Ian Shapiro, PE, LEED, AP
Taitem Engineering
Ithaca, NY

GEOTHERMAL HEAT PUMPS

Description:

The term *geothermal* means, "relating to the earth's natural internal heat." A geothermal heat pump system uses the relative warmth, as well as the coolth, of the earth to provide efficient heating and cooling for buildings. A geothermal heat pump system differs from a system that directly provides heat by piping water from underground geothermal hot springs directly into buildings and homes. Such systems are common in countries such as Iceland and Turkey. In contrast, geothermal heat pumps use water which is heated or cooled by the earth, in conjunction with the action of heat pumps inside the building or home, to deliver heating or cooling.

According to the New York State Energy Research and Development Authority, "Throughout New York State, the temperature below the surface of the earth remains in the low 50°F range throughout the year. This stable temperature provides a source for heat in the winter and a means to reject excess heat in the summer. Geothermal heat pumps transfer heat between the constant temperature of the earth and a building, maintaining the temperature conditions in the building's interior space. Water is circulated between the building and the "ground-loop" piping buried in the ground. In the winter, the water picks up heat from the ground and moves it to the building (heating the building). In the summer, it works in reverse—the water picks up heat from the building (cooling the building) and delivers this heat to the geothermal water. Heat pumps make the collection and transfer of this heat to and from the building possible."[1]

The underground, stable-temperature geothermal water can be a natural source of ground water (an open-loop system), or it can be water that is circulated through a set of pipes in the ground (an approach referred to as a closed-loop system). The current trend is toward using closed-loop systems, to avoid water quality problems that are associated with open loop systems.

Within a building, heat pumps most commonly deliver heating and cooling through forced air systems (fans and ductwork). A less common option is to use a heat pump to deliver heating only, by supplying hot water to heat the space. A flexible feature of a geothermal heat pump system is that portions of a building can be heated while other portions are cooled. For example, on a spring day, a room with a large window and full sun exposure might need cooling, while a north-facing room needs heating. As long as the building has been zoned with multiple heat pumps, one heat pump can cool a room, and a separate heat pump can heat another room.

Because of their positive impact on the environment and their affordable and efficient delivery of heat and coolth, the use of heat pump systems is increasing

across the country for use in residential homes and public and commercial buildings. "In New York State, installations have ranged from single family homes, to hotels, to 500,000-square-foot office buildings."[2] In addition, they are a particularly high-efficiency heating option for rural areas, which often do not have access to natural gas.

These systems' capability of heating and cooling different parts of a home or building simultaneously make their use particularly attractive for buildings with fluctuating usage schedules (such as schools, hotels, or offices) or widely varying heating and cooling requirements within individual zones (such as senior housing apartments, single-family homes, or museums), which are difficult to meet efficiently with conventional systems.

Geothermal heat pumps are sometimes viewed as a renewable energy option. However, while geothermal heating from hot springs (such as Iceland's and Turkey's systems) can be considered a renewable energy alternative, geothermal heat pumps are not renewable, and depend on electricity. Only if the electricity is 100 per cent generated by renewable sources (solar photovoltaic, wind, hydroelectric, etc.) can geothermal heat pumps be fully viewed as being a renewable option.

References:

[1, 2] New York State Energy Research and Development Authority, Albany, NY.

Benefits:

For older people, people with disabilities, and families:

- Supports aging in place by increasing the affordability of home ownership and of rental charges.

- The green aspects of this option promote health for all community residents.

- The flexibility of simultaneously heating and cooling different areas of a home or building:
  - Allow for greater responsiveness to the comfort and health needs of different populations, such as older people, bed-bound individuals, babies, both physically active and sedentary workers, and people of varying sizes and tolerances.
  - Saves money by reducing energy usage in areas of a home or building where heating or cooling is not needed.

For homeowners and building operators:

- Contrary to a conventional heating or cooling system, installation of a heat pump system can be carried out incrementally – allowing an owner of a home or building to install heat pumps one by one.

- Systems are space-saving:
  - Smaller equipment—no large boiler, chiller, or cooling tower.

- Pumps can often be installed above ceilings or in closets—no need for a large mechanical room.

