Books

Product Innovation and Eco-efficiency: Twenty-three Industry Efforts to Reach the Factor 4, edited by Judith E. M. Klostermann and Arnold Tokker. Dordrecht, the Netherlands : Kluwer Academic Publishers, 1998, 296 pp., ISBN 0-7923-4761-7, $163.50 hardcover.

Eco-efficiency makes business sense. By eliminating waste and using resources wisely, eco-efficient companies reduce costs and become more competitive. And as environmental performance standards become commonplace, eco-efficient companies will be at an advantage for penetrating new markets and increasing their share of existing markets. These simple and compelling truths need to be disseminated and demonstrated broadly, repeatedly, and clearly to both industrial and academic audiences. Only then will a business climate emerge that supports meaningful investments in industrial ecology, design for environment, and similar innovations that produce quantum leaps in eco-efficiency.

How disappointing it is, then, to review a book that completely misses the mark, and wastes an opportunity to reinforce the above message. "Product Innovation and Eco-efficiency" begins auspiciously enough, offering an overview of industry drivers and available tools, followed by a compilation of industry experiences from companies that have implemented eco-efficiency initiatives. The organizational concept set forth in the introduction is acceptably alliterative—three main sections will describe the *issues* (driving factors), *instruments* (available tools), and *industries* (sector-specific case studies). The situation quickly deteriorates, however, as one attempts to follow the meandering and often elementary overview discussion of the state of the practice. A brief summary of "environmental demands" related to sustainability goals omits a number of important factors, including land use, water quality, and biodiversity. The subject of social expectations and lifestyles in developing economies is not mentioned, despite its obvious importance for product innovation. The "toolbox" of quantitative instruments that is offered is rather empty—only life-cycle assessment and total cost assessment are listed. A method for calculating the eco-efficiency of a particular industrial process is nowhere to be found. Finally, the discussion of industry's environmental strategies is woefully abstract and elementary. By the end of the 30-page introduction, one is longing for the more substantive material that must surely follow.

Once again, the reader's hopes are dashed. Part II of the book is supposed to address driving factors, but is actually a compilation of case studies of eco-efficient technologies for an assortment of products and processes, including metal machining, cement, co-extruded polyvinyl chloride (PVC) pipe, energy services, and food production. Although all the chapters present interesting, self-contained discussions, they do not contribute in any clear pattern to the overall theme that was proposed. Part III is somewhat more satisfying, because a number of industrial examples of the application of quantitative tools, mainly life-cycle assessment, are presented. Nevertheless, the lack of a consistent framework and vocabulary is disconcerting, and the later chapters in this part of the book grow increasingly esoteric and obscure. Part III consists of a residual collection of case studies that did not fit into either Parts I or II, although the logic of these choices is not very obvious. Ultimately, a mere compilation of conference papers is not sufficient to constitute a book, although attending the individual presentations might have been very informative. One might derive value from this book by scanning the list of chapters to see whether any of the sector-

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specific papers are relevant to your interests. I see little or no value, however, in attempting to read the book continuously.

Interpreting between the lines, I must conclude that this book suffers from an absence of commitment. It is based on a collection of papers that were to be presented at a conference organized by TNO, a Dutch consulting and research organization, in 1996, but the conference was mysteriously "suspended." The editors do not approach the subject with a strong conceptual framework, and their introductory comments are unenlightening. For example, no clear definitions are offered of any of the key topics presented—sustainability, eco-efficiency, product innovation, and so forth. (It should be noted that the TNO staff members responsible for these writings were relatively junior, so these shortcomings do not necessarily reflect a lack of TNO experience, just a lack of attention to this work product.) Although the list of contributors includes an impressive number of major European firms, such as Unilever and Akzo Nobel, the quality of the individual chapters is highly variable, ranging from overly brief to excessively pedantic. Readers hoping for a richer and more comprehensive source of information on eco-efficiency are better served by consulting the publications of the World Business Council for Sustainable Development, where references to books of greater rigor, depth, and practicality can be found.

Joseph Fiksel
Battelle Memorial Institute
Columbus, OH USA

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Biomimicry: Innovation Inspired by Nature, by Janine M. Benyus. New York: William Morrow & Co., 1997, 308 pp., ISBN 0-688-13691-5, $25.00.

Cats' Paws and Catapults: Mechanical Worlds of Nature and People, by Steven Vogel. New York: W. W. Norton & Co., 1998, 382 pp., ISBN 0-393-04641-9, $27.50. (The paperback version of this book is now available in the United States, ISBN 0-393-31990-3, $14.95.)

