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Combined Power and Process Exergy Method *The Exergy Method of Thermal Plant Analysis* *The Exergy Method of Energy Systems Analysis* **Exergy Efficiency of Biomass Energy Sustainable Development Indicators** **Exergy Analysis of Heating, Refrigerating and Air Conditioning Application of Exergy Practical Approach to Exergy and Thermoeconomic Analyses of Industrial Processes** **Fuel Cells, Engines and Hydrogen The Efficiency of Industrial Processes** *Exergy, Energy System Analysis and Optimization - Volume I* **Solutions of Problems in the Exergy Method of Thermal Plant Analysis Application of Exergy Analysis to Energy Systems** [Exergy Sustainable Hydrogen Production Energy Systems](#) [Exergy Exergy Analysis of the Air Handling Unit at Variable Reference Temperature Modelling and simulation of low-temperature district heating systems for the development of an exergy-based assessment method.](#) **Exergy Analysis and Thermoeconomics of Buildings** [Exergy and Its Application Efficiency Evaluation of Energy Systems Practical Approach to Exergy and Thermoeconomic Analyses of Industrial Processes](#) **Primary Exergy Cost of Goods and Services Economics and Exergy Solutions Manual for the Exergy Method of Thermal Plant Analysis** **Exergetic, Energetic and Environmental Dimensions Thermodynamic Optimization of Complex Energy Systems** [Exergy Analysis and Design Optimization for Aerospace Vehicles and Systems Design and Performance Optimization of Renewable Energy Systems](#) **Thermal Design and Optimization Thermodynamics and the Destruction of Resources Resource Accounting in Factories Thermo-economic Optimization of Head Exchangers A New Approach to Flow Constraints in Exergy Analysis Exergetic Aspects of Renewable Energy Systems Thermodynamics Thermodynamics**

Preface to the Solution of the Problems (iii) -- Appendix G Problems (pp 288-319) -- Solutions of the Problems (pp 1-125). Quantifying exergy losses in the energy supply system of buildings reveals the potential for energy improvement, which cannot be discovered using conventional energy analysis. Thermoeconomics combines economic and thermodynamic analysis by applying the concept of cost (an economic concept) to exergy, as exergy is a thermodynamic property fit for this purpose, in that it combines the quantity of energy with its quality factor. Exergy Analysis and Thermoeconomics of Buildings applies exergy analysis methods and thermoeconomics to the built environment. The mechanisms of heat transfer throughout the envelope of buildings are analyzed from an exergy perspective and then to the building thermal installations, analyzing the different components, such as condensing boilers, absorption refrigerators, microcogeneration plants, etc., including solar installations and finally the thermal facilities as a whole. A detailed analysis of the cost formation process is presented, which has its physical roots firmly planted in the second law of thermodynamics. The basic principles and the rules of cost allocation, in energy units (exergy cost), in monetary units (exergoeconomic cost), and in CO2 emissions (exergoenvironmental cost), based on the so-called Exergy Cost Theory are presented and applied to thermal installations of buildings. Clear and rigorous in its exposition, Exergy Analysis and Thermoeconomics of Buildings discusses exergy analysis and thermoeconomics and the role they could play in the analysis and design of building components, either the envelope or the thermal facilities, as well as the diagnosis of thermal installations. This book moves progressively from introducing the basic concepts to applying them. Exergy Analysis and Thermoeconomics of Buildings provides examples of specific cases throughout this book. These cases include real data, so that the results obtained are useful to interpret the inefficiencies and losses that truly occur in actual installations; hence, the assessment of their effects encourages the manner to improve efficiency. Applies exergy analysis methods for the installation of building thermal facilities equipment components, including pipes, valves, heat exchangers, boilers and heat pumps Helps readers determine the operational costs of heating and cooling building systems Includes

exergy analysis methods that are devoted to absorption refrigerators, adsorption cooling systems, basic air conditioning processes, ventilation systems and solar systems, either thermal and PV Discusses the direct application of exergy analysis concepts, including examples of buildings with typical heating, DHW and air conditioning installations Presents a unique, stepwise exergy-based approach to thermodynamic concepts, systems, and applications Thermodynamics: A Smart Approach redefines this crucial branch of engineering as the science of energy and exergy—rather than the science of energy and entropy—to provide an innovative, step-by-step approach for teaching, understanding, and practicing thermodynamics in a clearer and easier way. Focusing primarily on the concepts and balance equations, this innovative textbook covers exergy under the second law of thermodynamics, discusses exergy matters, and relates thermodynamics to environmental impact and sustainable development in a clear, simple and understandable manner. It aims to change the way thermodynamics is taught and practiced and help overcome the fear of thermodynamics. Author Ibrahim Dincer, a pioneer in the areas of thermodynamics and sustainable energy technologies, draws upon his multiple decades of experience teaching and researching thermodynamics to offer a unique exergy-based approach to the subject. Enabling readers to easily comprehend and apply thermodynamic principles, the text organizes thermodynamics into seven critical steps—property, state, process, cycle, first law of thermodynamics, second law of thermodynamics and performance assessment—and provides extended teaching tools for systems and applications. Precise, student-friendly