For communities:

- Higher efficiency, reduced operating costs, and low maintenance costs:
  - Support the viability of the business community.
  - Result in a lower budgets for:
    - Public buildings, such as schools and public offices;
    - Religious facilities and service agency buildings.

- Rural areas—these systems are a high-efficiency heating option for rural areas, which do not have access to natural gas.

- The green aspects of this option contribute to a community's livability:
  - While heat pumps themselves rely on electricity, the overall system is automatically partially renewable; if the electricity used is generated by a renewable source (wind, hydroelectric, etc.), the entire geothermal heat pump system can be viewed as a totally renewable energy option.
  - The reduced need for electricity use has various environmental benefits.
  - Geothermal heat pumps are a path to zero-energy buildings.

- There are environmental benefits of reduced electricity use.

- Financial incentives are often available for implementing geothermal heat pump systems.

Impediments or barriers to implementation:

- While there is typically a good payback for new buildings, geothermal heat pump systems often have a higher installation cost than conventional systems, especially if closed-loop wells are used.

- Heat pumps can be noisy; if located indoors, they should located where the noise is not objectionable—for example, avoid locating heat pumps close to or above bedrooms, offices, or other areas where noise is objectionable.

- If open-loop systems are used, minerals in the water can foul heat exchangers and cause problems.

Resource—examples :

- For specific examples of geothermal projects in New York State, see the New York State Energy Research and Development Authority Web site: http://www.nyserda.org/programs/geothermal/default.asp. Including:
  - Tannery Pond Community Center—the entire building is operating on a geothermal heating and cooling system, saving over $24,000 per year in energy costs: http://www.nyserda.ny.gov/en/Programs/Renewables/~/media/Files/EERP/Residential/Geothermal/tannery-pond-community-center.ashx.

- Albany Molecular Research, Inc.: http://www.nyserda.ny.gov/en/Programs/Renewables/~/media/Files/EERP/Residential/Geothermal/albany-molecular-research.ashx.
- Bard College: http://www.nyserda.ny.gov/en/Programs/Renewables/~/media/Files/EERP/Residential/Geothermal/bard-college.ashx.
- Indian River School District: http://www.nyserda.ny.gov/en/Programs/Renewables/~/media/Files/EERP/Residential/Geothermal/indian-river-central-school-district.ashx.

Resource—written and web:

- New York State Energy Research and Development Authority (NYSERDA)—provides extensive information, examples, and resources on geothermal heat pumps, as well as a list of some companies that provide geothermal heat pump studies and some that have experience with design and installation of ground loops and mechanical systems in New York State. http://www.nyserda.ny.gov/~/media/Files/EERP/Residential/Geothermal/geothermal-manual.ashx?sc_database=web.

- Geothermal Heat Pump Consortium, Washington, DC (February, 2004; revised July, 2007). *Understanding and Evaluating Geothermal Heat Pump Systems: Information for Evaluating Geoexchange Applications*. 64-page technical assistance manual prepared for the New York State Energy Research and Development Authority, Albany, New York: http://www.nyserda.ny.gov/en/Programs/Renewables/~/media/Files/EERP/Residential/Geothermal/geothermal-manual.ashx.

- P. A. Collins, C. D. Orio, and S. Smiriglio (August, 2002). *Geothermal Heat Pump Manual*. New York City: New York City Department of Design and Construction. The handbook was created for project managers and consulting engineers who were working for the Department of Design and Construction, and includes definitions and benefits of geothermal heat pumps, as well as extensive information on the entire process of installing geothermal heat pumps: http://home2.nyc.gov/html/ddc/downloads/pdf/geotherm.pdf.

- U. S. Department of Energy, *Geothermal Technologies Blog*: http://www.eereblogs.energy.gov/geothermaltechnologies/post/A-Look-Inside-Our-Recovery-Act-Projects.aspx.

Resource—technical assistance contact names:

- Ian Shapiro, PE, LEED AP
  Taitem Engineering
  110 South Albany Street
  Ithaca, New York 14850
  (607) 277-1118, ext. 115
  imshapiro@taitem.com