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This form of energy, known as geothermal energy has been utilized throughout human history in the form of hot water from hot springs. Modern utilization of geothermal energy includes direct use of the heat and its conversion to other forms of energy, mainly electricity. Geothermal energy is a form of renewable energy and its use is associated with very little or no CO_2-emissions and its importance as an energy source has greatly increased as the effects of climate change become more prominent.

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geothermal energy from theoretical models to exploration ...
Geothermal Energy: From Theoretical Models to Exploration and Development Ingrid Stober, Kurt Bucher (auth.) The internal heat of the planet Earth represents an inexhaustible reservoir of thermal energy. This form of energy, known as geothermal energy has been utilized throughout human history in the form of hot water from hot springs.

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The internal heat of the planet Earth represents an inexhaustible reservoir of thermal energy. This form of energy, known as geothermal energy has been utilized throughout human history in the form of hot water from hot springs. Modern utilization of geothermal energy includes direct use of the heat and its conversion to other forms of energy, mainly electricity. Geothermal energy is a form of renewable energy and its use is associated with very little or no CO2-emissions and its importance as an energy source has greatly increased as the effects of climate change become more prominent. Because of its inexhaustibility it is obvious that utilization of geothermal energy will become a cornerstone of future energy supplies. The exploration of geothermal resources has become an important topic of study as geology and earth science students prepare to meet the demands of a rapidly growing industry, which involves an increasing number professionals and public institutions participating in geothermal energy related projects. This book meets the demands of both groups of readers, students and professionals. Geothermal Energy and its utilization is systematically presented and contains the necessary technical information needed for developing and understanding geothermal energy projects. It presents basic knowledge on the Earth's thermal regime and its geothermal energy resources, the types of geothermal energy used as well as its future potential and the perspectives of the industry. Specific chapters of the book deal with borehole heat exchangers and with the direct use of groundwater and thermal water in hydrogeothermal systems. A central topic are Enhanced Geothermal Systems (hot-dry-rock systems), a key technology for energy supply in the near future. Pre-drilling site investigations, drilling technology, well logging and hydraulic test programs are important subjects related to the exploration phase of developing Geothermal Energy sites. The chemical composition of the natural waters used as a heat transport medium in geothermal systems can be used as an exploration tool, but chemistry is also important during operation of a geothermal power plant because of potential scale formation and corrosion of pipes and installations, which needs to be prevented. Graduate students and professionals will find in depth information on Geothermal Energy, its exploration and utilization.

Geothermal Energy: Sustainable Heating and Cooling Using the Ground Marc A. Rosen and Seama Koohi-Fayegh, University of Ontario Institute of Technology, Canada Comprehensively covers geothermal energy systems that utilize ground energy in conjunction with heat pumps to provide sustainable heating and cooling The book describes geothermal energy systems that utilize ground energy in conjunction with heat pumps and related technologies to provide heating and cooling. Also discussed are methods to model and assess such systems, as well as means to determine potential environmental impacts of geothermal energy systems and their thermal interaction. The book presents the most up-to-date information in the area. It provides material on a range of topics, from thermodynamic concepts to more advanced discussions of the renewability and sustainability of geothermal energy systems. Numerous applications of such systems are also provided. Geothermal Energy: Sustainable Heating and Cooling Using the Ground takes a research orientated approach to provide coverage of the state of the art and emerging trends, and includes numerous illustrative examples and case studies. Theory and analysis are emphasized throughout, with detailed descriptions of models available for vertical and horizontal geothermal heat exchangers. Key features: Explains geothermal energy systems that utilize ground energy in conjunction with heat pumps to provide heating and cooling, as well as related technologies such as thermal energy storage. Describes and discusses methods to model and analyze geothermal energy systems, and to determine their potential environmental impacts and thermal interactions. Covers various applications of geothermal energy systems. Takes a research orientated approach to provide coverage of the state of the art and emerging trends. Includes numerous illustrative examples and case studies. The book is key for researchers and practitioners working in geothermal energy, as well as graduate and advanced undergraduate students in departments of mechanical, civil, chemical, energy, environmental, process and industrial engineering.

This book is dedicated to the numerical modeling of shallow geothermal systems. The utilization of shallow geothermal energy involves the integration of multiple Borehole Heat Exchangers (BHE) with Ground Source Heat Pump (GSHP) systems to provide heating and cooling. The modeling practices explained in this book can improve the efficiency of these increasingly common systems.

