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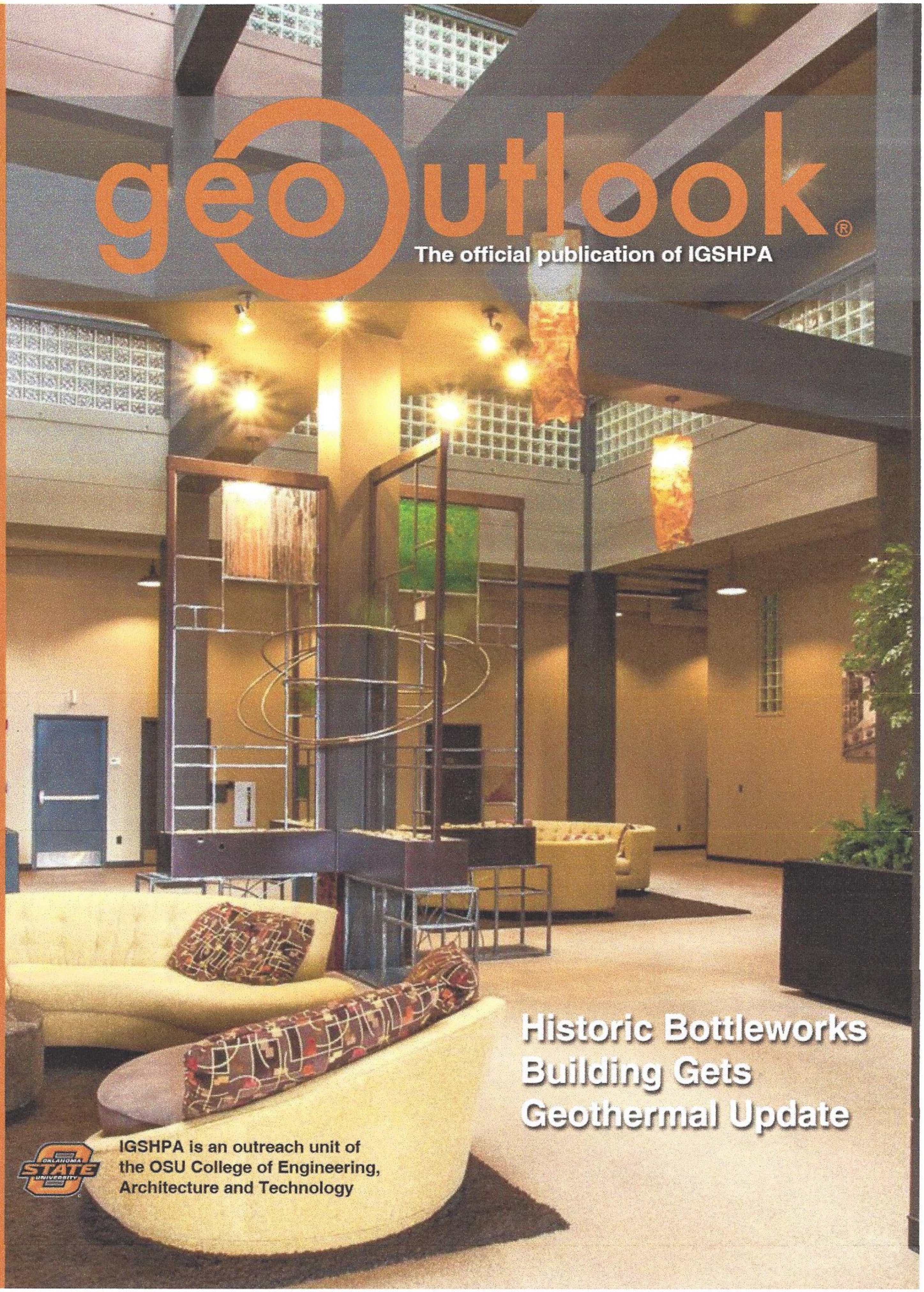


Historic Bottleworks Building Gets Geothermal Update

IGSHPA is an outreach unit of the OSU College of Engineering, Architecture and Technology

Geothermal Summit Connects Industry Leaders and Experts

Summit sparks discussion of geothermal benefits

On May 15, 2017, the first Clemson University Geothermal Summit was held at the new Watt Family Innovation Center on Clemson University Campus. More than 100 attendees from all disciplines, including architects, engineers, manufacturers, installers, drillers, policy-makers, professors and students, gathered to listen to speakers from Canada, Germany and the United States.