Here we have two books dealing (not exclusively) with biomimetics that are at opposite ends of a continuum of hope and understanding. Biomimetics? I have always defined it as the abstraction of good design from nature, and this seems to have caught on. For my purposes, "good design" covers not only the object you may see in front of you, but also, more significantly, its energy budget. With global energy accounting, it may turn out that nature's design is cheaper if an object is made lighter and repaired continuously, rather than made with a larger safety factor. This approach will also take into account the energy used for recycling, because this has to be an integral part of the original design. The term "biomimetics" was stolen from chemists who invented it in the late '70s, and it replaced the term "bionics," which is still in use in non-English-speaking Europe. Whichever term is used, the modern concept stems from the U.S. armed forces, although the hopes it encapsulates date back to the beginning of history.

Man has always cast around for ideas to make his life easier, and other organisms are perhaps the closest source for these ideas. Steven Vogel is a practising zoologist who hopes for very little because he understands so well the problems and myths. Janine Benyus derives her understanding at second hand, and so has more room for hope. Let's start with Benyus. She has three views: nature as model (solar cell inspired by a leaf), nature as measure ("rightness" of innovation—what works, what is appropriate, and what lasts), and nature as mentor (what we can learn from nature in terms of process). She has derived most of her information from a series of interviews that she recounts with the discursive approach of a newspaper reporter. This may soften the science for the nonscientist, but it also tends to obscure the message. She explores the visions of scientists and entrepreneurs who see in nature the implicit, if not the explicit, solution for a wide variety of problems in science and engineering, sociology, agriculture, medicine, computing, commerce, politics, and philosophy. Most of these ideas are chosen for their accessibility rather than their truth or utility, but at the same time she covers a far wider range of topics than does Vogel. In much of this she is uncritical, perhaps because she is unable to cope with the concepts, but more

likely, I feel, because she has an innate modesty about her capacity to analyze and synthesize what she has been told. In the last chapter, she starts to think for herself and synthesizes arguments of solidity and shape. It's a pity she does this so late. Her final message is a four-parter: stop, listen and look, echo ideas, and preserve. This is a fine message for the general reader, or the nonscientist. Tell someone that an idea comes from nature and you're halfway toward selling it. Nature is green, OK. Nature is sexy.

When Vogel writes about science, not only does he explain things elegantly, but people see fit to give him prizes for doing so. I like reading his books not only because they summarize much in few words, but also because Vogel has the wit to give his subjects their proper context, both scientific and sociological. As a result, the mix of nature and engineering that he reports can be seen to be a product of the times as much as of minds. The last third of the book is devoted to biomimetics, a subject about which Vogel is mostly very well informed. He argues closely about the origins of a number of ideas whose origin is often given as biological. I'm happy to agree that the Eddystone lighthouse was unlikely to be modeled on an oak tree, and anyone who bases a tunnelling system on a wood-boring shellfish is courting derision. But Paxton's Crystal Palace, covered by his patented ridge-and-valley self-draining glass roof, is repeatedly reported as reputedly copied from the support system of the leaf of the giant water lily, *Victoria amazonica*. Paxton was the first to grow these lilies in England, and so he had the opportunity to study them. Vogel reports a talk given by Paxton while the Crystal Palace was under construction in 1850 and somehow, I cannot see how, maintains that Paxton was using the leaf as an illustration rather than as the origin of his ideas. Vogel is too concerned, I feel, that engineers should not be demeaned because they can't be shown to be original. But it has often been said that good artists borrow, great artists steal.

So—here we have two books. One is discursive, full of wonderful biomimetic ideas with not a thing wrong to say of them, the other highly critical and to the point. Both of them miss my mark of what biomimetics is and where it could go. Neither of them says anything about the creative processes that are required to remove the idea from the cage of local optimizations within which it functions, and place it, adaptively, within another context. Neither of them makes an attempt to analyze the competence of biomimetics as an approach (although Benyus takes a far wider view). They also fail to compare it with other problem-solving paradigms or techniques such as TRIZ, a system invented in Russia about 50 years ago that provides a set of rules and a large database of patents and principles. So neither of them is a handbook to biomimetics.

This review uses the word "hope" rather a lot. Perhaps this is significant, as biomimetics is essentially untried and untested as a tool of design. We still don't know how to interrogate nature effectively. And anyone who has had to turn a design into a product will know that development and production are far more difficult than having the original concept. My own feeling is that if you have a design deadline approaching and large amounts of money at stake, you will not care too much where the ideas come from as long as they work. But that's the way nature works, too.

