Kopernik Space Education Center
Vestal, New York


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When the Roberson Museum and Science Center in Binghamton, New York planned to expand its astronomical observatory in nearby Vestal, the heating and cooling options were limited. Natural gas was not available at the remote site. Although electricity heated the original building, and portable air conditioners cooled it, the Museum wanted to make the new facility more energy efficient. Consequently, a GeoExchangeK (geothermal) system was selected to heat and cool the new building, and to replace the electric resistance heating system in the old building.

"They had no other choice for fuel, unless they wanted to put an oil tank in there," recalls James Miller, the mechanical engineer who designed the system. The facility sits on a high, rocky hill, however, and access to the site is a concern during winter, so an oil-fired system was a less-than-optimal solution, he says.

The Kopernik Space Education Center

The new $2 million Kopernik Space Education Center is an addition to a 2,500-square-foot astronomical observatory. Construction of the Center began in the fall of 1992, and the 8,000-square-foot facility opened in June 1993. The facility houses three astronomical observatories with four telescopes, four classrooms, a space science theater, and laser physics and computer-imaging laboratories. The only educational facility of its kind in the northeastern United States, the Center hosts 15,000 to 18,000 visitors each year, two-thirds to three-quarters of them children under the age of 14 years.

The Center's GeoExchange system provides efficient, reliable, cost-effective heating and cooling. The system promotes the Center's mission by giving the teachers, students, and visitors a working example of an alternative to traditional energy sources and an idea of the benefits of geothermal energy. It also provides a state-of-the-art alternative energy showcase for the local electric utility, which paid for the geothermal system, and real-world data on its operation.

GeoExchange System Details

The 24-ton system includes five heat pumps ranging from 3.5 to 7 tons. Each is independently controlled by a single wall thermostat. An energy management system initiates operation of the GeoExchange system in response to a call for heating or cooling from a thermostat. The system also can be monitored remotely, an important feature since personnel are not always on site. (Temperatures are set

System Features

- Vertical closed-loop
- 16 x 250-foot boreholes
- Two 1½-hp pumps
- 2-speed heat pumps
- Heat pump control system permits remote control and monitoring
- Total heat exchanger length: 8,000 feet
- Total installed GeoExchange capacity: 24 tons (5 heat pumps)

at 72EF when the building is occupied, and 63EF when it is unoccupied.) Two main 1.5-horsepower pumps circulate water from the ground heat exchanger to the building's water loop. Although they usually operate independently, the pumps can work in parallel to provide a maximum flow of 140 gallons per minute.

The building's water loop is connected to eight supply and return run-outs the service the ground heat exchanger. Each run-out has its own 1/6-horse power circulating pump and serves two 1.25-inch U-tubes. Each tube runs through a 250-foot-deep borehole drilled into granite bedrock.

"The bedrock is very close to the surface on the site, and it turned out to be a very good coupling mechanism," notes Miller.

Located east of the building, the field of 16 boreholes makes up the ground heat exchanger. The subsurface temperature of the bedrock remains relatively constant year-round, and heat from the surround granite warms the fluid in the tubes. The heat is carried into the building, where it is transferred to the internal water loop system that heats and cools the facility.

Valves in the system permit the borefield to be bypassed when conditions warrant, or for individual run-outs to be shut off. The heat pump system runs about 15 to 24 hours per day during the summer, and about 5 to 10 hours per day during the winter when there are fewer visitors and the Center is used less.

"It's not like a school house or an office," says E. Jay Sarton Jr., an educational consultant and former Center director. "The heat pump system functions when there are people there, and that can be anytime of the day or night."

Project Costs

The capital costs of the GeoExchange system totaled $75,000, excluding the cost of the system controls, according to a representative of the local utility and the building owner. A cost breakdown was unavailable, so an engineering firm derived the capital cost estimates presented in Table 1. The estimates are based on typical component costs reported in case studies published by the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) and the 1996 Mean's *Mechanical Cost Data* directory. For comparison, the costs of a system with electric resistance baseboard heaters and rooftop air conditioners were estimated.

As shown in Table 1, the price of the GSHP system was almost twice that estimated for the alternative system. The energy savings realized by the GSHP and presented in Table 2, however, provide a simple payback period of just under 7 years. [Because

Table 1: Capital Costs

Equipment	Estimated GeoExchange System Costs	Estimated Conventional System Costs*
Heat pumps	$18,700	$0
Circulation pumps	4,800	0
Ground heat exchanger	29,500	0
Piping, ducting, other	22,000	0
Rooftop air conditioners plus ducting	0	24,500
Electric baseboard	0	10,000
Total	$75,000	$34,500

*Conventional system includes rooftop air conditioning and electric baseboard radiators.
Source: Caneta Research Inc., Mississauga, Ontario, Canada

the local electrical utility, New York State Electric & Gas (NYSEG), funded the geothermal system, the Center actually saw an immediate payback.] Energy expenses were an important consideration for the Center because it has a limited operating budget, and the less it spends on energy the more it can spend on educational programs.

