Service life modeling was performed to gauge the viability of unitary 3.5 kWt, ground-source terminal heat pumps (GTHP) employing horizontal directionally drilled geothermal heat exchangers (GHX) over air-source terminal heat pumps (PTHP) in hotels and motels and residential apartment building sectors in California's coastal and inland climates. Results suggest the GTHP can reduce hourly peak demand for the utility by 7%-25% compared to PTHP, depending on the climate and building type. The annual energy savings, which range from -1% to 5%, are highly dependent on the GTHP pump energy use relative to the energy savings attributed to the difference in ground and air temperatures (ΔT). In mild climates with small ΔT, the pump energy use may overcome any advantage to utilizing a GHX. The majority of total levelized cost savings - ranging from $0.18/ft² to $0.3/ft² - are due to reduced maintenance and lifetime capital cost normally associated with geothermal heat pump systems. Without these reductions (not validated for the GTHP system studied), the GTHP technology does not appear to offer significant advantages over PTHP in the climate zones studied here. The GTHP levelized cost was most sensitive to variations in installed cost and in some cases, energy use (influenced by climate zone choice), which together highlights the importance of climate selection for installation, and the need for larger market penetration of ground-source systems in order to bring down installed costs as the technology matures. Ground-Source Heat Pumps presents the theory and some of the most recent advances of GSHPs and their
implementation in the heating/cooling system of buildings. The authors explore the thermodynamic cycle with calculation, operation regimes and economic indicators and GHG emissions of a vapor compression heat pump. They go on to examine substitution strategies of non-ecological refrigerants and types of compressors and heat pumps, before delving into the different GSHP systems, as well as their compared economic, energy and environmental performances using classical and optimized adjustment for various operating modes. Surface water heat pumps and ground water heat pumps are covered, and special focus is given to both vertical and horizontal ground-coupled heat pump systems, for which modelling and simulation is discussed, and experimental systems are described. Due to its advanced approach to the subject, this book will be especially valuable for researchers, graduate students and academics, and as reference for engineers and specialists in the varied domains of building services. Explores fundamentals and state-of-the-art research, including ground-coupled heat pump (GCHP) systems. Includes performance assessment and comparison for different types of GSHP, numerical simulation models, practical applications of GSHPs with details on the renewable energy integration, information on refrigerants, and economic analysis. The text describes the main features of currently available heat pumps, focusing on system operation and interactions with external heat sources. In fact, before choosing a heat pump, several aspects must be assessed in detail: the actual climate of the installation site, the building’s energy requirements, the heating system, the type of operation etc. After discussing the general working principles, the book describes the main components of compression machines – for EHPs, GHPs and CO2 heat pumps. It then addresses absorption heat pumps and provides additional details on the behavior of two-fluid mixtures. The book presents a performance comparison for the different types, helping designers choose the right one for their needs, and discusses the main refrigerants. Notes on helpful additional literature, websites and videos, also concerning relevant European regulations, round out the coverage. This book will be of interest to all engineers and technicians whose work involves heat pumps. It will also benefit students in energy engineering degree programs who want to deepen their understanding of heat pumps.

Drying of solids is one of the most common, complex, and energy-intensive industrial processes. Conventional dryers offer limited opportunities to increase energy efficiency. Heat pump dryers are more energy and cost effective, as they can recycle drying thermal energy and reduce CO2, particulate, and VOC emissions due to drying. This book provides an introduction to the technology and current best practices and aims to increase the successful industrial implementation of heat pump-assisted dryers. It enables the reader to engage confidently with the technology and provides a wealth of information on theories, current practices, and future directions of the technology. It emphasizes several new design concepts and operating and control strategies, which can be applied to improve the economic and environmental efficiency of the drying process. It answers questions about risks, advantages vs. disadvantages, and impediments and offers solutions to current problems. Discusses heat pump technology in general and its present and future challenges. Describes interesting and promising innovations in drying food, agricultural, and wood products with various heat pump technologies. Treats several technical aspects, from modeling and simulation of drying processes to industrial applications. Emphasizes new design concepts and operating and control strategies to improve the efficiency of the drying process. Geothermal Heat Pumps is the most comprehensive guide to the selection, design and installation of geothermal heat pumps available. This leading manual presents the most recent information and market developments in order to put any installer, engineer or architect in the position to design, select and install a domestic geothermal heat pump system. Internationally respected expert Karl Ochsner presents the reasons to use heat pumps, introduces basic theory and reviews the wide variety of available heat pump models. This book collects selected full papers presented at the International Symposium on Energy Geotechnics 2018 (SEG-2018), held on 25th – 28th September 2018, at the Swiss Federal Institute of Technology in Lausanne (EPFL). It