Julian Vincent
University of Reading
Reading, UK

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Human Choice and Climate Change [four-volume set], edited by Steve Rayner and Elizabeth L. Malone. Columbus, OH: Battelle Press, 1998, 1,714 pp., ISBN 1-57477-040-3, $100.00 paperback.

This four-volume set is the result of a major enterprise that started in 1993 under the heading of Global Climate Change and the Social Sciences. The project, initiated by Steve Rayner and Chester Cooper of Battelle Memorial Institute, was triggered by the growing awareness among social scientists that climate change is as much a social sciences issue as it is a natural sciences issue. Until the early eighties, the climate-change problem had been framed by natural scientists primarily as a problem of growing atmospheric concentrations of greenhouse gases.

Their remedy, as reinforced by political declarations in the late eighties and early nineties, was a direct reduction of emissions by 20% by the year 2005 or in a later year, a stabilization of emissions at the 1990 level by 2000, and, as agreed in the December 1997 Kyoto Protocol, a reduction of emissions by 6% to 8% by 2010 as compared to 1990.

Even in the early nineties (and more so today), it was clear to many scientists and policy makers that something was missing in the debate. The whole notion of people and institutions altering their patterns of energy production and land use in view of a long-term and relatively remote problem such as climate change was not considered to be as straightforward as many of the natural scientists had thought in their early recommendations regarding policy responses.

What was missing was a thorough social sciences analysis of the issue: What do we know about past behavioral changes in view of long-term problems and related choices by individuals, groups, and institutions? How may people in local settings with given local priorities respond to global issues? What type of cost-benefit analysis do people, groups, institutions, and countries make under such circumstances? What can we learn from earlier societal responses to similar or comparable circumstances, and so on?

The goal of the initiators of this social sciences analysis has been to assess the state of knowledge in the social sciences domain, including public policy, history, economics, law, and international relations. This is a very challenging enterprise. This is particularly so, as social scientists do not have the record of long-term and fruitful international cooperation that the natural scientists do. The natural scientists, by the nature of their work, have the ability to build a consensus on what is generally accepted as the truth, what is less certain, and what is speculative. In contrast, the object of study in the social sciences is a continuously moving target, and the way this target moves is at least partially dependent on the way the target is described. Assessing the state of knowledge in the social sciences domain is considerably more of a challenge than in the natural sciences domain.

It is not surprising, therefore, that it took the initiators about five years to reach their goals. The result was published in 1998 by Batelle Press. The publication consists of four volumes with the following titles: Volume 1, The Societal Framework; Volume 2, Resources and Technology; Volume 3, The Tools for Policy Analysis; and Volume 4, What Have We Learned. The last volume is a very practical summary of the enterprise as a whole.

First, the editors should be complimented on their long-term commitment to the goals they had set for themselves. It is clear, not only from the acknowledgment, but also from the main text that the volumes have been written and reviewed by the best social scientists on global environmental change the world can presently provide. A second compliment I want to make is that the volumes and their findings are very relevant and will not easily be outdated. Although the target of the study is moving, the authors have identified a number of major "laws" that will remain valid for years, and maybe decades to come.

This four-volume set is the most comprehensive social sciences analysis of the issue of global climate change presently available. Because it is focused on the social sciences as such, it is more comprehensive than the social sciences chapters of the Intergovernmental Panel on Climate Change (IPCC) Assessment Report. Of course, it also has fewer constraints than are present in the IPCC process, where governments have to agree on the formulation of the starting document as well as the formulation of the final policy makers' summary.

Focusing on the notion of human choice (whether individual, as a group, or institutional) has helped the editors and also helps the readers to come to grips with the very broad topic of global climate change. In natural sciences terms, climate change may be a unique problem, but the authors illustrate that this is not necessarily so when climate change is studied by the social sciences community as an issue of choice. We can learn much from an analysis of how society has made choices in the past.

The authors have edited the book in such a way that it can be used as a work of reference by the social and the natural scientists as well as the decision makers and their advisors. Interesting are some of the bold statements about population growth not being a very relevant and useful

parameter in the debate about addressing climate change. Similarly interesting is the finding about framing the issue of global climate change in a much wider context than emissions control. According to the authors, it should be framed in terms of employment, defense, economic development, and public health.

To list a few shortcomings as well, I would like to raise the issue of power and established interests. This topic has not been covered so well in the publication. What I would have appreciated is an analysis of the way in which the tobacco industry has responded to claims about the health effects of smoking. (Could there be any parallel in the way the energy industry has responded to the issue of climate change?) Overall, the authors of this potentially controversial book have formulated the issues and the findings in a way that is only marginally biased. The U.S. government's position can be recognized, such as in the preference for acting later, as the action may become cheaper over time, and in the notion that emissions control in poor countries would be cheaper. These are positions that could easily be disputed. If the editors had been European, the counterarguments would definitely have been more elaborate.

