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Large commercial installations of ground source heat pumps (GSHPs) offer exciting opportunities for everyone involved. Developers and building owners can offer “green” facilities that offer occupants comfort while operating dependably and efficiently. Facility managers reap the rewards of lower operating and maintenance costs, along with straightforward building controls and reduced staffing requirements. And architects and engineers optimize project design and construction, while project managers pull the pieces together for timely project execution. A team approach among all of these parties assures successful projects and happy tenants.

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Architects and engineers apply their special expertise to take advantage of GSHP attributes, including no outside or rooftop equipment, smaller mechanical rooms, scalability of equipment selection, and the ability to take advantage of diversity of heating and cooling requirements in different parts of the building. And project managers can use helpful references like ASHRAE Guide SP-94 “Commissioning, Preventive Maintenance, and Troubleshooting for Commercial Ground-Source Heat Pump Systems” to assure successful system start-up and operation.

So get your team organized and communicating early to reap all the rewards of GeoExchange technology.

This issue of Geo Outlook features articles about the successes that GeoExchange systems are experiencing in the US and Canada. Several articles include side-by-side comparisons of the performance of comparable buildings that continue to demonstrate the GeoExchange advantage. Presentations at the 2006 Annual Conference also highlighted performance advantages and first cost differences. It is not uncommon to see operating costs of GeoExchange systems to be one-half that of conventional systems. The question is: What is considered to be a conventional system of either type so that comparisons can be made? Who’s doing what to control first costs to make GeoExchange systems more competitive?

Without claiming any exhaustive research, the single element appears to be “keeping it simple and repetitive!” Many engineers new to the business attempt to use the same old techniques and design styles, which incorporate central station pumping, one single bore field, etc. New designs are using multiple, smaller borehole fields and headers and load-matched circulators on each heat pump. Smaller heat exchanger piping and repetitive designs to reduce labor costs are something to consider. Find someone who is successful and take the time to understand what this person is doing. Call it research for the lack of a better word. Better yet, identify the good ideas and leave the bad ones alone.
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David Hatherton
CEO
NextEnergy, Inc.

David Hatherton has been a leader in the domestic and international geothermal, renewable and energy efficiency industry for over 27 years. He is CEO of NextEnergy, Inc. of Elmira ON Canada, the largest implementer of residential geothermal technology in Canada, through its network of over 300 dealers, with exclusive rights to ClimateMaster’s line of geothermal residential products.

In 1980 he founded Earth Systems Inc., which trademarked the WaterFurnace tradename, becoming the world’s largest distributor of geothermal systems. In 1983 Hatherton with Dan Ellis, now president of ClimateMaster, expanded WaterFurnace into the US, co-founding WaterFurnace International (WFI).

Companies that Hatherton has been a founder of have an installed base of geothermal products of over 250,000 systems (750,000 tons), annually transferring approximately 3.75 billion KwHrs of renewable geothermal energy, reducing greenhouse gas emissions by over 3.5 million metric tons of carbon annually and electric demand by over 1500 Megawatts.

Greg Wells
Geothermal Sales Engineer
Jackson & Sons Drilling/Geothermal

Greg Wells is a geothermal sales engineer for Jackson & Sons Drilling/Jackson Geothermal in Mansfield, Ohio. He is responsible for commercial sales, commercial field design and installation quality control. Jackson Geothermal has installed thousands of tons of vertical geothermal heat exchanger systems from coast to coast. Wells has 20 years of experience in the geothermal industry as an electric utility representative, a territory manager for a geothermal heating and cooling manufacturer, a general manager of a large geothermal installation company, prior to being employed at Jackson Geothermal. Wells is currently serving on IGSHA's Advisory Council, is an IGSHA accredited installer and trainer and an IGSHA/AEE Certified GeoExchange Designer.
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Geothermal on a Grand Scale

By Kelly Green
At the Citizen Potawatomi Nation (CPN) in Shawnee, Okla., geothermal technology has a pretty positive reputation. With four of the tribe’s major enterprises employing the technology and saving the tribe about $20,000 a month on energy costs, it is not hard to see why. According to its Web site, CPN is a nation that “believes strongly that economic development which benefits the entire community is in the best interest of both tribal members and non-Indians.” To this end, CPN Public Works Director Richard Kunze said geothermal exceeds their expectations. “For our part of the world, it’s the most applicable,” Kunze said. “When you compare cost to savings, geothermal makes the most sense.”

FireLake Grand Casino is the tribe’s largest and most recent geothermal project. The 200,000-square-foot facility houses 1,800 Vegas-style games, three restaurants and an entertainment venue. More than 44 miles of pipe was required to provide FireLake Grand with 1,000 tons of HVAC capacity. The casino opened its doors in grand fashion in October 2006.
A Successful Track Record

Geothermal was selected for the FireLake project because of its successful track record with the tribe. Chairman John Barrett mandated CPN’s first geothermal application for the expansion of the tribe’s health clinic in 1999. “Our chairman has a lot of vision and a lot of foresight,” Kunze said. “He stays in touch with state-of-the-art technology and opportunities to make money and save money. He was a big believer in geo when I arrived.”

Satisfied with the results at the health clinic and curious whether or not geothermal could benefit the tribe in future projects, Kunze then contacted geothermal experts Drs. Jim Bose and Marvin Smith at Oklahoma State University. “With a quick tour of the facilities including the golf course, which offers some water for heat exchangers, they were quick to seize on a bunch of opportunities to make geothermal applications,” Kunze said.

Following their advice, CPN built a pond on the first tee of the golf course as the heat exchanger for its second geothermal installation at the tribe’s Cultural Heritage Center. Well water used to irrigate the golf course was routed to that pond to create a constant flow. Copper pipes were submersed in the pond to provide about 100 tons of capacity for the 36,000-square-foot facility. Lastly, CPN also elected to install geothermal for its travel plaza. The 12-ton system utilizes 12 vertical boreholes.

A Grand Affair

Even with their gained experience and confidence in geothermal, CPN knew that the installation at FireLake Grand Casino would be like nothing they had ever done before. The 1,000-ton system required ground heat exchangers buried in soil and submersed in water. The tribe utilized a lagoon that holds treated wastewater to submerse 120,000 feet of 1 1/4 inch high density polyethylene pipe. In addition, CPN included 100 boreholes drilled to 400 feet deep. A third set of pipe is also submerged in the basin of a fountain located at the entrance of the casino.
The pond is also a reservoir for treated wastewater.