Professor Kate Schwennsen, director of the Clemson University School of Architecture and former AIA president, welcomed the attendees and pointed out that architects, engineers, and other decision-makers have the responsibility to learn the benefits of geothermal technology in order to take full advantage of its long-term financial benefits, thermal comfort, reliability, and sustainability.

Former International Ground Source Heat Pump Association (IGSHPA) Board of Directors president, John Turley, spoke on the importance of educating the general public and, more specifically, on the role of education, communication and active participation of all parties involved in the geothermal industry. Ed Lorenz, former chair of the IGSHPA Training Committee, warned about the dangers of using rules of thumb when comparing geothermal systems with other heating and cooling alternatives and emphasized the role and responsibility of design engineers. Among other speakers, Jack Dienna, long-term national and international advocate for geothermal initiatives, discussed the opportunity of geothermal systems in curbing the societal energy demand and highlighted the increasing involvement of utility companies and co-operatives in developing and maintaining geothermal fields for residential and commercial applications.

The presenting sponsor, Waterfurnace, made the summit possible with its generous contributions. Bret Ross, director of dealer sales and the Waterfurnace keynote speaker, discussed how the geothermal industry should no longer focus on tax credits but should concentrate on innovation and progress to make the geothermal industry more competitive. He also highlighted the fact that the geothermal industry is currently one of the fastest growing activity sectors and employers in South Carolina thanks to the many advantages that geothermal heat pumps provide.

The Clemson University School of Architecture and the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) chapter of Greenville, South Carolina, co-hosted the summit. Vincent Blouin, associate professor of Architecture and Engineering at Clemson University, and Kater Heine, sales director of geoKOAX, anticipated the Geothermal Summit with hopes of spreading the benefits of geothermal technology to the widest audience possible. Graduate Assistant, Rebecca Wilson, who studied architecture at Clemson University, was added to the team to help with the organization, branding and logistics of the conference.

With the success of the Clemson University Geothermal Summit, it is clear that there is a strong demand for continued discussion in the Southeast region of the United States in promoting the geothermal industry. With more regional conferences and trade-shows focused on bringing innovative products such as the new geoKOAX® heat exchanger to market, the geothermal industry can play a more important role in the economic growth of the Southeast as well as stopping climate change. As Professor Schwennsen stressed the importance of the interdisciplinary approach in the School of Architecture's educational program, it is also important for the geothermal industry to work together from all angles to benefit the economy and the environment.

The summit was partially sponsored by the South Carolina Energy Office, whose indispensable support is sincerely acknowledged by all.

18 INDUSTRY INSIGHTS

Breaking Barriers for GSHP Systems in the HVAC Market

Part one: Overcoming high first costs

By: Mark Metzner

INTRODUCTION

Practitioners in the ground source heat pump (GSHP) industry are keenly aware of the benefits of GeoExchange technology for building space conditioning. Still, the GSHP industry only comprises a small fraction of the conventional heating, ventilation and air conditioning (HVAC) market, between 0.75 and 2.0 percent. Why?

A number of reasons are in play, such as little to no use of 8760 hour energy modeling as a design tool, poor design practices via a lack of understanding of how GSHP systems function, questionable on-site installation practices with absent oversight processes, lack of accountability and responsibility for overall system performance once projects are completed, lack of commissioning and inexperienced operation.

However, high first cost is the most frequently cited reason that a GSHP system is not chosen over other HVAC options.

To overcome high first costs, there are a number of design and installation options that should be taken into consideration.

The majority of commercial GSHP installations rely upon vertical boreholes with a plastic pipe ground heat exchanger (GHEX) inserted. There are other configurations for closed heat exchangers, such as horizontal, submerged and standing column systems, as well as open systems such as drilled wells and direct extraction from bodies of water.

These other system configurations work very well when certain site-specific resources are available such as large land areas for horizontal systems, a nearby and adequately sized body of water for submerged systems or open direct use systems, competent bedrock for standing column wells and productive aquifers with good quality ground water for drilled open systems.