The book begins by explaining the basic theory of heat transport processes in man-made as well as natural media. . These techniques are then applied to the simulation of borehole heat exchangers and their interaction with the surrounding soil. The numerical and analytical models are verified against analytical solutions and measured data from a Thermal Response Test, and finally, a real test site is analyzed through the model and discussed with regard to BHE and GSHP system design and optimization.

Rising pollution, climate change and the depletion of fossil fuels are leading many countries to focus on renewable-based energy conversion systems. In particular, recently introduced energy policies are giving high priority to increasing the use of renewable energy sources, the improvement of energy systems' security, the minimization of greenhouse gas effect, and social and economic cohesion. Renewable energies' availability varies during the day and the seasons and so their use must be accurately predicted in conjunction with the management strategies based on load shifting and energy storage. Thus, in order to reduce the criticalities of this uncertainty, the exploitation of more flexible and stable renewable energies, such as the geothermal one, is necessary. Geothermal energy is an abundant renewable source with significant potential in direct use applications, such as in district heating systems, in indirect use ones to produce electricity, and in cogeneration and polygeneration systems for the combined production of power, heating, and cooling energy. This Special Issue includes geothermal energy utilization and the technologies used for its exploitation considering both the direct and indirect use applications.

The internal heat of the planet Earth represents an inexhaustible reservoir of thermal energy known as Geothermal Energy. The 2nd edition of the book covers the geologic and technical aspects of developing all forms of currently available systems using this "renewable" green energy. The book presents the distribution and transport of thermal energy in the Earth. Geothermal Energy is a base load energy available at all times independent of climate and weather. The text treats the efficiency of diverse shallow near surface installations and deep geothermal systems including hydrothermal and petrothermal techniques and power plants in volcanic high-enthalpy fields. The book also discusses environmental aspects of utilizing different forms of geothermal energy, including induced seismicity, noise pollution and gas release to the atmosphere. Chapters on hydraulic well tests, chemistry of deep hot water, scale formation and corrosion, development of geothermal probes, well drilling techniques and geophysical exploration complete the text. This book, for the first time, covers the full range of utilization of Geothermal Energy.

Geothermal Energy Systems provides design and analysis methodologies by using exergy and enhanced exergy tools (covering exergoenvironmental, exergoeconomic, exergetic life cycle assessment, etc.), environmental impact assessment models, and sustainability models and approaches. In addition to presenting newly developed advanced and integrated systems for multigenerational purposes, the book discusses newly developed environmental impact assessment and sustainability evaluation methods and methodologies. With case studies for integrated geothermal energy sources for multigenerational aims, engineers can design and develop new geothermal integrated systems for various applications and discover the main advantages of design choices, system analysis, assessment and development of advanced geothermal power systems. Explains the ability of geothermal energy power systems to decrease global warming Discusses sustainable development strategies for using geothermal energy sources Provides new design conditions for geothermal energy sources-based district energy systems

Ron DiPippo, Professor Emeritus at the University of Massachusetts

Dartmouth, is a world-regarded geothermal expert. This single resource covers all aspects of the utilization of geothermal energy for power generation from fundamental scientific and engineering principles. The thermodynamic basis for the design of geothermal power plants is at the heart of the book and readers are clearly guided on the process of designing and analysing the key types of geothermal energy conversion systems. Its practical emphasis is enhanced by the use of case studies from real plants that increase the reader's understanding of geothermal energy conversion and provide a unique compilation of hard-to-obtain data and experience. An important new chapter covers Environmental Impact and Abatement Technologies, including gaseous and solid emissions; water, noise and thermal pollutions; land usage; disturbance of natural hydrothermal manifestations, habitats and vegetation; minimisation of CO2 emissions and environmental impact assessment. The book is illustrated with over 240 photographs and drawings. Nine chapters include practice problems, with solutions, which enable the book to be used as a course text. Also includes a definitive worldwide compilation of every geothermal power plant that has operated, unit by unit, plus a concise primer on the applicable thermodynamics. * Engineering principles are at the heart of the book, with complete coverage of the thermodynamic basis for the design of geothermal power systems * Practical applications are backed up by an extensive selection of case studies that show how geothermal energy conversion systems have been designed, applied and exploited in practice * World renowned geothermal expert DiPippo has including a new chapter on Environmental Impact and Abatement Technology in this new edition