covers a wide range of topics in energy geotechnics, including energy geotechnologies, energy geostorage, thermo-hydro-chemo-mechanical behaviour of geomaterials, unconventional resources, hydraulic stimulation, induced seismicity, CO2 geological storage, and nuclear waste disposal as well as topics such as tower and offshore foundations. The book is intended for postgraduate students, researchers and practitioners working on geomechanics and geotechnical engineering for energy-related applications. This handbook provides a comprehensive summary on the energy systems used in green buildings, with a particular focus on solar energy - the most common renewable energy source applied in this field. With the growing concern about environmental protections, the concepts of green building have been widely promoted and implemented in nowadays building designs and constructions. Among all, sustainable energy systems, including energy harvesting, conversion, and storage, is one of most important design factors in green buildings. Unlike traditional energy systems which highly rely on fossil fuel, green buildings utilize renewable energy source or high efficient energy systems, or both, to provide environmental friendly, low carbon waste energy. The most updated concepts, designs, technologies developed and implemented in heat pumps, cooling systems, power systems, and energy storage will be discussed here in details. This handbook is subdivided into 7-9 main sections to provide an in-depth discussion from foundational principles to practical techniques. In addition, different cases about green energy systems implemented in global will be discussed. The book will be structured easy-to-read, to make it more accessible to graduate students and professionals in diverse scientific and engineering communities, including applied physics, civil engineering, electrical engineering, mechanical engineering, material engineering, and chemical engineering. In-depth, practical details on geothermal HVAC systems This definitive guide covers commercial and residential geothermal heating, ventilation, and air conditioning technologies and explains how to take advantage of their money- and energy-saving features. Geothermal HVAC: Green Heating and Cooling reviews the array of choices currently available, offers market values for systems based on varying options and conditions, and describes how to pair the best systems for each application and budget. Whether you're a contractor or a consumer, you'll find out what you need to know to implement a geothermal HVAC system in a retrofit or new construction project, and start benefiting from this sustainable, affordable technology. Find out how to: Learn the basic types of heat transfer--convection, conduction, and radiation Understand how geothermal earth-coupled heat pumps work Determine which ground loops to use for earth coupling to best meet the demands of the site Use load sharing to channel the heat differential of one device into useful energy for another Calculate system efficiencies and heat gain and loss Understand geothermal project proposals and system pricing Benefit from incentives, tax credits, and rebates for geothermal HVAC systems Calculate your long-term return on investment Verify that your installed system is working as intended Troubleshoot your system and avoid common problems The work presented in this thesis focuses on reducing the energy demand of a residential building by using a coupled ground-source heat pump/energy recovery ventilation (GSHP-ERV) system to present a novel approach to space condition and domestic hot water supply for a residence. The proposed system is capable of providing hot water on-demand with a high coefficient of performance (COP), thus eliminating the need for a hot water storage tank and circulation system while requiring little power consumption. The necessary size of the proposed system and the maximum and normal heating and cooling loads for the home were calculated based on the assumptions of an energy efficient home, the assumed construction specifications, and the climate characteristics of the Blacksburg, Virginia region. The results from the load analysis were used to predict energy consumption and costs associated with annual operations. The results for the predicted heating annual energy consumption and costs for the GSHP-ERV system were compared to an air-source heat pump and a natural gas furnace. On average, it was determined that the proposed system was capable of reducing annual energy consumption by 56-78% over air-source heat pumps and 85-88% over a
natural gas furnace. The proposed GSHP-ERV system reduced costs by 45-61% over air-source heat pump systems and 52-58% over natural gas furnaces. The annual energy consumption and costs associated with cooling were not calculated as cooling accounts for a negligible portion (6%) of the total annual energy demand for a home in Blacksburg. The recommendations summarise the state of the art. Their aim is the proper exploitation of the ground for geothermal purposes without adversely affecting the ground or the groundwater on the one hand and the operation of the system and nearby buildings on the other. The recommendations should be used during consulting, design, installation and operation in order to achieve optimum and sustainable use of the ground at a specific location. Authorities responsible for supervising and approving projects can use the recommendations as a guide when taking decisions and making stipulations. The Geothermal Energy Study Group was set up in Bochum in 2004 and became the joint DGGV/DGGT study group in 2007. Some 20 specialists from universities, authorities and engineering consultants are active in the group and meet two or three times a