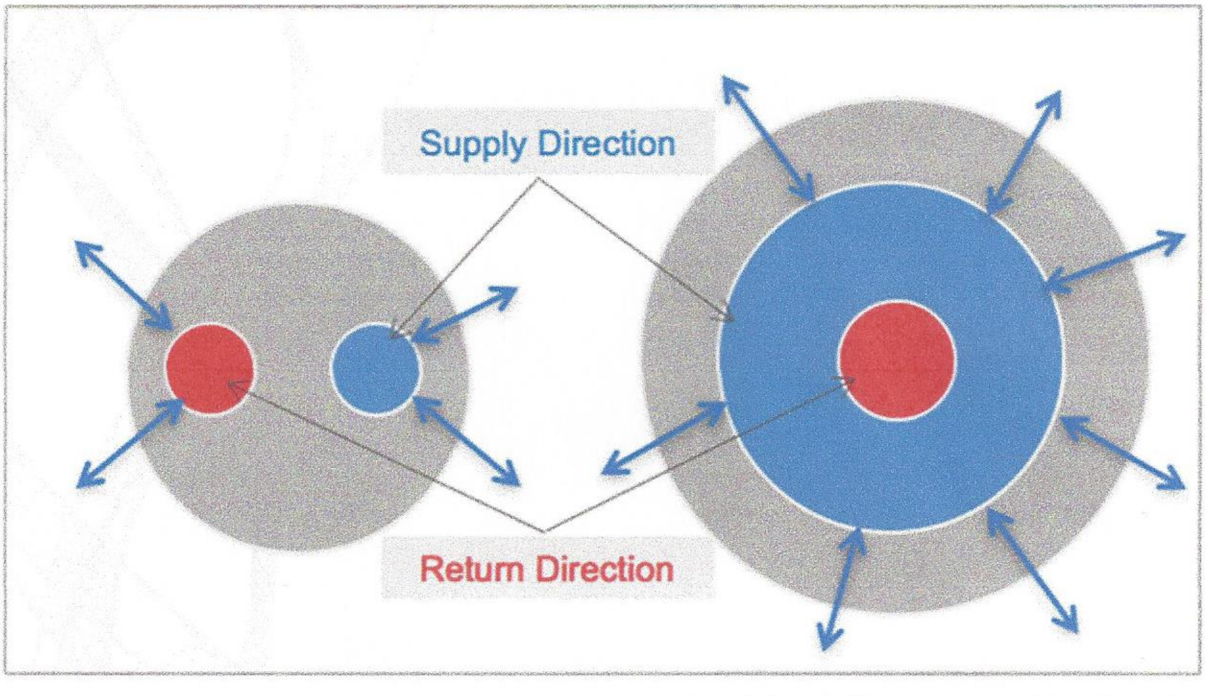


Figure 1: Double U-bend versus coaxial configuration.

Heat Exchanger Fluid Volume

	Coaxial 5.00"	Single 1.25" U-tube	Single 1.00" U-tube	Single 0.75" U-tube
Volume / meter (liters)	12.90	1.87	1.17	0.75
Volume / foot (gallons)	3.41	0.49	0.31	0.20
Percentage of volume vs. Coaxial	100%	14%	9%	6%

Figure 2: Table compares U-bend and coaxial configurations on exchanger fluid volume, which influences the ability of GSHP systems to handle peak loads.

VERTICAL BOREHOLE GROUND HEAT EXCHANGERS

Vertical borehole GSHP systems have had virtually no change in decades with respect to the inserted plastic pipe heat exchanger.

The only variance the industry has seen in single U-bend applications, on a commercial basis, is a difference in the diameter of the pipe employed (0.75 inch, 1.00 inch, 1.25 inch and in some cases 1.50 inch and 2.00 inch). Double U-bends have been used widely in Europe, and to a limited degree in North America. The rationale in Europe is to insert as much ground heat exchanger into a borehole as possible to exploit energy transfer to and from the earth.

The expensive component of this method is the drilling procedure, so these installations use relatively less expensive plastic pipe. For the most part, North America has not embraced this approach. In the mean time, a relatively new ground heat exchanger design is taking hold in Europe: Coaxial assemblies.