Installation was completed entirely by tribal employees. CPN assembled the team during the heritage center project when they realized geothermal would continue to be an option for them in future projects. Geo-Enterprises Inc., a Tulsa-based design and distribution firm, served as consultants for capacity, volume, piping and equipment selection, Kunze said.

Despite the massive amount of pipe necessary for the job, Donny Vaughan, geothermal manager for CPN, said installation was fairly simple and straightforward. “It was pretty much an empty slate to put the installation in,” Vaughan said. “Once we got all the boreholes drilled and got everything set up for the headers and got everything in, we did lack a little time because of the weather, but we finished and we didn’t really have any obstacles in our way.”

With the installation of the ground heat exchanger complete, the tribe then began the interior installation process. The tribe opted to hybridize the system installing two 500-ton chillers to heat and cool the facility. A single 50-ton ground source heat pump unit serves

Copper coils provide 100 tons of heating and cooling for CPN’s Cultural Heritage Center.
the administrative offices located inside the casino. “So, the fluid in all of our loops serves to maintain those two 500-ton chillers,” Kunze said. Both of the chillers and the GSHP were manufactured by Trane.

**Savings and Operation**

Nearing the end of its first year in service, Vaughan said the system operates well needing little to no maintenance. Vaughan said the chillers had some trouble handling return fluid temperatures if they began to reach 85°F, but with some adjustments are now running properly. “The chillers are really sensitive to the loops,” he said. “With every new building there is some trial and error, but once we got it all up and going it’s been perfect.” Three air handlers located on the third floor of the casino also help to maintain the temperature inside the building.

Kunze said when the project began CPN expected to save about 30 percent a year on energy costs and pay off the system installation in just under four years. To this point, he thinks those estimations are holding true. Using tribal employees also helped offset the upfront costs to the tribe. “I would expect that based on 1,000-ton capacity for the casino itself we probably spent an extra $500,000 to $700,000 to be able to install geothermal technology,” Kunze said.

**CPN’s Geothermal Future**

The opening of FireLake Grand Casino completes the first of a three phase construction project for the tribe.
Future plans call for the addition of a hotel and a larger events center. CPN plans to incorporate geothermal for both. Kunze said the hotel’s geothermal system will tie into the casino’s existing ground heat exchanger. Two fluid coolers added during construction of the casino should prevent the need for more drilling. “We added two closed-loop fluid coolers to handle the additional capacity for the hotel,” Kunze said. “With the fluid coolers in place, we think we’ll be able to bring the hotel on line and still be able to handle it with the existing loops.” Kunze said they are still unsure about the new events center in terms of size and load.

With successful past projects and current ones coming on-line smoothly, the future for geothermal at CPN looks bright. Kunze said the tribe recently completed 25 new duplex housing units with two-ton ground source heat pumps on each side. They are also planning to construct industrial facilities outfitted with geothermal.

“More development is coming all the time,” Kunze said. “I can’t imagine we will do anything but use geothermal technology every time we build something we own.”
Profile to Success: Phil Schoen

By Marie Kada vy

President and CEO Philip Schoen established Geo-Enterprises Inc., in Catoosa, Okla., 10 years ago, but his experience in the industry totals nearly 30 years. In 1978, Schoen began his geothermal career while working with Cooper Supply to develop a better piping material. Schoen continued his efforts to improve piping systems and was instrumental in developing U-Bend after meeting Dr. Bose at Governor Nigh’s 1980 energy conference. Schoen was also involved in the development of the unicoil product while working with Performance Pipe, but, perhaps his biggest contribution to the industry has been the header vault.

A header vault is a closed piping distribution system enclosed in a buried vault that allows fluid control at various parts of a well field. Schoen developed the header vault when he saw the need for an outside location for underground valving that would require a load-bearing design capable of withstanding vehicle traffic. The vault has increased the reliability of earth heat exchanger systems because individual circuits can be isolated and repaired and the system can be flushed without interfering with the operating system inside the building, Schoen said.

Schoen introduced the product in schools 18 years ago and has been involved in installations at more than 350 educational facilities. “I think probably schools nationally are still the single largest market for commercial geothermal activity around the country,” he said.

Schoen, a member of the International Ground Source Heat Pump Association (IGSHPA) since the beginning, is the current chairman of IGSHPA and is on the board of directors of the Geothermal Heat Pump Consortium (GHPC). He became an accredited installer in 1989 and has been conducting training workshops since 1996. Schoen said he feels the industry has been successful because of the professionals who have worked together through IGSHPA to build the infrastructure to deploy geothermal technology. “You can develop great ideas in a laboratory-based environment, but you have really got to go out and deploy them in the field before you really see the result,” Schoen said.

Schoen attributes his personal success to Geo-Enterprises’ geothermal focus. “I think we have been successful because we still maintain 100 percent of our focus on the adapted use of geothermal technology as it relates to heating and cooling, and we don’t focus on multiple technologies in the HVAC business.”
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Warms to the Idea of GeoExchange

By Marie Kadyz

In 1957, Warren, a small community just up the road from Winnipeg, Manitoba, built an ice arena to meet its winter sport needs. Fifty years later, citizens of Warren began skating under a new roof. The South Interlake Credit Union Arena, which replaced the 1957 facility, serves the surrounding area with nine months of ice.

A hockey player tests the ice maintained by Ice Kube units.
Despite the negative temperatures of the Canadian winter, the arena also keeps its visitors warm. The arena’s 50-year-old predecessor didn’t even offer its hockey players, skaters or spectators heating, but, with a geothermal system and community support, the arena keeps visitors comfortable and bills affordable.

From Ice Cubes to Ice Kubes

For this small community of just 750, operating costs had to be low to maintain the arena. “There are hockey rinks up and down the highway that are going to be shut here shortly because the little communities can’t afford to run them,” Chuck Lefley, a member of the South Interlake Recreation Board, said. “That, I think, was the driving force in why we did this because it would be fine to save money when we built it, but then, if we can’t afford to keep the doors open, it didn’t do us much good.” A geothermal system was chosen so that people could actually use the facility, Jim Lindsay, president of the South Interlake Recreation Board, said. “If we had to pay $60,000 a year in energy costs, it would be very difficult to run.”