year. This book analyses solar-assisted ground-source heat pump systems, a technology meant for producing heating and cooling energy for buildings. It focuses on ground source heat pump, reversible central heating and cooling system that transfer heat from or to the ground, applications which use solar thermal collectors. Providing deep insights into energy-saving, solar thermal system operating strategies, it illustrates examples of useful configurations and controlling approach for different climates for different vertical ground heat exchanger depths. Offering an overview of solar assisted ground source heat pump systems, including design principles and energy-performance data for different climates, it is a valuable resource for designers and scientists who focus on building heating and cooling technologies. A unique approach to the study of geothermal energy systems This book takes a unique, holistic approach to the interdisciplinary study of geothermal energy systems, combining low, medium, and high temperature applications into a logical order. The emphasis is on the concept that all geothermal projects contain common elements of a "thermal energy reservoir" that must be properly designed and managed. The book is organized into four sections that examine geothermal systems: energy utilization from resource and site characterization; energy harnessing; energy conversion (heat pumps, direct uses, and heat engines); and energy distribution and uses. Examples are provided to highlight fundamental concepts, in addition to more complex system design and simulation. Key features: Companion website containing software tools for application of fundamental principles and solutions to real-world problems. Balance of theory, fundamental principles, and practical application. Interdisciplinary treatment of the subject matter. Geothermal Heat Pump & Heat Engine Systems: Theory and Practice is a unique textbook for Energy Engineering and Mechanical Engineering students as well as practicing engineers who are involved with low-enthalpy geothermal energy systems. This paper describes the field performance of space conditioning and water heating equipment in four single-family residential structures with advanced thermal envelopes. Each structure features a different, advanced thermal envelope design: structural insulated panel (SIP); optimum value framing (OVF); insulation with embedded phase change materials (PCM) for thermal storage; and exterior insulation finish system (EIFS). Three of the homes feature ground-source heat pumps (GSHPs) for space conditioning and water heating while the fourth has a two-capacity air-source heat pump (ASHP) and a heat pump water heater (HPWH). Two of the GCHP-equipped homes feature horizontal ground heat exchange (GHX) loops that utilize the existing foundation and utility service trenches while the third features a vertical borehole with vertical u-tube GHX. All of the houses were operated under the same simulated occupancy conditions. Operational data on the house HVAC/Water heating (WH) systems are presented and factors influencing overall performance are summarized. Best practices for designing nonresidential geothermal systems (ground-source heat pump, closed-loop ground, groundwater, and surface-water systems) for HVAC design engineers, design-build contractors, GSHP subcontractors, and energy/construction managers;
includes supplemental Microsoft Excel macro-enabled spreadsheets for a variety of GSHP calculations'—Best practices for the design and engineering of geothermal HVAC systems With a focus on market needs and customer goals, this practical guide explains how to realize the full potential of geothermal HVAC by integrating hydronic systems and controls at maximum capacity. Modern Geothermal HVAC: Engineering and Control Applications explains how to engineer and specify geothermal HVAC for building projects in varying geographic regions. Typical details on control parameters are provided. By using the proven methods in this innovative resource, you will be able to develop highly efficient, long-lasting, and aesthetically pleasing geothermal HVAC systems. Coverage includes: Low-temperature geothermal or earth coupling Geothermal heat-pump equipment Variations in earth coupling Application of earth coupling with regard to site conditions Closed-loop earth coupling and fusion Intermediate heat exchanger usage in geothermal applications Standing column and open geothermal systems Fundamentals of comfort, psychrometrics, and thermodynamics Hydronic and air HVAC system basics Hydronic HVAC system efficiencies, heat gain, and loss Geothermal rebates, incentives, and renewables legislation The combination of heat pumps and solar components is a recent development and has great potential for improving the energy efficiency of house and hot water heating systems. As a consequence, it can enhance the energy footprint of a building substantially. This work compares different systems, analyses their performance and illustrates monitoring techniques. It helps the reader to design, simulate and assess solar and heat pump systems. Good examples of built systems are discussed in detail and advice is given on how to design the most efficient system. This book is the first one about this combination of components and presents the state of the art of this technology. It is based on a joint research project of two programmes of the International Energy Agency: the Solar Heating and Cooling Programme (SHC) and the Heat Pump Programme. More than 50 experts from 13 countries have participated in this research.Renewable Heating and Cooling: Technologies and Applications presents the latest information on the generation of heat for industry and domestic purposes, an area where a significant proportion of total energy is consumed. In Europe, this figure is estimated to be almost 50%, with the majority of heat generated by the consumption of fossil fuels. As there is a pressing need to increase the uptake of renewable