In summary, this set is an excellent work that provides a broad overview of what the social and policy sciences have to say about climate change. After reading it, one will be convinced that it is only the start of a much larger exercise: developing global cooperation among human dimensions researchers that is of an intensity comparable to that of their colleagues in the natural sciences. Fortunately, an International Human Dimensions Program of Global Environmental Change is presently shaping up. As a follow-up to initiatives such as this book, a series of Human Dimensions Research projects have been launched under the auspices of the International Council of Scientific Unions and the International Social Sciences Council. The projects are, respectively, Environment and Human Security, Institutions, Land Use and Cover Change, and Industrial Transformation. In a few years time, the field plowed by Steve Rayner, Elizabeth Malone, and their 120 coauthors and reviewers will deliver more and more systematic information on how to deal with the complex issue of global environmental change. This four-book set on human choice and climate change is a good starter for anyone that has the ambition to do research or form an opinion on human behavior that affects the global environment. It will tell you that simple answers are not necessarily robust answers.

Pier Vellinga
Institute for Environmental Studies
Vrije Universiteit
Amsterdam, The Netherlands

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Cool Companies: How the Best Businesses Boost Profits and Productivity by Cutting Greenhouse Gas Emissions, by Joseph J. Romm. Washington, DC: Island Press, 1999, 200 pp., ISBN 1-55963-709-9, $24.95 hardcover.

Profit Centers in Industrial Ecology: The Business Executive's Approach to the Environment, by Ronald S. Smith, Jr. Westport, Connecticut: Quorum Books, 1998, 288 pp., ISBN 1-56720-209-8, $65.00 hardcover.

Joseph Romm, a veteran of the U.S. Department of Energy, has written a "benchmarking book" about some companies' successes in improving energy efficiency. His intention is to encourage managers in other firms to follow suit. Ronald Smith, previously at the New York City Department of Sanitation, wrote his book to show, through numerous examples, how executives can set up environmental management programs that improve the financial position of their firms.

Romm and Smith are kindred spirits. Both inhabit the "win-win" camp in the debate on business and the environment. So the broad outlines of their arguments are similar, and familiar (if not necessarily palatable) to students of industrial ecology. Smith says, for example, "A serious commitment to energy conservation would result in a drop in energy requirements of up to 30% with no deterioration in current living standards" (p. 5); and Romm writes about "companies that have boosted profits and productivity by cutting greenhouse gas emissions: . . . any

company can do this and every company should do this" (p. ix).

Even for readers who are skeptical of propositions of this sort, each book contains useful information. Readers of *Natural Capitalism: Creating the Next Industrial Revolution*, by Paul Hawken, Amory Lovins, and L. Hunter Lovins, will find many of the same companies discussed in Romm's book, but Romm devotes more space to technological nuts and bolts that make the stories more interesting and persuasive. Smith, too, is knowledgeable about the engineering aspects of environmental management. Each book is especially strong on technical questions involving lighting, and Romm is good on motors as well. Managers who have been persuaded of the importance of investing more time and effort in improving environmental performance are likely to find interesting ideas in either book, particularly if they are not engineers.

Despite their strengths in engineering, neither book is a reliable guide to the economic and financial aspects of environmental management. Both are imprecise in their treatment of basic financial arithmetic. Consider this sentence: "In this book, a one-year simple payback means a $1 investment that generates $1 in savings each year, which equates to a 100 percent ROI" (Romm, p. 5). This is true only if the savings stream lasts forever. Now consider this definition: Net present value is "the present value of the expected net cash flows of an investment, discounted at the cost of capital, less the initial cost outlay of the project. An investment is profitable if the NPV of the net revenues it generates in the future exceeds its cost, that is, if the NPV is positive" (Smith, p. 251). Here "NPV" refers to two different quantities when it appears two times in the very same sentence.

Romm includes the word "productivity" throughout his book, even in its title, but does not define it explicitly. Usually he means labor productivity, or output per unit of labor. Once (p. 41), drawing on *Dynamic Manufacturing* by Robert H. Hayes, Steven C. Wheelwright, and Kim B. Clark (1988), he points out that total factor productivity (TFP) is really the important measure: "TFP examines the overall efficiency of a process, as opposed to the efficiency with which it uses any single factor, such as labor." This is exactly right. But then TFP is absent from the rest of the book. Clearly, a company can increase labor productivity by adding capital, or can increase energy efficiency by substituting capital and managerial attention; the question is, when are these purchases worth the opportunity costs of the inputs, including the managers' time? More attention to this fundamental question would have made Romm's book much more useful both to managers and to scholars.

