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

This book focuses on recent trends in the areas of green and renewable energy, especially as applied to the carbon footprint of energy production, transmission, and use. Discussing the latest developments and advances in the materials and processes involved in energy generation, transmission, distribution and storage, with a particular focus on the management and policies related to these systems, it is a valuable resource for researchers, practitioners, and policy makers working in these areas.

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.

Proceedings of the 8th International Symposium on Heating, Ventilation and Air Conditioning is based on the 8th International Symposium of the same name (ISHVAC2013), which took place in Xi'an on October 19-21, 2013. The conference series was initiated at Tsinghua University in 1991 and has since become the premier international HVAC conference initiated in China, playing a significant part in the development of HVAC and indoor environmental research and industry around the world. This international conference provided an exclusive opportunity for policy-makers, designers, researchers, engineers and managers to share their experience. Considering the recent attention on building energy consumption and indoor environments, ISHVAC2013 provided a global platform for discussing recent research on and developments in different aspects of HVAC systems and components, with a focus on building energy consumption, energy efficiency and indoor environments. These categories span a broad range of topics, and the proceedings provide readers with a good general overview of recent advances in different aspects of HVAC systems and related research. As such, they offer a unique resource for further research and a valuable source of information for those interested in the subject. The proceedings are intended for researchers, engineers and graduate students in the fields of Heating, Ventilation and Air Conditioning (HVAC), indoor environments, energy systems, and building information and management. Angui Li works at Xi'an University of Architecture and Technology, Yingxin Zhu works at Tsinghua University and Yuguo Li works at The University of Hong Kong.

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.

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 utillize 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.

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.

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.

"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. This book 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."--Back cover.

This multi-disciplinary volume presents information on the state-of-the-art in sustainable energy technologies key to tackling the world’s energy challenges and achieving environmentally benign solutions. Its unique amalgamation of the latest technical information, research findings and examples of successfully applied new developments in the area of sustainable energy will be of keen interest to engineers, students, practitioners, scientists and researchers working with sustainable energy technologies. Problem statements, projections, new concepts, models, experiments, measurements and simulations from not only engineering and science, but disciplines as diverse as ecology, education, economics and information technology are included, in order to create a truly holistic vision of the sustainable energy field. The contributions feature coverage of topics including solar and wind energy, biomass and biofuels, waste-to-energy, renewable fuels, geothermal and hydrogen power, efficiency gains in fossil fuels and energy storage technologies including batteries and fuel cells.

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 report presents the measured performance of four advanced residential ground-source heat pump (GSHP) systems. The GSHP systems were developed by WaterFurnace International to minimize the need for electric resistance backup heating and featured multiple speed compressors, supplemental water heating, and at most sites, multiple-speed fans. Detailed data collected for a complete year starting in June 1994 shows that the advanced design is capable of maintaining comfort without the use of electric resistance backup heating. In comparison with a conventional air-source heat pump, the advanced-design GSHP reduced peak heating demand by more than 12 kilowatts (kW) per residence and provided energy savings. The report describes the cooling and heating season operation of the systems, including estimated seasonal efficiency, hours of operation, and load profiles for average days and peak days. The electrical energy input, cooling output, and efficiency are presented as a function of return air temperature and ground loop temperature.

"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"--

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.
During the 1960s and 1970s, electric baseboard heating systems were a common space heating approach in multi-unit residential buildings due to low installation costs, minimal use of interior space and the relatively low price of electricity. As a result, approximately 50% of apartment buildings in Canada have electric baseboard heating. However, rapidly increasing costs of electricity, concerns over environmental damage associated with conventional generating stations and the very age of most electric baseboards in apartment buildings will necessitate the development of alternative space heating strategies. This is a report of research to investigate the technical potential and economic benefits of retrofitting electrically heated apartment buildings with ground-source heat pumps. The report presents results of a literature and web search and review of available components and equipment suitable for the application, and analyses the most promising combination using an example building complex in the Greater Toronto area. Both the cases of no benefit and full benefit for central air conditioning are considered. Comparisons are drawn with retrofitting natural gas heating systems under the same circumstances. Conclusions and recommendations for new component development are identified and the economic results are as attractive under some circumstances as natural gas heating system retrofits.
AEO 2009. The Annual Energy Outlook 2009 presents projections and analysis of US energy supply, demand, and prices through 2030. The projections are based on results from the Energy Information Administration's National Energy Modeling System. The AEO2009 includes the reference case, additional cases examining energy markets, and complete documentation.
Ground source heat pumps (GSHPs) offer an efficient method for cooling and heating buildings, reducing energy usage and operating cost. In hot, arid regions such as Texas and the southwest United States, building load imbalance towards cooling causes design and performance challenges to GSHP systems in residential and commercial building applications. An integrated building load and GSHP model is developed in this thesis to test approaches to reduce GSHP cost, to properly size ground heat exchanger (GHEX) installations and to offer methods to improve GSHP performance in commercial buildings. The integrated model is comprised of a three-story office building, heat pumps, air handling system and a GHEX. These component models were integrated in the Matlab® Simulink® modeling environment, which allows for easy model modification and expansion. The building-load model was developed in HAMBASE, which simulates the thermal and hygric response of each zone in the building to external weather and internal loads. The building-load model was validated using the ASHRAE 140-2007 Standard Method of Test and with results from EnergyPlus. The heat pump model was developed as a performance map, based on data commonly provided by heat pump manufacturers. This approach allows for easy expansion of the number and type of heat pump models supported. The GHEX model was developed at Oklahoma State University and is based on Eskilson's g-function model of vertical borehole operation. The GHEX model accurately represents the interaction between boreholes and the ground temperature response over short and long time-intervals. The GHEX model uses GLHEPRO files for parameter inputs. Long time-interval simulations of the integrated model are provided to assess the sensitivity of the GSHP system to various model parameters. These studies show that: small changes in the total GHEX length reduce system cost with minimal impact on performance; increased borehole spacing improves system performance with no