Thermoacoustic energy conversion systems have attracted much attention in recent decades due to their lack of moving components and relatively benign environmental impact, showing a promising prospect in the utilization of low-grade heat sources such as geothermal energy, industrial waste heat, solar thermal energy and exhaust heat of internal combustion engines, etc. Recent developments in thermoacoustic engines (TAEs) and thermoacoustic electric generators (TAEGs) indicate that the coupling of multiple physical fields plays an important role in the energy conversion between thermal, acoustic and electric energy. In-depth understanding of multi-physics coupling and attendant energy conversion processes is pivotal for the systematic design and optimization of high-performance, efficient thermoacoustic systems. This thesis is devoted to reveal the underlying mechanisms of multi-physics coupling in standing-wave thermoacoustic systems by means of theoretical, numerical and experimental approaches. In this thesis, thermal-acoustic coupling between the temperature and acoustic fields in TAEs is first investigated numerically. High-fidelity three-dimensional (3D) Large Eddy Simulation (LES) of thermally induced flow in a quarter-wavelength standing-wave TAE is performed. The dynamic, acoustic, hydrodynamic and heat transfer characteristics of the TAE are discussed, which deepens the understanding of thermal-acoustic coupling from broader perspectives. A reduced-order network model based on linear thermoacoustic theory is used to verify simulation results. The numerical results using LES not only shed light on the mechanisms responsible for the acoustic energy generation and transportation inside the system, but also give insight into various nonlinear phenomena that result in the dissipation of the acoustic power. Following 3D LES, efforts are made to explore the underlying mechanisms of hysteresis of self-excited acoustic oscillations and nonlinear triggering of thermoacoustic limit cycles through a two-dimensional (2D) computational model which significantly reduces computational cost compared to 3D LES. It is found that the system may either be in the quiescent state or in limit-cycle oscillations if the temperature lies between the lower and upper critical temperatures, and an external acoustic pressure disturbance may induce oscillations to commence. These two nonlinear phenomena associated with thermal-acoustic coupling are further interpreted from both nonlinear dynamics and energy balance viewpoints by conducting bifurcation/phase space analyses and examining the simulated temperature fields. Subsequently, acoustic-mechanical coupling between the acoustic field of the TAE and the mechanical field of the external load is investigated. Attention is paid to the beating and quasi-periodic oscillations that were reported in previous experiments but not interpreted physically. In the theoretical study, an acoustic analysis on the effect of acoustic-mechanical coupling on the eigenvalues (natural frequencies) and eigenvectors (mode shapes) of the coupled system is first conducted. Then, a stability analysis considering the thermal-acoustic coupling is performed to obtain the stability curves of acoustic modes. Theoretical results reveal that the joint influence of acoustic-mechanical coupling and thermal-acoustic coupling decides whether the steady state is static (quiescent) or dynamic in the linear regime. Simultaneous excitation of acoustic mode(s) may lead to different steady-state waveforms such as limit cycles, beating and quasi-periodicity. Lastly, mechanical-electric coupling between the mechanical and electric fields in mechanical-to-electric transducers is investigated experimentally and theoretically. A thermoacoustic-piezoelectric energy harvester (TAPEH) is first constructed by integrating a piezoelectric transducer with a standing-wave TAE. System-level analysis is conducted to study the coupling of temperature, acoustic, mechanical and electric fields inside the TAPEH. Parametric studies are conducted to investigate the effect of geometrical and electrical parameters on the onset and energy conversion characteristics of the TAPEH. Following the study of TAPEH, an electret-based thermoacoustic-electrostatic energy harvester (TAEEH) is proposed by replacing the piezoelectric transducer with an electret-based electrostatic transducer. The dynamic responses of the TAEEH are investigated experimentally and compared with the theoretical models. The effect of key parameters on the overall performance of the TAEEH is examined through a series of experimental and theoretical studies.

This introduction to geothermal modeling deals with flow and heat transport processes in porous and fractured media related to geothermal energy applications. Following background coverage of geothermal resources and utilization in several countries, the basics of continuum mechanics for heat transport processes, as well as numerical methods for solving underlying governing equations are discussed. This examination forms the theoretical basis for five included step-by-step OpenGeoSys exercises, highlighting the most important computational areas within geothermal resource utilization, including heat diffusion, heat advection in porous and fractured media, and heat convection. The book concludes with an outlook on practical follow-up contributions investigating the numerical simulation of shallow and deep geothermal systems.