chapters cover fundamental concepts, thermodynamic laws, conventional and innovative power and refrigeration cycles, and more. This textbook: Covers a unique approach in teaching design, analysis and assessment of thermodynamic systems Provides lots of examples for every subject for students and instructors Contains hundreds of illustrations, figures, and tables to better illustrate contents Includes many conceptual questions and study problems Features numerous systems related examples and practical applications Thermodynamics: A Smart Approach is an ideal textbook for undergraduate students and graduate students of engineering and applied science, as well researchers, scientists, and practicing engineers seeking a precise and concise textbook and/or reference work. Many people, professionals and non-professionals alike, recognize that it is of critical importance to solve global energy and environmental issues. For this purpose, it is essential to have a scientific understanding of what is meant by the “energy” issue is and the “environmental” issue. The concept of “exergy” is a scientific concept that exactly fits. The concept of ‘energy’ is a scientifically-well established concept, namely ‘to be conserved’. Then the question is what is really consumed. Exergy: Theory and Applications in the Built Environment is dedicated to answer this fundamental question by discussing the theory of “exergy” and by demonstrating its use extensively to describe a variety of systems in particular for built-environmental conditioning. Our immediate environmental space works within the flow of energy and matter in an “exergy-entropy” process, and the built environment can be designed with these energy & environmental issues in mind. Exergy: Theory and Applications in the Built Environment introduces readers who are not familiar with thermodynamics to the concept of exergy with a variety of discussion on the built-environmental space such as heating, cooling, lighting, and others. Readers, including students, researchers, planners, architects and engineers, will obtain a better picture of a sustainable built-environment. Exergy has been defined as the maximum work that is useful, extracted from any process toward its equilibrium. Hence, it has a very strong connection with the second law of thermodynamics. In energy harvesting and management systems, the concept of exergy is very important because it represents the efficiency of the system. Exergy can be used as a tool to measure resource efficiency, as well as whole system sustainability. In addition, it can also be used to analyze and clarify the performance of each process; hence, methods of improvement can be determined. This book is the result of a very careful selection of chapters and contributors in the related field. The book is divided into three main

sections according to the approaches and purpose of each proposed chapter. The first section is an introduction to the book. The second section, "Advanced energy conversions", describes several advanced technologies that are considered to have great potential in energy conversion and harvesting, and comprises three chapters focusing on photovoltaic/thermal systems with nanofluid, power-to-gas energy storage systems coupled with a combined cycle employing chemical looping combustion technology, and electromagnetic-based power generation. The third section focuses on the idea of "innovative energy management systems" toward high-quality energy systems. In this section, two different chapters describe the introduction of electric vehicles for demand-side energy management and the utilization of supercapacitors for very responsive energy storage in low-power modules. It is expected that this book will provide and enrich the state of the art in advanced energy systems, including energy conversion and management. All the chapters cover a broad range of disciplines, which are correlated in terms of the efforts toward efficient energy systems. In addition, the correlation between energy and exergy, and their understanding, are believed to be very important to improve energy efficiency and guarantee better energy quality. The exergy method makes it possible to detect and quantify the possibilities of improving thermal and chemical processes and systems. The introduction of the concept thermo-ecological cost (cumulative consumption of non-renewable natural exergy resources) generated large application possibilities of exergy in ecology. This book contains a short presentation on the basic principles of exergy analysis and discusses new achievements in the field over the last 15 years. One of the most important issues considered by the distinguished author is the economy of non-renewable natural exergy. Previously discussed only in scientific journals, other important new problems highlighted include: calculation of the chemical exergy of all the stable chemical elements, global natural and anthropogenic exergy losses, practical guidelines for improvement of the thermodynamic imperfection of thermal processes and systems, development of the determination methods of partial exergy losses in thermal systems, evaluation of the natural mineral capital of the Earth, and the application of exergy for the determination of a pro-ecological tax. A basic knowledge of thermodynamics is assumed, and the book is therefore most appropriate for graduate students and engineers working in the field of energy and ecological management. Considered as particularly difficult by generations of students and engineers, thermodynamics applied to energy systems can now be taught with an original instruction method. Energy Systems applies a completely different approach to the calculation, application and theory of multiple energy conversion technologies. It aims to create the reader's foundation for understanding and applying the design principles to all kinds of energy cycles, including renewable energy. Proven to be simpler and more reflective than existing methods, it deals with energy system modeling, instead of the thermodynamic foundations, as the primary objective. Although its style is drastically different from other textbooks, no concession is done to coverage: with encouraging pace, the complete range from basic thermodynamics to the most advanced energy systems is addressed. The accompanying Thermoptim™ portal

