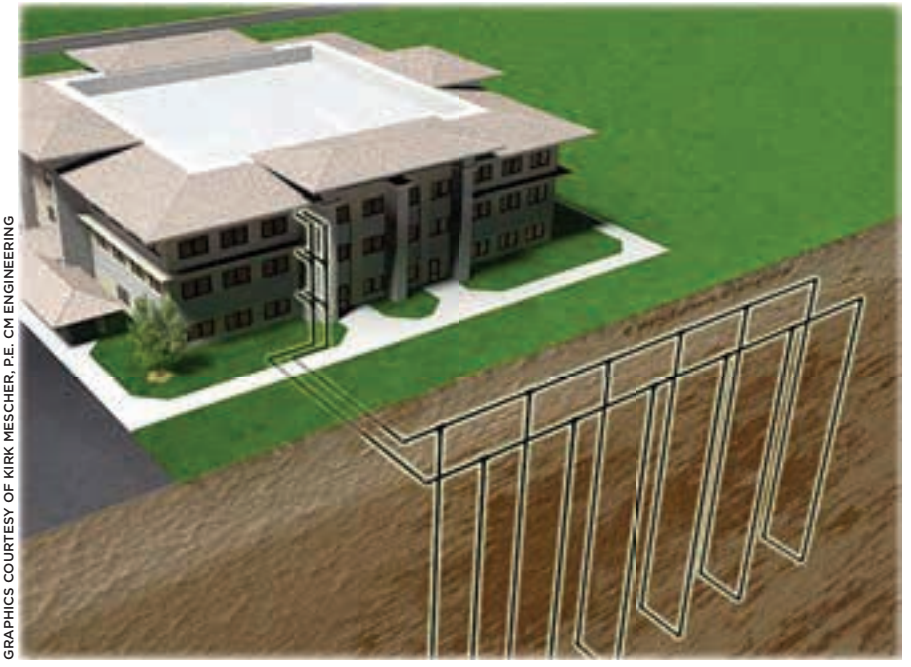
Geothermal Heating and Cooling: Digging Deep for Energy Savings

Explore the wide-ranging benefits of geothermal heating and cooling.

By Luann T. Kolstad, CSBO



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Prospect Heights School District in Illinois serves approximately 1,550 PreK–8 students in four buildings. Three of the schools and the administration building are located on one main campus; the fourth school is located approximately one mile from the main campus.

In early 2012, the district's 10-year life safety plan and facilities master plan provided a pretty dismal picture of the buildings' mechanical systems:

- Obsolete unit ventilators and controls
- Boilers at the end of useful life and beyond
- Air-handling units at the end of useful life and beyond
- No air conditioning in three schools, except in the offices
- The heating, ventilating, and air-conditioning system at one school and offices in other buildings all reaching the end of useful life

Because of financial constraints, the district had deferred maintenance and replacement of all mechanical units and thus faced very expensive replacement costs. The cost to replace only the priority mechanical items, which represented approximately 50% of the necessary mechanical replacements, was more than $5 million—and that did not include adding air conditioning.

In 2008, the district received an estimate to air-condition all the buildings at a cost of $3.6 million. By 2012, when added to the cost of replacing only the priority mechanical items, the total exceeded $8.7 million. How could the district justify replacing only 50% of the end-of-useful-life mechanicals and adding air conditioning at that cost?

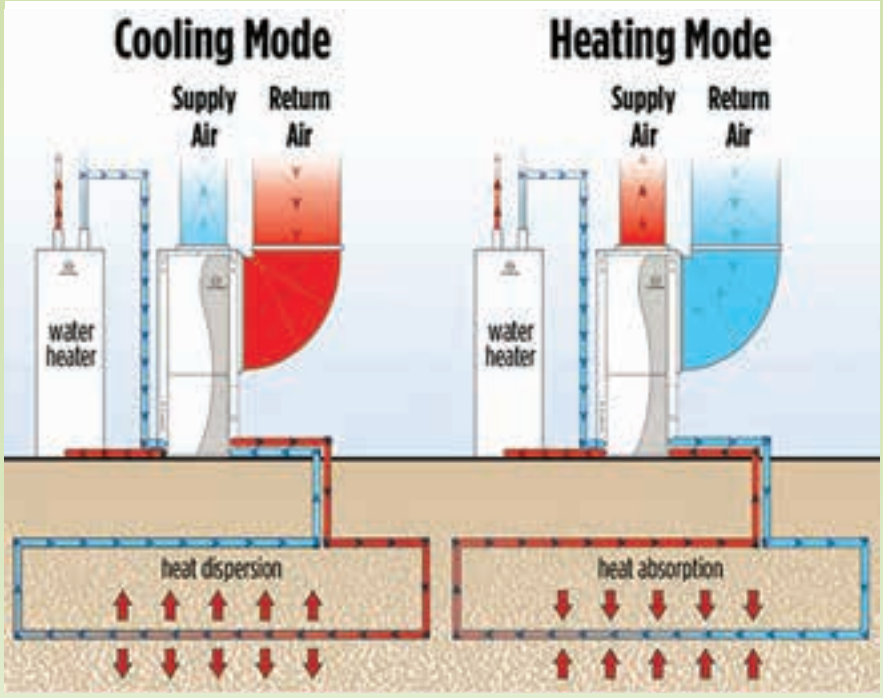
How can we expect students and staff who live in an air-conditioned world outside of school, work and learn in a non-air-conditioned environment?