This is basically a pipe within a pipe an example of which can be seen in Figure 1. Coaxial assemblies are outpacing conventional double U-bend installations throughout the European Union.

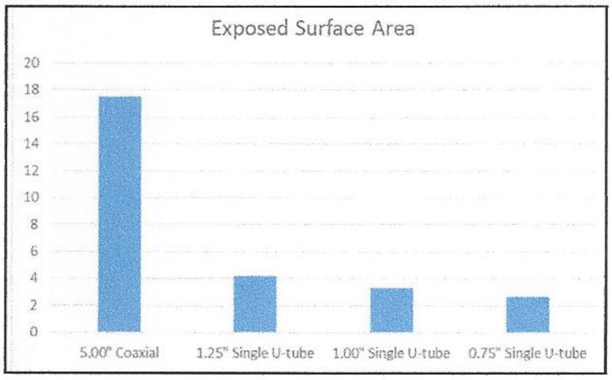
SURFACE AREA

One of the fundamental issues in installing GSHPs is the pipe surface area exposed to the surrounding geology where energy transfer takes place.

In comparison to 0.75 inch single U-bends, the 5.00 inch coaxial has more than 6.6 times the exposed surface area. Compared to 1.00 inch single U-bends, the 5.00 inch coaxial has more than 5.3 times the exposed surface area. Compared to 1.25 inch single U-bends, the 5.00 inch coaxial has more than 4.2 times the exposed surface area.

GROUND SOURCE HEAT EXCHANGER FLUID VOLUME

Another item in cost considerations is the heat exchange fluid volume contained within the ground heat exchanger and the ability of the system to respond to instantaneous building demands. The graphs in figures 3 and 4 compare a 5.00 inch diameter coaxial design to single U-bend designs with 1.25 inch, 1.00 inch and 0.75 inch configurations.



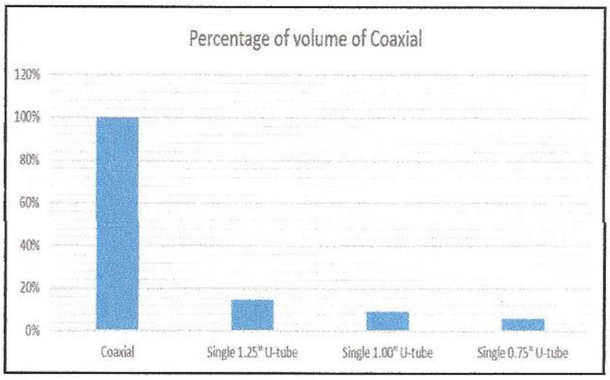


Figure 3 (Top): Compares U-bend and coaxial assembly surface areas. Figure 4 (Bottom): Shows U-bend and coaxial assemblies' exchanger fluid volume.

BOREHOLE THERMAL RESISTANCE

To determine the required length of vertical ground heat exchangers, one of the parameters considered is the borehole thermal resistance[1], which is the ability of the GHEX to resist heat transfer. Selecting appropriate materials and configurations to reduce the borehole thermal resistance can help decrease overall borehole length.

To reduce the borehole thermal resistance of GHEXs comprised of one or more U-bends, innovations such as space clips for separating U-bends in the borehole and thermally enhanced grout[2] have been developed. These advancements have been met with varying degrees of acceptance. Further work has recently been conducted on coaxial GHEXs, where the exchanger consists of two pipes imbricated into each other.

The impact of the flow rate and the pipe diameter and thermal conductivity on the heat transfer rate was investigated with numerical simulations.[3]

Detailed experiments have been performed to evaluate the borehole thermal resistance of different coaxial GHEX configurations, where the external flow channel was made of several small pipes[4] or a flexible liner molded to the borehole wall, avoiding the use of backfill material.[5]

An analytical solution was also developed to estimate the vertical temperature distribution in the ascending and descending pipe of a coaxial GHEX to improve the analysis of thermal response tests.[6]

While previous research has shown potential advantages to using coaxial GHEXs, further investigation has been undertaken to substantiate the possible bore length reduction associated with coaxial configurations.[7]

When compared to the more commonly used single or double U-pipes, coaxial GHEXs can contain a larger amount of water, allowing greater heat storage to buffer building peak loads. Thermally enhanced pipes made of carbon nanoparticles and high-density polyethylene can further reduce the borehole thermal resistance of coaxial GHEXs.[8]

HEAD LOSS AND TURBULENT FLOW

Head loss is a major issue with ground heat exchanger systems because it must be overcome with pumping power.