(http://direns.mines-paristech.fr/Sites/Thopt/en/co/_Arborescence_web.html) presents the software and manuals (in English and French) to solve over 200 examples, and programming and design tools for exercises of all levels of complexity. The reader is explained how to build appropriate models to bridge the technological reality with the theoretical basis of energy engineering. Offering quick overviews through e-learning modules moreover, the portal is user-friendly and enables to quickly become fully operational. Students can freely download the Thermoptim™ modeling software demo version (in seven languages) and extended options are available to lecturers. A professional edition is also available and has been adopted by many companies and research institutes worldwide - www.thermoptim.org This volume is intended as for courses in applied thermodynamics, energy systems, energy conversion, thermal engineering to senior undergraduate and graduate-level students in mechanical, energy, chemical and petroleum engineering. Students should already have taken a first year course in thermodynamics. The refreshing approach and exceptionally rich coverage make it a great reference tool for researchers and professionals also. Contains International Units (SI). Sustainable Hydrogen Production provides readers with an introduction to the processes and technologies used in major hydrogen production methods. This book serves as a unique source for information on advanced hydrogen generation systems and applications (including integrated systems, hybrid systems, and multigeneration systems with hydrogen production).

Advanced and clean technologies are linked to environmental impact issues, and methods for sustainable development are thoroughly discussed. With Earth's fast-growing populations, we face the challenge of rapidly rising energy needs. To balance these we must explore more sustainable methods of energy production. Hydrogen is one key sustainable method because of its versatility. It is a constituent of a large palette of essential materials, chemicals, and fuels. It is a source of power and a source of heat. Because of this versatility, the demand for hydrogen is sure to increase as we aim to explore more sustainable methods of energy. Furthermore, Sustainable Hydrogen Production provides methodologies, models, and analysis techniques to help achieve better use of resources, efficiency, cost-effectiveness, and sustainability. The book is intellectually rich and interesting as well as practical. The fundamental methods of hydrogen production are categorized based on type of energy source: electrical, thermal, photonic, and biochemical. Where appropriate, historical context is introduced. Thermodynamic concepts, illustrative examples, and case studies are used to solve concrete power engineering problems. Addresses the fundamentals of hydrogen production using electrical, thermal, photonic, and biochemical energies Presents new models, methods, and parameters for performance assessment Provides historical background where appropriate Outlines key connections between hydrogen production methods and environmental impact/sustainable development Provides illustrative examples, case studies, and study problems within each chapter The main scope of this study is to emphasize exergy efficiency in all fields of industry. The chapters collected in the book are contributed by invited researchers with a long-standing experience in different research areas. I hope that the material presented here is understandable to a wide audience, not only energy engineers but also scientists from various disciplines. The book contains seven chapters in three sections: (1) "General Information about Exergy," (2) "Exergy Applications," and (3) "Thermoeconomic Analysis." This book provides detailed and up-to-date evaluations in different areas written by academics with experience in their fields. It is anticipated that this book will make a scientific contribution to exergy workers, researchers, academics, PhD students, and other scientists in both the present and the future. Fuel cell technology is the most exciting and legitimate alternative source of power currently available to us as world resources of non-renewable fuel continue to be depleted. No other power generating technology holds the same benefits that fuel cells offer, including high reliability and efficiency, negligible environmental impact, and security of supply. Fuel cells run on hydrogen - the simplest and most plentiful gas in the universe - although they can also run on carbon monoxide, methane, or even coal. Their applications are diverse, from powering automobiles, buildings and portable electronics, to converting methane gas from wastewater plants and landfills into electricity. Fuel Cells, Engines and Hydrogen is a controversial text that challenges the accepted industry parameters for measuring fuel cell performance and efficiency. Based on his interdisciplinary experience in the fields of power, nuclear power, and desalination, the author contends that the development potential of the fuel cell is related to the quantity fuel chemical exergy, which, like electrical potential, is a quantitative measure of work done. The fuel cell community currently characterises these devices in terms of the enthalpy of combustion (calorific value) - however the author argues a correct, qualitatively different and fourfold larger characterisation is via the fuel chemical exergy, in units of work, and not energy. He asserts that the distortion introduced by this accepted perspective needs to be corrected before relatively efficient fuel cells, integrated with