The use of the phrase "profit center" in Smith's title may lead readers to think that the book will enlighten them on questions of incentive design and organizational structure. This is not one of its strengths, however. A "profit center" in Smith's book is not the same as a "profit center" as ordinarily defined by accountants. For Smith, a profit center is "any commodity, activity, task, or service that creates a positive cash flow after all start-up expenses have been paid. Wasted resources and excess production become cost centers. Cost centers reduce profitability and lessen the stability of any enterprise. Profit centers infuse the company with investment capital. Cost centers flush it away" (p. 2). To an accountant, a profit center is just an organizational unit whose performance can be measured in terms of the difference between its revenues and its expenses. A cost center is a unit whose contributions to the firm's revenue are so expensive to trace that the firm deems the exercise to be not worth the effort (cf. Anthony and Reece 1983). In this more conventional vocabulary, legal departments and environmental staff offices are ordinarily cost centers, but this does not mean, of course, that they reduce the profitability or lessen the stability of the enterprises to which they belong.

The most serious problem with both books is their failure to study failure. Each book contains numerous "case studies," ranging in length from a sentence to a few pages, of companies that have successfully (in the views of the respective authors) implemented programs to improve environmental management, enhance energy efficiency, or boost labor productivity. Neither book examines firms that have tried to implement such programs and found themselves unable to do so, or that have implemented such programs and subsequently lost money. It is simply not

possible to determine the conditions necessary for success in any arena without studying examples of failure. The authors' inattention to such examples causes their books to be stronger on exhortation than analysis.

Forest Reinhardt
Harvard Business School
Boston, MA, USA

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Options for Closed Water Systems: Sustainable Water Management, edited by H. Aalderink, E. Van Ierland, B. Klapwijk, G. Lettinga, M. Lexmond, and P. Terpstra. Water Science and Technology series, Vol 39/5. Amsterdam: Pergamon Press, 1999, 272 pp., ISBN: 0-08-043641-2, $163 paperback.

"Water, water everywhere, nor any drop to drink." This famous quote from Samuel Taylor Coleridge's *The Rime of the Ancient Mariner* could be a very apt description of *Options for Closed Water Systems: Sustainable Water Management*, published as volume 39/5 of the *Water Science and Technology* book series. This volume contains thirty-two selected proceedings of the International Congress held in Wageningen, the Netherlands in the spring of 1998. Sustainability is a concept difficult to define in strict terms, and this book offers only limited help. One paper starts with the premise that sustainability "is the ability of people and their representative organizations to sustain lifestyles compatible with environmental integrity." A more helpful and pragmatic approach (Braden and van Ierland) defines sustainability of water management as "maintaining the abundance and quality of water resources [for] ecosystems and future human needs while also meeting current household and commercial water requirements." The authors of this definition further argue that "the most important threat to sustainability is the failure of institutions to translate social costs and benefits into individual costs and benefits." They call for internalization of environmental impacts into the total costs of water use and note that "attempting to circumvent these costs in the name of disaster relief or aid to the poor or economic development or affordability will only lead to unsustainable choices in land uses and water management." Accordingly, "ecological outcomes must be included in the assessment of benefits and costs" and "treating ecological targets as sacred or ignoring them altogether will result in inappropriate and unsustainable decisions that may later have to be undone." This paper should be a required reading for all interested in sustainability (however it is defined) (pp. 17–23). Similarly, the discussion of historical concepts and new paradigms behind sanitation (Harremoes) is also a must-read item. The "inherited concepts" of centralized water supply and wastewater treatment are contrasted with three new principles that will guide water management (in urban areas) in the future. These three principles are (1) concern for confined resources, which should be used without exhaustion, (2) protection of the environment against irreversible damage, and (3) concern for the welfare of the coming generations. Against this background, the author discusses different options for handling materials flow through a society and some related alternatives for infrastructure development. He concludes that "in the industrialized cities, the inherited infrastructure weighs heavily in favor of continuation of centralized management of water in urban areas." In contrast, "the options in developing cities are many, but lack of control of the urban development, lack of economy, and lack of the political priority will not favor adequate solutions"(pp. 1–8).

