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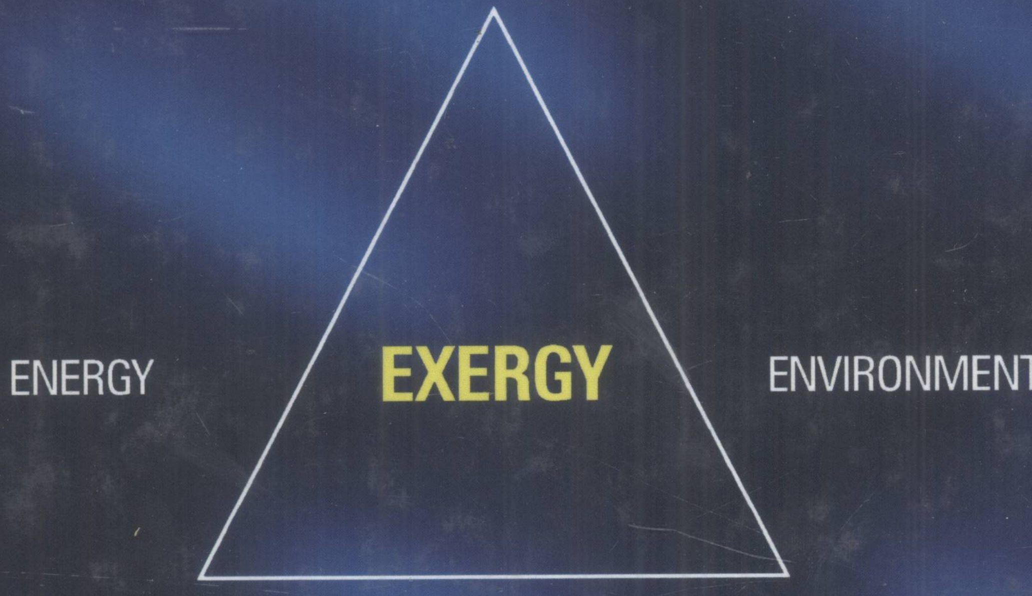
EXERGY

ENERGY, ENVIRONMENT AND SUSTAINABLE DEVELOPMENT



IBRAHIM DINCER | MARC A. ROSEN

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Ibrahim Dincer and Marc A. Rosen

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PREFACE

Exergy analysis is a method that uses the conservation of mass and conservation of energy principles together with the second law of thermodynamics for the analysis, design and improvement of energy and other systems. The exergy method is a useful tool for furthering the goal of more efficient energy-resource use, for it enables the locations, types and magnitudes of wastes and losses to be identified and meaningful efficiencies to be determined.

During the past two decades we have witnessed revolutionary changes in the way thermodynamics is taught, researched and practiced. The methods of exergy analysis, entropy generation minimization and thermoeconomics are the most visible and established forms of this change. Today there is a much stronger emphasis on exergy aspects of systems and processes. The emphasis is now on system analysis and thermodynamic optimization, not only in the mainstream of engineering but also in physics, biology, economics and management. As a result of these recent changes and advances, exergy has gone beyond thermodynamics and become a new distinct discipline because of its interdisciplinary character as the confluence of energy, environment and sustainable development.

This book is a research-oriented textbook and therefore includes practical features in a usable format often not included in other, solely academic textbooks. This book is essentially intended for use by advanced undergraduate or graduate students in several engineering and non-engineering disciplines and as an essential tool for practitioners. Theory and analysis are emphasized throughout this comprehensive book, reflecting new techniques, models and applications, together with complementary materials and recent information. Coverage of the material is extensive, and the amount of information and data presented is sufficient for exergy-related courses or as a supplement for energy, environment and sustainable development courses, if studied in detail. We believe that this book will be of interest to students and practitioners, as well as individuals and institutions, who are interested in exergy and its applications to various systems in diverse areas. This volume is also a valuable and readable reference for anyone who wishes to learn about exergy.

The introductory chapter addresses general concepts, fundamental principles and basic aspects of thermodynamics, energy, entropy and exergy. These topics are covered in a broad manner, so as to furnish the reader with the background information necessary for subsequent chapters. Chapter 2 provides detailed information on energy and exergy and contrasts analysis approaches based on each. In Chapter 3, extensive coverage is provided of environmental concerns, the impact of energy use on the environment and linkages between exergy and the environment. Throughout this chapter, emphasis is placed on the role of exergy in moving to sustainable development.

Chapter 4 delves into the use of exergy techniques by industry for various systems and processes and in activities such as design and optimization. This chapter lays the foundation for the many applications presented in Chapters 5 to 16, which represent the heart of the book. The applications covered range from policy development (Chapter 5), psychrometric processes (Chapter 6), heat pumps (Chapter 7), drying (Chapter 8), thermal storage (Chapter 9), renewable energy systems (Chapter 10), power plants (Chapter 11), cogeneration and district energy (Chapter 12), cryogenic systems (Chapter 13), crude oil distillation (Chapter 14), fuel cells (Chapter 15) and aircraft systems (Chapter 16).

