

Ground Source Heat Pump Residential And Light Commercial Design And Installation Guide Geothermal Installer Manuals

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.

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 geothermal resources of the Earth are enormous. The resource is considered to be an environmentally friendly clean energy source that could significantly contribute to the reduction of GHG emissions when utilized for electrical power generation or direct heating applications. The source of geothermal energy is the continuous heat energy flux flowing from the interior of the Earth toward its surface. Geothermal energy resources vary geographically, depending on the depth and temperature of the resource, the rock chemical composition, and the abundance of ground water. This book is the result of contributions from several experts and researchers worldwide. The introductory chapter highlights the principles of geothermal power generation using LEGE-ORC technology and presents a summary of the following book chapters. Due to its important utilization and future prospects, various interesting topics of research related to geothermal energy explorations are covered in this book. It is hoped that the book will become a useful source of information and basis for extended research for researchers, academics, policy makers, and practitioners in the area of renewable geothermal energy explorations.

Ground-source Heat Pump Systems for Residential and Commercial Applications

Handbook of Energy Systems in Green Buildings

Residential Geothermal Systems

For Designing Systems in Heating Dominated Climates

Geothermal Heat Pumps: Installation Guide

Heating and Cooling with Ground-Source Heat Pumps in Cold and Moderate Climates

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. A residential-size ground-source integrated heat pump (GSIHP) system has been developed and is currently being

field tested. The system is a nominal 2-ton (7 kW) cooling capacity, variable-speed unit, which is multi-functional, e.g. space cooling, space heating, dedicated water heating, and simultaneous space cooling and water heating. High-efficiency brushless permanent-magnet (BPM) motors are used for the compressor, indoor blower, and pumps to obtain the highest component performance and system control flexibility. Laboratory test data were used to calibrate a vapor-compression simulation model (HPDM) for each of the four primary modes of operation. The model was used to optimize the internal control options and to simulate the selected internal control strategies, such as controlling to a constant air supply temperature in the space heating mode and a fixed water temperature rise in water heating modes. Equipment performance maps were generated for each operation mode as functions of all independent variables for use in TRNSYS annual energy simulations. These were performed for the GSIHP installed in a well-insulated 2600 ft² (242 m²) house and connected to a vertical ground loop heat exchanger (GLHE). We selected a 13 SEER (3.8 CSPF)/7.7 HSPF (2.3 HSPF, W/W) ASHP unit with 0.90 Energy Factor (EF) resistance water heater as the baseline for energy savings comparisons. The annual energy simulations were conducted over five US climate zones. In addition, appropriate ground loop sizes were determined for each location to meet 10-year minimum and maximum design entering water temperatures (EWTs) to the equipment. The prototype GSIHP system was predicted to use 52 to 59% less energy than the baseline system while meeting total annual space conditioning and water heating loads.

This project team analyzed supplemental heat rejection/recovery (SHR) devices or systems that could be used in hybrid ground source heat pump (HGHP) systems located in arid or semi-arid regions in southwestern U.S. Identification of effective SHR solutions would enhance the deployment of ground source heat pumps (GHP) in these regions. In a parallel effort, the team developed integrated GHP models that coupled the building load, heat pump, and ground loop subsystems and which could be applied to residential and commercial office buildings. Then GHP and HGHP performances could be compared in terms of operational performance and life-cycle costs. Several potential SHR devices were analyzed by applying two strategies: 1) to

remove heat directly from the water in the ground loop before it enters the ground and 2) to remove heat in 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. Cooling towers, adsorption coolers, and thermoelectric liquid coolers were included in strategy 1, and expanded desuperheaters, thermosyphons, and an optimized VCC were included in strategy 2. Of all SHR devices analyzed, only the cooling tower provided a cost-effective performance enhancement. For the integrated GHP model, the project team selected the building load model HAMBASE and its powerful computational Simulink/MatLab platform, empirical performance map models of the heat pumps based upon manufacturers' performance data, and a ground loop model developed by Oklahoma State University and rewritten for this project in Simulink/MatLab. The design process used GLHEPRO, also from Oklahoma State University, to size the borehole fields. The building load and ground loop models were compared with simulations from eQuest, ASHRAE 140-2008 standards, EnergyPlus, and GLHEPRO and were found to predict those subsystems' performance well. The integrated GHP model was applied to a 195m² (2100ft²) residential building and a 4,982m² (53,628ft²) three-story commercial office building, and it ran 10-15 year simulations. The integrated GHP model and its Simulink platform provided residential data, ranging from seconds to years, and commercial office building data, ranging from minutes to years. A cooling tower model was coupled to the base case integrated GHP model for the residential building and the resulting HGHP system provided a cost-effective solution for the Austin, TX location. Simulations for both the residential and commercial building models were run with varying degrees of SHR (device/system not identified) and the results were found to significantly decrease installation costs, increase heat pump efficiency (lower entering water temperature), and prolong the lifetime of the borehole field. Lifetime cycle costs were estimated from the simulation results. Sensitivity studies on system operating performance and lifetime costs were performed on design parameters, such as construction materials, borehole length, borehole configuration and spacing, grout conductivity, and effects of SHR. While some of the results are intuitive, these studies provided quantitative estimates of improved