The first two papers set the stage, and the remaining twenty-nine contributions cover the technological, economic, social, and ecological aspects of sustainable urban water management systems. The first group of papers deals with sus-

tainable water use in individual households or small settlements. Options discussed include the reuse of graywater and augmentation of individual supplies by rainwater (Dixon et al.; van der Hoek et al.). In this context, a systems approach is especially interesting as it provides a rigorous framework for the analysis of domestic water supplies in urban areas (Terpstra). In applying this approach to planning a new large residential development, different options for the water supply were compared and ranked in terms of costs and environmental consequences (Icke et al.). Although, in the presented case, a conventional water supply had the lowest cost, the authors believed that other, more "sustainable" approaches were worth the additional expenditures. The transparency of this approach makes it especially valuable, as additional costs are clearly assigned to perceived environmental benefits.

In parallel with the first group of presentations, several other authors report on small-scale collection of wastewater and runoff and on small-scale wastewater treatment options. Separation of different wastewater sources (graywater and blackwater in households) is espoused as an important factor for feasibility and further optimization of water reuse systems (Otterpohl et al.: Skjelhaugen). For small-scale treatment, anaerobic processes (Elmitwalli et al.; Zeeman and Lettinga; Rebac et al.) and filters (van Buuren et al.) offer a lot of promise, although nontechnical factors (such as odor control or community acceptance) may have more weight than strictly technological performance (Kalker et al.; Tao and Hills).

Rainwater has been previously suggested as a significant source of water. The presented papers from the United Kingdom (Dixon et al.) and Denmark (Mikkelsen et al.), however, conclude that rainwater collection offers only a very small addition to water supply. In addition, rainwater quality varied considerably depending on the intensity of the rain, its duration, and the types of roof materials used. Concentrations of metals and selected organics (e.g., polyaromatic hydrocarbons) in collected rainwater exceeded appropriate health standards in many instances (Förster). Although the impact of rainwater collection on water supply may be minimal, its effects on stormwater runoff and combined sewer overflows (CSO) could be quite significant. An analysis of historical rainfall data combined with models for rainwater capture and storage show a large potential for CSO reductions (Vaes and Berlamont). Similar benefits were accomplished using permeable pavements and subsurface storage at a small hotel site (Pratt).

A section of the proceedings is devoted to water reuse in industry, in agriculture, and at centralized wastewater treatment plants. Results of several studies using advanced treatment processes (like ozonation, membrane filtration, and anaerobic reactors) (Roeleveleld and Maaskant: Terras et al.; Hien et al.; Al-Gohary and Nasr; Rozzi et al.; van der Graaf et al.) indicate that water reuse is possible in different industries. Alternative treatments may include wetlands (Willers et al.) and slow sand filtration (van Os). Generalization of these individual experiences, however, is difficult, not only because of local differences, but also because an assessment framework is largely missing.

The development of such an assessment methodology is the focus of the last three papers. A semiquantitative presentation (Lundin et al.) of long-term trends of water consumption, wastewater treatment, and, notably, energy demands for a large city leads to a vague conclusion that the studied city "is moving towards a more sustainable status." A more structured approach (Mels et al.; Ashley et al.) considers life-cycle assessment and multicriteria analysis for evaluation of different options for water supply and wastewater treatment. These tools, adopted from industrial ecology, are very promising for an integrated assessment of water management and its impact on society and the environment.

Overall, despite the best efforts of the editors, the volume is a bit of a mixed bag. Most of the papers present valuable information of different aspects of sustainable water management or provide new insight into the topics. Some, however, limit their discussion to platitudes or baffle the reader with phrases such as "the consequences of modernity of the alternatives to conventional treatment." Although burdened with a few shortcomings, the volume is nonetheless a valuable contribution to the study of sustainability

that, according to the authors of the last paper (Ashley et al.), "is hard to define and harder to achieve."

Slav Hermanowicz
Department of Civil and Environmental Engineering
University of California Berkeley
Berkeley, CA, USA

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Special Series on Education in Industrial Ecology

Regionaler Stoffhaushalt: Erfassung, Bewertung, Steuerung [Regional Materials Management: Analysis, Evaluation, Control], by Peter Baccini and Hans-Peter Bader. Heidelberg, Germany: Spektrum Akademischer Verlag, 1996, 416 pp., ISBN 3-86025-235-6, DM 78.