Tower Engineering, a firm certified by the Leadership in Energy and Environmental Design (LEED) program, served as the mechanical and electrical design engineers as well as construction managers for the project. Greg Jorgensen, a professional engineer at Tower Engineering, recommended a geothermal system for the building. “They are energy efficient, compact and easy to operate,” Jorgensen said. “Ice arenas, cold-storage warehouses and packing plants are ideal for heat pump applications because they require heating and cooling at the same time.”

The South Interlake Recreation Board had discussed the option of a geothermal system with Frontier Refrigeration, an installation contractor, and, while fundraising for the new arena, the board watched the progress and success of Frontier’s geothermal projects for five or 10 years. For the arena in Warren, Frontier suggested an Ice Cube System. The systems are well-suited for ice rinks because they are specifically designed for very low-temperature applications. The arena’s three 25-ton low-temperature, water-to-water units and one 5-ton water-to-water unit manage to produce ice, provide domestic hot water, heat and air condition the building all for much less than a conventional system. “It’s way more energy efficient,” Derrek Wertepny, the installer of the system, said.

The three 25-ton heat pumps keeps visitors warm.

The facility uses a combination of open- and closed-loop applications. The closed-loop portion of the system chills the rink surface to make ice and also recycles waste heat to warm the building. The open-loop portion acts as a supplementary heat system. Using 150-foot supply and return wells vertically installed on opposite sides of the arena, the open-loop system adds or subtracts heat to the building loop based on demand. Early in the season, when the building has no use for heat, the open loop rejects heat. On days of extreme cold, when the extraction and rejection heat don’t adequately heat the facility, the open loop supplies heat.

Ice is made on the rink’s concrete slab lined with 66,000 feet of 1-inch high density polyethylene (HDPE) pipe. Under the 6-inch concrete slab, the thermal buffer offers an additional 12 to 18 inches of dry, compacted
material that can be refrigerated. The thermal storage beneath the ice supplements refrigeration when flooding, lights or people increase the load, Walter Lehmann, president of Ice Kube Systems, said.

A total of 75 pounds of environmentally-friendly refrigerant R404 is used in the ice-making process, while the 5-ton water-to-water unit, which produces the building’s domestic hot water, operates on approximately six pounds of the refrigerant. The units use Fluorescent Geothermal Solution, a heat transfer solution specifically designed for low-temperature geothermal applications, which includes fluorescent dye to help differentiate between condensation and actual leaks.

The 30,000-square-foot arena, complete with seating area, dressing rooms and canteen, includes all in-floor heating via 3/4-inch high-density geopipe. Even when doors open to temperatures of minus 20°F, the arena manages to stay warm. “We were a little afraid we weren’t going to be able to keep the lobby area comfortable,” Jim Lindsay said. “But it just seems when those doors shut, the heat coming up from the floor recovers quickly, and it stays really comfortable in there.”

Lefley said the difference is obvious. “In our old building, it was an ice cube,” he said. “It was just the coldest. If it was 20 below outside, you could be sure it was 25 below in the arena. There wasn’t a stitch of insulation. We’ve gone from that to a very comfortable, modern building that is warm.” Controls in the new arena, designed and installed by Larry Kyrzyk of Frontier, allow for varied temperatures in the different areas of the facility. The lobby and dressing rooms are kept at a warm 70°F while the bleacher area is maintained at about 45°F. The ice slab is kept at 19°F to 21°F.

“With the in-floor heat, we get good recovery on the heat,” Lindsay said. “The floors are always dry, and, when guys get in the shower area, the cement isn’t cold,” Lindsay said. “We get a lot of compliments on that.”

Heat pipes also run through the approximately 500 seats in the viewing area, keeping spectators comfortable. In addition to keeping fans warm, two dehumidifiers prevent moisture from collecting on the board glass, allowing fans to see the action. In the summer, the dehumidifiers act as air conditioners to cool the building during community events.
The rink is open seven days a week from Sept. 1 through May 31, offering approximately 500 visitors per week ice for winter sports, but Lindsay hopes the building will be utilized year round. In the summer, the arena transforms into an events center, housing the local high school graduation, community socials, a music festival and a weekend farmers’ market.

**A Green Beacon in the Canadian Cold**

“For a typical building like that, we would be in the $60,000 range for annual energy costs,” Lindsay said. The expected annual energy savings for the $2.8 million arena are between $30,000 and $40,000. “We believe our energy savings is 50 percent of what we used to use,” LeFley said. “We counted everything, our lights, our ice plant and heating our water in the old facility, and that was over $5,000 a month. We are now at about $2,200 a month, and we heat our building on top of it.” LeFley called the energy savings a bright light. “The savings just caught our eye,” he said. And, the arena’s energy efficiency caught the eye of Natural Resources Canada.

Natural Resources Canada awarded the South Interlake Credit Union Arena the maximum amount of $60,000 through its Commercial Building Incentive Program (CBIP). “The intent of CBIP is to fund better design,” Michel Lamanque, a Natural Resources Canada representative, said. To qualify for the CBIP grant, the arena had to be 25 percent more efficient than a comparable facility built to the Model National Energy Code for Buildings. “We far exceeded every standard that they needed to give us this grant,” LeFley said. In fact, the arena was 61.6 percent more efficient. “They decided to do the whole nine yards,” Lamanque said.

In addition to the energy efficiency of the geothermal system, the building boasts efficient lighting fixtures and bulbs, including occupancy sensors in the dressing rooms, heat recovery ventilators, compressors with an average energy efficiency rating of 10.7 and the ability to store compressed heat. “What makes this project interesting is not everyone has the capacity to store heat,” Lamanque said.

The geothermal system and green features not only save money but also reduce greenhouse gas emissions. The arena cuts greenhouse gas emissions by 375 tons each year, the equivalent of taking 68 cars off the road, according to the U.S. Environmental Protection Agency Web site.

LEED Accredited Professional Jeff Penner, of Stantec Architecture and Road Architecture Inc., served as project architect and, with support from Ted LeBlond, Tower Engineering,LDA and HTFC, designed the building with a sustainable approach according to LEED guidelines. The future of the project could hold further development of the arena per the architecture firms’ Master Plan for the recreation center, including a six-sheet curling club, visitor and gathering atrium, community hall and festival grounds with a lake view.
Overcoming the Extra Capital Cost

Construction of the new facility and installation of the geothermal system left the arena with a million dollar debt. Rising above the upfront cost and patiently waiting for payback is always a challenge. Luckily, the facility received $575,000 in grants and incentives. In addition to the CBIP grant, Manitoba Hydro awarded the arena a $15,000 Power Smart grant for installing automatic lighting systems and efficient fixtures and bulbs. It also received an infrastructure grant from both the provincial and federal government for a total of $500,000.

