, AT&T already offers many products and services that address the needs of teleworkers. Some of these offerings include facsimile machines, as well as conference call, data transmission, and TV conferencing services. And more offerings are on the way.

Yet another example of a market being defined by government environmental regulation and customer demand is the increasing pressure—especially in northern Europe—for producers to take back their products after consumers are done with them. The purpose of such a take-back program is to facilitate the recycling of products, their components, or constituent materials. Some take-back requirements, which impose a cost penalty on products not designed for refurbishment and recycling, can substantially change a manufacturer's economies of operation. Products that are competitive when first sold may lose their market advantage if their life-cycle management costs have not been considered and appropriate design changes made before production.

More fundamentally, additional business challenges and opportunities will arise in developing and

maintaining the logistics systems, recycling technologies, and recycling centers that product takeback will inevitably generate. Accordingly, companies must become highly competent in materials issues and DFE to ensure that their products will remain cost competitive over a much more complex life cycle. Product takeback, however, is only the initial step of an evolution that leading policymakers—especially in Europe—see ending in a "functionality economy" in which consumers primarily purchase functions and not products.

The Future

Most customers want to buy a product's functions rather than the materials it contains. Given this realization—and recognizing that industry can be regulated more readily than the consuming public—some Europeans are proposing a "functionality economy" in which customers primarily purchase function and not products. Thus, for such offerings as automobiles, computers, and even telephones, the manufacturers would retain responsibility for product performance and for recycling or disposal. Consumers would simply lease the products or otherwise purchase the service the products happen to provide.

Obviously, the foregoing scenario would apply only to nonconsumables. Food, personal-care products, pesticides, and the like provide function only as their constituent materials are consumed. For nonconsumables, product life-extension programs to slow down obsolescence and reduce the need for new materials become important.

The end result of such an arrangement would be a dramatically different world in which relationships with customers would revolve around service provisioning and not product sales. Combined with the need to extend product life, the result is that manufacturing would become an underlying platform for service offerings. Thus, companies that rely solely on manufacturing volume rather than good life-cycle design and service provisioning could rapidly lose their competitive edge.

The competencies required by companies in such an economy—including service orientation; logistics efficiency in both product distribution and return; lifecycle material, component, subassembly, and product-management skills; and related planning capabilities—are far different from those needed in today's market.

And yet, these competencies are not unprecedented. After all, prior to divestiture, the old Bell System did something similar with virtually all the telephones in the United States. Likewise, AT&T still manages the embedded base of its leased equipment. Such companies as AT&T—having strong competencies in design, manufacturing, and services—are well positioned to compete effectively in a functionality economy.

Once informed, consumers probably would be delighted to lease state-of-the-art information terminals having service guarantees and an unlimited take-back policy. This equipment would also be backed by an environmentally responsible product- and material-management system.

For companies like AT&T, however, the potential competitive implications of an increasingly constrained, environmentally aware world are far more significant. It is apparent that energy and raw materials will become more costly over time as the external environmental elements (social costs) associated with them are factored into their prices.

It is also apparent that the cost of information management—measured in both processing power and transmission bandwidth availability—will continue to fall rapidly. Moreover, the technological explosion of sensor technology means that the ability to obtain relevant data will also expand significantly.

The combination of the two aforementioned fundamental trends implies considerable substitution of information collection and management for more traditional, too frequently profligate economic inputs of raw materials and energy. Just such a process is evident in the evolution of the modern automobile, which to a large extent has used increased information processing not only to improve environmental performance, but also to provide higher quality, safer transportation (for example, the installation of air bags linked to deceleration sensors).

AT&T recognizes, therefore, that current fads or market conditions are not the only factors driving the need for DFE, its value, and the concomitant practice of the theory of industrial ecology. Rather, looking into the future, it is accurate to consider electronics and communications as keys for achieving a sustainable economy.

The opportunities inherent in industrial ecology and the role that the information society will play in transforming the economy create a fundamental and even daunting responsibility for AT&T and other companies. Many additional opportunities will also be created.

The race is to become the most innovative, the most visionary, and the most effective company understanding industrial ecology and implementing DFE. The prize is not just competitive success, but also a better world in which to live. It is a race in which AT&T has already begun to compete in earnest.

References

1. F. Hermann and P. Kleinsorge, "Environmental Certification of AT&T-GIS in Augsburg, Germany," *AT&T Technical Journal*, Vol. 74, No. 6, November/December 1995, pp. 72-78.
2. J. C. Borum and B. F. Dambach, "Meeting AT&T's Global Environmental Goals," *AT&T Technical Journal*, Vol. 74, No. 6, November/December 1995, pp. 36-43.
3. See, for example, J. N. Baillargeon, A. Y. Cho, R. J. Fischer, P. J. Pearah, and K. Y. Cheng, "Electrical Characteristics of InP Grown by Molecular Beam Epitaxy Using a Valved Phosphorous Cracking Cell," *Journal of Vacuum Science & Technology B*, Vol. 12, No. 2, 1994, pp. 1106-1109.
4. See, for example, A. Y. Cho, ed., *Molecular Beam Epitaxy*, AIP Press, New York City, 1949, pp. 1-2.
5. T. E. Graedel and B. R. Allenby, *Industrial Ecology*, Prentice Hall, Englewood Cliffs, New Jersey, 1995.

(Manuscript approved October 1995)

Braden R. Allenby *is research vice president, technology and environment, at AT&T Global Manufacturing and Engineering in Basking Ridge, New Jersey. He is currently on assignment as the director for energy and environmental systems at the Lawrence Livermore National Laboratory (LLNL) in California, where he is developing an industrial ecology research program for LLNL and the U. S. Department of Energy. Mr. Allenby holds a B.A. degree from Yale University in New Haven, Connecticut. He also holds a J.D. in law and an M.A. in economics from the University of Virginia in Charlottesville, and M.S. and Ph.D. degrees in environmental science from Rutgers University in New Brunswick, New Jersey. Mr. Allenby joined AT&T in 1983.*

Robert A. Laudise *is adjunct chemical director at AT&T Bell Laboratories in Murray Hill, New Jersey. He is responsible for environmental research and policy, especially industrial ecology. He is also active in electronic materials preparation and properties, crystal growth of electronics materials, and chemical research directions and priorities. Mr. Laudise has a B.S. degree in chemistry from Union College in Schenectady, New York, and a Ph.D. in inorganic chemistry from the Massachusetts Institute of Technology in Cambridge. He is a member of both the National Academy of Engineering and the National Academy of Sciences and has received numerous national and international prizes for his work in materials. Mr. Laudise joined AT&T in 1956.*