System Performance

The geothermal system at Kopernik has worked well, requiring only routine maintenance such as changing air filters. "Actually, it's been nearly maintenance free," says Tom Krawczyk, an astronomer and educator at the Center. "Occasionally there are some low-water-pressure problems, and the heat pumps go to a default mode and draw on the back-up electric heat system. We just reset the heat pump system once the water pressure comes back."

Table 2: Annual Energy Savings	
Conventional System* (Estimated)	$16,570
GeoExchange System (Actual)	10,409
Total Energy Savings	$6,161
Simple Payback Period (Years)	6.6

*Conventional system includes rooftop air conditioning and electric baseboard radiators.
Source: Caneta Research Inc., Mississauga, Ontario, Canada

A 6-month shake down disclosed some minor problems with the Center's geothermal system. The contractor that built the system left a little air in the line, which had to be bled out, according to Sarton. During the system's first winter of operation, an air intake vent stuck in the open position and one heat pump froze.

The computer control system has been "a little quirky," says Sarton, but steps are being taken to correct the problem. A cheaper, less reliable system was substituted for the Trane controller originally specified in the system plans. Consequently, there were difficulties in controlling the GeoExchange system. Replacing the computer controller could save an additional 10 to 15 percent of total energy, the building owner believes.

System Benefits

According to Sarton, the low operating costs and the payback period of 5 to 7 years calculated during the planning stages are the major benefits of Kopernik's GeoExchange system.

"The capital costs were there, but the [calculated] payback period was reasonable, and the operating costs are low," says Sarton.

"The operating costs are very favorable," says mechanical engineer James Miller, who designed the system, "more so than I thought they would be."

The addition to the original two-dome observatory, note Krawczyk and Miller, almost quadrupled the area of the facility, doubled the lighting per square foot, increased usage by a factor of 10, and still reduced energy expenses.

The system's reliability and its capacity to heat and cool the building are also important. "It's very quiet, and it heats very evenly," says Krawczyk. The single-story Center is well insulated, so cooling is required only a few days each year.

The system's educational value is another benefit for Kopernik, according to those involved in the project. "It's a neat educational tool to show students and teachers how the facility is heated and cooled," Sarton says.

Steven Blabac at NYSEG, agrees: "It's a very good place to demonstrate heat pump technology and to get students thinking about energy conservation."

Right now, heat pump education is done when requested, according to Krawczyk, who says Center staff would like to make heat pumps a bigger part of the educational program. The Center also has a photovoltaic array that is used in educational activities.

Electric Utility Participation

The Kopernik Space Education Center was NYSEG's first commercial heat pump installation. The opportunity to obtain data on heat pump performance in southern New York came in 1991, when the utility was already working on demand-side management and other projects.

"It was a demonstration project for us under our R&D budget. In 1991, the ground-source heat pump technology was just emerging in the northeast. We were pretty convinced it would work well, based on the theory and on installations in other parts of the country. To find out, we paid for the installation, 100 percent of it." says Blabac.

The Kopernik system was followed by several other installations, including a fire station, hotel, and office building.

Future Outlook

Despite the success of such projects, however, the adoption of GeoExchange technology remains slow. The high initial capital costs remain a barrier to greater use of heat pump systems, notes Blabac.

"We had hoped the technology would be adopted more," he says. "Probably the drilling costs are the biggest issue. There are a number of water well drillers, but no heat pump specialists" in the immediate area.

Still, those involved in the Kopernik Space Education Center GeoExchange system remain strongly in favor of the technology. "I'm very pleased with the results," says designer Miller. "As far as I'm concerned, I'd go to a heat pump system in jiffy if I had the right conditions for it."

Project Participants

Building Owner:
Roberson Museum & Science Center, Binghamton, New York, (607) 772-0660

Building Owner Representative:
Jay Sarton, Sarton Educational Services (formerly with Roberson Museum & Science Center), Vestal, New York, (607) 754-8811

Building Operator:
Tom Krawczyk, Kopernik Space Education Center, Vestal, New York, (607) 748-3685

Building Architect:
Trozze and Company, Binghamton, New York, (607) 722-1223

Ground Contractor:
Geotech Geothermal Heating & Cooling, Troy, New York, (518) 273-1066

Mechanical Engineer:
James Miller, Ram-Tech Engineers (formerly with Robson and Woese, Inc., Syracuse, New York), Syracuse, New York, (315) 463-7716

Utility Contact:
Stephen B. Blabac, Coordinator, Commercial/Industrial DSM Programs, New York State Electric & Gas Corporation, Binghampton, New York, (905) 737-6851

Courtesy Caneta Research, Inc.