performance and cost. One of the most important results of this sensitivity study is that overall system performance is very sensitive to these design parameters and that modeling and simulation are essential tools to design cost-effective systems.

Stay Warm, Keep Cool and Save Money with Geothermal Heating & Cooling

Residential Ground Source Heat Pumps with Integrated Domestic Hot Water Generation

Design and Installation of Ground Source Heat Pump Systems for Commercial and Residential Buildings

Performance and Economic Modeling of Horizontally Drilled Ground-source Heat Pumps in Select California Climates

Field Test of High Efficiency Residential Buildings with Ground-source and Air-source Heat Pump Systems

Final Project Report

Due to rising interests of utilizing energy more efficiently, new ways of maximizing the efficiency in heating and cooling systems are being explored. Although natural gas furnaces and central air conditioners are the most common heating and cooling systems used, geothermal heat pumps are also being used more. There are also two new technologies that use solar energy as the primary source of energy to power these heating and cooling systems. One system is an absorption air conditioner unit that uses direct solar heating, and the other is called a thermally driven heat pump. There are several computer programs that simulate the two common systems; however, there are no known programs that calculate the energy and cost during operation for the systems that use solar energy.

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.

Service life modeling was performed to gage 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 (PHTP) 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 PHTP, 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 ($[\Delta T]$). In mild climates with small $[\Delta T]$, 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 PHTP 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

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ground-source systems in order to bring down installed costs as the technology matures.

Ground Source Heat Pump Residential and Light Commercial Design and Installation Guide

Solar and Heat Pump Systems for Residential Buildings

Air-source Versus Ground-source

Summary of Measured Performance of Ten Residential Ground Source Heat Pump Systems

Using Emerging Ground Coupling Technologies

Ground Source Heating and Cooling

Geothermal Heating and Cooling

Heating and Cooling with Ground-Source Heat Pumps in Cold and Moderate

Climates: Design Principles, Potential Applications and Case Studies focuses on

applications and cases studies of ground-source heat pumps in moderate and cold

climates. It details technical aspects (such as materials, thermal fluid carriers and

pumping, and drilling/trenching technologies), as well as the most common and

uncommon application fields for basic system configurations. The principles of

system integrations and applications in moderate and cold climates (such as hybrid

solar-assisted, thermo-syphon, foundation, mines, snow melting, district heating

cooling ground-source heat pump systems, etc.) are also presented, each followed

by case studies. Based on the author's more than 30 years of technical experience

Discusses ground-source heat pump technologies that can be successfully applied in

moderate and cold climates Presents several case studies, including successful

energy results, as well as the main lessons learned This work is aimed at design

HVAC systems, as well as geological, mechanical, and chemical engineers

implementing environmentally-friendly heating and cooling technologies for

buildings.

Advances in Ground-Source Heat Pump Systems relates the latest information on

ground 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

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 indicate 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 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 variation across regions of Ontario - and this is based on weather, soil conditions, and level of energy use - the overall conclusion is a compelling case for GSHPs as a viable alternative to the use of natural gas.

