METER ENVIRONMENT Ground Source Heat Exchange Systems Instructions

METER ENVIRONMENT

Instructions

IMPROVING THE EFFICIENCY OF GROUND-SOURCE HEAT EXCHANGE SYSTEMS

In an effort to find sustainable energy solutions for heating and cooling buildings, many homeowners, companies, and university campuses are turning to ground source heat exchange systems (GSHE) to reduce energy usage and greenhouse gas emissions. GSHE systems are designed to take advantage of the moderate and nearly constant temperatures in the ground as the exchange medium for space heating and cooling and to heat water for domestic use.

In these systems, water or specially formulated geothermal fluid is circulated through plastic pipes (i.e., ground loops) installed in vertical boreholes. In the winter, geothermal loops tap heat from the ground, while in the summer, heat from the surface is transferred to the ground. Currently, the application of ground source heat exchange systems reduces overall carbon emissions by up to 50%, and according to the U.S. Department of Energy, they are up to 4 times more efficient than gas furnaces.

Contents

ARE GSHE SYSTEMS AS EFFICIENT AS THEY CLAIM TO BE?

The answer, according to researchers at the University of Illinois at Urbana- Champaign (UIUC), is that it depends. Drs. Yu-Feng Forrest Lin and Andrew Stumpf and their associates at the Illinois State Geological Survey (a division of the Prairie Research Institute) at the UIUC and their collaborator, Dr. James Tinjum from the University of Wisconsin–Madison (UWM), is working on a project funded by the UIUC Student Sustainability Committee (SSC) to improve the efficiency of GSHE systems. They also hope to show that ground-source heat exchange systems could be included in the University's multifaceted sustainability plan to reduce carbon emissions on campus to zero by 2050. Members of their research team are trying to determine whether GSHE systems would be feasible for heating and cooling buildings on campus with the existing subsurface geologic conditions.

A TEMPOS thermal properties analyzer will provide a better understanding of how thermal energy is stored and transported in the subsurface.

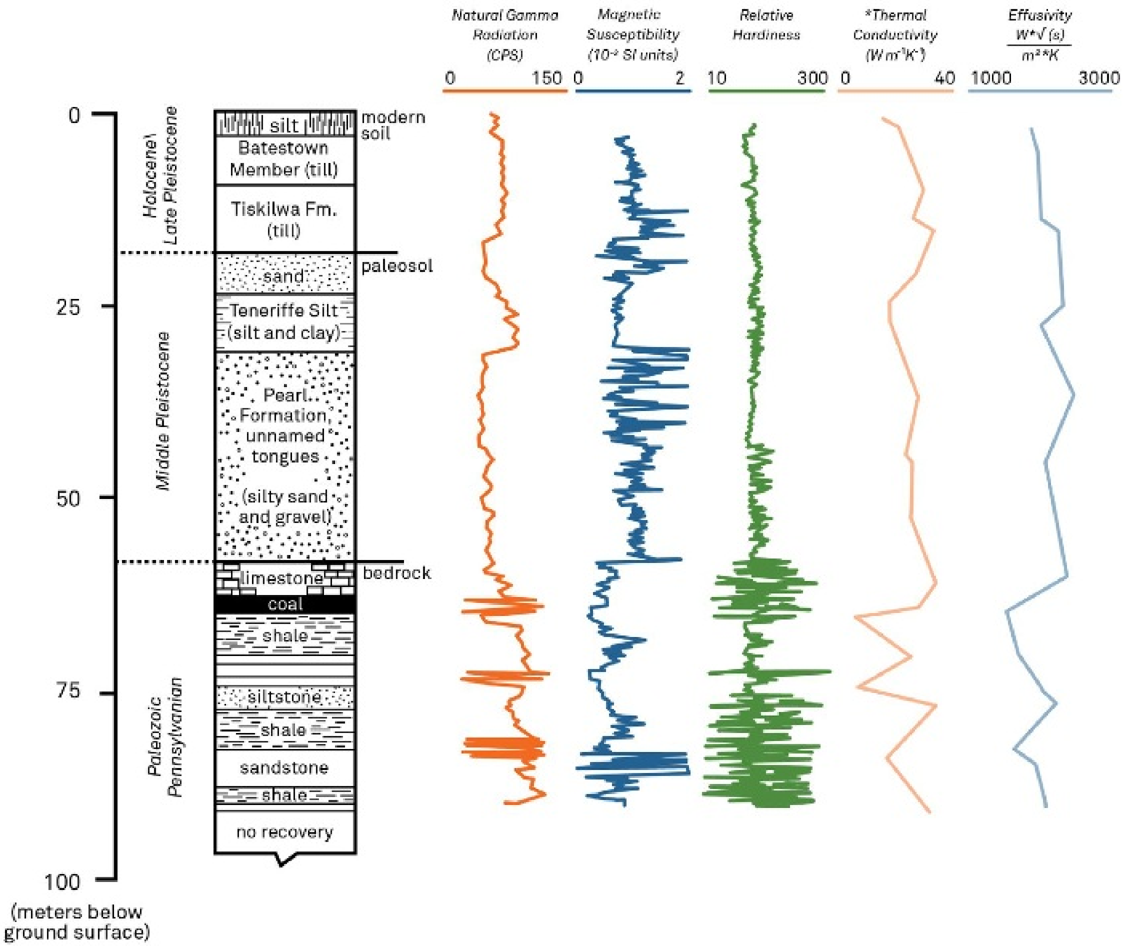
The UIUC is not the first university to explore the development of GSHE systems. For example, Ball State University recently replaced its coal-powered heating and cooling system on campus with a large district-scale GSHE system. Other universities with similar systems include the Missouri Institute of Science and Technology and the University of Notre Dame. These ground-source heat exchange systems are specifically designed to meet future energy needs. However, as Dr. Stumpf notes, “Historically, quite a few large district-scale systems have not achieved their projected efficiencies. Some systems have even overheated the ground, forcing them to go offline. We’re trying to come up with a way to make borehole fields more efficient and prevent these hazards from occurring.”

