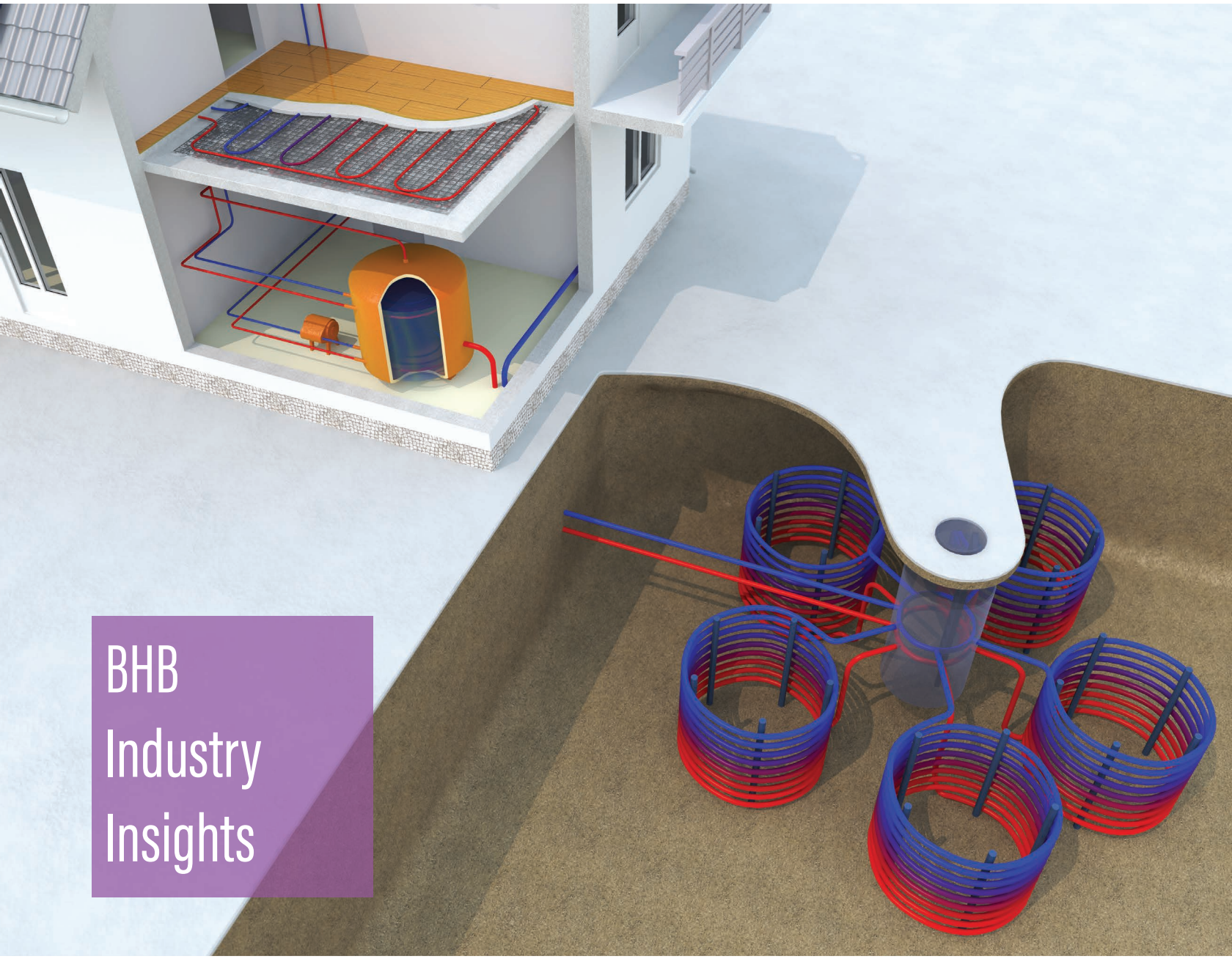

BHB
Industry
Insights

GEOTHERMAL HEAT PUMP SYSTEMS

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BAIRD, HAMPTON & BROWN
building partners

Mechanical System Solutions

The Components to Keeping your Facility Running Successfully

At BHB, we understand that the least glamorous aspects of a building are often the most vital. Regardless of the type of facility you operate, it goes without saying that you want your occupants to be comfortable. Selecting the best HVAC system for your building and maintaining it properly is paramount to successful operations; in some facilities such as healthcare or food service you may even face legal requirements that a certain temperature be maintained for safety reasons.