Supplemental Heat Rejection in Ground Source Heat Pumps for Residential Houses in Texas and Other Semi-arid Regions

Project Negatherm for Ground Source Heat Pumps : Improving the Geothermal Borehole Drilling Environment in California

Fundamentals and Basic Concepts

Advances in Geothermal Energy

Geothermal HVAC

A Guide for Planning and Installing

This project team analyzed supplemental heat rejection/recovery (SHR) devices or systems that could be used in hybrid ground source heat pump (HGHP) systems located in arid or semi-arid regions in southwestern U.S. Identification of effective SHR solutions would enhance the deployment of ground source heat pumps (GHP) in these regions. In a parallel effort, the team developed integrated

GHP models that coupled the building load, heat pump, and ground loop subsystems and which could be applied to residential and commercial office buildings. Then GHP and HGHP performances could be compared in terms of operational performance and life-cycle costs. Several potential SHR devices were analyzed by applying two strategies: 1) to remove heat directly from the water in the ground loop before it enters the ground and 2) to remove heat in 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. Cooling towers, adsorption coolers, and thermoelectric liquid coolers were included in strategy 1, and expanded desuperheaters, thermosyphons, and an optimized VCC were included in strategy 2. Of all SHR devices analyzed, only the cooling tower provided a cost-effective performance enhancement. For the integrated GHP model, the project team selected the building load model HAMBASE and its powerful computational Simulink/MatLab platform, empirical performance map models of the heat pumps based upon manufacturers' performance data, and a ground loop model developed by Oklahoma State University and rewritten for this project in Simulink/MatLab. The design process used GLHEPRO, also from Oklahoma State University, to size the borehole fields. The building load and ground loop models were compared with simulations from eQuest, ASHRAE 140-2008 standards, EnergyPlus, and GLHEPRO and were found to predict those subsystems' performance well. The integrated GHP model was applied to a 195m² (2100ft²) residential building and a 4,982m² (53,628ft²) three-story commercial office building, and it ran 10-15 year simulations. The integrated GHP model and its Simulink platform provided residential data, ranging from seconds to years, and commercial office building data, ranging from minutes to years. A cooling tower model was coupled to the base case integrated GHP model for the residential building and the resulting HGHP system provided a cost-effective solution for the Austin, TX location. Simulations for both the residential and commercial building models were run with varying degrees of SHR (device/system not identified) and the results were found to significantly decrease installation costs, increase heat pump efficiency (lower entering water temperature), and prolong the lifetime of the borehole field. Lifetime cycle costs were estimated from the simulation results. Sensitivity studies on system operating performance and lifetime costs were performed on design parameters, such as construction materials, borehole length, borehole configuration and spacing, grout conductivity, and effects of SHR. While some of the results are intuitive, these studies provided quantitative estimates of improved performance and cost. One of the most important results of this sensitivity study is that overall system performance is very sensitive to these design parameters and that modeling and simulation are essential tools to design cost-effective systems. 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.

"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"--

Design of Ground-Source Heat Pump Systems

Performance Results from Long-term Monitoring

Design of Geothermal Systems for Commercial and Institutional Buildings

Residential Ground Source Heat Pumps with Integrated Domestic Hot Water Generation :

Ground Source Heat Pumps

An Efficient Choice for Residential and Commercial Use

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.

NEW EXPANDED EDITION with color illustrations and spacious 8.5 x 8.5 format adds detailed descriptions of the components of the heat pump, open loops systems and important decisions that the homeowner must make. Interest in residential geothermal systems has grown as more people realize they can replace their fossil-fuel heating system with one that is three to five times more efficient and doesn't require a chimney to exhaust noxious fumes. Currently in the USA there is a federal 30% tax credit that applies to the total installation cost. These newer, safer systems provide heating as well as cooling simply by transferring heat between the home and the ground or a nearby body

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of water. Since this is a relatively new technology, the number of experienced installers is limited, but growing. Therefore, there is a burden on homeowners interested in installing one of these systems to absorb as much information about residential geothermal systems as possible. This book was written specifically to meet that need as well as to help HVAC professionals who are new to residential geothermal systems. Readers will learn how heat pumps are able to extract heat from relatively low temperature water circulating in ground loops and raise it to a temperature high enough to heat a home. They will also learn how to estimate the size of the heat pump required and the ground loop size as well for straight 2-pipe, 4-pipe, 6-pipe and Slinky loop configurations. This is important in order to verify that the installer correctly sizes the system. An incorrectly sized system will result in an unhappy homeowner. Both horizontal and vertical loop systems, for GX and DX, are covered. Some of the technical issues that are addressed include: Loop water flow rates and Reynolds Number, heat of extraction/rejection, heating capacity, desuperheater setup, open-loop/closed-loop, SCW, pond loops, DX, Manual-J, COP. The final chapter consists of a set of flowcharts guiding the homeowner to ask the pertinent questions needed for a successful installation. Geothermal energy means the natural heat energy from the Earth. The geothermal resources of the Earth are huge and unlike other conventional and renewable energy sources, geothermal energy has unique features; namely, it is available, stable at all times throughout the year, independent of weather conditions, and has an inherent storage capability. Geothermal energy is also considered to be an environmentally friendly clean energy source that could significantly contribute to the reduction of GHG emissions. The utilization of geothermal energy is usually divided into the part used for electricity generation and the part used for heating applications. Due to its important utilization and future prospects, various interesting topics of research related to geothermal energy are covered in this book. This book is the result of contributions from several researchers and experts worldwide. It is hoped that the book will become a useful source of information and basis for extended research for researchers, academics, policy makers, and practitioners in the area of geothermal energy.