comparatively low performing gas turbines, reach the market. Fuel Cells, Engines and Hydrogen features a foreword by Dr Gerry Agnew, Executive VP Engineering of Rolls Royce Fuel Cells Systems Ltd. It is essential reading for all engineers involved with fuel cells and/ or the manufacture of hydrogen from natural gas, as well as academics in related disciplines such as thermodynamics, physical chemistry, materials, physics, mechanical and chemical engineering. This book is a unique, multidisciplinary effort to apply rigorous thermodynamics fundamentals, a disciplined scholarly approach, to problems of sustainability, energy, and resource uses. Applying thermodynamic thinking to problems of sustainable behavior is a significant advantage in bringing order to ill-defined questions with a great variety of proposed solutions, some of which are more destructive than the original problem. The articles are pitched at a level accessible to advanced undergraduates and graduate students in courses on sustainability, sustainable engineering, industrial ecology, sustainable manufacturing, and green engineering. The timeliness of the topic, and the urgent need for solutions make this book attractive to general readers and specialist researchers as well. Top international figures from

many disciplines, including engineers, ecologists, economists, physicists, chemists, policy experts and industrial ecologists among others make up the impressive list of contributors. Details energy and exergy efficiencies of all major aspects of bioenergy systems Covers all major bioenergy processes starting from photosynthesis and cultivation of biomass feedstocks and ending with final bioenergy products, like power, biofuels, and chemicals Each chapter includes historical developments, chemistry, major technologies, applications as well as energy, environmental and economic aspects in order to serve as an introduction to biomass and bioenergy A separate chapter introduces a beginner in easy accessible way to exergy analysis and the similarities and differences between energy and exergy efficiencies are underlined Includes case studies and illustrative examples of 1st, 2nd, and 3rd generation biofuels production, power and heat generation (thermal plants, fuel cells, boilers), and biorefineries Traditional fossil fuels-based technologies are also described in order to compare with the corresponding bioenergy systems Energy is essential to all human activities as well as critical to social and economic development. Sustainable energy planning encompassing the concept of smart cities has a high potential to significantly contribute to climate change mitigation. For improved energy efficiency, it is essential to find low carbon solutions for the urban environment. The integration and management of energy supply with predominant exploitation of local resources is examined through the fundamental concept of exergy. This book can assist in decision making, with regard to sustainable energy design both at a national and local level. Design and Performance Optimization of Renewable Energy Systems provides an integrated discussion of issues relating to renewable energy performance design and optimization using advanced thermodynamic analysis with modern methods to configure major renewable energy plant configurations (solar, geothermal, wind, hydro, PV). Vectors of performance enhancement reviewed include thermodynamics, heat transfer, exergoeconomics and neural network techniques. Source technologies studied range across geothermal power plants, hydroelectric power, solar power towers, linear concentrating PV, parabolic trough solar collectors, grid-tied hybrid solar PV/Fuel cell for freshwater production, and wind energy systems. Finally, nanofluids in renewable energy systems are reviewed and discussed from the heat transfer enhancement perspective. Reviews the fundamentals of thermodynamics and heat transfer concepts to help engineers overcome design challenges for performance maximization Explores advanced design and operating principles for solar, geothermal and wind energy systems with diagrams and examples Combines detailed mathematical modeling with relevant computational analyses, focusing on novel techniques such as artificial neural network analyses Demonstrates how to maximize overall system performance by achieving synergies in equipment and component efficiency Although the exergy method has been featured as the subject of many publishing papers in scientific and engineering journals and at conferences, very few comprehensive books on this subject have been published so far. Practical Approach to Exergy and Thermoeconomic Analyses of Industrial Processes details the exergetic and thermoeconomic analyses of industrial processes using Aspen Plus and a novel Microsoft Excel Application developed by the authors which can be applied to industrial processes across the board. Employing a practical approach to an innovative and complex energy process, every chapter contains extensive explanations of a complex and real case and numerous examples whose solution demonstrates the application of theory to a wide range of real and practical problems. Illustrations, tables and graphs support and illustrate the new methodology to build a deep understanding of the real employment of the fuel used and the cost formation and increase inside the process. Practical Approach to Exergy and Thermoeconomic Analyses of Industrial Processes provides users, students and practitioners of process analysis, power plant design and fuel use optimization, with a broad introduction and approach to computer aided process optimization. It also serves as a comprehensive guide to the operational application of the MHBT to real cases analysis. Presents a unique, stepwise exergy-based approach to thermodynamic concepts, systems, and applications Thermodynamics: A Smart Approach redefines this crucial branch of engineering as the science of energy and exergy—rather than the science of energy and entropy—to provide an innovative, step-by-step approach for teaching, understanding, and practicing thermodynamics in a clearer and easier way. Focusing primarily on the concepts and balance equations, this innovative textbook covers exergy under the second law of thermodynamics, discusses exergy matters, and relates thermodynamics to environmental impact and sustainable development in a clear, simple and understandable manner. It aims to change the

