A Geothermal Solution to Urban Blight in Detroit
MAKING

GEO-EXCHANGE

AS SIMPLE AS IT GETS

SMART, SIMPLE, PROVEN!
Made in America by Americans
theslimjim.com | 888.277.2932
CONTENTS

DEPARTMENTS
4 Geo Outlook Staff
6 IGSHPA Updates
8 Association Updates
18 IGSHPA Chapter Updates
42 Earth Insights

INDUSTRY INSIGHTS
10 Let's Play! The Thermal Conductivity Testing Game
   By Dan Bernstein
14 A Geothermal Solution to Urban Blight in Detroit
   By IGSHPA Staff Writer
20 Energy Piles: Construction, Design, and Outlook
   By Dr. Fleur Loveridge
26 International Geothermal Conference a Success!
   By Erin Portman
28 A Diamond in the Rough
   By Kevin Christensen
32 To Setback or not to Setback....
   By Ed Lohrenz and Ian Lohrenz
38 Utility Market Opportunities
   By David Thomison

Direct-exchange geothermal on the map in downtown Detroit

GSHP and drilling conference in Sweden draws a crowd
Assistant Dean of Outreach & Extension  
Ed Kirtley

Acting Executive Director - IGSHPA  
Roshan Revankar

Communications Specialist - IGSHPA  
Erin Portman  
erin@igshpa.org

Intern - IGSHPA Communications Department  
Drew Slattery

Advertising  
1-800-626-4747

Geo Outlook magazine reaches thousands of industry professionals each quarter, including installers, drillers, trainers, manufacturers and engineers. Advertise with us to get your products and/or services the exposure they need in the HVAC community.

Full page | 8” x 10.5”  
$1,540 1-3x $1,465 4x

Half Page | 6.25” x 4.25”  
$940 1-3x $895 4x

Quarter Page | 3” x 4.25”  
$615 1-3x $585 4x

Video Ad | Video inside Your Ad  
$150

For more information, or to download our media kit please visit:  
http://www.igshpa.okstate.edu/publication/ad_opportunity.htm

Geo Outlook is published quarterly by Oklahoma State University and the International Ground Source Heat Pump Association (IGSHPA), 1201 S. Innovation Way, Suite 400, Stillwater, OK 74074. Send questions, story ideas, photos and comments to igshpa@okstate.edu, Geo Outlook, c/o IGSHPA, or call 800-626-4747. Visit our Web site at www.igshpa.okstate.edu.

Copyright 2013 by the Board of Regents for the Oklahoma State University Agricultural and Mechanical College and IGSHPA all rights reserved.

Articles written by third parties reflect the opinions of the writer and are not necessarily the opinions or views held by IGSHPA or Oklahoma State University (OSU). IGSHPA and OSU make no claims to the accuracy of statements made in such articles.
Extreme Efficiency

The temperature of the earth below a depth of 10 feet remains relatively constant and mild throughout the year, despite extreme fluctuations in the air temperature above ground. While the air may rise to above 100 degrees Fahrenheit or drop to below zero above ground, generally speaking the temperature of the soil below 10 feet will remain between 40 and 60 degrees, depending on location.

The more extreme the air temperature, the harder a traditional air-source heating and cooling system has to work in order to normalize and regulate the indoor building temperature. This means expending massive amounts of energy, often times in the form of polluting fossil fuels, to bring ice-cold winter air up to a comfortable 72 degrees or sweltering summer breezes down to something more refreshing. This is not the case with ground source heat pump (GSHP) systems, which tap into the relative constant temperature of the earth to regulate temperature, rather than burning fossil fuels.

Put simply, the more extreme the season- the more extreme the performance of a GSHP system, making it the ideal choice.
THANK YOU!

As we wrap up this first year of the new Geo Outlook, all I can say is THANK YOU. Thank you to the board of directors for believing in my staff as we tackled this endeavor to create a new industry magazine, to Roshan Revankar for being our go-to source and area expert for all things geothermal when questions arose, to our contributing writers for imparting knowledge to our membership base, and to our advertisers for their support of the industry magazine.

To our readers, thank you for your comments and suggestions on what you want to see in the magazine. Each of you has helped and continues to help shape the magazine into what it is today.

Thank you to the industry review board that was expanded on this past year. This review panel reviewed all the articles before publication to ensure accuracy of the technology information presented and helped put together a professional publication that meets the needs of the industry. The review board was a big part to our successful first year.

Lastly, thank you to Drew Slattery. Drew has been with IGSHPA as a student intern for the last two years. He has fully grasped the industry and association in a way that is bar none for his brief time here. When we took on this new endeavor, he jumped right in and helped plan, organize, and even fully design the last three issues. Drew will be graduating college in December and he will be thoroughly missed at IGSHPA. We wish him the best of luck in his future.

As we look towards 2017, I can only see greater things for Geo Outlook and the industry as a whole. Keep sending me what you desire to see in the industry publication!

From The Board
By John Turley
Board of Directors President

When I look back on this year at IGSHPA, there has been much progress, and there are many exciting things to look forward to. Sometimes our membership doesn’t see what goes on behind the scenes. I want to mention some of the highlights.

2016 marks the second year of the existence of IGSHPA’s Board, which is elected by our members. As a new Board, we have worked to understand and implement the bylaws that were adopted a few years ago. These bylaws not only spell out how IGSHPA operates, but also guarantee that each member, and each sector, will have a say in their organization. It also insures that our leadership will change and we will have new people and fresh ideas coming onto the Board each year. This January there will be two spots up for election—one from the Dealer/Contractor sector and one from the GHEX (drillers).

This past year the IGSHPA staff worked hand in hand with our seven committees to tackle much needed changes. Our Standards Committee put a lot of effort into creating Section 7 (standards for DX), as well as a total rewrite of Section 3. The Training Committee continued to improve and promote the Inspectors Course, has new shorter courses in the works for both DX and Open Loop Systems, and is finalizing the Residential Design Course. IGSHPA’s Sweden Chapter hosted the first-ever international IGSHPA conference. Our Conference Committee is putting the finishing touches on the next conference that will be held this March in Denver. It will include a research track and many other changes that should make it the best in many years. Membership and Marketing have worked to help design and send out another member survey, to keep our finger on the pulse of what the industry needs. For the first time, IGSHPA published an annual report to its members. These are just a few of the changes that have been made by the Board, Staff and our many volunteers.

As I mentioned earlier, there is much to do in the coming year. By the time this is in your mailbox we may know whether the federal tax credits will be extended. This will undoubtedly influence the near-term needs of our membership. Whichever way it goes, we know that long-term GSHP’s will be one of the key technologies as the world moves toward a lower-carbon future and IGSHPA will have an important role to play. Please continue to support YOUR organization by remaining a member and volunteering on one of our committees.
Together at Last: Our Best Features, Now in Our Most Sustainable System.

ADVANCED COMFORT AND CONTROL

REDUCES ANNUAL HEATING AND COOLING COSTS BY UP TO 70%*

EXPANDED FEATURES = EXPANDED BUSINESS

Introducing Infinity® Geothermal Systems From Carrier.

The Infinity Touch™ control’s convenient and cost-saving features are now paired with an already super-efficient geothermal system. Less grid and more loop mean greater savings. Get in the geothermal loop at carrier.com/geothermal.

carrier.com/geothermal

©Carrier Corporation 9/2015. A unit of United Technologies Corporation. Stock symbol UTX.
*Savings calculated using Carrier® LoopLink software. Comparison based on simulation in Dallas, TX. Carrier 6-ton unit vs. standing pilot propane furnace, standard air conditioner and local fuel rates. Actual savings will vary based on configuration, weather and local energy costs.
ONLINE CEUS NOW AVAILABLE!
IGSHPA members have been asking for the opportunity to earn continuing education units online. IGSHPA is pleased to announce that members can now earn CEUs online through the IGSHPA website. Members can earn .2 CEUs per hour of videos watched with an online quiz passing grade of 100%. To gain access to the videos to earn CEUs, visit ceu.igshpa.org/signup to register for the video site.

For your individual membership renewal, you will need a total of 8 CEUs, 7 of which can be achieved through employment and organization membership. You will need 1 CEU that can be achieved by watching these learning videos and taking a short quiz at the end of each video. Access to these videos is FREE until January 31, 2017.

CSA C448 SERIES 16 LICENSE AND DISTRIBUTION AGREEMENT REACHED
IGSHPA and the Canadian Standards Association entered into a license and distribution agreement November 1, 2016, for IGSHPA to distribute ANSI/CSA C448 Series-16-Design and Installation of Ground Source Heat Pump Systems for Commercial and Residential Buildings. IGSHPA is able to offer the standards to IGSHPA members as a member benefit for a special member price of $100, whereas, the list price for the standards is $155.

Members can visit www.igshpa.okstate.edu/publication/manuals.htm to purchase their copy of the standard.

Exhibit Space & Sponsorships Now Available!
Take advantage of these sponsorship opportunities and put your product in front of hundreds of conference and class attendees in Denver at the 2017 IGSHPA Conference and Expo at the Crowne Plaza Denver Airport Convention Center.

Booth Rental Includes:
- Pipe and drape
- Six-foot skirted table, waste basket & two chairs
- One 7” x 40” ID sign
- Name & company description in conference program & on Exhibitors List on IGSHPA website
- Sponsors of $3,000 or more receive a link to their website in the online list

Sponsorship Levels
Platinum • Gold • Silver • Bronze
- Lanyards
- Hotel Key Cards
- Conference Meals
- Conference Program/Notebook
- Wednesday Night Welcome Reception

Call 405-744-5175 today to receive more information or visit www.igshpa.okstate.edu/conf/conf_sponsor.asp
Since 1999, HomeAdvisor has connected millions of project-ready homeowners to the nation’s largest network of pre-screened home service pros. Over 95,000 pros rely on HomeAdvisor to grow their business.

New! HomeAdvisor will offer exclusive membership benefits to IGSHPA professionals starting in January.

To learn how you can win more jobs with HomeAdvisor visit homeadvisor.com/igshpa or call 877-800-3177.

EarthLoops™ from Centennial Plastics, Inc. is the Gold Standard for geothermal heat pump installations!

- EarthLoops™ are factory-pressurized and sealed with our exclusive test-caps to prevent leaks and contaminants.
- Bullet™ U-Bend fittings are securely and uniformly butt-fused to EarthLoops™ using computerized fusion equipment.
- The pipe identification code and bore depth are permanently heat-indentented for easy identification.
- Coils of EarthLoops™ are securely stretch-wrapped and banded for safe delivery.
- Our large inventory of EarthLoops™ assures fast order turnaround.