heating and cooling (RHC) to reduce greenhouse gas emissions, this book provides a comprehensive and authoritative overview on the topic. Part One introduces key RHC technologies and discusses RHC in the context of global heating and cooling demand, featuring chapters on solar thermal process heat generation, deep geothermal energy, and solar cooling technologies. Part Two explores enabling technologies, special applications, and case studies with detailed coverage of thermal energy storage, hybrid systems, and renewable heating for RHC, along with case studies in China and Sweden. Users will find this book to be an essential resource for lead engineers and engineering consultants working on renewable heating and cooling in engineering companies, as well as academics and R&D professionals in private research institutes who have a particular interest in the subject matter. Includes coverage on biomass, solar thermal, and geothermal renewable heating and cooling technologies Features chapters on solar thermal process heat generation, deep geothermal energy, solar cooling technologies, and special applications Presents case studies with detailed coverage of thermal energy storage, hybrid systems, and renewable heating for RHC Explores enabling technologies and special applications 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. Advances in Ground-Source Heat Pump Systems relates the latest information on source heat pumps (GSHPs), the types of heating and/or cooling systems that transfer heat from, or to, the ground, or, less commonly, a body of water. As one of the fastest growing renewable energy technologies, they are amongst the most energy efficient systems for space heating, cooling, and hot water production, with significant potential for a reduction in building carbon emissions. The book provides an authoritative overview of developments in closed loop GSHP systems, surface water, open loop systems, and related thermal energy storage systems, addressing the different technologies and component methods of analysis and optimization, among other subjects. Chapters on building integration and hybrid systems complete the volume. Provides the geological aspects and building integration covered together in one convenient volume. Includes chapters on hybrid systems. Presents carefully selected chapters that cover areas in which there is significant ongoing research. Addresses geothermal heat pumps in both heating and cooling modes. The combination of heat pumps and solar components is a recent development and has great potential for improving the energy efficiency of house and hot water heating systems. As a consequence, it can enhance the energy footprint of a building substantially. This work compares different systems, analyses their performance and illustrates monitoring techniques. It helps the reader to design, simulate and assess solar and heat pump systems. Good examples of built systems are discussed in detail and advice is given on how to design the most efficient system. This book is the first one about this combination of components and presents the state of the art of this technology. It is based on a joint research project of two programmes of the International Energy Agency: the Solar Heating and Cooling Programme (SHC) and the Heat Pump Programme. More than 50 experts from 13 countries have participated in this research. The potential for energy transformation from geothermal heat is limitless. For millennia natural sources of this energy, in the form of thermal springs, have been used by populations for heating, cooking and bathing. Modern-day usage has been extended to electricity generation from binary cycle power plants, heat extraction from geothermal heat pumps and use in greenhouses for industrial crop growing. Perspectives for Geothermal Energy in Europe highlights the status of geothermal energy in countries where natural sources of this energy are available. It concludes with a presentation of current geothermal policy and regulations within Europe, and discussion of how this fits in with the EU Energy and Climate Framework. Suitable for students, academics and practitioners in the fields of energy studies, geology and the earth sciences, electrical engineering and environmental economics, this book is the first comprehensive review of the practicalities of geothermal extraction and use in Europe. Heat pump systems are becoming a popular choice for residential heating and cooling across the United States. Heat pumps are among the cleanest and best energy- and cost-efficient heating and cooling systems available today. However, cost is a prime motivator when choosing among residential heating and cooling systems and it is therefore desirable to analyze the costs associated with heat pump system operation. This research provides a method of direct comparison between the economics of air-source and ground-source heat pump system operation. The objective is to provide a cost comparison with respect to climate locations across the United States, since heat pump performance is heavily influenced by operating conditions.
environmental conditions such as the ambient air temperature. A purely analytical approach is used for the comparison, avoiding the complexities and costs associated with surveys or experiments, and obtaining actual utility information. Heat pump systems are briefly surveyed, and the thermodynamic operation of vapor compression refrigeration cycles is examined. Analytic models are developed to simulate heating and cooling operation of dual-mode air- and ground-source heat pumps based upon readily available climate data. Finally, a cost ratio relationship is developed to directly compare the associated operating costs for air- and ground-source heat pump systems for a 31 city sample covering much of the continental United States. The annual cost ratio provides the opportunity to evaluate potential cost savings for the operation of air- or ground-source heat pump installations.

