大学环境教育丛书

影印版

Edward S. Rubin
Cliff I. Davidson

Introduction to Engineering & the Environment

工程与环境引论

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出版前言

在跨入21世纪之际，面临不断恶化的生存环境，人类清醒地认识到要走可持续发展之路。而发展环境教育是解决环境问题和实施可持续发展战略的根本。高等学校的环境教育，是提高新世纪建设者的环境意识，并向社会输送环境保护专门人才的重要途径。为了反映国外环境类教材的最新内容和编写风格，同时也为了提高学生阅读专业文献和获取信息的能力，我们精选了一些国外优秀的环境类教材，组成大学环境教育丛书（影印版），本书即为其中的一册。所选教材均在国外被广泛采用，多数已再版，书中不仅介绍了有关概念、原理及技术方法，给出了丰富的数据，还反映了作者不同的学术观点。

我们希望这套丛书能对高等院校师生和广大科技人员有所帮助，同时对我国环境教育的发展作出贡献。

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PREFACE

Environmental concerns today profoundly influence all aspects of modern engineering design and practice. Yet, most colleges and universities have been slow at integrating environmental considerations into the fabric of engineering curricula. Although elective courses and degree programs in environmental engineering can be found at many engineering schools, students who do not major in environmental engineering often receive little or no exposure to environmental issues relevant to their profession. At the same time, concern for the environment has been recently highlighted by the Accrediting Board for Engineering and Technology (ABET), and by major U.S. technical societies, as part of the basic ethical responsibility of all engineers.

This text was designed to introduce environmental issues and problem-solving methods to engineering students in all disciplines, primarily at the freshman and sophomore levels. Many of the chapters also have been used successfully in upper-division courses, especially for students with little or no prior background in environmental studies.

The book uses a case study approach to environmental education, drawing on basic science and engineering principles to assess a particular problem, and to design solutions that reduce or eliminate environmental impacts. The case studies thus demonstrate how environmental considerations can be an integral part of good engineering practice. Through applications in different disciplinary domains, students develop and apply the fundamental skills and insights needed to recognize and address a variety of environmental problems. They also gain an appreciation of the interdisciplinary nature of environmental issues and solutions. This case study approach has proved an effective method of introducing environmental subjects in pilot applications at Carnegie Mellon University.

The pedagogical emphasis of this book is on principles of green design and pollution prevention. Thus, the primary thrust is on ways to avoid creating environmental problems in the first place. In many applications, of course, the design and analysis of waste treatment and remediation processes are still very important, and examples of such technologies are also presented. Nonetheless, we believe the green design perspective best reflects the future direction of the environmental field, and of engineering education in general. Although there are limitations on how far this approach can be developed in an introductory textbook, there are substantial opportunities even at the freshman and sophomore levels for students to apply their technical skills to solve environmental problems through improved design. Detailed illustrative examples are included throughout the text to assist students toward this end, along with a set of homework problems at the end of each chapter. More advanced students can be challenged by supplemental projects and assignments that are more open-ended, and that emphasize engineering judgment and the integration of disciplinary knowledge to address particular problems.

Organization and Use of This Book

The text is organized into four parts. Part 1 includes a brief introductory chapter that lays out the relationships between the things engineers do and their environmental consequences. Environmental impacts are seen to arise from both the design and the deployment of technology. The selection of materials, the design of products and manufacturing processes, and the use of energy in its various forms, are identified as areas where engineers play a key role in influencing environmental outcomes. A life cycle perspective and the principles of industrial ecology and sustainable development are also introduced to lay the groundwork for elaboration in later chapters.

The second chapter gives an overview of current environmental issues, including problems related to atmospheric emissions, water pollution, solid wastes, resource depletion, land use, and ecological impacts. This chapter motivates the need for cleaner technologies and better methods to understand and address environmental concerns. Its coverage is broad, but its primary emphasis is on problems and issues most relevant to engineering design, analysis, and practice. This chapter provides the principal background material for the subsequent chapters. Relevant sections of Chapter 2 can be discussed in class, or assigned to students as background reading on selected topics.