Insist on EarthLoops™ from Centennial Plastics, Inc. for all your geothermal heat pump installations!
The temperature vs. time data should be graphed in red and not blue

**Answer B:** Nothing. This is a beautiful data set

**Answer C:** The temperature climbs too quickly during the first 10 hours

**Answer D:** Can I call a friend?

The answer to question 1 is **B**. This is a pretty nice looking data set. In Figure 1, the classic temperature vs. time graph shows the borehole heating up in the first 12 hours before heat begins radiating out from the borehole in a more steady state process. Generally speaking, most conductivity tests should return data that looks similar. If it does not, there may be a need to troubleshoot the test, resolve the issue, and then conduct another test.

**QUESTION 2: WHAT IS WRONG WITH THE FIGURE 2 TEST DATA SET?**

**Answer A:** There was an earthquake during the test

**Answer B:** Nothing. This is a beautiful data set

**Answer C:** Why is it still in blue?

**Answer D:** The flow rate wasn’t constant during the test

The answer to question 2 is **D**. In this graph, the temperature
vs. time data are not smooth like they are in Figure 1 and the first test. While there is more than one possible reason for a data set to look like this, in this specific example, the reason is that the flow rate was not stable throughout the test. If the flow rate varies during the test process, then heat transfer will vary as well, leading to an unsatisfactory temperature profile such as the one pictured here. Flow rates can fluctuate due to many reasons, chiefly; incomplete air purging, plugged filters, circulation pump problems and related hardware issues. It is critical that the flow rate remains constant throughout the duration of test, which will be explained in more depth later.

**QUESTION 3: WHAT IS WRONG WITH THE FIGURE 3 DATA SET?**

- **Answer A:** This test is too long
- **Answer B:** Nothing. This is a beautiful data set
- **Answer C:** This could be a power stability issue.
- **Answer D:** There aren’t enough ups and downs between hour 20 and hour 80

The best answer to question 3 is C. In Figure 3, the temperature vs. time data are not smooth like they are in Figure 1. While there is more than one possible reason for a data set to look like this, in this specific example, the reason is that the power supply was not stable throughout the test. Additionally, please note that this test is also unnecessarily long; an ideal test lasts around 48 hours, whereas this test lasted nearly 100 hours long. The actual power data from this test can be seen in Figure 4.

It is critical that the power supply remains constant throughout the test. It is generally recommended that testers use a generator that has approximately 2x the power requirements minimum needed for the test. For example, if a certain test requires 7000 watts of power, the generator ideally should have a 15 kW capacity. To determine how much power a test needs, multiply the depth of the borehole (in feet) by 15 to 25 watts/ft. Note that maintaining a perfectly stable power supply is difficult. ASHRAE standards suggest that power quality is acceptable as long as the standard deviation is less than 1.5% of the average power.

Below in figure 5 you can find a graph of what a stable power supply looks like during the duration of a test.

Sometimes the question is raised as to why the power and flow rate need to remain stable. After all, all three temperature vs. time graphs in this article look more or less the same, regardless. They all start out with a steep climb before gradually flattening out. The answer to this question lies in how the data points are analyzed to calculate a thermal conductivity value.

To calculate the thermal conductivity from a test, we plot the mean fluid temperature against the logarithm of time as can be seen in Figure 6 on the next page.

In Figure 6, the straight red dotted line is the plot of interest. We first determine the slope of this line, then plug the slope into the thermal conductivity line source equation, which then enables us to calculate the thermal conductivity.
Here is a sample equation for calculating the thermal conductivity (k) from P (power in watts), L (borehole length) and slope: 

\[ k = \frac{3.412 \times P}{4\pi L \times \text{Slope}} \]

If the data set is very smooth, like the data in Figure 1, the slope remains stable throughout the entire steady state portion of the test. This is important because the person analyzing the data generally has to select the range of data he/she wishes to use in the final analysis. If the test data analyst decides to determine the conductivity using data from hour 12 through hour 40 or say from hour 12 through hour 50, the calculated thermal conductivity result will be about the same in both cases. This is good news. Note that the first 12 hours of data typically are not used for slope calculations and conductivity calculations because during this time the borehole itself is being thermally saturated, and thus will not provide a clear and accurate picture.

Unfortunately, if the data set is not smooth (such as in Figure 2 or Figure 3), then the slope can vary quite a bit depending on the time period analyzed. If the analyst selects a data end point that corresponds to a power surge and its corresponding temperature jump, the slope of the line and the resultant conductivity value will vary quite a bit compared to an end point that corresponds to say a power drop and its concomitant temperature drop. In other words, if the data set is not smooth, we begin to lose confidence in our test results. This is why it is so important that a thermal conductivity test has a stable flow rate and stable power.

In summary, it is important to remember that while the thermal conductivity test is not particularly complex or challenging, it is a scientific test that requires both quality equipment and serious attention to detail.

Dan Bernstein is a founder and President of Gaia Geothermal, LLC., the developers of the Ground Loop Design (GLD) software suite. He has been working in the industry since 2001 and has provided commercial geothermal design training to engineers in dozens of countries, Dan has his master’s degree in environmental policy from Johns Hopkins University and received his bachelor’s degree from Pomona College while studying physics, chemistry and biology.

HYDRONICS IS NOW IN THE CODE

New provisions addressing accessibility, attic and underfloor applications, and roof installation of appliances and equipment used in solar energy, hydronic, and geothermal energy systems

New hydronics chapter provides minimum requirements:
- Radiant heating and cooling
- Snow melt systems
- Geothermal
- Capacity of heat sources
- Heating appliances and equipment
- Piping, joints and connections
- System controls
- Space heating
- Auxiliary systems
- Installation, testing and inspection of hydronic systems

Order Your Copies Today!

To read 2015 USEHC online, visit http://epubs.iapmo.org/USEHC/
IGSHPA Industry Awards Nominations Now Open!

IGSHPA will honor the outstanding applications and innovations in the ground source heat pump industry over the past year at an awards dinner on March 15 during the 2017 IGSHPA Conference & Expo in Denver, Colorado. Award areas open for nomination are:

- Residential Innovation
- Commercial Innovation
- Friends of the Industry
- IGSHPA Visionary Award
- IGSHPA Ambassador Award

Nomination deadline is December 31, 2016.

To view guidelines and submit a nomination, visit: http://conf.igshpa.org/nominate
A Geothermal Solution to Urban Blight in Detroit

A four-story home on a 30-foot by 90-foot lot is proving to the world just how flexible the geothermal heat pump industry can be.

By: Staff Writer

The plight of Detroit, Michigan, is common knowledge these days. Left in a state of severe urban decay, the residential streets of the once iconic Motor City are now lined with dilapidated and abandoned structures. Despite this grim situation, there is a glimmer of hope; for the first time since its founding in 1701 the city of Detroit is fundamentally a clean slate, ready and waiting for redevelopment, modernization, and rebirth. This clean slate is serving as an ideal proving ground for an alternative geothermal technology and ground-source design: the proprietary direct-exchange geothermal system created by EarthLinked Technologies Inc., of Lakeland, Florida.

VICTORIAN REHABILITATION

Jarmila Senkyrikova had been in Detroit for nearly a decade, residing in a gated community condominium style residence, when she decided she was ready for a house of her own. However, after beginning her search she quickly came to realize that all of the readily-livable homes in Detroit came attached to astronomical price tags, while the abandoned and blighted structures could be had at next to nothing. Detroit’s unique and troubled housing market forced her hand; Senkyrikova made the decision to find one of the affordable but blighted structures she could turn into a project house and make her own.

A longtime member of the Michigan Urban Farming Initiative, Senkyrikova soon realized that an abandoned Victorian era home owned by the initiative at 256 Horton Street in the North End neighborhood of Detroit was due to be demolished, under the Detroit mayor’s 2010 mandate to clean up urban blight within the city. She made the decision to rescue the decaying structure and turn it into an ultra energy-efficient and modern home for her family. After six months of negotiations she received a clear title to the property and began the rehabilitation and remodeling of the structure in September of 2015.

Located just blocks from the famous Fisher Building, and near one of the largest urban farms in the nation, 256 Horton Street is a 3,300 square foot, four-floor residence, with a full basement and finished attic. The structure had stood vacant for years before Senkyrikova came along, succumbing to the same blight and decay as countless other Detroit homes. Missing and broken windows, damaged walls, busted plumbing, and many more issues all provided ample work to be done before

256 Horton Street is built in the traditional Victorian row house style, creating unique space requirements for all structural rehabilitation activities.

Photo provided by: EarthLinked Technologies, Inc.
Drilling and loop installation activities took place over the course of a single work day.

Photo provided by: EarthLinked Technologies, Inc.

the home could be brought up not only to code and livability, but also to the stringent energy efficiency levels Senkyrikova demanded.

CONSUMER RESEARCH

The centerpiece of any energy-efficient residential building, especially in a heating dominant climate like Detroit’s where the average annual high is 58 degrees, is the HVAC system. Senkyrikova knew this, and began to do her research into what the best options for the climate-control solution were. Extremely driven to accomplish her energy efficient rehabilitation goals, Senkyrikova spent many hours combing through data and sales pitches from the different HVAC system manufacturers online. She ruled out traditional HVAC systems almost immediately, due to their inefficiency and reliance on expensive and polluting fossil fuels. Through further investigation, Senkyrikova found geothermal and ground-source heat pumps to be the next logical step up in terms of efficiency and climate-control ability.

After a few exchanges with regional contractors and dealers, she was told geothermal was not feasible, due to the lack of physical space for the loop field and drilling activities. The property’s extremely small size, only 30 feet wide and 90 feet long with the house covering most of the land, had thrown a wrench in Senkyrikova’s plans. But she was not to be easily deterred from her energy-efficient dreams; continuing her research she eventually stumbled upon the direct-exchange geothermal system design from EarthLinked. This system design boasts the smallest loop surface area and mechanical space footprint on the market; an aspect which immediately jumped out to Senkyrikova as the solution to both her space issue and efficiency requirements. Upon reaching out to EarthLinked, she was immediately referred by the company to one of their Michigan-based dealer/contractors- Scott Roberts of Roberts’ Geothermal Solutions. Based in Niles, Michigan, Roberts has been working with direct-exchange based geothermal systems since the late 1980s.