A sooner than expected payback will help, too. It is estimated the geothermal system installation cost $250,000 more than a conventional system. “I think when we looked into putting this in they thought there would be a 20-year payback,” Lefley said. “We believe it’s going to be a lot sooner. With us saving $2,000 a month, that doesn’t seem to take very long.” The expected payback time has been cut in half to about 10 years.

After years of planning and fundraising, the expertise of Ice Kube Systems, Frontier Refrigeration and Tower Engineering and the support of a little community passionate about ice sports brought an efficient, affordable solution to Warren and the residents of Woodlands and Rosser municipalities.

“You would think a brand-new system and everything there would be some glitches, but we’ve been very fortunate,” Lefley said. “These people put it together impossibly. We’ve been pretty much trouble-free.”
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Robert C. Webber, A Modern Pioneer

By Kelly Green

Robert C. Webber (1911-1984) is acknowledged by most to be the inventor of the ground-coupled heat pump system. According to a September 1948 issue of The Refrigeration Industry, Webber was the first to heat his seven-room home in Indianapolis, Ind., by reversing the cycle on his home freezer. The issue featured Webber as “the refrigeration industry’s man of the month.”

Webber’s “freezer in reverse” was also featured in Ripley’s Believe It Or Not in 1948.

Even before his heat pump invention, Webber made a name for himself in the field of low-temperature refrigeration. He began his career in 1929 installing and servicing ammonia and sulphur dioxide systems for the Carolina Refrigeration Company. He broadened his expertise a few years later installing the mechanical cooling system on one of the first and largest refrigerated fishing boats. According to the Industry article, Webber also accompanied the vessel on its maiden voyage where the refrigeration equipment held 122 tons of fish at minus 10°F.

During the Depression, Webber worked as an independent service and installation contractor picking up refrigeration service work wherever it was available.
During a brief stay in Texas, Webber helped a local hotel lower the head pressure of its cooling system from 275 pounds, which exceeded city code, to 160 pounds in a single day. He solved the problem by shutting down the system, cleaning the condensers, tying the condensers together in a series and reversing the fan on the cooling tower so that it pulled air from the outside and discharged it into the hotel’s laundry. According to the Industry article, Webber charged the hotel manager $32 for the job. Another firm had previously told the hotel the only solution was a new cooling tower that cost $1600.

In 1932, Webber settled in Indianapolis and began working for the Indianapolis Power and Light Company. After years of successful work, which included working his way up through the department, Webber became supervisor of the company’s entire service operations.

It was at this point that Webber began the work that would lead to his heat pump invention: he began building food freezers. While experimenting with one of his homemade freezers, he discovered 183°F waste heat coming out of the compressor. Knowing this was too much heat to be thrown away, Webber utilized the waste heat from the family’s four freezers (6 1/2, 12, 15 and 18-cubic-foot models) to heat water in a tank. He then circulated this heated water through the home’s hot water radiators and heated the house all winter long.

The following year, Webber extended the system to provide cooling as well. He buried 400 feet of 3/4-inch tubing in a 50-foot trench in his backyard. He installed a 3-horsepower, air-cooled condensing unit in his basement and changed the system from hot water to hot air heat. According to the Industry article, this homemade heat pump system kept the Webber home at a constant 75°F both summer and winter.

“We had the first real green house in the ‘40s,” Webber’s oldest son, Don, said. “We were some of the first with air conditioning in our home.”

The Industry article stated that Webber intended to sell his original heat pump units to electric utilities for a “fact-finding period.” Then they would be marketed to homeowners.

With 21 patents to his name, Webber left a legacy of innovation. His son Don, who now lives in the Indianapolis home he calls the “heat pump house,” said he hopes his father is remembered most for his great hard work.

*Many details for this piece were adapted from the September 1948 issue of the Refrigeration Industry.
Dare to Compare

McDonald Buildings
Palo Alto, California

By Dara McCoy

Hang around the ground source heat pump industry (GSHP) for very long and you’re bound to hear boasting of the technology’s long life and low maintenance requirements, discussion of return on investment or length of payback, and claims of substantial energy savings and invisible, quiet operation. “It’s just a better way to heat and cool a home/building/space,” is an oft quoted phrase.

But from where and whom do these ringing endorsements come? This was the type of question Jerry Brown, key account manager with the city of Palo Alto, Calif., was asking himself in 2003 when reviewing GSHP technology for use in city projects. One of the driving factors for Brown was his desire to replace the high level of natural gas usage in housing in Palo Alto with a more environmentally friendly heating method.

Brown had been involved in a few GSHP projects and heard all the geo-junkie promotion, but wanted some hard evidence before considering using public money to defray Palo Alto Utilities customers’ costs of installing GSHP. “I really wanted to see a real, live comparison,” said Brown. “Everything else had been done in laboratories and theoretical models. I wanted to make sure that we could actually see that there was a difference in the efficiency.”

Finding a Test Site

To get his real world comparison, Brown used research and development money in the city’s public benefits fund to create a $78,000 grant to offset the GSHP installation costs of a comparative HVAC analysis. Requests for proposals were sent out to building owners or developers who owned identical or nearly identical buildings and were willing to take part in the test by installing conventional HVAC in one building and GSHP in the other.

Brion McDonald, a general contractor, developer and owner of Universal Building Systems, met Brown while renovating one of his two office buildings in Palo Alto. McDonald’s buildings fit the bill for the city’s test project. Both were nearly identical two-story, 10,000-square-foot, concrete tilt-up office buildings built in the 1960s and sat adjacent to each other. McDonald was planning to remodel both, including updating the HVAC in both buildings.
Brown introduced McDonald to the GSHP technology and the test project the city was planning. “I had a desire to try something new because in the building industry, as a general and commercial contractor, I install a lot of traditional mechanical units,” McDonald said. “This was an opportunity to gain some new knowledge and test geexchange technology, its ability to reduce a building’s operating costs and carbon footprint.” McDonald submitted an application for the city’s grant and his buildings were selected as the research site for the project.