way thermodynamics is taught and practiced and help overcome the fear of thermodynamics. Author Ibrahim Dincer, a pioneer in the areas of thermodynamics and sustainable energy technologies, draws upon his multiple decades of experience teaching and researching thermodynamics to offer a unique exergy-based approach to the subject. Enabling readers to easily comprehend and apply thermodynamic principles, the text organizes thermodynamics into seven critical steps—property, state, process, cycle, first law of thermodynamics, second law of thermodynamics and performance assessment—and provides extended teaching tools for systems and applications. Precise, student-friendly chapters cover fundamental concepts, thermodynamic laws, conventional and innovative power and refrigeration cycles, and more. This textbook: Covers a unique approach in teaching design, analysis and assessment of thermodynamic systems Provides lots of examples for every subject for students and instructors Contains hundreds of illustrations, figures, and tables to better illustrate contents Includes many conceptual questions and study problems Features numerous systems related examples and practical applications Thermodynamics: A Smart Approach is an ideal textbook for undergraduate students and graduate students of engineering and applied science, as well researchers, scientists, and practicing engineers seeking a precise and concise textbook and/or reference work. Increasing concerns about energy systems and their environmental implications, as well as the costs, supply and security of energy resources, are fostering increasing interest in energy. Understanding the economics of energy systems is crucial to the proper development and beneficial application of advanced energy technologies, and to progress in society's quest for energy sustainability. New approaches to energy economics that facilitate more cost-effective use energy resources are of particular interest. This book focuses on the integration of exergy and economics and provides a novel approach that offers significant potential to improve our energy systems and their utilisation. Bridging the gap between concepts derived from Second Law of Thermodynamics and their application to Engineering practice, the property exergy and the exergy balance can be a tool for analyzing and improving the performance of energy conversion processes. With the exergy analysis it is possible to evaluate the performance of energy conversion processes not only on a thermodynamics basis but also by including production costs and environmental aspects and impacts of the studied processes. This comprehensive approach of the use of energy has, as one of the most important feature, the identification of sustainable ways of energy resources utilization. Based on the fundamentals of the exergy concept, its calculation, graphical representations and exergy balances evaluation, Exergy: Production Cost And Renewability describes the application of detailed exergy and thermoeconomic analysis to power plants and polygeneration systems, petroleum production and refining plants (including hydrogen production), chemical plants, biofuel production routes, combined production of ethanol and electricity, aircraft systems design, environmental impact mitigation processes and human body behavior. The presented case studies aim at providing students, researchers and engineers with guidelines to the utilization of the exergy and thermoeconomic analysis to model, simulate and optimize real processes and industrial plants. Analyzing the self-sufficient Danish island of Samsø, this book explains sustainability through a bio-geophysical understanding of how to best use society's limited resources to achieve true sustainability. The method used derives from the thermodynamic function of exergy. By analyzing exergy flows and establishing a system for evaluating the energy and the materials used in a society, the author creates a platform for monitoring certain indicators of sustainability. These indicators inform readers about the actions that must be taken and the time frames for achieving sustainability goals. The exergy-based approach is an important tool for carrying out such an analysis because it Focuses on several key thermodynamic concepts and the usefulness of exergy analysis for evaluating sustainability Explains sustainability by implementing thermodynamic laws to societal consumption and the use of resources Discusses new methods that integrate energy and material fluxes and evaluates them against each other Provides direct indicators for finding the largest problems/obstacles and deciding where measures should be taken Includes instructions on how to establish an accounting system for evaluating the energy and the materials used in a society This book is aimed for professionals, researchers, and students working on nature conservation and environmental management projects related to sustainability. This book deals with exergy and its applications to various energy systems and applications as a potential tool for design, analysis and optimization, and its role in minimizing and/or eliminating environmental impacts and providing sustainable