The developed nations are consuming resources at a rate that, according to present knowledge, cannot be extended to the entire world population without serious consequences at the beginning as well as at the end of the resource chain. Thus, new strategies are needed to restructure the so-called metabolism—the materials flows and stocks—of the anthroposphere. The goal of the textbook *Regionaler Stoffhaushalt* by Baccini and Bader is to present a methodology to analyze, evaluate, and in part control metabolic processes at the regional level. The authors focus on densely populated urban areas with a high turnover in energy and materials typical of European and North American regions. In an original and systematic way, they develop their methodology of materials flow analysis (MFA), which forms the main methodological backbone of the book. The resulting view of the metabolism of a region will be new to most readers. The book offers an exciting range of examples of how to incorporate this view and its corresponding tools into the search for solutions of problems related to resources, wastes, and the environment.

The book begins with a review of the development of the anthroposphere during the cultural evolution of mankind, investigating the main geogenic and man-made processes. Their associated flows and stocks of materials are investigated on a regional scale. Using case studies about nutrients and heavy metals, the authors show how materials flow analysis (MFA) can be used to recognize early environmental impacts and resource accumulations or depletions. The authors also show how MFA helps to set priorities in the management of resources and the environment, and how this tool can be used to optimize the regional metabolism in view of goals such as sustainable development.

The main chapters focus on the presentation and application of models to assess and control metabolic processes. First, the basic ideas, terms, definitions, and application ranges for materials flow analysis are explained. The background needed to understand the physical and mathematical modeling of anthropogenic metabolism is given. Field application results are used to show the power of static and dynamic modeling. These examples cover a variety of topics, such as manufacturing of paper, transportation by passenger cars, glass recycling, and landfilling of wastes. Next, the phenomenology, that is, the facts (including numerical values) concerning processes, flows, and stocks of the regional metabolism are investigated in a systematic way, thereby defining the most important anthropogenic activities in detail. The authors synthesize a hypothetical model region called METALAND, and use the characteristics and data of this region to discuss crucial management problems related to resource conservation and environmental protection.

In the final chapter, methods to evaluate and control the regional metabolism are discussed. Basic policy tools to direct material and energy flows, such as regional planning, environmental regulation, and market instruments, are investigated in view of their potential to guide regions towards more sustainable management. Again, several case studies are used to illustrate how metabolic processes can be improved and optimized by applying materials flow analysis. These examples cover goods and processes not only on the regional level, but also on the level of individual households, manufacturing companies, agricultural farms, and public utilities.

Each chapter concludes with a summary and is accompanied by questions and short exercises (including answers). Thus, the book is well suited for use as a graduate-level textbook. The reader will especially appreciate the comprehensive and consistent methodology based on MFA, the abundance of phenomenological data about the regional metabolism, and the wide range of applications exhibited by the case studies. Practitioners in the field of regional and urban planning as well as in environmental and waste management will find a wealth of tools and information for their everyday work.

One of the main advantages of this book is that it presents a basically simple and complete tool, MFA, which can be generally applied to investigate metabolic processes on many levels, from single households to global economies. The book is well-written, can be followed easily, and has started to educate the next generation of resource and environmental engineers and managers. Hence, the chance increases that, in the future, materials flow analysis and corresponding computer-supported models will be more widely and uniformly used to assess and improve the metabolism of regions. This will result in the accumulation of more data and information, and will allow greater understanding and better management of future flows and stocks of materials and energy through regions.

Two drawbacks of *Regionaler Stoffhaushalt* are noteworthy. First, despite its interdisciplinary approach, it focuses mainly on the natural science part of metabolism. But because the control of materials and energy flows is most often dependent on factors lying in the domain of the social sciences as well, it will be necessary in the future to link social science research with metabolic studies for best results in regional management. Second, the book is available only in German (an earlier book by Baccini and Brunner (1991), *Metabolism of the Anthroposphere*, is available in English, but it is not a textbook and it does not include the important chapters on modeling). Because most of the case studies apply to European conditions, readers from overseas might find some of the materials flow and stock data not applicable for local purposes.

In summary, *Regionaler Stoffhaushalt* is the first textbook to offer a profound and valuable methodology for analyzing, evaluating, and, in part, controlling the metabolism of regions. Thanks to the comprehensive theoretical and practical experience of the authors in research and teaching of materials flow analysis, this book is of great value for graduate students as well as professionals in the fields of environmental management, resources and waste management, regional planning, and regional envirometrics.

Paul H. Brunner
Institute for Water Quality and Waste Management
Vienna University of Technology
Vienna, Austria

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Industrial Ecology, by Thomas E. Graedel and Braden R. Allenby. Englewood Cliffs, NJ: Prentice Hall, 1995, 412 pp., ISBN 0-13-125238-0, $ 43.50.