additional cost; supplemental heat rejection reduces installation costs and improves system performance; industry-recommended design cutoff temperatures properly size the GHEX system; and, while cooling is the greatest contributor to operating cost in the southwest and southcentral United States, heating is the limiting design case for GHEX sizing.

With the increased interest in climate impacts, sustainability, and efficiency, more responsibility is being placed on boiler operators to help improve performance and reduce emissions. This third edition of the Boiler Operator’s Handbook is intended to help such operators in the quest for improved operability and performance of their boilers and their plants. The theme of this book is to "operate wisely". The goal is to instill not only "know how" but "know why". The main details have been provided by the original author, Mr. Ken Heselton. This updated version has been somewhat expanded to include a wider range of examples and some of the more recent environmental requirements. To illustrate these points, topics include multi boiler operations, understanding the plant load, maintenance issues, and controls. Every plant is different. However, it is hoped that with the information provided in this book, the wise operator will be able to address the various unique issues posed by the specific plant and provide timely solutions to meet the present-day requirements.

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.

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.

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 volume presents challenges in transportation infrastructures and geotechniques, advancements in recycling, soil stabilization and reinforcement technologies, and assessments of roadway conditions using modern tools and techniques. The articles presented in this volume focus on fundamental investigations on various aspects of civil engineering materials and structures. The scope of this volume is the application of findings for solving problems in geotechnical, pavement, concrete and transportation engineering using through smart, green and emerging techniques. The primary audience of this work will be researchers, professionals, and practitioners around the world. This volume is based on contributions to the 6th GeoChina International Conference on Civil & Transportation Infrastructures: From Engineering to Smart & Green Life Cycle Solutions -- Nanchang, China, 2021.

This twelve-month field study analyzes the performance of a 7.56W (2.16- ton) water-to-air-ground source heat pump (WA-GSHP) to satisfy domestic space conditioning loads in a 253 m2 house in a mixed-humid climate in the United States. The practical feasibility of using the ground as a source of renewable energy is clearly demonstrated. Better than 75% of the energy needed for space heating was extracted from the ground. The average monthly electricity consumption for space conditioning was only 40 kWh at summer and winter thermostat set points of 24.4°C and 21.7°C, respectively. The WA-GSHP shared the same 94.5 m vertical bore ground loop with a separate water-to-water ground-source heat pump (WW-GSHP) for meeting domestic hot water needs in the same house. Sources of systemic irreversibility, the main cause of lost work are identified using Exergy and energy analysis. Quantifying the sources of Exergy and energy losses is essential for further systemic improvements. The research findings suggest that the WA-GSHPs are a practical and viable technology to reduce primary energy consumption and greenhouse gas emissions under the IECC 2012 Standard, as well as the European Union (EU) 2020 targets of using renewable energy resources.

Residential Ground Source Heat Pump Design GuideFor Designing Systems in Heating Dominated ClimatesGeothermal Heating and CoolingDesign of Ground-Source Heat Pump Systems

Household appliances encompass a large variety of equipment including the cold appliances (refrigerators and freezers), the wet appliances (washing machines, dishwashers and dryers), the space conditioning appliances (heaters, air conditioners, heat pumps, fans, boilers), the water heaters, the cooking appliances, a wide array of consumer electronics (such as TVs, VCRs, HiFi systems) and miscellaneous small appliances (such as vacuum cleaners, irons,

toasters, hairdryers and power tools). Household appliances save a large amount of domestic labour to perform the household tasks, as well as provide comfort conditions and convenience to the household occupants. The European Community SAVE Programme has promoted the efficient use of energy, in particular in domestic appliances. SAVE has sponsored a variety of studies to characterise the use of the main household appliances and lighting and to identify cost-effective technical options to improve the energy efficiency, as well as to identify the strategies to promote the penetration ofefficient equipment in the market place. National energy agencies, independent experts and appliance manufacturers have participated in the SAVE activities and have done a remarkable job. While the energy efficiency ofthe main household appliances has been improved, at the same time it was possible in most cases to improve the appliance performance, reliability and qualityofservice.

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