development. In this regard, several key topics ranging from the basics of the thermodynamic concepts to advanced exergy analysis techniques in a wide range of applications are covered as outlined in the contents. Offers comprehensive coverage of exergy and its applications, along with the most up-to-date information in the area with recent developments Connects exergy with three essential areas in terms of energy, environment and sustainable development Provides a number of illustrative examples, practical applications, and case studies Written in an easy-to-follow style, starting from the basics to advanced systems This edited book looks at recent studies on interdisciplinary research related to exergy, energy, and the environment. This topic is of prime significance – there is a strong need for practical solutions through better design, analysis and assessment in order to achieve better efficiency, environment and sustainability. Exergetic, Energetic and Environmental Dimensions covers a number of topics ranging from thermodynamic optimization of energy systems, to the environmental impact assessment and clean energy, offering readers a comprehensive reference on analysis, modeling, development, experimental investigation, and improvement of many micro to macro systems and applications, ranging from basic to advanced categories. Its comprehensive content includes: Comprehensive coverage of development of systems considering exergy, energy, and environmental issues, along with the most up-to-date information in the area, plus recent developments New developments in the area of exergy, including recent debate involving the shaping of future directions and priorities for better environment, sustainable development and energy security Provides a number of illustrative examples, practical applications, and case studies Introduces recently developed technological and strategic solutions and engineering applications for professionals in the area Provides numerous engineering examples and applications on exergy Offers a variety of problems that foster critical thinking and skill development The Exergy Method of Thermal Plant Analysis aims to discuss the history, related concepts, applications, and development of the Exergy Method - analysis technique that uses the Second Law of Thermodynamics as the basis of evaluation of thermodynamic loss. The book, after an introduction to thermodynamics and its related concepts, covers concepts related to exergy, such as physical and chemical exergy, exergy concepts for a control method and a closed-system analysis, the exergy analysis of simple processes, and the thermocentric applications of exergy. A seven-part appendix is also included. Appendices A-D covers miscellaneous information on exergy, and Appendix E features charts of thermodynamic properties. Appendix F is a glossary of terms, and Appendix G contains the list of references. The text is recommended for physicists who would like to know more about the Exergy Method, its underlying principles, and its applications not only in thermal plant analysis but also in certain areas. This book illustrates the editors' application of a scientific principle, the second law of thermodynamics, for aerospace engineering. It discusses how they applied this law to advance aerospace systems analysis and design optimization. It also discusses their research program which incorporates a systematic theoretical basis for constructing the proper formulas quantifying exergy balance, development of new computational capabilities for calculating exergy destruction, and exploration of novel approaches for system-level design. Topics include: identification of the upper limits on engineering system performance using the second law of thermodynamics; design methodology integration with tools developed in CFD and MDA/MDO; application of exergy methods to all levels of flight vehicle design; and, future directions, including constructal theory, quantum thermodynamics, and numerical methods in light of the second law Efficiency is one of the most frequently used terms in thermodynamics, and it indicates how well an energy conversion or process is accomplished. Efficiency is also one of the most frequently misused terms in thermodynamics and is often a source of misunderstanding. This is because efficiency is often used without being properly defined first. This book intends to provide a comprehensive evaluation of various efficiencies used for energy transfer and conversion systems including steady-flow energy devices (turbines, compressors, pumps, nozzles, heat exchangers, etc.), various power plants, cogeneration plants, and refrigeration systems. The book will cover first-law (energy based) and second-law (exergy based) efficiencies and provide a comprehensive understanding of their implications. It will help minimize the widespread misuse of efficiencies among students and researchers in energy field by using an intuitive and unified approach for defining efficiencies. The book will be particularly useful for a clear understanding of second law (exergy) efficiencies for various systems. It may serve as a reference book to the researchers in energy field. The definitions and concepts developed in the book will be

explained through illustrative examples. Low temperature district heating (LTDH) offers possibilities for efficient heat supply based on renewable energies. For the analysis of LTDH, the exergetic assessment is a suitable method. Hence, an exergy-based assessment method was developed in which energy as well as economic and sustainability aspects are combined. As part of a technology comparison, the method is applied to case studies to verify the applicability of the assessment approach. The approach highlights innovative supply solutions by identifying the advantages and disadvantages of different supply strategies. Improve and optimize efficiency of HVAC and related energy systems from an exergy perspective. From fundamentals to advanced applications, Exergy Analysis of Heating, Air Conditioning, and Refrigeration provides readers with a clear and concise description of exergy analysis and its many uses. Focusing on the application of exergy methods to the primary technologies for heating, refrigerating, and air conditioning, Ibrahim Dincer and Marc A. Rosen demonstrate exactly how exergy can help improve and optimize