By reducing head loss, the overall operating costs of the whole system can be reduced. In general, many different borehole heat exchangers (BHEs) are used in these systems; these BHEs are connected to the central heat pump via pipes, pipe fittings, distribution manifolds and valves.

Head losses rely strongly on flow velocity and are a result of wall friction or dissipation induced by these fittings, valves or other mechanical parts within the fluid flow. The BHE is only responsible for part of the system's head losses, but a crucial part in regard to pressure drop associated with its length.

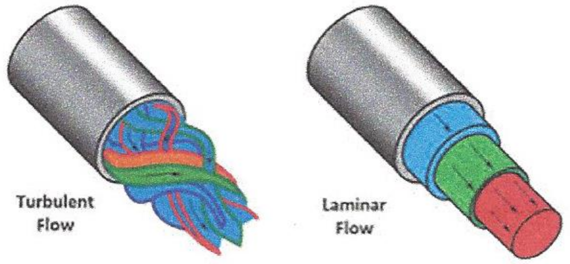


Figure 5: Illustrates how heat is transfered in both turbulent and laminar flows.

In U-bend applications, the heat exchange fluid must be forced through pipes with the doubled length of the borehole, while in coaxial ground heat exchangers with a 5-inch outer diameter and a 1.25-inch inner pipe, the head loss over the downflowing section (annulus) is significantly lower. Smaller pipe diameters increase the head loss exponentially, making large coaxial BHEs more beneficial than single U-bends with 1.00 or 0.75 inch pipes from the standpoint of pumping costs.

Another important aspect of efficient cost-saving GSHP design relates to the heat transfer capabilities of the BHE. Heat transfer between a liquid in motion and a solid surface, such as the pipe's inner wall in a geothermal system, is greater when the fluid flow is turbulent as opposed to laminar, as shown in Figure 5.

The fluid flow begins transitioning from laminar to turbulent when the Reynolds number is greater than 2500. The Reynolds number depends on the fluid velocity. Turbulence inside a U-bend pipe is usually achieved with higher fluid flow rates.

This may translate into the need for larger circulation pumps to pass the fluid through the pipes at high velocity, and as a result larger amounts of electrical energy.

A further advance in coaxial ground heat exchangers has seen the introduction of the vortex turbulator. The vortex turbulator mechanically and passively induces turbulent flow. Turbulence is created as the fluid passes through helical vanes that are affixed to the inner return pipe approximately every 5 feet (1.5 m) over the entire length of each coaxial ground heat exchanger assembly.

The vortex turbulators create turbulence without significantly increasing flow resistance.[9] As a result, the energy transfer to and from the coaxial heat exchanger is maximized with little increase in required pumping power, significantly reducing ongoing operational costs.

THE COAXIAL ADVANTAGE

The above factors, greater surface area, increased fluid volume, low pumping head loss and passively induced turbulent flow, all combine for a substantial reduction in required vertical footage to support building loads. The reduction in footage can be between 30 and 50 percent depending on ground conductivity, deep earth temperature and type of geology.

There is usually an increase in drilling cost per foot for a larger diameter borehole to accommodate the 5.00-inch coaxial heat exchanger and tremie line as well as an increased cost in the piping material, however, overall installation costs are reduced 25 to 30 percent.

Coaxial ground heat exchangers are a significant advancement in addressing real reduction in high first costs and will prove to be a disruptive force in the ground source heat pump industry.

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Mark Metzner has over a decade and a half of experience in the successful installation of GeoExchange systems. Mark has raised the standards of ground loop installations in Canada and the United States by Chairing the ANSI / CSA C448 Bi – National Standard. Mark has the unique ability to effectively communicate and achieve goals from the construction site through to the C - Suite. Mark has provided GeoExchange expertise to various clients and has been responsible for all aspects of commercial GeoExchange installations – Project Management, Vertical Borehole Drilling, Lateral Tie-in, Commissioning and Setting Geothermal Utility Rates.