While Roberts was initially skeptical upon receiving the call to discuss a direct-exchange system for a blighted house in downtown Detroit, a three-hour drive outside his shop’s normal range, it only took one consultation with the homeowner and viewing of the site before he jumped at the opportunity to be a part of the project. “Her passion about and commitment to this project are astounding... her drive to see this through is infectious,” Roberts says of Senkyrikova. Interestingly enough, during one of their initial planning meetings at a local restaurant Roberts happened to look across the street to see a familiar sight- drill rigs and coils of HDPE pipe. The building across the street from the meeting place was having a traditional commercial-sized geothermal system installed. Roberts was able to walk with Senkyrikova over to view some of the work; enabling her to see with her own eyes
the type of HVAC solution she had been researching, albeit at a much larger scale. This only solidified Senkyikova’s decision to install a direct-exchange system, demonstrating to Roberts just how valuable job site visits can be to potential customers.

**PRINCIPALLY THE SAME – TECHNICALLY DIFFERENT**

The direct-exchange system from EarthLinked has been on the market for over 30 years now and has seen installation across all 50 states and in 16 different countries across the globe. This system design relies on the direct-exchange of heat between R-410A refrigerant and the Earth, facilitated through ½ inch or ¼ inch diameter copper tubes, which have a thermal conductivity rating of 231 BTU/(hr*ft*°F). The other major difference between the traditional geothermal and direct-exchange systems is that direct-exchange circulates in the ground, which – contrary to water/glycol – goes through an isothermal phase change that allows for a higher temperature gradient and in turn for a higher capacity per foot of loop. Simply put, direct-exchange systems operate in the same manner as traditional air-source HVAC systems using the vapor-compression cycle, but with the Earth providing heat exchange duties rather than the outside air.

Each direct-exchange system is pre-engineered and pre-fabricated, to specification, at EarthLinked headquarters in Florida. Dealers and contractors like Roberts “crunch the numbers” using industry accepted software tools to determine the system capacity for the building size, soil conductivity, climate, and load trends. These calculations then allow EarthLinked to engineer a system designed specifically for the building, which is then shipped directly to the job site for assembly and installation. To facilitate this process, the corporate decision to utilize standard system dimensions across the board was made. All loops have a set diameter; vertical and diagonal loops have a ½ inch vapor line and a ¼ inch liquid line while horizontal loops have a ½ inch line all across. Loops also have a set length, regardless of orientation, which varies between 100 feet and 150 feet per nominal ton of system capacity.

**AN INNOVATIVE SOLUTION**

Roberts served as direct-exchange system salesman, designer, and installer for the project; a division of labor which is quite common with smaller residential-sized systems. Total system size for the home on Horton Street came out to five tons. The homeowner wanted a hybrid forced air/radiant floor system, so Roberts designed her a system which uses a high velocity air handler and two-inch ducts to deliver air everywhere but the basement, while also including radiant pipes that run through all four floors. This extensive radiant floor setup, an uncommon design for the region as most homes only have radiant floor systems in the basement, enables the house to have a large thermal mass; ensuring that if the home loses electricity for a few days during a storm or other outage, it will remain livable from a temperature standpoint. Direct-exchange lends itself to hybrid designs such as this, as all direct-exchange systems are split systems and can easily work with both radiant and forced air technology simultaneously.

A five-ton PRIME series PSDH-060-1C combo unit was recommended by Roberts for the home. This feature-rich unit specifically enabled the hybrid system, radiant floor, and hot water assist all while meeting the home’s space conditioning needs.

Drill contractor for the job, Buschur’s Refrigeration out of Saint Henry, Ohio, completed the diagonal loop drilling and installation for the entire five-ton system in a mere 10-hour work day, all within a four-foot by eight-foot header pit. Buschur specializes in drilling within confined space for direct-exchange systems; using a small and highly maneuverable directional bore unit, the team was able to squeeze into the small backyard and complete the loop drilling process without
extensive disturbance to the surrounding area. Ten diagonal holes were drilled for the loop field, each at a depth of 75 feet, making each loop a total of 150 feet down-and-back. Header piping and the lines from the pit to the house are buried approximately five feet deep and enter the home at the box sill area, penetrating the home above grade and eliminating the possibility of foundation leakage.

To maximize her efficiency levels, Senkyrikova made the decision to have the walls stripped down to the studs and spray-foamed with insulation before replacing the walls. In fact, the home is sealed so tight that a heat-recovering ventilator is required to bring fresh air into the environment. LED lighting has been used throughout the house, as well as low-flow plumbing fixtures and gas filled windows. The direct exchange system is also linked to hot water production for the home, via an internal hot water assist setup. A solar array is in the works, with the hope being to be completely self-sufficient from an electricity generation standpoint by the end of 2017.

Direct-exchange geothermal has enabled Senkyrikova to realize her dreams of rehabilitating a blighted urban house into an ultra energy-efficient residence for her and her family. The direct-exchange system’s high efficiency levels, coupled with unique space requirements, made it a perfect fit for this job and put geothermal on the map in downtown Detroit.
Australia

Eleven people attended the Geoexchange Installer Training August 24-31, 2016, at the Innovation Campus of the University of Wollongong, New South Wales, Australia. Courses offered were the Geoexchange Design Course and the WaterFurnace Service and Installation Course. The training was held at the Sustainable Buildings Research Centre. The SBRC features a ground source heat pump with three 90 meter vertical boreholes and two horizontal heat exchanger fields 1.5 meters below ground under the urban agricultural gardens. The building is monitored by 12 vertical temperature-monitoring boreholes to monitor the system’s long-term performance. The building has a performance target of net-zero energy, water, and waste over a 12 month continuous occupancy period.

China

The Chinese Chapter co-organized the 8th Senior Forum for Ground Source Heat Pump Industry of China in Hangzhou, China, August 10-13, 2016. More than 500 geothermal experts from institutes, universities, industry, and government officials participated. The topics included GSHP related techniques, products, and policies. At the forum, IGSHPA was introduced to the Chinese fellows. Mark Metzner, president of IGSHPA Canada, spoke at the forum to exchange ideas and experiences. IGSHPA China also organized several GSHP seminars with local associations and universities, such as Jiangsu Geothermal Association and Shandong Jianzhu University. Invited also was the Director of International Geothermal Office, Mr. Hesken, to present at the forum and seminar, and to exchange ideas with the chapter members.

Sweden

In addition to the IGSHPA Sweden conference in September (see page 26), Sweden continued lectures and knowledge spreading in quarter three of 2016. Sweden has also been coordinating a grouting course to be offered in connection with the IGSHPA conference in Denver in March 2017 while also building the organizations foundation and recruiting new members.

Canada

IGSHPA Canada has formed a number of committees that will address the top challenges by calling on the donation of expertise from members to a greater degree than ever in the past. The top activities listed on the association’s website are:

- Lobby regulators to require utilities to provide a discount tariff for the portion of electricity used for a heat pump, including an “extra” discount for power consumption in off-peak time-of-use periods;
- Develop outlines for installation and funding by cooperatives at a municipal level, which will appeal to communities that strive to become a ‘Smart City’ or to transition to a “100% renewable” vision;
- Revive an old proposal that would involve the aggregation of carbon emission credits from individual building owners, which could be used under a cap-and-trade or carbon market to generate a funding source for additional marketing initiatives;
- Lobby governments for a “GreenTherms standard” similar to the EU Directive on Renewable Heating where fossil fuel distributors would be required to sell a regulated percentage of their energy value from green heat sources, including geothermal heat, solar thermal and biothermal technologies;
- Extensive development of social media materials to advance recognition and acceptance of the technology as the optimal NetZeroPlus option;
- Development of promotional material for system owners which provide recognition for the “invisible” contribution made by ground-coupled systems.
1. You control your costs. Subscribe for $50/month whenever you have design work. Your projects will always be awaiting your return.

2. You can share your projects with anyone straight from LoopLink PRO. You control permissions and we track revision history.

3. Your existing projects from other software can be directly imported into LoopLink PRO in seconds.

4. We actively maintain and update a complete catalog of equipment. New equipment and manufacturer updates are automatic.

5. Equipment performance is calculated in real time based on current manufacturer data and your defined system operating parameters.

6. LoopLink PRO is the first and only ground loop design software to account for flow throughout the entire project.

7. Tracking flow allows LoopLink PRO to automatically design balanced reverse-return headers for you.

8. Everything in LoopLink PRO is purpose built to allow you to experiment with design scenarios quickly and easily.

9. You will be supported by experts actively involved with maintaining and developing LoopLink PRO.

---

**TRY FREE FOR 1 WEEK**

LoopLinkPRO.com
INTRODUCTION

Piles are long and slender structural foundations embedded within the ground to support overlying buildings or other infrastructure, such as bridges. Piles were first converted to energy piles in Europe in the 1980’s (Brandl, 2006). Typically the structural steel reinforcement in the pile is equipped with heat transfer pipes and then these are connected to a normal ground source heat pump system. Since this first innovation, construction of this type of ground heat exchanger has spread around the world (e.g. Henderson et al., 1998, Sekine et al., 2007, Pahud & Hubbach, 2007, Alberdi et al, 2016), but not as yet become routine. This article sets out to examine the main types of energy pile construction and how their geometry can affect their thermal behaviour leading to important design differences compared with tradition vertical ground heat exchangers. Some performance data are then briefly examined, before finishing with an outlook for the future.

TYPES OF CONSTRUCTION

Piles can be constructed using a number of different techniques and these construction methods will control how the heat transfer pipes are introduced into the pile and hence energy efficiency implications related to the position of the pipes. The first energy piles were made using rotary bored piles. In this construction technique a cylindrical hole is bored using an auger, often with casing used to support the ground in the upper part of the hole. The steel reinforcement, with pipes attached, is then lowered into the hole and hung off the casing while the concrete is poured into the hole. Finally the casing is removed and the concrete left to cure.

For rotary bored piles there are two important nuances regarding introduction of the pipes into the pile. First, where possible it is quicker and more economic to attach the heat transfer pipes to the steel reinforcement in the factory where the reinforcement is put together. This means that there is no additional time (and therefore cost) of converting a standard pile to an energy pile. However, in some deep piles, or where sites are constrained so overhead lifting is restricted then the steel reinforcement must be prefabricated in two (or more) lengths and spliced together on site. In such cases it is not possible to fix the heat transfer pipes in advance and this must be done on site as the steel is lowered into the hole (Figure 1). This will add a small additional time and cost to the project.

The other scenario which can effect rotary piles is that the bending moments and shear forces being resisted by the steel reinforcement may not be present over the full depth of the pile. In such cases the length of the pile is controlled by the requirement for the foundation to carry vertical load using pile wall friction. If the steel does not extend to the base of the pile then additional measures (e.g. Nicholson et al, 2013)
are required to weight the heat transfer pipes beneath the reinforcement so that they do not become buoyant within the wet concrete.

