Geoexchange: Getting it Right

By William C. Johnson and Paul Ormond

Here's a real-life scenario. A prestigious institution of higher education entered into an agreement with a developer to build new space on campus. They wanted to achieve LEED Gold certification, and to help meet this goal they incorporated a geoexchange system into the design. We're good so far.

Then, as is often the case, they applied misguided geoexchange design methods. Not only was the well field designed to be 30 to 50 percent larger than needed (translating to a million dollars in costs), but it was configured in a manner that would simply heat up over time. Entering water temperatures were predicted to be well over 120 degrees Fahrenheit within 10 to 15 years of operation. Ultimately, they ended up with a system that cost much more than it should, and that was designed to fail.

SO WHAT HAPPENED?

Unfortunately, many designers fail to conduct thoughtful analyses when determining how fields will perform over time, and many still rely on residential-scaled rules of thumb for even large-scale geoexchange systems. These practices were initially developed for small well fields and are inadequate to predict and analyze how larger institutional/commercial-sized systems will perform. This often results in well fields that are much larger than they need to be—and cost much more than necessary—that will still heat up over time and result in system failure.

It's one of the more unusual characteristics of large geothermal system design—bigger is not always better, and it's entirely possible for a system to be much larger than it needs to be, yet still fail over time. This can readily happen when the design tools developed for small residential systems are scaled up and applied to larger systems.

Practices which have been successful for small residential and small commercial systems completely miss the mark for larger-sized systems. Why does this happen? The long-used approaches do not adequately take into consideration heating and cooling load imbalance, which can have major implications to the design and performance of geoexchange systems.

BIGGER IS NOT ALWAYS BETTER

In this particular case, the annual cooling load was about seven times the annual heating load. Robust modeling and analysis would have readily revealed that the geoexchange system was destined to simply heat up and fail within about ten years. However, on this project, this kind of analysis was not performed.

Design techniques exist which can readily manage an imbalanced situation and will not only help ensure long term performance, but result in far less costly designs. For this project, however, one of the fundamental design issues, load imbalance, was not recognized or researched.

Another project setback was that the geoexchanger designer issued bid documents with non-specific provisions related to drilling and well installation procedures. During construction,

prescriptive well field installation specifications and constant on-site supervision of the installation contractors is required, and is not optional, based on extensive forensic evidence of why systems ultimately fail.

Within the first week of this particular project, it was found that each 500-ft well was only 480 ft deep, a 20 ft discrepancy on each well. Some may say, "So what's the big deal?" The big deal is that when applied to over 200 wells, this translates to some 4,000 ft of lost heat exchanger,

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not to mention the extra $32,000 (at $8/ft) in profit to the installer.

Short drills are common for several reasons: 1) the driller comes to the site with the wrong equipment, often because the specifications and project subsurface information wasn't specific enough; 2) high yielding rock fractures are encountered and, without the right capacity lift equipment to get the tailings out, they stop; and 3) there isn't anyone supervising the process. There are only two ways to prevent these things from happening: tight specifications and constant supervision—both of which will guarantee a properly installed field. Remember, there is only one opportunity to get this right.

LESSONS LEARNED

Ultimately, for this project, an independent design consultant well versed in design and optimization techniques was able to rescue the project from failure. The drilling contractor was held to a higher level of performance and the system was redesigned with additional equipment which, not only addressed design deficiencies, but actually decreased project costs. This resulted in improved long-term thermal and financial performance.

Accurately quantifying field performance is an important step in designing a system that is the proper size and capacity. If done right, optimized geoexchange systems can be one of the most cost-effective, powerful options to accomplish the goal of improved energy efficiency and reduced carbon emissions.

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