In the shade of the unfolding debate regarding the content of industrial ecology, the field's growing curriculum is determining the path for the coming generation of "Industrial Ecologists." As both pioneer students and organizers of the Industrial Ecology Program at the Norwegian University of Science and Technology (NTNU), we have been exposed both to the curriculum and to this debate. Our contribution to this development is the following review of a crucial piece of the curriculum, Graedel and Allenby's *Industrial Ecology*, in the light of our experiences. The understanding of industrial ecology we are using in this regard is to better understand how industrial activities and environmental concerns can better be integrated.

Considering the rapid development of the field, it is indeed challenging to write a textbook on industrial ecology. Graedel and Allenby's early contribution to the curriculum, therefore, is an important concretization of the content of the concept. The authors have managed to give

us a glance into the many considerations posed by an industrial ecology perspective for industry; and the focus on LCA and DfE, as significant tools to achieve the objectives, is indeed appropriate. Beyond this rather technological approach, industrial ecology also describes the importance of an open system and, hence, cross sectoral understanding when searching for answers to the questions addressed by industrial ecologists. Despite its holistic perspective, the book does not go into the implications of such an approach. The result is, unfortunately, a rather limited approach with a technological focus.

Industrial Ecology is divided into five main parts. Part one introduces us to the overall challenge industrial ecology is facing: ". . .[T]he planet and its population are far from a steady state and clearly on an unsustainable path" (p. 4). Intentionally, this part seeks to legitimize the existence of industrial ecology. The second part, "Relevant *external* factors" (our italic), is concerned with the nontechnological aspects of industrial ecology: ". . .[I]ndustrial systems are constrained by governmental policies and regulations, and, more broadly, by social morays [sic] and economic and technological conditions" (p. 63). The next two parts of the book are technically oriented. First, life cycles and assessments of these life cycles are described, and then the more action-oriented design for environment is presented. In the last part of the book are some "Forward looking topics," like internal organizational aspects, environmental management, relation to the demands of the market, and, finally, some thoughts and suggestions about what industry will look like in the future.

It is difficult to grasp the transition from the macro-oriented perspectives in part I to the technological and company-oriented topics in parts III and IV. In other words, the book jumps from discussing sustainability and the necessary interaction between industry and the environment into detailed descriptions on how to perform a life-cycle assessment. What is in between? According to our understanding, it is the core of the challenge for industrial ecology to place the industry in the dialectic of the macro, or national and global, level with the micro, or individual or consumer, level. Only then can the potential of industrial ecology be released. Excess consumption in Western societies is, by far, the chief factor causing the environmental problems we are facing today, as well as those we will be facing in the future. Shouldn't we challenge ourselves beyond producing less environmentally damaging products? Most of us will agree that we should, but many questions as to how to accomplish this goal remain. A broader perspective might help us answer some of these questions.

Certainly, this book gives a lot of information on industrial ecology, but by itself it does not increase the students' understanding or lay a foundation for critical reflection on the various parts of industrial ecology.

And so, *Industrial Ecology* contains loopholes when used as the main textbook in a course. We would, therefore, appreciate a second volume by Graedel and Allenby addressing the interaction among industrial companies and the macro *and* micro levels, thus satisfying the premises for industrial ecology. A deeper discussion of issues such as infrastructure, consumption, and boundary conditions is needed. Such an additional volume would probably also strengthen the organizational quality of *Industrial Ecology*.

An immediate way to strengthen the book as it is—and, perhaps, through more than one volume—would be the presentation of a single case study throughout the book. In the industrial ecology courses at NTNU, we did this quite successfully. By using one case, the different aspects and elements of industrial ecology more readily appear, and the debates and facts concerning the various components of the cradle-to-grave process would naturally be incorporated in the presentation.

A further improvement would be to incorporate the discussion exercises into the text, rather than presenting them, as they are now, as endnotes to each chapter.

Some of these problems with *Industrial Ecology* would vanish if the text were addressed to a certain homogeneous group of students, but then our understanding of the interdisciplinary meaning of IE would vanish as well. At NTNU, the policy has been, and still is, that a course in industrial ecology should be accessible to students in technology, natural sciences, and social sciences. The different backgrounds of students in these fields require that the level of difficulty

in each element of the curriculum be carefully chosen. Graedel and Allenby's book is, in our opinion, too technically detailed and too nontechnologically shallow, to reach all the students in an industrial ecology course. As it is, the book needs to be used together with other literature in order to capture the broader perspective of industrial ecology. This is possible if, and only if, the nontechnological disciplines are accepted as equal to technology in importance for the development of a sustainable society.

Kjetil Røine and Hilde Opoku
Industrial Ecology Programme
Norwegian University of Science and Technology
Trondheim, Norway