In many congested cities rotary bored piles are being replaced with continuous flight auger-vern (CFA) piles (also called auger pressure grouted or APG piles). With CFA piles the auger is continuous and the concrete is placed in the hole via the hollow stem of the auger as it is withdrawn. This means that the steel reinforcement must be placed into the pile after the concrete. Especially for cases with short reinforcement lengths this makes it harder to install the heat transfer pipes. In these cases the pipes are typically attached to a separate steel bar for weight and plunged into the wet concrete after the main reinforcement (Amis et al, 2014, Loveridge et al, 2016). This construction arrangements result in a very different arrangement of pipes. While for rotary piles it is possible to install many pipes near the circumference of the pile for CFA piles installations are limited to one or two loops near the centre (Figure 2).

Other types of piles have been converted to energy piles including driven concrete piles (e.g Alberdi et al, 2016) and steel piles (e.g Henderson et al., 1998) which are prefabricated offsite and then hammered into the ground, often until “set”. Precast concrete driven piles may be square in cross section, or sometimes cylindrical. Some cylindrical driven piles made from spun concrete have space in the centre which can be used to install the pipes and then later grouted (e.g. Park et al, 2013).

For all types of piles it is very important that the pipes are protected during the construction process to prevent damage. Many piles are “broken out” after construction to expose the steel reinforcement to permit a structural connection to be made to the building via slabs, columns and other structural members. This process is a risk period for the pipes and staff education and training is as important as physical protection measures such as foam sheaves.

THERMAL DESIGN DIFFERENCES

Energy piles are superficially similar to traditional borehole heat exchangers in that they often offer radial symmetry and are relatively long and thin. However, when that slenderness is measured as an aspect ratio then piles are found to be typically 15 to 50 times longer than their diameter, whereas boreholes may be 500 to 2000 times longer than their diameter (Loveridge & Powrie, 2013a). The larger diameter and reduced slenderness of piles compared with boreholes is important when considering their thermal behaviour.

Taking first the external thermal behaviour of a pile, Figure 3 (following page) shows a typical G-function that might be used for a pile compared with that of a borehole. The G-function makes the same assumptions for both cases, i.e. a finite line source with homogeneous and isotropic ground conditions and a constant surface temperature, but the pile is seen to reach a long term thermal steady state much sooner due to its shorter aspect ratio. However, we must also question whether the classic G-function boundary conditions of a constant surface temperature is appropriate for piles. Piles are most commonly (although not exclusively) situated beneath buildings. This has led some to suggest that an insulated boundary would be more appropriate at the surface. This would potentially lead to much reduced long term axial effects for piles compared with boreholes. However, some initial monitoring data from ground heat exchangers beneath buildings in Australia and France suggest that there is likely to be some thermal interaction with the building (Mikhaylova et al, 2016, Habert et al 2016) and hence further work is required to understand the best design approach.

Another very important factor for energy piles is that their larger diameter means that the concrete will take much longer to reach thermal steady state than boreholes. Boreholes may reach a thermal steady state within the grout in a few hours. This means that it is common to assume a constant
thermal resistance in design calculations. However, for piles, a constant thermal resistance may take many days or even weeks of constant heating to be achieved. Figure 4 shows that a Fourier number (non-dimensional time value) of at least five must be reached before the resistance of rotary bored energy piles approaches a constant value. Since the Fourier number is dependent on the square of the heat exchanger radius then the time to steady state is easily larger than the time scale of applied thermal demand variation (Table 1). Consequently use of a constant thermal resistance in design will always overestimate temperature changes that may occur and hence underestimate the capability of these systems.

Table 1: Example times for pile concrete to approach a thermal steady state (Fo = 5) and hence constant thermal resistance when subjected to continuous heating.

<table>
<thead>
<tr>
<th>Pile Diameter</th>
<th>Thermal diffusivity 0.5x10^-6 m^2/s</th>
<th>Thermal diffusivity 1.5x10^-4 m^2/s</th>
</tr>
</thead>
<tbody>
<tr>
<td>300mm</td>
<td>63 hours</td>
<td>21 hours</td>
</tr>
<tr>
<td>600mm</td>
<td>250 hours</td>
<td>83 hours</td>
</tr>
<tr>
<td>900mm</td>
<td>563 hours</td>
<td>188 hours</td>
</tr>
<tr>
<td>1200mm</td>
<td>1000 hours</td>
<td>333 hours</td>
</tr>
</tbody>
</table>

A better approach is to carry out transient analysis within the pile during design. This can be done in one of two ways. Either the G-function adopted needs to consider the pile and ground temperature changes in one solution (e.g. Li & La, 2012) or a separate transient function (such as those shown in Figure 4) is also required for the pile performance (e.g Loveridge & Powrie, 2013b). The former approach can be challenging since the G-functions become a function of the pipe numbers and arrangements as well as the aspect ratio and thermal properties. The latter approach can be simpler to some extent, but is less accurate.

Nonetheless the concept of resistance can still be applied to compare the potential thermal performance of different types of pile. Here it can be seen that the most important factor is the number of pipes installed. Thus larger diameter piles with the potential to install larger numbers of pipes at reasonable spacing will have a lower resistance to heat transfer (Loveridge & Powrie, 2014). On the other hand, CFA type piles where the pile diameter maybe large, but only a small number of pipes may be installed at closer spacing, will have a higher resistance (Loveridge & Cecinato, 2016).

Despite these recent improvements in understanding of the thermal design of energy piles there are few validated design approaches available for practitioners to use. PILESIM, based on Hellstrom’s Duct Storage model remains the only validated software tool for energy piles (Pahud, 2007). However, the model is dependent on both a steady (and therefore constant) resistance within the piles and the assumption of the regular arrangement of the piles forming the thermal store. Both these assumptions can be problematic for piles. In the latter case it is rare for pile layouts to be regular like boreholes fields since pile positions are dependent on structural columns, with a small pile group often supporting a single column and then greater spacing between these piles and the next column.

The final important aspect for the thermal design of energy
The design of energy piles requires careful liaison with the geotechnical and structural design teams responsible for the load carrying capacity of the pile. It is important that the soil surrounding energy piles does not freeze and so temperature limits for the heat transfer fluid need to be agreed between all parties. At the upper range heat pump efficiency is likely to be the practical limit for constraining temperatures. Control systems to prevent over heating or over cooling of the pile are therefore also important.

**LONG TERM MONITORING DATA AND PERFORMANCE**

Despite a number of high profile energy piles success stories such as Zurich Airport and Keble College Oxford (Pahud & Hubbach, 2007, Nicholson et al, 2014) there remains reticent in some parts to take up energy piles more regularly. To make further progress greater and higher quality monitoring data is required. Some data is now being gathered in the UK, France, Denmark and other locations (Loveridge et al, 2016, Habert et al, 2016, Alberdi et al, 2016) but many of these projects are in relatively early stages.

Other operational or long term test data for energy exchange rates are summarised in Table 2. However, such “rules of thumb” must be considered guidance only and full analysis carried out for the detailed design state of projects.

Compared with other ground heat exchangers, energy piles should offer at least as good thermal performance. Their larger surface area and potential for greater numbers of pipes to be installed compared with boreholes should lead to greater heat transfer rates per drilled metre (Bozis et al, 2011, CIBSE, 2013). In terms of long term seasonal performance factors then comparable results should be achieved to other GSHP systems. Reported SPF of COPs are summarised in Table 3 on the next page. Some of these values are lower than should be achieved and are known to relate to the mechanical design or implementation issues (Loveridge et al, 2016, Alberdi et al, 2016). In this respect energy piles schemes are no different to other GSHP systems, which require careful integration of the design from the ground to the delivery system to prevent excessive pumping energy and other energy losses on the building side (e.g. see Spitler, 2016).

**OUTLOOK**

Energy piles offer a convenient route to the construction of ground heat exchangers using the foundations to buildings. This can prevent the additional construction of separate borehole fields. GSHP systems using energy piles have been demonstrated to work effectively in many places, but systems require appropriate design to realise good performance. This design needs to both recognise the differences between boreholes and piles, especially in relation to the use of constant resistance, but also not neglect the mechanical design which when implemented poorly can reduce system performance for any heat pump. Future work is needed to bring design tools and methods to the market for energy piles. These solutions, along with further standardisation will make it easier to implement the technology and hence increase uptake.

<table>
<thead>
<tr>
<th>Reference</th>
<th>Pile Type</th>
<th>Pile Diameter (mm)</th>
<th>Monitoring Period</th>
<th>Heat Transfer Rate (W/m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alberdi et al, 2016</td>
<td>Concrete driven</td>
<td>300 (square)</td>
<td>12 months</td>
<td>13</td>
</tr>
<tr>
<td>Henderson et al., 1998</td>
<td>Steel tubes with concrete infill</td>
<td>200</td>
<td>12 months</td>
<td>16 extraction 18 injection</td>
</tr>
<tr>
<td>Wood et al., 2010a, b</td>
<td>Bored cast in situ</td>
<td>300</td>
<td>7 months</td>
<td>26</td>
</tr>
<tr>
<td>Murphy et al., 2015</td>
<td>Bored cast in situ</td>
<td>910</td>
<td>22 months</td>
<td>91 - 95</td>
</tr>
<tr>
<td>Pahud &amp; Hubbach, 2007</td>
<td>Bored cast in situ</td>
<td>900 - 1500</td>
<td>24 months</td>
<td>15 extraction 16 rejection</td>
</tr>
<tr>
<td>Sekine et al., 2007</td>
<td>Bored cast in situ</td>
<td>1500</td>
<td>15 months</td>
<td>120 extraction 100 – 220 rejection</td>
</tr>
<tr>
<td>Kipry et al., 2009</td>
<td>Various schemes</td>
<td></td>
<td></td>
<td>&lt;30 extraction &lt;35 injection</td>
</tr>
</tbody>
</table>

Table 2: Heat transfer rates for energy piles from the literature
### Table 3: Energy performance of schemes from the literature

<table>
<thead>
<tr>
<th>Reference</th>
<th>Pile Type</th>
<th>Pile Diameter (mm)</th>
<th>Monitoring Period</th>
<th>COP / SPF*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nicholson et al, 2014</td>
<td>Bored cast in situ</td>
<td>450</td>
<td>12 months</td>
<td>5.8 cooling (COP)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3.9 heating (COP)</td>
</tr>
<tr>
<td>Loveridge et al 2016</td>
<td>CFA</td>
<td>1200</td>
<td>24 months</td>
<td>2.5 to 3.0 (COP)</td>
</tr>
<tr>
<td>Alberdi et al 2016</td>
<td>Concrete driven</td>
<td>300</td>
<td>5 months</td>
<td>2.7 heating (SPF)</td>
</tr>
<tr>
<td>Pahud &amp; Hubbach, 2007</td>
<td>Bored cast in situ</td>
<td>900 - 1500</td>
<td>24 months</td>
<td>3.9 heating (SPF)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2.7 cooling (SPF)</td>
</tr>
<tr>
<td>Sekine et al., 2007</td>
<td>Bored cast in situ</td>
<td>1500</td>
<td>15 months</td>
<td>3.2 heating (COP)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3.7 cooling (COP)</td>
</tr>
<tr>
<td>Kipry et al., 2009</td>
<td>Various schemes</td>
<td></td>
<td></td>
<td>3.0 to 6.5 (SPF)</td>
</tr>
</tbody>
</table>

**REFERENCES**


- Murphy K.D., McCartney J.S., Henry K.S. (2015) Thermo-mechanical response tests on energy foundations with different...