“Looking at the manufacturer’s data on the proposed geexchange units implied that we’d see some improvements in operating expenses,” McDonald said. “We were already committed to doing a mechanical upgrade to the site so having the opportunity to have the city participate in sharing those costs was another inducement.”

Let the Comparison Begin

McDonald’s remodeling efforts to the conventional building were underway when he became the grant recipient. Fifteen tons of York direct air-exchange, gas package units were installed on the roof of the conventional building with total installation costs ringing up at $92,000. McDonald said trucking the York units on site and using a crane to place them on the roof was a straightforward process.

Installing the GSHP system was more complicated. McDonald said the biggest challenge was drilling the loop field underneath an existing parking lot that was in use at the time. “That required that we cordon off portions of the parking lot for segments of the construction calendar and presented challenges because the drilling process is not the cleanest process,” he said.

The 18 tons of WaterFurnace units required for the GSHP building were installed within the high ceilings of the office space. GSHP installation costs totaled $165,000 (45 percent paid through city grant). While GSHP was $72,000 more expensive than conventional to install, McDonald said he had instantaneous payback thanks to the city grant, but would’ve reached payback on the GSHP system in seven years even without the

These buildings in Palo Alto, Calif, were the subjects in a comparative HVAC analysis that documented the efficiency advantage of ground source heat pumps.
grant, something a conventional system can never offer.

To retrieve energy savings and efficiency numbers for the test, Brown and McDonald went several steps further than just comparing energy bills for the two buildings. “This is not your typical project,” Brown said. “This was so well instrumented in order to get the correct data that we needed.” McDonald said a lot of time went into defining the important variables to collect in order to present “a coherent, valuable data set after the project was over.”

That’s where George Bell, vice president of business development for Automated Energy Inc., a company that provides online load profiling and energy management tools to the city came in to help with data collection and reporting on the project. Energy Management Systems were installed as part of the HVAC retrofits to the buildings which allowed Automated Energy to take “data streams not only from the revenue meters from the city, but also from the EMS and put those online for comparison, display and analysis,” Bell said.

“Where it’s not conventional is we certainly added a few more strategically placed sensors,” said Carl Salas, president of the involved engineering firm, Salas O’Brien. “Kilowatt meters so you can actually measure the current drawn by each of the individual units, current transducers and temperature sensors for water coming out of the ground and the water going back into the ground.”

The Cold, Hard Facts

When the data was collected and the numbers crunched, the GSHP building posted a whopping 30 percent energy savings over the conventional building, McDonald said. “The results that we are seeing so far are more than what we really had set forward to do,” said Brown.

In the annual energy cost bar graph the numbers pulled from the meters at each building outline where the difference in energy efficiency hurts most: the pocketbook. In 2006, the year McDonald indicated as most fair for comparing the two systems, the GSHP beat out the conventional system with about $2,000 in energy savings.

The load profile report of a random day shows a marked difference in the kilowatt hour usage between the cooling modes of the conventional and GSHP systems. One load profile report dated May 15 showed a 392 kWh usage for the conventional system and a 282 kWh usage for the GSHP. Advantage GSHP for 28 percent less use of electricity that day.
Beyond the Numbers: A Quick Qualitative Analysis

While hard data was truly the goal behind the project involving McDonald’s buildings, other opinions of a more qualitative nature were also formed. McDonald’s company occupies the GSHP building while he leases the conventional building to Texas Instruments. In the role of a building owner with tenants, he has discovered other benefits of a building equipped with GSHP.

“In the conventional building with TI, unfortunately, we’ve had a series of complaints over the three years about mechanical noise and vibration, which required modifications to the building and its mechanical system to correct,” McDonald said. “We haven’t had that complaint with the geo building.” He has also found maintenance and roofing to be more challenging on the conventional building because of all the rooftop units than with the clean roofs of the GSHP building.

However, McDonald, Bell and O’Brien all stressed that taking on a GSHP installation required more effort and attention in proper planning and design, and its success depended more on the quality of the team than is usually the case with a conventional building. Was the extra hassle worth it for GSHP? “Absolutely, we are committed to bringing to market better systems that improve cost efficiencies as well as environment impacts,” McDonald said.

“We’ve always dealt with hassles short-term,” said O’Brien. “What’s being valued now is really looking at the long-term hassle of the decisions you make with a short-term attitude. It’s important that you put together

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The Results are in, Now What?

After going through the painstaking detail necessary to provide such an impressive comparative HVAC analysis, almost everyone involved in the process went away with something beneficial. For Brown, who provided the impetus for the project, the results were exactly what he needed to evaluate GSHP and its potential role in future city of Palo Alto projects.

“The key will be to go forward now with the data and develop a program with the city to do incentives for using this technology for our citizens,” Brown said. In fact, the city has been moving forward since the results of the test were posted. The city’s children’s library, a historical building, will be installing a GSHP system not only because of its proven energy efficiency but also because of its low visible impact and quiet operation, Brown said.

Palo Alto’s planning department has also caught the buzz from Brown’s real-world analysis and plans to promote GSHP in city projects. Brown has hopes that an upscale community with 46 homes and a 65,000-square-foot country club facility currently in very early planning stages may become an all-GSHP community.

McDonald even gained more from the project than just an energy efficient building. In his job as a general contractor, he can now pull GSHP from his “quiver of solutions” when dealing with his own clients, he said. “The primary reason I moved forward with the project was because if it was successful, as it has proven to be, I could bring that to other commercial building owners, clients, architects and other engineers that I work with,” McDonald said.

O’Brien said the wealth of data on this comparison has really been an eye-opener to how mechanical systems work and served as an excellent teaching tool for the younger engineers in his firm. “After 30 years of engineering, to have this kind of data, it’s fascinating to see what the systems really do,” he said.

Bell was able to see his data collection and report-
ing tools used in a broader scope than ever before. “I have always wanted to do a project like this where we were actually evaluating technology rather than evaluating performance of individual machines,” Bell said. “It’s really been an opportunity of a lifetime.”

And the Winner is...

Brown’s comparison put conventional heating and cooling technology in head-to-head competition with GSHP technology in a way that may never have been done before. It’s been said that numbers don’t lie. Numbers that come from sources who had no vested interest in GSHP outperforming conventional technology ring even truer.