Many discussions around the district table centered on the need to air-condition the buildings. We had all suffered through large classes with no air conditioning, right? When I asked our board, "Are your home and car air-conditioned?" they answered yes. When I asked if their home and car were air-conditioned when they went to school, they answered no.

The lightbulb went on! How can we expect students and staff who live in an air-conditioned world outside of school, work and learn in a non-air-conditioned environment? We had to go back to the drawing board. Could we find a solution that included replacing all of our mechanicals and air-conditioning our buildings?

HOW DOES GEOTHERMAL WORK?

C**ooling:** In the cooling mode, the earth acts as a heat sink enabling circulating fluid to transfer the heat rejected by the heat pump units from the building zones to the earth, where it is absorbed and stored for future heating requirements. The earth has a built-in time delay. During those times of year when the cooling requirements are highest, the earth's temperature is still relatively cool, allowing easy absorption of excess heat into the ground. The ground temperature actually lags the outside temperature by several months. So by the time its temperature has increased, the building's total cooling requirements have been reduced.



Heating: In the heating mode, the earth acts as a heat source allowing the circulating fluid to extract heat from the earth and transfer it to the space where it can be used for heating. During those times of the year when the heating requirements are highest, the earth's temperature is still relatively warm, which makes heat extraction from the ground easy. In the heating mode, the building unit's function is reversed from that of the cooling mode. The geothermal unit absorbs heat from the ground and transfers it to the building zones that require heat. The ground temperature again lags the outside temperature. So by the time its temperature has decreased, the building's total heating requirement has diminished. For most of the year, the building requires both cooling and heating, allowing the water temperature in the ground loop to remain relatively constant throughout the day.

— Kirk Mescher, PE, Principal, CM Engineering, Columbia, Missouri

Geothermal heating and cooling had been tossed around in different conversations with the board, but they were always dismissed as being too expensive. However, in a discussion with the district's architect, I learned that a school in West Aurora, Illinois, was converting to geothermal heating and cooling. The engineer on that project had successfully installed more than 80 geothermal projects in schools in other states and in southern Illinois. I was pleasantly surprised to discover that his simple one-pipe solution for geothermal heating and cooling was substantially less expensive than other designs I had seen.

The estimated cost to install geothermal heating and cooling in all four schools was $6.2 million. That cost would include replacing all mechanical systems in the four buildings—systems that would require minimal maintenance for at least 20 years. Once work was completed, only the new high-efficiency water heaters installed in the buildings would use natural gas, which equates to a savings on utilities for the school district.

After many months of educating both the board and the community about how this system could work at a much lower cost than traditional heating and cooling systems, we moved forward with our project. In addition to the geothermal work, the board voted to replace ceilings and install high-efficiency lighting, occupancy sensors, and flooring in the facilities.

Work Begins

Beginning in February 2013, the two well fields were drilled and installed: one on the main campus sized to serve a middle school, two grade schools, and an administration building, totaling approximately 200,000 square feet; and one at Eisenhower School, serving approximately 38,000 square feet. The main campus well field was installed under a playing field, and the one at Eisenhower was installed under an empty detention pond.

During summer 2013, MacArthur Middle School was converted to geothermal heating and cooling. The system went online in August 2013, providing much-needed air conditioning in the warm months of August and September.

Although I knew the system would save money, I was shocked when I reviewed our January 2014 natural gas bill. That January, our area of the country experienced some of the coldest weather on record. Yet MacArthur Middle School—at 110,000 square feet—used 384 therms of natural gas. My own humble home of 2,900 square feet used 254 therms of natural gas!

The only gas used at the middle school now is for water heating and kitchen appliances. All building heating is completed by geothermal heat pumps, which are capable of providing 350% more heating energy than an electric heater with the same energy input.