From industrial warehouses to museums housing precious artifacts, every building owner will be faced with the following considerations when choosing an HVAC system:

- Initial cost to install
- Maintenance requirements
- Operating cost
- Available space for indoor or outdoor equipment
- Efficiency
- Acoustics

Our team of mechanical engineers kicks off each project by establishing a thorough understanding of your facility's intended use, space requirements, and any special prerequisites. We will also work with our in-house civil and electrical engineers to check that city utilities are suited to the building's requirements. After our engineering analysis, we will design an HVAC system to meet the unique needs of your building.

There are many different options when it comes to commercial-grade HVAC systems. In this four-part series, we dive into the following:

- Variable refrigerant flow (VRF)
- Geothermal heat pump
- Direct expansion rooftop units (DX RTUs)
- Chilled water/heating water

Geothermal Heat Pump Systems

Overview

Geothermal heat pumps, sometimes referred to as earth-coupled, ground-source, or water-source heat pumps, use underground piping and the earth's natural temperature as the source for heat transfer (instead of outside air). Despite seasonal temperature changes, the ground a few feet below the earth's surface remains at a relatively constant temperature of 45°F to 75°F – warmer than the outside air temperature during the winter and cooler during the summer. This makes the earth an ideal thermal "battery" for rejecting heat in the summer and absorbing heat in the winter.

Advantages & Disadvantages

Advantages

Efficiency

A geothermal heat pump system is one of the most efficient HVAC systems available. In cooling mode, the Seasonal Energy Efficiency Rating (SEER) for indoor heat pumps can range from 18.0 to 27.0 depending on water temperatures. By comparison, 13.0 SEER is the current minimum standard per the energy code, and most rooftop units or split systems have a SEER rating between 13.0 and 17.0. In heating mode, the Coefficient of Performance (COP) rating measures how effective a unit transfers heat versus the amount of electrical power it consumes. The typical COP for a water source heat pump with 60°F entering water is 5.0. Compare that to an air-cooled package rooftop unit with a COP of 3.6, meaning it takes 1.4 times more energy to get the same level of heating from the air-cooled system.

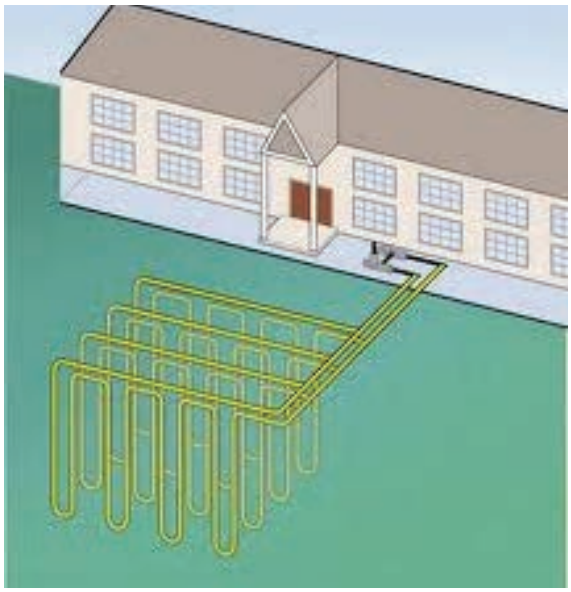
Natural Heat Source

A geothermal system typically utilizes underground piping and the earth's natural temperature as the source for heat transfer. This is an enormous advantage over air-cooled equipment, since all of the piping is below ground, and it isn't susceptible to the same wear-and-tear of equipment located outside in the elements. The piping contains tap water in a closed loop, so no water treatment is required. In addition, since the entire condenser loop is below ground, there are no issues with noisy outdoor equipment. Most geothermal systems in mild climates have the capacity to heat the entire building without the addition of natural gas or auxiliary electric heat.