efficiency, environmental performance, and cost-effectiveness. The book also discusses the analysis tools available, and includes many comprehensive case studies on current and emerging systems and technologies for real-world examples. From introducing exergy and thermodynamic fundamentals to presenting the use of exergy methods for heating, refrigeration, and air conditioning systems, this book equips any researcher or practicing engineer with the tools needed to learn and master the application of exergy analysis to these systems. Explains the fundamentals of energy/exergy for practitioners/researchers in HVAC&R fields for improving efficiency Covers environmental assessments and economic evaluations for a well-rounded approach to the subject Includes comprehensive case studies on both current and emerging systems/technologies Provides examples from a range of applications – from basic HVAC&R to more diverse processes such as industrial heating/cooling, cogeneration and trigeneration, and thermal storage This book explore how exergy analysis can be an important tool for assessing the sustainability of buildings. Building's account or around 40 percent of total energy conditions depending on local climatic conditions. Due to its nature, exergy analysis should become a valuable tool for the assessment of building sustainability, first of all considering their scope and the dependence of their energy demands on the local environmental and climatic conditions. Nonetheless, methodological bottlenecks do exist and a solution to some of them is proposed in this monograph. First and foremost, there is the still-missing thermodynamically viable method to apply the variable reference environment temperature in exergy analysis. The monograph demonstrates that a correct approach to the directions of heat exergy flows, when the reference temperature is considered variable, allows reflecting the specifics of energy transformation processes in heating, ventilation, and air conditioning systems in a thermodynamically viable way. The outcome of the case analysis, which involved coordinated application of methodologies based on the Carnot factor and coenthalpies, was exergy analysis indicators – exergy efficiency and exergy destroyed – obtained for air handling units and their components. These methods can be used for the purposes of analysing and improving building technical systems that, as a rule, operate at a variable environment temperature. Exergy analysis becomes more reliable in designing dynamic models of such systems and their exergy-based control algorithms. This would improve the possibility to deploy them in building information modelling (BIM) technologies and the application of life cycle analysis (LCA) principles in designing buildings, thus improving the quality of the decision-making process. Furthermore, this would benefit other systems where variable reference environment plays a key role. This book is relevant to academics, students and researchers in the field of thermodynamic analysis considering HVAC equipment, building energy systems, energy efficiency, sustainable development of technical systems of energy, mechanics, and construction, as well as preservation of natural resources. Planners, designers, engineers of HVAC equipment, building energy systems, and developers of appropriate simulation tools (e.g., BIM) will also find it of use. Exergy, Energy System Analysis, and Optimization theme is a component of the Encyclopedia of Energy Sciences, Engineering and Technology Resources which is part of the global Encyclopedia of Life Support Systems (EOLSS), an integrated compendium of twenty one Encyclopedias. These three volumes are organized into five different topics which represent the main scientific areas of the theme: 1. Exergy and Thermodynamic Analysis; 2. Thermoeconomic Analysis; 3. Modeling, Simulation and Optimization in Energy Systems; 4. Artificial Intelligence and Expert Systems in Energy Systems Analysis; 5. Sustainability Considerations in the Modeling of Energy Systems. Fundamentals and applications of characteristic

methods are presented in these volumes. These three volumes are aimed at the following five major target audiences: University and College Students, Educators, Professional Practitioners, Research Personnel and Policy Analysts, Managers, and Decision Makers and NGOs. This book describes the Exergy-based Input - Output (ExIO) framework, a comprehensive methodology for assessing the primary fossil fuels requirements for the production of goods and services within a given economy from a lifecycle perspective. In the ExIO approach, exergy is assumed to be the best suited thermodynamic metric for characterizing fossil fuels. The mathematical formulation of ExIO is based on Input-Output analysis, which defines boundaries in time and space for any system or product analyzed, encompassing its entire lifecycle. The Hybrid-ExIO approach has been developed to increase the accuracy of results and to analyze energy systems in detail, leading to the definition of criteria and indicators for identifying and optimizing the primary fossil fuels requirements of system products. Lastly, the Bioeconomic ExIO model has been proposed to account for the side effects that the working hours required for producing goods and services have on the total primary fossil fuels consumption. As such, the book will be of considerable interest to both researchers and engineers in industry, offering them essential guidelines on the utilization of exergy and thermoeconomic analysis. A comprehensive assessment of the methodologies of thermodynamic optimization, exergy analysis and thermoeconomics, and their application to the design of efficient and environmentally sound energy systems. The chapters are organized in a sequence that begins with pure thermodynamics and progresses towards the blending of thermodynamics with other disciplines, such as heat transfer and cost accounting. Three methods of analysis stand out: entropy generation