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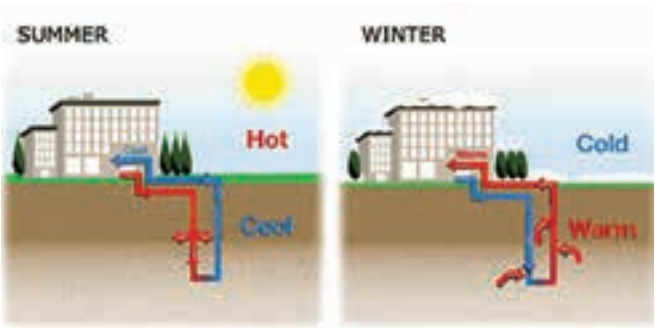
During summer 2014, Anne Sullivan and Betsy Ross Elementary Schools were converted to geothermal heating and cooling. Both facilities came online in August 2014, providing cooling in the late summer and readily switching over to heating in the fall. We learned a lot along the way about our facilities and geothermal heating and cooling—knowledge that will be used as we complete Eisenhower School this summer.

Understanding Our Geothermal System

Traditional unit ventilator systems use boilers and chillers to heat and cool a building. Geothermal systems use the energy storage properties of the earth to both heat and cool a building.

At Prospect Heights, the storage and recycling of heat take place below the ground in a well field composed of thousands of feet of high-density polyethylene pipe, known as the ground loop heat exchanger. The heat exchanger located on the central campus is composed of 120, 500-foot-deep boreholes that are connected to form a single closed loop. The heat exchanger located at Eisenhower School is composed of 32,500-foot-deep boreholes.

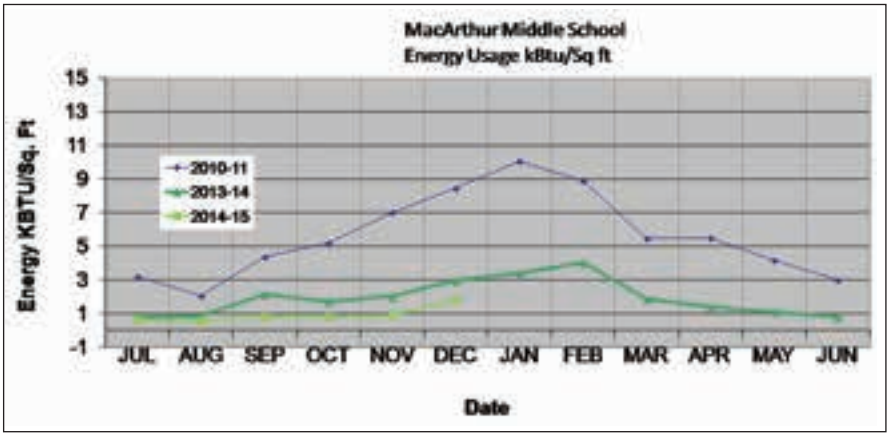


Both Prospect Heights geothermal well field loops use a closed-loop system, which continuously circulates the same water that it was filled with during start-up. There is no transfer between system water and groundwater in the system; therefore, it does not negatively affect water tables in the area. That fact is important since all homes in Prospect Heights are on private wells.

The traditional unit ventilators and air handlers at our schools were replaced with geothermal heat pump units, which reject their heat to the loop or draw heat from the loop based on the heating or cooling requirement for that specific location. Our schools have been designed with a "one-pipe" loop system, which means that one classroom can call for heat, while the one right next door calls for cooling. An added benefit is that the heat pumps generate a minimal amount of noise when running.

Benefits of Our Geothermal Systems

The district is experiencing relatively low operating and maintenance costs for the new geothermal systems. In addition, system maintenance requires no specialized training; we have only had to replace the air filters at MacArthur Middle School, and that was easy, because the filters are typical of those seen in home applications. I think I could even handle this!



Given our results with MacArthur Middle School and the Ross–Sullivan campus, the system has proved to be highly efficient, while providing students and faculty with a comfortable building that will maximize the educational environment for many years to come.

The journey to creating a healthy, energy-efficient learning and work environment for our students and staff has been a rewarding one. One of the best comments I heard after

we finished MacArthur Middle School was from a board member. Her son came home and told her it was too cold in the air-conditioned classroom. It brought a smile to both of our faces.

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As you consider how to create an environment more conducive to learning and work, think about making the facility energy efficient. Seek out the foremost experts in the field. (Geothermal projects in Illinois are overseen by the International Ground Source Heat Pump Association, the National Ground Water Association, and the Illinois Department of Public Health.) Take your time to research your project and educate your board and community—it will pay dividends in the end.

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