Dr. Fleur Loveridge is a Royal Academy of Engineering Research Fellow and University Academic Fellow. She works on the thermal behaviour of ground heat exchangers and the soils and rocks surrounding them, with a particular interest in energy piles and other thermo-active geotechnical structures. Prior to her return to academia Fleur spent nine years working as a consultant in geotechnical engineering, mainly at Mott MacDonald and before then Babtie Group. Her work included investigation, design and construction supervision for a variety of infrastructure schemes and applied research and development projects. Fleur is a Chartered Engineer and a Chartered Geologist. She was a contributing author to the Ground Source Heat Pump Association Thermal Pile Standard.
The first IGSHPA Sweden International GSHP Conference was held September 15-16, 2016, at the KTH Royal Institute of Technology, Stockholm, Sweden, and at the Wenngarns Castle, Sigtuna, Sweden. The conference, hosted by IGSHPA Sweden and the Swedish Avanti Driller’s Association, was a rousing success with 100 attendees. IGSHPA Board of Directors President, John Turley; IGSHPA Acting Executive Director, Roshan Revankar; National Ground Water Association CEO, Kevin McCray; and OSU Regents Professor and OG&E Energy Technology Chair in Mechanical and Aerospace Engineering, Jeffrey Spitler, spoke during this event. Additional presenters included a diverse group of researchers, contractors, manufacturers, product representatives and other industry participants. Also in attendance from the US was Dominique Durbin representing IGSHPA training. Pictures from the event can be seen on the opposite page.

Participants toured the KTH heat pump lab and visited a local university that employs a district geothermal system for its heating and cooling. The KTH lab is the also the home of geothermal pioneer Palne Mogensen’s original thermal conductivity testing unit, which was developed in the early 1980’s.

In addition to the conference was the annual Brunnsborrardagen/The Drillers’ Day with 34 exhibitors, 8 seminars and 400 visitors. The Driller’s Day showcased drilling equipment and other products used in the Scandinavian GSHP industry.

Kevin McCray, NGWA Chief Executive Officer

“Recognizing the beneficial role qualified drilling professionals can provide to the ground source heat pump sector, NGWA values the opportunity to listen and learn from our colleagues around the world. The Swedes have a long and impressive reputation of their work in the GSHP sector and it was well demonstrated at the IGSHPA Sweden and Driller’s Day events in September. A big part of what NGWA does for its members is to create connections and relationships. We were able to build and expand those with this visit.”

John Turley, IGSHPA Board of Directors President

“The IGSHPA Sweden Conference & Driller’s Day was a fantastic demonstration of the many ways this new international relationship will benefit our respective members, and the industry in both countries. By attending international conferences hosted by our chapters, IGSHPA gains broader expertise in the technology, which leads to better programs and training.”

Dominique Durbin, IGSHPA Trainer

“The Swedish drillers I met during the IGSHPA Sweden Conference and additional Driller’s Day were all very friendly. We talked shop about drilling sites and our toys just like we were old friends. The supply house and manufacturer’s representatives were quick to show off new advancements on their drilling equipment. I picked up a new drilling method that I am very intrigued and am ready to try it out in the US. I truly hope I get an opportunity to go back to Sweden. It’s beautiful and the people were fantastic plus I left an unfinished conversation about grouting there.”

International Geothermal Conference a Success
By: Erin Portman
Heat Pump Systems

USA
- Commercial buildings: Distributed heat pumps
- Hybrid: Some commercial systems use cooling towers or fluid coolers to reject excess heat.

Scandinavia
- Commercial buildings: Central heat pumps
- Hybrid: Residential systems generally rely on backup electric resistance heating.

Disadvantages:
- low toxicity (leakages)
- good thermophysical properties
- low pumping power (compared to propylene glycol)

Sweden => common conc. between 20 and 25% molar, quality: us: 11% w% denaturing agents (ketones, propyl and n-butyl alcohols)
What is a PDC? (Polycrystalline Diamond Compact)

The Polycrystalline Diamond Compact is a drill bit specifically designed for hard and consolidated rock formations such as sandstone, limestone, and shale. In these formations, the PDC out-performs tri-cone rock bits on the average 3 - 1 and some instances where they out-penetrate a tri-cone as much as 5 - 1. When compared to a hammer, the penetration is comparable in most formations but with an increased savings in fuel costs. Savings of $400 - $500 a day in fuel after switching over to a PDC are quite common in the field.

These diamond cutters are very hard, making them very brittle. This brittleness can cause problems in the field, especially in gravel-type formations. In some cases, a steel body PDC can drill through 130,000 feet of sandstone without repair, but be destroyed in just 20 feet of gravel. How and where a PDC is deployed will mean the difference between saving drill time and fuel money, or destroying an expensive bit in a short period of time.

A PDC is basically ran the opposite of a tri-cone; tri-cone is best ran with low RPM and high weight on bit, while the PDC is best ran with high RPM and low weight on bit.

Below is a standard recommendations to follow for getting the best life out of your bit. Note the graph is for WEIGHT ON BIT, hydraulic not pull down. A 5 inch bit should be run with 5000 lbs. of actual weight on the bit.

<table>
<thead>
<tr>
<th>Weight on Bit</th>
<th>1000 lbs./inch of bit diameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>RPM</td>
<td>80 - 120 RPM (harder formations = slower RPM)</td>
</tr>
<tr>
<td>Circulation</td>
<td>Min. 10 GPM (more is better)</td>
</tr>
</tbody>
</table>

There are two main components of a PDC, the bit body and the diamond cutter, with many variances of each. First we will look at the body of the bits, which comes in two main types: matrix and steel.

Matrix Body PDC

A matrix body has a certain percentage of tungsten carbide powder blended into the steel when it is manufactured. This process makes it a very hard, durable and long lasting bit body. The problem with the whole concept of the matrix body is it was specifically designed for oilfield use and to be in the hole for thousands of feet without the need for tripping. In oilfield PDC’s there are industry standards that regulate the high percentage of tungsten carbide powder that is in the matrix. In the GSHP drilling industry, there are no industry standards to follow. For example, a manufacturer can put only 5 percent tungsten in the body and call it a matrix. In addition, a matrix body PDC is generally more expensive than a steel body.

To properly repair a matrix body PDC, an oven is required; the bit needs to be preheated before they are worked on and put back in the oven to cool slowly. If this procedure isn’t followed the body will crack.

Steel Body PDC

The other type of PDC body is the steel body PDCs, which come in two main styles. The first, the traditional or full body style, comes in a 3, 4, 5 or 6 wing design. Additionally, the junk slots are very small; leaving only a small area for cuttings to get by the bit body. For these two reasons it is not recommended to run the full body PDC in softer formations. They have a
tendency to plug up at least one of the circulation ports; if the drill is penetrating fast the cuttings can’t get by the body in time and the bit balls up. The 5 and 6 wing design it is a very durable bit and does well in harder limestone, sandstone, and fractured formations.

The second style of steel body PDC is the winged PDC. This style of bit was modeled after the drag bit. The high wing profile and large junk slots helps this bit penetrate very fast with no problem clearing the cuttings. It is available in 4, 5 and 6 wing designs, and the 4 and 5 wing design do extremely well in the softer formations and when drilling through layers, going from soft to hard. The circulation ports are out the side, which protects the large circulation ports, which in turn reduces the possibility of a port being plugged. Additionally, the large area for cuttings to flow by the body helps reduce the likelihood of the bit balling up. The 6 wing bit, performs best in the harder, more consolidated formations. Finally, the winged PDC is also more economical to repair compared to other PDCs. Unlike the traditional body PDC, if a pocket is damaged beyond repair the bit is junked out. On the winged PDC, the damaged wing can be removed and replaced with a new wing, saving the bit from being junked out.

The most important component is the PDC cutter itself. The most common size of cutter in the industry is a 1308, which stands for 13 mm across and 8 mm thick. The cost of a 1308 cutter can range $10 to $78. On larger bits, the cutters increase in size and can go up to 1913. The options can seem almost endless when purchasing cutters; with cutters coming in a wide variety of fashions that are more impact resistant, erosion resistant, or thermal resistant. For example, if drilling in abrasive sandstone, use an erosion resistant cutter, while if drilling in fractured limestone, an impact resistant cutter will perform better.

On the very edge of the cutter there is a chamfer. Chamfers come in many varieties of degree, a zero-degree chamfer will provide a very high rate of penetration however it has high tendency to chip, while a chamfers closer to 20 degrees is very durable and chip resistant cutter with a noticeably reduced penetration rate.

**Bit Repair**

The PDC is a very expensive bit and the best way to reduce bit costs per foot for running it is to take very good care of the bit. Send it in to a reliable and reputable bit company before the bit is damaged beyond repair. It is recommended to send the bit in for repair when it has 4-5 cutters either chipped or broken. For a good quality repair, 50% of the pocket has to be intact. The bit can then be built back up, with the repair company re-machining the pocket and soldering in a new cutter. The pocket that the cutter is set in is extremely important part of the bit and repair process. Cutters are soldered into place during the repair process with a low temp silver solder. Diamond cutters can easily be damaged if too much heat is applied when soldering them into the pocket; the strength comes from the pocket, not the solder. The pocket is milled .005 larger than the diamond cutter. In some instances, questionable repair companies work on PDCs and instead of re-machining the pocket they have simply ground it back down, thus removing the majority of the pocket and then applying the cutters. This repair looks good, but the bit life is very short, thanks to the shoddy repair design.

Taking a close look at the cutters on a dull bit can tell a lot about the bit. One of the most damaging things to a PDC is heat; if run in a hard formation with too many RPM’s and not enough circulation fluid / air, the bit will heat up and either damage the diamond or the low temp solder will let loose and the whole cutter will come out of the pocket.

If you’ve never run a PDC before, now maybe the time to try one. Call your bit supplier and talk to them. Make sure you are in the proper formations for a PDC, and talk though all the possibilities to make the best call on which bit and cutter is best, for your specific needs. If you are running PDC’s, there may be options available to lower your bit costs per foot.