Geo Power

Technical and Economic Assessment of Ground Source Heat Pump Systems (GSHPs) in Ontario

Analysis and Tools to Spur Increased Deployment of ?Waste Heat? Rejection/Recycling Hybrid Ground-source Heat Pump Systems in Hot, Arid Or Semiarid Climates Like Texas

Effective Energy Flows Climate Management

Residential Ground Source Heat Pump Design Guide

Heating and Cooling with Ground-Source Heat Pumps in Cold and Moderate Climates: Fundamentals and Basic Concepts covers fundamentals and design principles of vertical and horizontal indirect and direct expansion closed-loop, as well as ground and

surface-water ground-source heat pump systems. It explains the thermodynamic aspects of mechanical and thermochemical compression cycles of geothermal heat pumps, and describes the energetic, economic, and environmental aspects associated with the use of ground-source heat pump systems for heating and cooling residential and commercial/institutional buildings in moderate and cold climates. Based on the author's more than 30 years of technical experience Focuses on ground-source heat pump technologies that can be successfully applied in moderate and cold climates Discusses technical aspects as well as the most common and uncommon application fields of basic system configurations This work is aimed at designers of HVAC systems, as well as geological, mechanical, and chemical engineers implementing environmentally-friendly heating and cooling technologies for buildings.

Heating and Cooling with Ground-Source Heat Pumps in Moderate and Cold Climates, Two-Volume Set focuses on the use of very low-temperature geothermal energy for heating and cooling residential, institutional, and industrial buildings, and aims to increase the design community's awareness and knowledge of the benefits, design, and installation requirements of commercial/institutional building ground-source heat pumps (GSHP). This set helps readers assess applicability, select a GSHP system type, and estimate building thermal load to ensure proper size for ground-source subsystems, appropriate brine and groundwater flow rates, and apt design of building closed-loops with distributed or central geothermal heat pumps. The first volume addresses fundamentals and design principles of vertical and horizontal indirect and direct expansion closed-loop, as well as ground- and surface-water ground-source heat pump systems. It explains the thermodynamic aspects of mechanical and thermochemical compression cycles of geothermal heat pumps, as well as the energetic, economic, and environmental aspects associated with the use of ground-source heat pump systems for heating and cooling residential and commercial/institutional buildings in moderate and cold climates. The second volume focuses on applications and cases studies of ground-source heat pumps in moderate and cold climates. It details technical aspects, as well as the most common and uncommon application fields of basic system configurations. The principles of system integrations and applications in moderate and cold climates are also presented, each followed by case studies. This comprehensive work is aimed at designers of HVAC systems, as well as geological, mechanical, and chemical engineers implementing environmentally-friendly heating and cooling technologies for buildings.

Residential Ground Source Heat Pump Design Guide For Designing Systems in Heating Dominated Climates
Geothermal Heating and Cooling
Design of Ground-Source Heat Pump Systems
Investigation of Optimal Heating and Cooling System in Residential Buildings

Renewable Geothermal Energy Explorations

The Economics of Heat Pump Systems

An Introduction to Thermogeology

Analysis & Tools to Spur Increased Deployment of "Waste Heat" Rejection/Recycling Hybrid Ground-source Heat Pump Systems in Hot, Arid Or Semiarid Climates Like Texas

Solar Assisted Ground Source Heat Pump Solutions

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 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.

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.

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 GSHP-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.

Feasibility Analysis of Implementing Ground Source Heat Pump Systems for Commercial and Residential Buildings in the United States

Design Principles, Potential Applications and Case Studies

Benefits, Drivers and Barriers in Residential Developments

Development of a Residential Ground-Source Integrated Heat Pump

Heating and Cooling with Ground-Source Heat Pumps in Moderate and Cold Climates, Two-Volume Set

Ground Source Heat Pump Systems