Part 2 of the book is a set of case studies focused on the environmental design of technology. Each chapter begins with an overview of the technology, its societal benefits, and its environmental concerns. For example, Chapter 3, "Automobiles and the Environment," discusses the problems of automotive emissions, energy use, materials consumption, and the disposal of used cars. Science and engineering fundamentals are then introduced and used to explore in greater detail the engineering design variables that can alter environmental outcomes. Armed with these insights, students can propose and analyze alternative technology designs that reduce or eliminate environmental problems. The choice of case studies in Part 2 reflects a spectrum of major environmental concerns, as well as a variety of disciplinary approaches to environmental problem solving. Part 2 concludes with a chapter on life cycle assessments that illustrates how different technologies are linked from an environmental perspective. This chapter reinforces an industrial ecology perspective by looking beyond the immediate boundaries of an engineering design problem to consider overall environmental impacts, including upstream and downstream processes.

The case studies in Part 3 focus on environmental modeling. Again, science and engineering fundamentals are employed to understand and predict how various types of pollutants (such as air emissions from power plants, wastewater discharges from manufacturing processes, or CFCs from household refrigerators) are transported and transformed in the environment. The understanding and insights obtained in each case are applied to identify strategies that engineers and society can adopt to control adverse environmental effects. The topics chosen for Part 3 span a range of local, regional, and global environmental concerns involving all environmental media (air, water, and land). Greater emphasis is given to regional and global issues—such as urban air pollution, bioaccumulative chemicals, and global warming—that are likely to dominate the environmental agenda in coming decades.

Finally, Part 4 addresses selected topics in environmental policy analysis. These topics include engineering economics, cost–benefit analysis, risk assessment, decision analysis, and environmental forecasting. Most engineering students are not usually exposed to these topics, although some universities, like Carnegie Mellon, do incorporate policy-related studies as an option for undergraduate engineering and science students. These subjects are especially important in the context of environmental issues, which are seldom purely technical. Accordingly, the topics introduced in Part 4 provide the basic tools needed to extend the technical analyses of Parts 2 and 3 to also consider the costs, risks, and benefits of environmental control strategies and policy options. Chapter 15, "Environmental Forecasting," also includes introductory treatments of population dynamics, economic development, and technological change as they relate to future environmental quality. Some instructors may wish to introduce one or more of these topics at the outset in order to motivate environmental discussions.

Following the first two chapters, students and instructors should feel free to visit the remaining topics of this book in whatever order they desire. Each chapter was designed as a stand-alone module, relying mainly on Chapter 2 for a background discussion of the environmental concerns and impacts of the topic at hand. Although all of the technology design cases in Part 2 are also related to topics in environmental modeling (Part 3) and policy analysis (Part 4), instructors may wish to select (or vary) the subjects presented. The range of topics covered is sufficiently broad to support an introductory course tailored to the particular needs and interests of faculty and students. Thus a selection of chapters from Parts 2, 3, and 4 can be combined to explore certain topics in depth, or the introductory sections of a chapter can be used to obtain a brief overview of the subject. A more detailed guide for instructors is available that includes further suggestions on the use of this text.

ACKNOWLEDGMENTS

Several Carnegie Mellon colleagues played an especially important role as contributors to this text. Professor Cliff Davidson deserves special recognition as a contributor in this effort. He is particularly acknowledged as the author of Chapters 7 and 10, and principal contributor to Chapter 11. He also has strongly supported our joint efforts to enhance the environmental content of undergraduate education at Carnegie Mellon, especially a recent project supported by the National Science Foundation, which was the genesis for several chapters of this book. Another colleague, Professor Spyros Pandis, contributed his special insights as the principal author of Chapter 8. Professors Dave Dzombak and Dick Luthy (now at Stanford University) lent their expertise as the principal authors of Chapter 9.

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ESR
Pittsburgh, PA
June 2000

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