minimization, exergy (or availability) analysis, and thermoeconomics. The book reviews current directions in a field that is both extremely important and intellectually alive. Additionally, new directions for research on thermodynamics and optimization are revealed. A comprehensive and rigorous introduction to thermal system design from a contemporary perspective Thermal Design and Optimization offers readers a lucid introduction to the latest methodologies for the design of thermal systems and emphasizes engineering economics, system simulation, and optimization methods. The methods of exergy analysis, entropy generation minimization, and thermoeconomics are incorporated in an evolutionary manner. This book is one of the few sources available that addresses the recommendations of the Accreditation Board for Engineering and Technology for new courses in design engineering. Intended for classroom use as well as self-study, the text provides a review of fundamental concepts, extensive reference lists, end-of-chapter problem sets, helpful appendices, and a comprehensive case study that is followed throughout the text. Contents include: * Introduction to Thermal System Design * Thermodynamics, Modeling, and Design Analysis * Exergy Analysis * Heat Transfer, Modeling, and Design Analysis * Applications with Heat and Fluid Flow * Applications with Thermodynamics and Heat and Fluid Flow * Economic Analysis * Thermoeconomic Analysis and Evaluation * Thermoeconomic Optimization Thermal Design and Optimization offers engineering students, practicing engineers, and technical managers a comprehensive and rigorous introduction to thermal system design and optimization from a distinctly contemporary perspective. Unlike traditional books that are largely oriented toward design analysis and components, this forward-thinking book aligns itself with an increasing number of active designers who believe that more effective, system-oriented design methods are needed. Thermal Design and Optimization offers a lucid presentation of thermodynamics, heat transfer, and fluid mechanics as they are applied to the design of thermal systems. This book broadens the scope of engineering design by placing a strong emphasis on engineering economics, system simulation, and optimization techniques. Opening with a concise review of fundamentals, it develops design methods within a framework of industrial applications that gradually increase in complexity. These applications include, among others, power generation by large and small systems, and cryogenic systems for the manufacturing, chemical, and food processing industries. This unique book draws on the best contemporary thinking about design and design methodology, including discussions of concurrent design and quality function deployment. Recent developments based on the second law of thermodynamics are also included, especially the use of exergy analysis, entropy generation minimization, and thermoeconomics. To demonstrate the application of important design principles introduced, a single case study involving the design of a cogeneration system is followed throughout the book. In addition, Thermal Design and Optimization is one of the best newsources available for meeting the

recommendations of the Accreditation Board for Engineering and Technology for more design emphasis in engineering curricula. Supported by extensive reference lists, end-of-chapter problem sets, and helpful appendices, this is a superb text for both the classroom and self-study, and for use in industrial design, development, and research. A detailed solutions manual is available from the publisher. Hardbound. The subject of this book is the exergy analysis of the efficiency of processes involving energy and matter transformations. Efficiency is one of the most important criteria used in evaluating the performance of all types of processing plants; in particular those of the energy and chemical industries. The beauty of the exergetic approach to thermodynamic analysis is that it permits a universally applicable definition of efficiency and is free of contradictions in its treatment of numerous and diverse systems. The book provides the reader with the quantitative methods and calculations of efficiency considered to be applicable to different systems and their components. Methods, procedures and instructions for using the efficiency analysis in optimizing the performance of thermal, chemical and other industrial plants are also given. Numerous examples are used in the book to aid the reader in understanding the concepts of efficiency, exergy and the Exergy analysis is a practical approach to evaluate the merit of energy conversion or distribution processes and systems. With the aid of an energy analysis, the performance of an energy conversion system cannot be evaluated efficiently and precisely. But, an exergy analysis complements and enhances an energy analysis. Exergy analysis involves the application of exergy concepts, balances, and efficiencies to evaluate and improve energy and other systems. Many scientists suggest that processes or systems can be well evaluated and improved using exergy analysis in addition to or in place of energy analysis. Application of exergy analysis has given us more beneficial opportunities through a big part of a wide range of processes and systems particularly for the evaluation of energy systems and technologies as well as an environmental impact in all existing thermal and nuclear power plants. Conventional energy technologies, especially for power generation plants, have made numerous energy and exergy analyses and have produced beneficial results. Also, the use of energy and exergy analyses for advanced nuclear energy technologies can be expected to provide meaningful insights into performance that can assist in achieving optimal design concepts. Finally, explaining the analysis of thermal and nuclear power plant systems deals with exergetic approach.

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