What do a city government utility official, a general and commercial building contractor, an engineer and a data processing guru in California have in common? They all have a new-found appreciation for GSHP and have seen for themselves why the industry is eager to endorse the technology.

“I have been promoting this type of technology to anybody that has come and asked,” Brown said. “I’m really excited about it. I think it’s just a better, cleaner technology, and I’m hoping that this catches on and everybody can benefit.” Brown may be dangerously close to joining the ranks of self-proclaimed geo-junkies.

Then there are the final words of the man who offered his property as the testing site for GSHP technology he’d never really heard of until Brown came along.

“I think it’s a better way to do the job,” McDonald said. “It’s a better way to heat and cool your building.” Sound familiar?

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Garrett Buildings
Oklahoma City, Oklahoma

By Dara McCoy

This 20,000-square-foot office building in Oklahoma City, Okla. saves 50 percent on annual energy costs using a closed loop geothermal system.

How much difference can ground source heating and cooling really make? That is the driving question behind the “Dare to Compare” series. In Palo Alto, Calif., a ground source heat pump (GSHP) heated and cooled office building runs 30 percent cheaper in total energy costs, saving its owner thousands each year. In Oklahoma City, Okla., Steve Garrett, president of Garrett and Company, LLC owns two adjacent buildings where the GSHP building operates at almost 50 percent less than the conventional building in total energy costs.

However, there are some major differences in this comparison besides location. With the Garrett buildings, more effort must be put into digging out the GSHPs’ impact because the buildings are not as identical as in Palo Alto. Yet, the differences do little to minimize the GSHPs’ portion of such a huge savings difference. So, grab a shovel—what will be unearthed makes another bold statement for the GSHP industry.

What’s the Difference?

For starters, Steve Garrett was a businessman who needed an office for his businesses in real estate and development. In 1987, he built a 15,000-square-foot, two-story office building utilizing a VAV air handler system with an air-cooled condenser and a gas-fired boiler.
for heating and cooling needs, which cost $100,000 to install in 1987, according to a ClimateMaster case study. Ten years later, he needed more office space.

Garrett’s heating and cooling contractor recommended a closed-loop geothermal heat pump system for the new building. In 1997, Garrett built a very similar office building on the same property as the ’87 building. He installed a vertical loop field of 40 boreholes at 250 feet deep underneath the parking lot, which connected to 16 ClimateMaster water source heat pump units throughout the building and cost $128,700 to install in 1997, according to the case study.

“We have essentially two identical buildings that have identical exterior envelopes, same amount of glass, facing the same direction, same kind of occupancy and same layout and usage,” said Dan Ellis, ClimateMaster president, whose company designed the GSHP system for the Garrett building.

The building differences that concern the HVAC comparison are 1) the conventional building and system is 10 years older than the GSHP building and system, 2) the conventional building is 5,000 square feet smaller than the GSHP building, 3) the GSHP building utilized improved insulation, BuildBlock, a type of Insulated Concrete Form (ICF), on the exterior walls and more energy efficient windows.

**Does Age, Size or Material Matter?**

In terms of advancements in HVAC technology, age matters. Ellis admitted that if Garrett were to update the conventional system installed in 1987 with the best VAV system today, he could probably see a 20 to 30 percent jump in efficiency of the heating and cooling portion of energy costs. Just because newer conventional technology would help the conventional building in our head-to-head comparison doesn’t mean Ellis was willing to throw in the towel.

If Garrett were to also update the GSHP water source units installed in 1997 with the best water source units available today, he could see an almost 50 percent jump in efficiency of the heating and cooling portion of energy costs based on the 13 Energy Efficiency Rating (EER) of ’97 units and 20 EER achievable in 2007, Ellis said. Such updates would put the units on an equal timeframe in HVAC comparison and would, at the very least, cancel each other out when trying to recalculate the energy savings numbers. “I really don’t think the age difference is that big a factor when you think that way,” he said.

Obviously, the size of a building directly impacts heating and cooling efficiencies. More space to heat and cool, more people and equipment to affect the heat load, and so on are important factors. Having 20,000 square feet of space to heat and cool compared to the conventional building’s 15,000 would seem to be a major disadvantage to the GSHP system when numbers are being pulled from the two buildings’ energy bills, but this is not the case.

From July 2005 to June 2006, Garrett’s total energy costs (gas and electric) for the VAV building totaled $23,783 while the GSHP building cost $22,491 despite the 5,000 additional square feet of the GSHP building. In the 06-07 year, the gap widened with the VAV building’s energy bill totaling $23,917 and the GSHP building’s bill totaling $19,107. That’s savings of $1,292 in 05-06 and $4,810 in 06-07 on energy bills of the 5,000-square-foot bigger GSHP building.

Now what about materials? Dr. Xiaobing Liu, systems engineering manager for ClimateMaster, used
eQuest, a software program developed by the Department of Energy, to put the discrepancies between the buildings’ construction materials to rest. According to Liu’s eQuest simulations, only 2.5 percent of the 50 percent annual savings seen in the newer GSHP building can be attributed to the ICF insulation and double low-e tint windows. That leaves about 47 percent of the savings difference up for grabs, and the GSHP system primed for taking the credit.

**Putting Aside Differences**

With all the relevant structural differences of the two comparison buildings laid out, that annual operating energy savings of 50 percent for the GSHP heated and cooled building still looms large. Can any one or combination of the aforementioned disparities between the 1987 conventional building and the 1997 GSHP building explain that enormous gap better than the disparity between methods of heating and cooling?

In the monthly energy use graph (figure 1), Ellis calculated the kBtu usage per square foot to offset the size difference in the two buildings. In the monthly peak demand graph (figure 2), he displays the peak demand in watts per square foot each month.

Ellis also gathered all the energy bills and maintenance costs of the two respective systems from Garrett to calculate the total energy operating costs of each building and divided it by the square footage of each building. For the 05-06 year, the VAV building cost $1.87 per square foot in energy operation compared to $1.14 for the GSHP building. In 06-07, the VAV building cost $2.13 per square foot and the GSHP $9.67. “We’ve had this data year after year,” Ellis said. “Every two or three years, we’ll go back and the savings are consistently there.”