Kevin Christensen started his employment at Palmer Bit in 1977, manufacturing Red Devil bits for the big seismic boom. In 2005, he and his wife 50 percent of the company from Dick Palmer. In 2008, they designed and marketed the Diamond Devil PDC into the geothermal market. They grew from selling bits in the Williston basin to every state in the union and exporting to 17 countries around the world. In 2012 they purchased the rest of the company from Dick and presently run the company with their two sons.
Outreach & Extension units of the College of Engineering, Architecture and Technology bring Oklahoma State University to the community and make a difference in people's lives with education, support and quality of life advancements.

Annually providing services to more than 60,000 people worldwide through the services of

- Applications Engineering Program
- Center for Local Government Technology
  - Fire Protection Publications
  - Fire Service Training
- International Fire Service Accreditation Congress
- International Ground Source Heat Pump Association
- New Product Development Center
  - Professional Development
  - Web Handling Research Center

ceat.okstate.edu
DIG IN to reach the next level

This year, we’re changing things up. With a new start day, expanded breakout session slots, and dedicated expo hours, you’re sure to find all you need to DIG IN to the ground source heat pump industry. We’re focusing this year’s conference and expo on providing you with the tools and information you need to take your geothermal business to the next level. And we’ve invited friends of the industry to join us in the exhibit hall, so you’re bound to see some new faces that can help support your work.

To learn more or register visit igshpaconference.com
Setting back the temperature overnight in an unoccupied building has long been considered a standard energy saving strategy. Reducing the temperature difference between the building and the outdoors reduces heat transfer, and therefore it reduces energy consumption... right?

Well...not really. When a building cools overnight, everything in the building cools... furniture, paper, the building structure, etc. It takes time and energy to warm the building and everything in it the following morning. Energy modeling for a 24,000 ft² (2,230 m²) building located in Minnesota shows there is less than 1% difference in annual energy requirements in heating or cooling regardless of whether the temperature is set back or not. Figure 1 compares monthly energy loads (kBtu) and peak heating and cooling needs with a standard 7°F (4°C) setback, a temperature setback with an extended warm up period and the building with no temperature setback.

![Figure 1: Monthly cooling and heating energy loads (kBtu) and peak loads (kBtu/hr) in were developed using hourly energy modeling software. The building was modeled with a standard night setback of 7°F in heating and 5°F in cooling with a start-up time of 9 am, with the same night setback but with a 3-hour start up period and without a night setback. Annual heating and cooling loads show less than a 1% difference in total energy consumption (kBtu). Peak heating load, however, shows a reduction of 35% when the warm up period occurs over 3 hours, and a 53% reduction without night setback.](image)

![Figure 2: The graphs illustrate the impact of three different night setback control strategies on the peak heating load (red line) of the building.](image)
The largest impact temperature setback has in this building is on peak heating loads. When a system must warm a building in a short time the full heat pump system capacity is engaged.

**Impact of Night Setback on GHX Performance**

With the exception of the higher peak heating loads for a few hours per day in the heating season, the building loads are essentially the same with the three different night setback control strategies. The difference in the daily loads are seen in Figure 3. Does this in turn affect the performance and size of GHX needed to maintain reasonable operating temperatures?

![Figure 3: A daily peak heating load profile is shown with three different night setback scenarios. A standard night setback with the building temperature setpoint dropped 7°F (4°C) overnight with the setpoint increases at 9:00 am shows a peak heating load of 611,000 Btu/hr (179 kW). The second graph shows the impact of spreading the temperature ramp-up period over three hours beginning at 7:00 am. The peak heating load drops to 398,000 Btu/hr (117 kW) with an extended warm up. The third graph shows the building loads without night setback, dropping peak heating requirement by 52% to 290,000 Btu/hr (85 kW).](image)

During the warm up period, full heat pump capacity is needed to warm the building. That’s when the maximum amount of energy is extracted from the fluid in the GHX. Using hourly energy loads in conjunction with GHX design software makes it possible to predict the fluid temperature in a GHX system on an hourly basis. This is illustrated in Figure 4 where the temperature of the fluid is predicted with the three night setback scenarios. The high peak created during a short warm up period creates the greatest temperature drop. Extending the warm up period creates a smaller temperature drop, while the system without a night setback sees only a small drop in temperature.

![Figure 4: Graph on the left compares predicted GHX temperature on an hourly basis with warm up from standard night setback, a three hour warm up period, and a building without a setback. With the standard setback the GHX was modeled with 7,440' (2,268 m) of borehole…the same building with an extended warm up and without night setback was modeled with only 6,240' (1,902 m) of borehole. The graph on the right shows GHX supply and return temperatures in a building with night setback in cooling mode…as the heat pumps start cooling the building at 6:00 am, GHX temperature immediately increases y 20-25°F (11-14°C). The simultaneous start-up time also has an impact on the demand charges from the electrical utility.](image)
The high rate of heat extraction during the warm up period lowers the temperature of the fluid in the GHX. Heat isn’t absorbed from the ground as quickly as it’s taken from the fluid and the only way to limit the temperature drop is to increase the size of the GHX. The impact of the high peak heating loads on the GHX temperature is shown in Figure 5.

Without a night setback the peak heating during the warm up period disappears. The large temperature drop in the GHX of 18°F (7°C) seen with a standard temperature setback, is reduced to 8°F (4.5°C) when there is no setback. The minimum temperature seen in the GHX is about 5°F (3°C) warmer, even though the GHX not subject to the warm up period has 1,200’ (365 m) less borehole.

When the warm up period is extended by warming up different areas of the building over three hour period the peak heating load is reduced but is still significant impact on the size of the GHX.

To see the impact on the performance and size of GHX required for each of the night setback scenarios, an hourly energy model was developed for the building with the three building temperature control strategies. The loads were input into GHX design software. The performance was modeled using both the cylindrical steady state model described in the ASHRAE Handbook\(^1\) and the line source model developed at Lunn University. GHX modeling results are shown in Figure 6.

<table>
<thead>
<tr>
<th>Night Setback</th>
<th>Cylindrical Model (Boreholes)</th>
<th>Line Source Model (Monthly)</th>
<th>Line Source Model (Hourly)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard Night Setback</td>
<td>6,750’</td>
<td>76.5</td>
<td>32.0</td>
</tr>
<tr>
<td>Night Setback - 3 Hour Warmup</td>
<td>6,750’</td>
<td>84.2</td>
<td>32.0</td>
</tr>
<tr>
<td>No Night Setback</td>
<td>6,747’</td>
<td>85.0</td>
<td>34.3</td>
</tr>
</tbody>
</table>

Figure 5: The graph on the left compares the hourly GHX temperature profile of a building without night setback with that of a building with a standard night setback control and a building with a night setback control but with an extended warm up period. Note that the temperature range is greater because of the higher peak heating load during the warm up period and that it in turn lowers the minimum temperature which will be seen by the heat pump system when there is a night setback.

Figure 6: Total borehole length was modeled in GHX design software using both the Cylindrical Steady State model (ASHRAE) and the Line Source model. The Line Source model was calculated using monthly energy and peak loads as well as hourly loads. Total bore was extended or eliminated. The models were designed to operate at a minimum temperature of 32°F (0°C) delivered to the heat pumps in heating or a maximum temperature of 85°F (29.5°C).

When the building was modeled with a standard night setback control, total borehole length required was based on the minimum temperature. Heat extraction during the high peak heating load required during the warm up period drives the temperature of the GHX down. To maintain a minimum temperature of 32°F (0°C) requires more heat exchanger in the ground. When the peak heating load is reduced by extending the warm up period after night setback, or by eliminating the night setback altogether, total borehole length can be reduced.

\(^1\) Kavanaugh, S., Rafferty, K., 2014. “Geothermal Heating and Cooling, Design of Ground Source Heat Pump Systems”, American Society for Heating, Refrigeration and Air Conditioning Engineers (ASHRAE)
Impact on System Design

Figure 1 shows a significant difference in peak heating load when night setback controls are implemented. In the 24,000 square foot (2,230 m²) building used in this example, peak heat loss dropped from 611,000 Btu/hr to 290,000 Btu/hr (179 kW to 85 kW). Peak cooling loads in the building remained about the same at 469,000 Btu/hr, or 39 tons (137 kW).

If the building was modeled and built with night setback controls, heat pumps would have to meet a peak heating load of 611,000 Btu/hr. With 32°F (0°C) fluid, that would require approximately 72 tons (252 kW) of heat pump capacity. Eliminating night setback reduces the peak heating load to 290,000 Btu/hr (85 kW)...this would require less than 35 tons of heat pump equipment at minimum GHX design temperature.

Peak cooling load in the building is 39 tons (137 kW). If night setback controls are eliminated, a 40-ton (140 kW) heat pump system will meet both the peak heating and cooling loads, eliminating the need for 32 tons (112 kW) of heat pump equipment.

Peak system flow rates can be reduced from 215 gpm to 120 gpm when night setback controls are eliminated. This affects the configuration of the GHX as well as the overall size and cost.

Conclusions

In many buildings night setback control does little to reduce energy consumption...but it does have an impact on the peak heating and cooling loads. Higher peak loads affect the size, cost and performance of the GHX:

- The size and cost of the GHX increases when night setback controls are implemented;
- Peak heat pump capacity must be increased to meet higher peak loads when setback controls are used;
- Flow rates through the GHX must increase for the increased heat pump capacity needed with setback controls;
- There is less impact on the size and performance of a GHX if the warm up period is extended or eliminated;
- Setback controls increase equipment capacity required and will increase peak electrical demand;
- It is incumbent on the system designer to specify the sequence of operations to ensure setback controls, if required, are installed as intended because of potential impact on performance of the GHX.

In some projects, eliminating peak heat extraction (and corresponding low GHX temperatures) created by the warm up period after temperature setback may keep GHX temperatures high enough to eliminate the need to add antifreeze to the GHX. This provides additional cost savings for installation and improves pumping efficiency.

Energy and GHX modeling can predict the operation of different control strategies on the size and performance of a GHX and is an important step in optimizing a GSHP system.

Ed is the founder of GEOptimize Inc., a consulting firm focused on the improving the design and implementation of geothermal heat pump systems. He has worked in almost all facets of the industry since 1982, including the design and installation of residential systems, heat pump manufacturing, equipment distribution and the design and implementation of large scale and district geothermal systems.

Ian works with Demand Side Energy Consultants as an Energy Engineer and Commissioning Specialist. He has worked in the HVAC industry for over 8 years with much of that experience in designing ground heat exchangers and creating energy models for buildings.
SPECIAL NOTICE:
IGSHPA Membership and Certification Changes

This page details the changes which have taken place in regards to IGSHPA memberships as well as their certifications and accreditations. These changes went into effect June 1, 2016 so please make note of them.