Flexibility

Indoor heat pump units are very flexible. They typically range in capacity from 0.5 to 25 tons. They can be installed vertically on the floor, or horizontally above a ceiling. Rooftop units, vertical stack units, and console units are also available. A water to water heat pump (sometimes called a desuperheater) also can provide domestic hot water for a building's plumbing needs. Some common options for heat pumps are electronically commutated motors (variable speed), two-stage compressors, and variable speed circulator pumps.

Disadvantages



Below Ground Installation
A typical geothermal system utilizes several deep wells to install piping loops below ground. They often range from 150 to 450 feet deep. It is a fairly expensive process to drill the well, install the piping loop, fill the void with grout, and connect each well to the manifold. Some less common methods for geo piping installations include horizontal loops, pond loops, or open ground water systems.

Space Constraints
Since the wells need to be spaced 15 to 20 feet apart for heat dissipation, a significant amount of land is required. However, well fields can be installed below areas like football fields or paved parking lots.

Summary

Although the geothermal heat pump system comes with a higher installation cost, the savings returned to the owner in energy make it a worthwhile choice long-term. Because of this, we recommend this type of system to owners that will operate the HVAC system for the life of the building, typically 25-35 years, and have sufficient real estate for the well fields. Good candidates include new K-12 schools, higher education institutions, and municipal buildings. Not only does this system have a longer-than-average lifespan, but because it takes advantage of the earth's natural temperature, a geothermal heat pump is also one of the most efficient systems available.

Case Studies

Keller ISD Timberview Middle School

BHB provided the mechanical, electrical, and plumbing design for Keller ISD's new 185,000 SF intermediate school. The 32-million-dollar project included the implementation of a geothermal ground source heat pump system that was utilized for heating and cooling. Geothermal was the best option for this facility because the district would not need to replace outdoor units, and the indoor units would provide individual temperature control for each classroom and/or zone. An added benefit was that geothermal well fields were designed to last for the life of the building and included polyethylene piping with a 50-year warranty.

Ventilation is usually the main, and most common challenge for these types of projects, and even more so for Timberview Middle School since the LEED credit EQc2 required 30% more outside air than the current ASHRAE standard. To meet this, energy recovery ventilators were utilized to pre-condition the incoming outside air so heat pump tonnages did not have to be increased.

Consisting of 488 wells drilled in 10 well fields located below the football field, parking lots, and some empty grass areas; the energy efficient design helped the project achieve LEED silver certification and increased the school's overall energy savings by 25%. The project was also awarded the EPA's National Excellence Award for Indoor Air Quality Plan.

All Saints Episcopal Upper School

Baird, Hampton & Brown provided the MEP engineering design for a new two-story, 81,000 square-foot upper school building. The project began design in 2003 and completed construction in 2006. The building houses typical classrooms, administration spaces, a theater/lecture hall, a large art classroom, engineering classrooms, computer/chemistry/biology/physics labs, a library, and a full commercial kitchen and cafeteria.

Several system types were considered for this project, and geothermal was the clear favorite for the following reasons:

- Efficiency - Water source heat pumps offered a SEER of 20.
- A constant ground temperature of 68°F is sufficient for the water source heat pump to provide heating and cooling year round. No additional source of heating was required.
- The campus had adequate land to install well fields. Once installed, the geo piping was a minimum of 48 inches below grade and will be maintenance-free for the life of the building.

The geothermal system consists of six geothermal well fields containing 390 wells (each 250 feet deep), spaced 15 or 20 feet apart below and around parking lots. A total of 68 indoor water source heat pumps each utilize two small pumps to circulate condenser water to/from the designated well field, which allows each unit to decide if it needs to heat or cool independent of what is happening to the other units around it. Three dedicated outside air units, tied into the same geothermal water loop, also provide pre-conditioned fresh air to the heat pumps. All geothermal piping, indoor and outdoor, is polypropylene with fusion joints, and carries a 50-year warranty from the manufacturer. All new units have controls interlocked with the existing control system that serves the entire campus.

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