Putting a magnifying glass to the maintenance costs between the two systems presents a stark difference. In 05-06, Garrett spent $4,243 on maintenance costs to the VAV system, which includes a monthly $280 service contract to maintain the system. In the same year, he spent $250 to maintain the GSHP units. It just wasn’t one bad year for the VAV either. In 06-07, the VAV ran up an $8,102 maintenance bill compared to the GSHPs paltry $70 for air filters.

“The low maintenance and operating costs of the
Loading Up on Savings

Ellis said differences in load factor between the two systems were also important to note. He mapped the load factor of the two buildings on a line chart (figure 3 on page 34).

To quantify the importance of load factor to utilities, Ellis got this explanation from OG&E: Just a 1 percent improvement in load factor for OG&E system wide would generate $35 million in additional annual revenue (a 2 percent increase) and $6 million in additional annual operating income (also a 2 percent increase). This is because they are getting higher utilization of their fixed assets in generation, transmission, and distribution. The only way they can increase system wide load factor, is building by building.

“The geothermal Garrett building has an average load factor of 47 percent and the VAV building average is 40 percent,” Ellis said. “This is a 7 percent improvement, which is very significant in light of how much even a 1 percent improvement is worth to OG&E and ultimately to their customers in the form of lower rates.”

The Biggest Difference of All

There’s no hiding the fact that there are differences between the Garrett buildings. Age, size, insulation, and heating and cooling systems are all differences in two buildings that, if you saw them standing side-by-side, the naked eye might not discern. The biggest difference of all also can’t be seen by the casual observer. The difference is in all the charts, graphs and numbers scattered through-

geothermal system makes financial sense for me as an owner and occupant of the building,” Garrett said. “Plus, you add that it’s environmentally friendly and saves energy—going geothermal is the right choice.”
Monthly Electricity Supply Load Factors

“The electric utility load factor is a measure of how efficiently the power generation system is being utilized. A low load factor demonstrates more erratic usage. A high load factor is less costly to serve because the generation capacity required is more level throughout the year,” according to a ClimateMaster case study.

Figure 3

out these pages—only visible because Steve Garrett opened up his files, Dan Ellis calculated them and Dr. Xiaobing Liu simulated them.

The biggest difference between the two buildings is a 50 percent lower operating cost for the GSHP heated and cooled building. Very little can be taken away from that number—2.5 percent—and attributed to anything else other than GSHP technology, despite pouring over structural disparities and their impact to this comparison. “These are statement-making projects for our industry,” Ellis said of the ‘Dare to Compare’ projects. “There are so many things that say they can save you 30 to 50 percent, but we really do save you that. Other products that make those claims save you 30 to 50 percent of a small part of your bill, the part that product influences, but we’re talking the whole building.”

Garrett’s original office building is heated and cooled with conventional equipment and displays a standard rooftop unit.
Canadian Prisons Highlight Geothermal Versatility

By Kelly Green

Innovation and efficiency are abundant in the Correctional Service of Canada’s (CSC) Atlantic region thanks to the flexibility of ground source heat pump technology. All five of the region’s prisons, Nova, Atlantic, Dorchester, Westmorland and Springhill, already operate or soon will operate with ground source heat pumps. None of the applications are standard, but for Brian Oblenes, CSC project leader for the Atlantic region, it’s the design flexibility that makes geothermal such a great fit for them. Oblenes said he can use ground source in many different scenarios.

“We have done it combined with boiler plants, without boiler plants, on new buildings and on renovations,” Oblenes said. “For heating and cooling you can use it for just about what ever you want.”

Two complications with conventional heating and cooling methods initially motivated the region to install ground source technology. First, natural gas lines do not run near the Atlantic region institutions. Second, CSC Green Plan Initiatives mandate that electric resistance heating is not to be used unless the coefficient of performance (COP) is at least 3-to-1. Confronted with these challenges, Oblenes knew ground source was his best option. “I’m kind of simple in the sense that I don’t like to run boiler plants and a whole lot of other equipment that we don’t have to,” Oblenes said. “Therefore, if I wanted to be all electric, I had to come up with a system that was equivalent to or better than a COP of 3.”

Geothermal was that system. Oblenes said: “What we have strived to do with ground source is come up with systems that are better than COPs of 3-to-1. We have done that. If you were to properly design a (geothermal) system today you could get close to 4-to-1. There’s no other system out there that I know of that would allow you to do that.”

The Nova Institution for Women—Atlantic’s First Geothermal Experience

Following the creation of the Green Plan Initiatives in 1992, the Atlantic region began design and construction on the Nova Institution for Women. The facility opened in 1995 and houses a total of 70 minimum, medium and maximum-security inmates. Outfitted with 21, 3 1/2-ton heat pumps, the facility is completely
heated and cooled by ground source technology.

Pumping costs, which Oblenes said are costs many complain about on geothermal installations, were reduced dramatically in the Nova project using a unique loop configuration. Heat pumps were placed in a series with the boreholes. They are arranged with a heat pump followed by a borehole followed by another heat pump and so on. “What happens is you basically recondition the water after it goes through the heat pump by sending it through another borehole,” Oblenes said. With this system, Oblenes said the 63 tons of heating is circulated at a rate 10 gallons per minute, with only two 1 1/2-horsepower pumps. “That’s unheard of,” he said.

The facility’s cooling load is a mere quarter of its heating load. Oblenes said the facility is cooled by pumping loop water straight through fan coils. He said they do not run compressors at all in the summer to cool.

Soon after opening, the institution was honored by the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) for innovation in design.

**Westmorland and Dorchester—One Site, Two Loads**

After successfully constructing Nova according to its Green Plan Initiatives, the CSC then began to renovate and improve existing structures. The Dorchester Institution, which was built in 1880, is the second oldest continually operating corrections facility in Canada, according to the CSC Web site. Today, it houses 450 medium-security inmates. Its neighbor, the Westmorland Institution, sits adjacent to Dorchester on the same site. Westmorland, a minimum-security institution, was originally an annex to Dorchester, but in 1975 was established as an autonomous institution.

Because of the buildings’ age and lack of space for ground heat exchangers, both institutions are heated from the boiler plant. All of the cooling, however, is provided by direct expansion (DX) ground source heat pumps.

DX heat pump systems differ slightly from closed-loop geothermal applications. “In a closed-loop system, you have to pump the water around through the ground heat exchanger,” Oblenes explained. “In a DX system, the refrigerant goes to the ground heat exchanger on its own so you save those pumping costs.” DX systems also use copper as the piping material instead of high-density polyethylene plastic as is common in closed-loop applications. The DX system also preheats fresh air coming into the building.