For more information, please call 405-744-5175 or visit http://www.igshpa.okstate.edu/membership/

General Changes

- Membership and certification are now 100% independent of each other and no longer linked except for a price reduction incentive when obtaining or holding both at the same time
- All dues paying members now have voting rights, regardless of membership type or accreditation
- All participating IGSHPA committee members are now required to hold an individual or corporate membership from any sector

Certification and Membership Incentives

- Certification will be independent of membership-meaning a member does not have to be IGSHPA certified to enjoy member benefits and a professional who is certified is not required to pay membership dues to keep certification
  - HOWEVER, incentives apply to renewing both simultaneously and are listed below
- IGSHPA Certified Accredited Installers (AI) & Certified Geothermal Inspectors (CGI) will enjoy a reduced payment structure as follows:
  - $50 per year dues cost for individual membership renewal
  - $300 recertification fee every 3 years (along with required CEUs)
  - $450 total cost to renew membership and certification for 3 years all at once
- Through industry partnerships, certain certification holders enjoy a reduced IGSHPA membership renewal fee of $50 per year for an individual membership:
  - CGD (Certified GeoExchange Designer) through AEE
  - CVCLD (Certified Vertical Closed Loop Driller) through NGWA

INDIVIDUAL MEMBERSHIPS:

<table>
<thead>
<tr>
<th>Level</th>
<th>Non-Certified Individual Member</th>
<th>Certified Professional Individual Member</th>
</tr>
</thead>
<tbody>
<tr>
<td>Requirements</td>
<td>No IGSHPA certification or accreditation</td>
<td>At least 1 current IGSHPA or partner affiliate accreditation or certification</td>
</tr>
<tr>
<td>Voting Benefits</td>
<td>1 vote in any selected sector</td>
<td>1 vote in any selected sector</td>
</tr>
<tr>
<td>Annual Dues</td>
<td>$125</td>
<td>$50</td>
</tr>
</tbody>
</table>

CORPORATE AND BUSINESS MEMBERSHIPS:

<table>
<thead>
<tr>
<th>Level</th>
<th>Large Corporate</th>
<th>Small Corporate</th>
<th>Business</th>
</tr>
</thead>
<tbody>
<tr>
<td>Requirements</td>
<td>Only open to: Manufacturers of 100 or more employees, Utility providers with 10,000 or more meters, Generation and Transmission (G&amp;T) Providers of any size</td>
<td>Only open to: Manufacturers of 100 or less employees, Utility providers with 10,000 or less meters</td>
<td>Any other business related to a GSHP industry sector, Any school, educational, or non-profit entity</td>
</tr>
<tr>
<td>Voting Benefits</td>
<td>4 total votes</td>
<td>3 total votes</td>
<td>2 total votes</td>
</tr>
<tr>
<td>Annual Dues</td>
<td>$1430</td>
<td>$640</td>
<td>$420</td>
</tr>
</tbody>
</table>
OVERVIEW
Brickell City Centre is a US$1.05 billion (909,000,000 Euro) mixed-use development in Miami developed by Swire Properties Inc. (US and Hong Kong). Strategically located in the Brickell financial district, the 5.4 million square-foot (501,000 sq m) development spans 9.1 acres (3.6 Hectares), includes underground garage, two mid-rise office buildings, two residential towers, a hotel with residences, retail and entertainment space. Construction began in June 2012, and is expected to be completed late 2016. The project is expected to create approximately 2,500 jobs while under construction and approximately 3,700 after completion.

HEATING AND COOLING BY BOSCH
Featuring twin residential towers housing 820 condominium units, and a luxury hotel, the developers for Brickell City Centre knew that they needed a long-term, high-efficiency HVAC solution that they could integrate into the design. The developer understood that an initial investment in capital costs could save a significant amount of money in future operating costs.

Bosch Thermotechnology Corp. worked with Alex Valdes of Jascko Corp., a manufacturer’s representative in South Florida, and Thermal Concepts, Inc. the mechanical contractor, to get the right combination of price, efficiency and footprint for the project. The three worked together to develop a specialized unit that fit in the limited space of the condos within the Centre. A custom variation of the Bosch FHP LV Model Water Source Heat Pump was designed and built for the residential condo units. These units are compact, yet extremely energy efficient, and an ideal choice for new construction or for energy-saving replacements.

“One of the challenges we had was to design a new product with single point power electrical heat in a small footprint package, and get the proper UL certification, which took approximately 4-5 months,” says Arthur Kunz, Bosch commercial sales manager for the Southeast.

PROJECT INCLUDED 800 BOSCH FHP LV MODEL WATER SOURCE HEAT PUMPS
The LV is an option-rich single stage product that is available in ½- to 6-ton sizes, and meets or exceeds ASHRAE 90.1 efficiency ratings. The unit comes with a unique sound package, designed to keep sound levels to a minimum while providing maximum comfort. They are water source heat pumps, so they do not require outside condensing air and permit easier placement in enclosed spaces, while allowing separate metering of utility costs for each condo unit.

CUSTOMIZED WATER SOURCE HEAT PUMPS
The units in this project were equipped with single-point electric heat and were seamlessly integrated into the structure’s Building Management System, thereby providing operating feedback and easier serviceability. The heat pumps are supplied with water by a BAC cooling tower. Bosch was selected because of the positive relationship and good results achieved in past projects, the heat pumps were priced right and fit the reduced footprint in the residences. With Bosch FHP water source heat pump units providing smart comfort, efficient and quiet operation, the future Brickell City Centre residents can live in ultimate comfort with lower energy cost.

BOSCH APPLIANCES FEATURED IN RESIDENCES
Residences feature a premium Bosch appliance package including 36 in. integrated panel refrigerator & freezer, 300 series microwave, integrated panel, extra-quiet dishwasher, built-in convection oven and ceramic glass stovetop.

boschheatingandcooling.com
A ground source heat pump (GSHP) is the only non-storage renewable “Base Load” energy source. The performance of a GSHP system is not dependent upon sunny days, wind forecasts, or rainfall levels, unlike other renewable energy sources. The energy GSHP systems rely on is available 24 hours a day, 365 days a year, regardless of weather or other factors. To accomplish this, GSHP systems utilize an in-ground heat exchanger loop to tap into the earth’s relatively constant temperature existing ten feet and deeper below the surface. This readily available and relatively small, out-of-sight footprint positions GSHP technology as an ideal on-demand site specific energy source to handle the space conditioning and water heating requirements in both residential and commercial buildings.

Sounds like the perfect renewable and clean way to condition a building’s interior air and heat its water, doesn’t it? Then why has the GSHP industry’s growth been stagnant to the point of declining in some sectors over the past decade? From a high-growth entrepreneurial perspective, the GSHP industry appears to have sub-optimized its “product / market fit or alignment”. Currently, the GSHP industry’s “product / market” alignment is focused directly at the residential and / or commercial building owners. It seems logical to focus on selling the product directly to the end user. However, for this to be successful and drive industry growth, it requires the GSHP industry to utilize a project oriented and individualized direct sales approach. This approach in turn requires technically oriented product education, complex financial energy analysis, and customer acceptance of a heightened risk / return profile. This is not exactly the ideal repeatable economies of scale customer acquisition process.

After studying the GSHP industry, numerous barriers and misalignments exist between GSHP technology products and the targeted residential and commercial customer market. The “product / market” misalignment here relates directly to the capital intensity of the product relative to the targeted customer’s capital availability in the market. This “upfront capital (cost) barrier” is only further complicated by the complexity of the required financial / energy analysis needed to justify said large capital investment. Unfortunately, as summarized in the current GSHP “product / market fit” assessment (Table 1), a majority of the remaining intangible attributes around the “product / market fit” appear to be misaligned. The direct consequences of this are a severely constricted market size with an expensive, un-scalable, and lengthy sales process.

These “product / market” misalignments are only exacerbated by the convenience and simplicity of competitive utility energy alternatives and the status quo within the market. In sharp contrast, residential and commercial building customers can access their full, instead of partial, energy requirements directly from their local utility. This utility competitor, in sharp contrast to a GSHP system, requires no large upfront energy source capital deployment, no long term energy commitments, no time consuming complex energy analysis, and no perceived increased risk profile. As a result, the utility energy acquisition process is easy and low risk; just turn it on and pay the convenient monthly bill.

Due to these “product / market” misalignments, the majority of GSHP market customers don’t even consider a GSHP system, despite its proven superior energy efficiencies, lower long-term operating costs, significant environmental advantages, eliminated commodity fuel volatility, and long-term renewable energy sustainability. Given these compelling advantages, the challenge then becomes how to create or reposition the “product / market fit” of GSHP to retain these inherently desirable utility residential commercial customer advantages for the GSHP industry.

Fundamentally a new “product / market fit” opportunity needs to be identified, designed, and developed; one that
acknowledges these barriers and then effectively mitigates their impact or eliminates them entirely. Strategically the simplest approach and perceived highest value would be to just replicate the current utility to residential and/or commercial relationship. Conceptually this can be accomplished by inserting the utility industry between the GSHP industry and the residential or commercial end customer. After all, this existing relationship even remains intact even when an end customer currently installs a GSHP system.

Basically, the utility industry needs to become the GSHP market customer and adopt an “intermediary wholesaler or value added reseller” function. In order to accommodate this utility industry repositioning, the GSHP “product” needs to be unbundled into its two distinctive and natural components; the in-ground “loop” (i.e. the energy source) and the GSHP in-building HVAC related equipment. This permits the utility industry to exclusively concentrate on the energy generation asset that constitutes the vast majority of incrementally required upfront capital. The utility would simply replicate and apply its existing strong low capital funding capacities, energy project management skills, and in-depth end customer knowledge to this new renewable geothermal energy source.

Most importantly, by embracing this new site specific micro-grid energy generation paradigm shift, the utility industry actually enhances its overall financial performance. Under the still predominant utility industry regulatory format, utility earnings for an Investor Owned Utility (IOU) or net free cash flow for a non-profit utility are directly controlled by the Utility Regulatory formula. Under this regulatory compact, a utility, over the long-term, can only grow its earnings or enhance cash flow by prudently growing its rate base. As a result, a utility must pursue the opportunity to make quality, least cost, energy related long-term capital investments which benefit both ratepayers and owners.