Chapter 17 covers the relation between exergy and economics, and the exploitation of that link through analysis tools such as exergoeconomics. Chapter 18 extends exergy applications to large-scale systems such as countries, regions and sectors of an economy, focusing on how efficiently energy resources are utilized in societies. Chapter 19 focuses the utilization of exergy within life cycle assessment and presents various applications. Chapter 20 discusses how exergy complements and can be used with industrial ecology. The book closes by speculating on the potential of exergy in the future in Chapter 21.

Incorporated throughout are many illustrative examples and case studies, which provide the reader with a substantial learning experience, especially in areas of practical application.

The appendices contain unit conversion factors and tables and charts of thermophysical properties of various materials in the International System of units (SI).

Complete references are included to point the truly curious reader in the right direction. Information on topics not covered fully in the text can, therefore, be easily found.

We hope this volume allows exergy methods to be more widely applied and the benefits of such efforts more broadly derived, so that energy use can be made more efficient, clean and sustainable.

Ibrahim Dincer and Marc A. Rosen
June 2007

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İbrahim Dinçer and Marc A. Rosen
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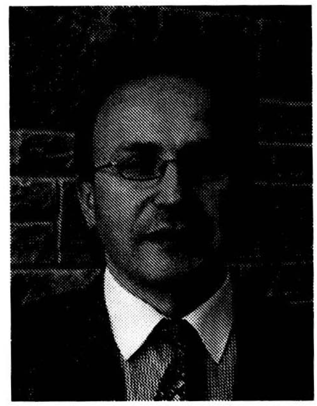
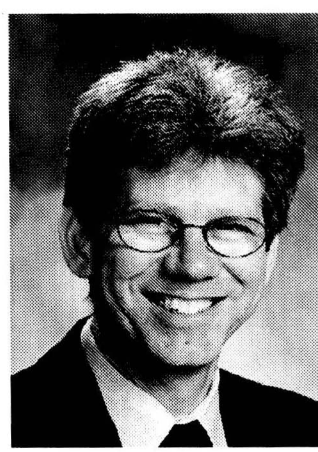
ABOUT THE AUTHORS



IBRAHIM DINCER

Ibrahim Dincer is a full professor of Mechanical Engineering in the Faculty of Engineering and Applied Science at UOIT. Renowned for his pioneering works he has authored and co-authored several books and book chapters, over 350 refereed journal and conference papers, and numerous technical reports. He has chaired many national and international conferences, symposia, workshops and technical meetings and is the founding chair or co-chair of various prestigious international conferences, including the International Exergy, Energy and Environment Symposium. He has delivered over 70 keynote and invited lectures. He is an active member of various international scientific organizations and societies, and serves as editor-in-chief (for International Journal of Energy Research by Wiley and International Journal of Exergy by Inderscience), associate editor, regional editor and editorial board member on various prestigious international journals. He is a recipient of several research, teaching and service awards, including the Premier's research excellence award in Ontario, Canada in 2004. He has made innovative contributions to the understanding and development of exergy analysis of advanced energy systems for his so-called: five main pillars as better efficiency, better cost effectiveness, better environment, better sustainability and better energy security. He is the chair of a new technical group in ASHRAE, named Exergy Analysis for Sustainable Buildings.



MARC A. ROSEN

Marc A. Rosen is founding Dean of Engineering and Applied Science at the University of Ontario Institute of Technology in Oshawa, Canada. A Past-President of the Canadian Society for Mechanical Engineering, Dr. Rosen received an Award of Excellence in Research and Technology Development from the Ontario Ministry of Environment and Energy, and is a Fellow of the Engineering Institute of Canada, the American Society of Mechanical Engineers, the Canadian Society for Mechanical Engineering, and the International Energy Foundation. He has worked for Imatra Power Company in Finland, Argonne National Laboratory and the Institute for Hydrogen Systems, near Toronto. Dr. Rosen is a registered Professional Engineer in Ontario. He became President-elect of the Engineering Institute of Canada in 2006 and has received that Institute's Julian C. Smith medal for achievement in the development of Canada. Prior to 2002, he was a professor in the Department of Mechanical, Aerospace and Industrial Engineering at Ryerson University in Toronto, Canada for 16 years. During his tenure at Ryerson, Dr. Rosen served as department Chair and Director of the School of Aerospace Engineering. With over 50 research grants and contracts and 400 technical publications, Dr. Rosen is an active teacher and researcher in thermodynamics and energy conversion (e.g., cogeneration, district energy, thermal storage, renewable energy), and the environmental impact of energy and industrial systems. He has been a key contributor to and proponent of advanced exergy methods and applications for over two decades.

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