Maritime Geothermal manufactured the DX units operating at Westmorland and Dorchester as well as most of the other units in service for the CSC. Oblenes said the region went with Maritime because the manufacturer was willing to custom-make units to fit their needs. When the Green Plan Initiatives prohibited the use of R12 and R22 refrigerants, for example, Maritime designed heat pumps for the Nova Institution that used 407C refrigerant instead. “Most of our heat pumps have been from Maritime Geothermal,” Oblenes said. “They were the ones we started out with at Nova because they custom built the heat pumps to our needs. The majority of what we have is theirs because they will do things that most manufacturers won’t do.”

In addition to the DX units that cool the Westmorland and Dorchester Institutions, other units provide heating to some farm buildings on the site. Westmorland operates a large farm for inmate employment.

**Springhill Institution—Pairing Geothermal with Radiant Floor**

The Springhill Institution is CSC’s largest fenced correctional facility sitting on 412 acres (167 hectares). The medium-security prison houses approximately 400 inmates. Constructed in 1967, the facility underwent a
renovation in 2000 that included new living units with geothermal and in-floor radiant heating. As with Westmorland and Dorchester, Oblenes said the 57-ton geothermal system at Springhill is used in conjunction with the institution’s central heating system. The heat pumps provide cooling and preheat the domestic hot water. A combination of DX and traditional water-to-water heat pumps serve the facility.

**Atlantic Institution—A System Fit for Growth**

The Atlantic Institution is the region’s only maximum-security facility. Since its opening in 1987, this facility has also been renovated to include an energy-efficient geothermal application. Originally, the facility operated a 60-ton chiller for cooling. It now uses well water and a heat exchanger. The idea to use geothermal to cool the facility originated when the CSC decided to set up a fish rearing operation at Atlantic for inmate employment. Oblenes said they discovered a good source of water when drilling the wells for the fish hatchery, and thought they would explore the possibility of connecting these wells to a heat exchanger that would cool the facility. What they came up with was a system that first runs the well water through the heat exchanger absorbing heat from the building and increasing the temperature of the water. The warmed water is then transferred to the fish rearing operation, which generates better growth in the fish.

“When we did that we were able to shut down the 60-ton chiller,” Oblenes said. “We haven’t run that chiller for a number of years.”

Atlantic is also currently undergoing an expansion. Oblenes said the CSC is adding an emergency response team facility to the institution that will be heated and cooled with ground source heat pumps.

**New Innovations Coming All the Time**

For future projects, Oblenes said he will implement yet another specialized geothermal application. He calls it a two-tank system, and it operates with a heating only heat pump. “The most reliable and cheapest heat pump to build is the heating only heat pump,” Oblenes said.

In this application, the heating only unit is placed between two tanks of water. The tanks are connected to a ground loop with a three-way valve. By design, the heat pump does only one thing: transfers heat from one tank, the cold tank, to the other, the hot tank. A computer then monitors the tanks and adds water from the ground loop to whichever tank requires modification in temperature. “This way you have the simplest and cheapest heat pump available, and all you do is change the groundwater from one tank to another,” Oblenes said.

In the summertime, when the unit is transferring a larger amount of heat to the hot tank, the loop will feed groundwater to that tank to cool it down. In the wintertime, when the system draws heat from the hot tank, the temperature of the cold tank drops so the groundwater is routed there to warm it up. Because the unit is heating only and contains no reversing features, an application like this allows Oblenes to have cooling or heating available anytime he needs it.

“This with the advent of computers and computer rooms there’s all kinds of closets around buildings today that need cooling 24/7,” Oblenes said. “You always have to have cooling available.”

Since the CSC’s Green Plan Initiatives came into effect over 15 years ago much has changed on the campuses of the Atlantic region’s five prisons. Each is now updated to the energy-efficient standards without using natural gas or electric resistance heat. The region was able to renovate the facilities and will continue to expand and meet its sustainability goals thanks to the flexibility of geothermal technology. Oblenes said the region is being very “green” by using ground source heat pumps.
Large Commercial Project Considerations

The dramatic fluctuations in energy prices over the last few years have significantly increased commercial GSHP market opportunities. Here are some points to consider when approaching large commercial projects:

• First Costs are always an issue. In large commercial projects, a general rule of thumb is GSHP system cost is approximately the same as a quality 4-pipe boiler/chiller system’s cost.
• Drilling Costs for water well drilling are much higher than geothermal drilling. When estimating a project, be sure to use production geothermal drilling costs, not water well costs.
• Estimating Cost References—currently, published reference materials have little, if any GSHP ground coupling costing information.
• Life Cycle Costs—GSHP systems have outstanding LCC performance. However, qualify your client. If the client will not be a long term owner/operator of the property, LCC benefits may not be a part of the buying decision.
• Ground Heat Exchange—consider all types of ground heat exchange both closed and open loop. Evaluating governing codes/regulations and site conditions will eliminate some or most ground heat exchange alternatives, identifying the ground heat exchange technology that best suits the site.
• Closed Loop Ground Heat Exchangers:
  • Pond or lake heat exchangers are typically the lowest cost, but require a body of water with acceptable size and depth.
  • Horizontal ground heat exchangers typically cost less than vertical ground heat exchangers if trenching conditions are suitable. However, they can encumber 2-3 times more land area than vertical systems.
  • Vertical ground heat exchangers are typically the most costly, but require the least amount of land area.
• Closed Loop Ground Heat Exchanger Locations:
  • “Green” areas are the first choice—open land areas such as lawns, parks, athletic fields, etc. that are intended to remain the same for the life of the facility.
  • Under parking lots is an excellent opportunity to utilize an otherwise unusable piece of property. There have been some concerns about putting loop fields under parking lots, but they are unfounded. Loops under parking lots have a long and very satisfactory operation and performance history in the GSHP industry.
• Under structures is being considered more frequently. Urban development/redevelopment or commercial properties with building footprints that leave no open or parking lot areas are being considered for GSHP applications by environmentally and/or energy conscious owners. The industry is divided on this type of application; some professionals consider it acceptable practice, others do not.

Mr. Rawlings has more than 30 years experience in the geothermal industry. He is a Certified Geoexchange Designer (CGD) and an IGSHPA Accredited Installer and Trainer.
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