So how does a utility “loop” capital investment competitively compete and benefit both the utility and the end user? The key lies in a GSHP loop technological attribute; it requires no fossil fuel expense. As highlighted in the Regulatory Formula or compact, a utility cannot make or lose money on fuel expenses. In other words, fuel constitutes a direct “pass-through” expense line item managed through various utility Fuel Adjustment Tariffs. Since natural gas fuel expenses can equate to 25% to 40% of natural gas generated electric utility revenues, versus 0% for a GSHP “loop”, this creates a tremendous financial opportunity to convert fuel revenues to non-fuel revenues. Provided the overall “levered costs” or total revenue requirements competitive, the utility would obviously prefer to sell a nearly 100% versus 65% gross margin energy product. Additionally, since the utility end customer base assumes 100% of all underlying commodity fossil fuel price volatility, a utility GSHP “loop” energy offering would obviously mitigate the commodity fuel risk since the “loop” uses no fuel.

As a result of this fuel expense differentiation, the comparative GSHP “loop” capital cost per KW can obviously be marginally higher than the corresponding capital cost per KW for an incremental natural gas power plant, and still meet the necessary utility regulatory requirements. Therefore the utility and the utility end customer share the same preference, though for different reasons, for non-fossil fuel energy generation sources.

By segregating the GSHP “product” into the “loop” and inserting the utility industry into an “intermediary customer or value-added reseller”, the existing incredibly market demotivating “upfront capital barrier” suddenly potentially flips into a positive “first capital benefit”. Secondly, the utility industry is comprised of technically sophisticated professionals, who are extremely comfortable in the comparative analysis, design, and marketing of various energy program offerings. By redefining the GSHP “product” as just the “loop” and realigning with the utility market, the corresponding new “product / market fit” will align extremely well (see Table 2).
The utility market in this “intermediary wholesale” function will effectively convert and manage the GSHP “product”, the “loop”, into a simplified standardized utility energy program offering. Basically the utility industry will develop a GSHP “loop” rate tariff, create a premium “green” energy offering, potentially a unique “fixed price” energy program, etc. and market this turnkey retail energy offering to its existing end user residential and/or commercial customers.

Given the utility’s strong energy provider/customer relationship, the utility industry constitutes the marginal lowest cost provider which further supports development of this proposed sales channel. After all, the utility industry has one of the lowest industry capital costs, possesses in-depth historical customer energy knowledge, understands the complexities of “least cost” energy analysis, and even already bills the customer.

The last strategic hurdle to the strong advocacy for this proposed new GSHP Utility Market initiative relates directly to the “least cost or lowest revenue requirements” for utility ratepayers. Given the significant national variability of individual utility energy rates, fossil fuel costs, weighted average cost of capital, operating costs, and GSHP geographical soil, drilling, and weather conditions, an applicable detailed comprehensive financial examination is prohibitive within the context of this article. However, an illustrative depiction of the key concepts is feasible. For conceptual comparison purposes, a core set of generic assumptions that fall within their respective applicable national ranges were specified (see Table 3). For example, the “loop” design/installation capital cost per KW certainly varies based upon the soil drilling conditions and the sizing driven by site specific geographic heating / cooling requirements, but the $1,750/KW reflects a “generic value” within the actual overall input variable range. Again for computation simplicity purposes, a theoretical 1 KW peak demand space conditioning & water heating building envelope was utilized.

Based upon these generic baseline assumptions, the corresponding ratetariff “least cost” requirements can then be computed to demonstrate the economic feasibility. Under this set of detailed input assumptions, a utility “loop” rate tariff would constitute the least cost or lowest revenue requirement for the utility residential or commercial customer and thereby satisfy the critical regulatory prudence test. As economically demonstrated within this conceptual modeling is that a utility GSHP “loop” energy offering can be extremely competitive with existing rate tariffs and incremental natural gas power plant generation costs primarily due the required fossil fuel costs. A recommended utility “loop” energy program offering can be extremely competitive with existing utility energy resources and internally generate superior financial benefits to any participating “intermediary” utility as highlighted within this conceptual economic evaluation. Given the widely accepted GSHP product payback periods of up to 10 years, this illustrated financial viability for select residential or commercial customers should not be a surprise. The economics and breadth of end customer viability will just be further increased as a result of the substantially lower utility cost of capital, the ability to diversify risk across a GSHP portfolio versus single installation, and the greatly extended capital recovery period to match the useful “loop” asset lifecycle. To recap, this utility has the opportunity to:

- Convert fuel revenues into non-fuel revenue and improve gross operating margins
- Prudently grow rate base and organically accelerate earnings and cash flow growth
- Cost effectively leverage end customer databases and knowledge
- Diversify the overall generation fuel portfolio mix
- Reduce area transmission & distribution capacity constraints through this micro-grid generation
- Enhance various “environmental” compliance mandates
- Improve service territory jobs through recurring outsourcing with local GSHP vendors
- Create as applicable or required a near “zero cost” DSM program offering
- Invest in a generation “asset class” that can actually increase in “value” over time given the “built-in” hedge against traditional fossil fuel commodity inflation
- Preemptively create a strategic decentralized micro-grid generation program

The opportunity to significantly supplement the current GSHP industry direct sales “pull marketing” residential and/or commercial customer sales channel with an independent parallel “push marketing” utility sales channel will substantially accelerate deployment of a superior renewable energy source. Actually a few “early adopter” utilities have already started exploring just such a concept. The time has come to diligently advocate within both the utility regulatory environment and the utility market to serve as a critical “intermediary” between the GSHP industry and the residential and/or commercial end customer under a GSHP Rate Tariff approach. A potential true “win/win/win”; for the utility, the utility ratepayer, and the GSHP Industry. Let the detailed evaluation and deployment begin.
David Thomison is a Clinical Assistant Professor and the George Kaiser Family Foundation Endowed Chair in Entrepreneurship at Oklahoma State University. Prior to joining Oklahoma State University he served as a Senior Vice President of Client Services Group of i2E, Inc. for over ten years. At i2E, he managed the statewide delivery of early stage commercialization advisory services to over 250 advanced technology companies, oversaw $50 million in Seed Venture Capital Funds, and championed the formation of SeedStep Angels, a statewide Oklahoma Angel Group. He has a breadth of business experience, ranging from start-up organizations to a Fortune 500 Utility, and industry knowledge, including energy, software, informational & financial services. His teaching focus includes Venture Capital, pre-startup Customer Discovery/Validation, and Startup Launch. In addition to teaching, he works out of 36 Degrees North, a Tulsa co-working space focused on assisting student and/or recent alumni business startups.
The following is from a discussion I overheard some time ago between a couple of subcontractor employees after a project “toolbox” safety meeting.

The comment was “Man, we sure waste a lot of time with all this safety stuff.” An offhand comment that didn’t seem like much until the conversation continued. “Yeah, the boss said he wastes a lot of time on safety stuff that doesn’t do a thing for the project, it’s just CYA stuff to let guys on up the ladder check off boxes.” Nothing could be further from the truth.

Safety is not "stuff," an inconvenience, or a waste of time. Regardless of OSHA and governing regulations and the possibility of related enforcement penalties, the proper approach to safety activities should be a safety related state of mind, commitment, and way of doing business that is shared throughout the company, from bottom to top. Your company should have a safety program that addresses all aspects of its day-to-day operation. If you don’t have one, you need one. Also, aside from your safety program and depending on the client, additional documented safety program/information requirements can go from none to extensive, especially if it’s a local, state, or federal government project.

Good safety practice is market segment blind; the same issues can arise on residential, commercial, or industrial class projects. For example, management, project managers, and foreman can give inadequate attention to safety issues and workplace supervision. Workers can be improperly or inadequately trained for the task they are performing. Tools can be improperly used, not in proper working order, or improperly/inadequately maintained/repaired. Equipment can be improperly used or operated in a manner that exceeds its capacity/capability. Site conditions can create hazardous working conditions for employees and equipment. Have you addressed these and any other related issues in the safest possible manner, or do you just hope you have?

Further, you should have a safety plan specific to each project. If the client does not require a documented project safety plan, you should at the very least, conduct a safety evaluation of the project. Remember, Murphy’s Law (What can go wrong will go wrong) is alive and well. However, proper safety planning, implementation and performance cuts Murphy’s odds of being right. You should do Accident Prevention and Activity Hazard Analysis plans or evaluations for each project - they define potential safety issues so they be addressed before an incident occurs.

Finally, I’m sure you’ve noticed that this is the 20,000’ view - very little detail or specifics. Regulations change, and every company and project presents different challenges. It is your responsibility to know and adhere to governing regulations and to provide proper safety evaluation, documentation, preparedness, and performance to address these needs. Doing so will significantly reduce the potential for workplace incidents.

Success means there is a strong probability that the client’s property was not damaged or destroyed, tools and equipment remain in proper working order, workers were properly trained and supervised at all levels, and no one was injured or worse. You don’t even want to consider the alternatives.

Phil Rawlings has more than 39 year’s experience in the geothermal industry. He is the Director of Geothermal Services for Trison Construction, a Certified GeoExchange Designer (CGD), an IGSHPA Accredited Installer and an IGSHPA Trainer. He is also a member of the IGSHPA Advisory Council and a member of the Association of Energy Engineers CGD Board.
NEW STANDARD IN PERFORMANCE FOR GEOTHERMAL LOOPS

INTRODUCING

TURBO COLLECTOR®

30% MORE EFFECTIVE CIRCULATION PUMPS
- Direct Savings of 30-50% on Electricity Bill vs. Smooth Pipe.
- Quicker Payback on Entire System, As Few As 2 Years in Some Cases.

HIGHER COP
- Lower Flow Rate With Same Results.
  Turbo Collector© requires only 1.5m³/h vs. Smooth Pipe Requiring 1.8m³/h.
- Reynolds Number 3.300 - 3.500, Smooth 3.400 - 3.800.

PROVEN TRACK RECORD
- Already 100,000 Installations of Turbo Collector© in European Market.

MuoviTech®
BEST IN EARTH.

MUOVITECH U.S. 1111 Foster Avenue Nashville TN 37210
PHONE +1 (615) 401 9142 WEB www.muovitech.com
Time is running out on the geothermal tax credit! 30% Federal tax credit for consumers on geo installations ends in 2016.

Upgraded SM

Best-in-class performance (COP) and low operating costs to save money

10 year Limited Warranty on parts and labor\(^{(1)}\)

Quiet operation with sound levels as low as 52 dB

Fiber-free, closed-cell insulation provides thermal and acoustic insulation while improving indoor air quality

Simplified installation, diagnostic tools, and enhanced serviceability for quick set-up and easy routine maintenance

Increased durability and formicary corrosion resistant with an all aluminum evaporator air coil\(^{(2)}\)

boschheatingandcooling.com

(1) Complete Warranty details are available at boschheatingandcooling.com
(2) All-aluminum coil available by Fall 2016 on vertical and counterflow units only