Whether you are preparing for a career in the building trades or are already a professional contractor, this practical book will help you develop the knowledge and skills you need to merge renewable heat sources (such as solar thermal collectors, hydronic heat pumps, and wood-fired boilers) with the latest hydronics hardware and low temperature distribution systems to assemble efficient and reliable heating systems. Easy to understand and packed with full color illustrations that provide detailed piping and control schematics and how to information you'll use on every renewable energy system, this one-of-a-kind book will help you diversify your expertise over a wide range of heat sources. Important Notice: Media content referenced within the product description or the product text may not be available in the ebook version.

Sets the baseline for the science behind an emerging technology Authoritative guide to skills needed to implement ground source heat pump schemes Only book using SI units to adequately focus on the geological aspects of ground source heat Ground Source Heat Pump Systems (GSHPs) are one of the most promising clean and low-carbon source of geothermal renewable energy technologies for heating, ventilation and cooling of homes. Geothermal heat pump (GHP) technologies, referred to as GeoExchange, comprise ground-source and/or water-source heat pumps that use the constant temperature of the earth as the exchange medium instead of the outside air temperature. This study is a technical and economic assessment of use of GSHPs to support the policy options for increasing the share of geothermal energy sources within the residential sector of Ontario. The study identifies the technical and economic barriers to the wide-spread adoption of ground source heat pumps in Ontario and is an assessment of the impacts of large-scale deployment of GSHPs on greenhouse gas (GHG) emissions. In this study, I have established the basis for evaluating the cost and environmental benefits of GSHPs in Ontario. The results provide a sound economic and technical foundation for supporting investment decisions in favour of implementing GSHPs as a viable alternative to traditional heating, ventilation, air-conditioning systems (HVACs), specifically, natural gas use for space heating and hot water usage in buildings.

The study reveals that geothermal ground source heat pumps have a great potential to reduce GHG emissions for Ontario's residential sector by a magnitude of 21.7 megatonnes (Mt) that will in turn reduce the overall emissions of Ontario by 13%. GSHPs are a cost-effective solution for implementation on a wide-scale. The economic analysis clearly indicates the horizontal ground source heat pump system (H.GSHPs) is a strong winner in multiple sensitivity analysis when considering different lifespans, discount factors, and base case scenario against comparative scenarios. The rankings of the twenty-seven (27) cities selected for this study identify that the GSHPs are more attractive compared to traditional HVACs from an investment point of view in cities of the southern and distinct region as compared to the northern regions because of low present value (PV) of costs. The PV compares the cash outflows based on the initial investment, operating costs, maintenance costs, and disposal costs in a project lifespan of 60 years that span life cycles of 20 - 30 years for GSHPs and 12 years for traditional HVAC applications. This study has conducted a comprehensive technical and economic assessment for twenty-seven (27) cities in Ontario to address the geographic variation of benefits. While there is a variation across regions of Ontario - and this is based on weather, soil condition and level of energy use - the overall
Conclusion is a compelling case for GSHPs as a viable alternative to the use of natural gas. Ground source heat pumps (GSHP) are efficient alternatives to air source heat pumps to provide heating and cooling for conditioned buildings. GSHPs are widely deployed in the midwest and eastern regions of the United States but less so in Texas and the southwest regions whose climates are described as being semi-arid. In these semi-arid regions, building loads are typically cooling dominated so the unbalance in energy loads to the ground, coupled with less conductive soil, cause the ground temperature to increase over time if the ground loop is not properly sized. To address this ground heating problem especially in commercial building applications, GSHPs are coupled with supplemental heat recovery/rejection (SHR) systems that remove heat from the water before it is circulated back into the ground loops. These hybrid ground source heat pump systems are designed to reduce ground heating and to lower the initial costs by requiring less number of or shallower boreholes to be drilled. This thesis provides detailed analyses of different SHR systems coupled to GSHPs specifically for residential buildings. The systems are analyzed and sized for a 2100 ft² residential house, using Austin, Texas weather data and ground conditions. The SHR systems investigated are described by two heat rejection strategies: 1) reject heat directly from the water before it enters the ground loops and 2) reject heat from the refrigerant loop of the vapor compression cycle (VCC) of the heat pump so less heat is transferred to the water loop at the condenser of the VCC. The SHR systems analyzed in this thesis are cooling towers, optimized VCC, expanded desuperheaters and thermosyphons. The cooling towers focus on the direct heat rejection from the water loop. The VCC, desuperheater, and thermosyphon systems focus on minimizing the amount of heat rejected by the VCC refrigerant to the water loop. In each case, a detailed description of the model is presented, a parametric analysis is provided to determine the amounts of heat that can be rejected from the water loop for various cases of operation, and the practical feasibility of implementation is discussed. An economic analysis is also provided to determine the cost effectiveness of each method.

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