SOME SYSTEMS DO NOT MEET THEIR EFFICIENCY TARGETS

Dr. Stumpf explains that many times, the contractors that install ground-source heat exchange systems do a single conductivity measurement in the borehole. Or they run a thermal response test (TRT) and then use these calculations to determine the conductivity of the geologic materials at the proposed site. In many cases, however, especially for district-scale GSHE systems with multiple large-bore fields and complex geology, this information does not adequately characterize the site conditions. He states, “Because only limited measurements are taken, many systems have developed problems and are unable to keep up with the thermal demands.”

To assist contractors and other groups involved in designing and installing ground-source heat exchange systems, the UIUC research team is studying the thermal conditions in a shallow geo-exchange system and collecting data from geologic samples from a 100-m-deep borehole located on the UIUC Energy Farm. A fiber-optic distributed temperature sensing (FO-DTS) system is being used to collect detailed temperature measurements in this borehole during and after a TRT. The FO-DTS system is an emerging technology that utilizes laser light to measure temperature along the entire length of a standard telecommunications fiber-optic cable. By analyzing the laser’s backscattered energy, the team can estimate temperatures along the entire sensor cable as a continuous profile. The ground temperature can be measured every 15 seconds, in every meter along the cable, with a resolution from 0.1 to 0.01 °C (depending on the measurement integration time). These data can be integrated with the TRT results, ultimately providing a better understanding of the subsurface thermal profile, which will lead to increasing the efficiency of the GSHE system.

Continuous core collected from the 100-m borehole was subsampled to measure the thermal properties of the subsurface geologic units, and testing was performed at the UWM with a **TEMPOS thermal properties analyzer.** The resulting information will provide a better understanding of how thermal energy is stored and transported in the subsurface.

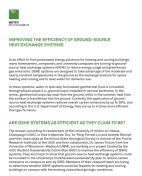


Geologic and geophysical logs from the borehole at the UIUC Energy Farm

EVERY SITE NEEDS UNIQUE DESIGN CONSIDERATION

Dr. Stumpf states that the ground under the UIUC Energy Farm includes various geologic materials that conduct heat differently and require some additional design considerations. He explains, “The upper 60 m of the borehole was drilled into glacial sediment, including till, outwash (sand and gravel), and lake sediment (silt and clay), which have different thermal conductivities. Flowing groundwater in the sand and gravel units also increases thermal transport. Conversely, the bottom 40 m of the borehole penetrated Pennsylvanian-age bedrock, mostly shale and siltstone, which included layers of coal. Unlike the other lithologies, coal has a very low thermal conductivity and is therefore not optimal for a GSHE system. The most efficient GSHE systems avoid low-conductivity geologic units and are optimized to take advantage of flowing groundwater.
To learn more about this research project, visit the UIUC sustainability **project site** or the **ISGS blog**.
Discover the **TEMPOS** thermal properties analyzer

Documents / Resources

	**METER ENVIRONMENT Ground Source Heat Exchange Systems** [pdf] Instructions Ground Source Heat Exchange Systems, Source Heat Exchange Systems, Heat Exchange Systems, Exchange Systems