Geothermal Energy: Applications in Building Construction

GEOTHERMAL comes from the Greek words *geo* meaning *Earth* and *therme* meaning *heat*. So geothermal literally means "heat from the Earth." While the United States uses geothermal energy for only 0.5 percent of its heating use, Iceland's capital city of Reykjavik uses geothermal energy for 90 percent of its heating. The great news is that geothermal can provide heating, cooling, and domestic hot water for many building types in various locations. Also, it is an environmentally friendly, energy-efficient, and comfortable way to cool and heat air and water for one or more buildings at the same time.

Objective:

Explain how geothermal energy is used in various building construction scenarios.

Key Terms:

- district heating
- geothermal
- high-density polyethylene (HDPE)
- horizontal loop
- pond loop
- radiant floor heating
- Slinky™ loop
- vertical loop

Understanding Geothermal Energy

Geothermal is heat (thermal) from Earth (geo). Today's geothermal energy systems can provide cooling as well as air and water heating. Geothermal systems can be installed in single-

family homes or in extremely large buildings. They can be used in **district heating**, which is a situation in which more than one building is provided heating and/or cooling from a central source. Geothermal technology is based on the fact that ground temperatures below the frost line remain at about 50 degrees year round. In Illinois, the frost line is 4 to 6 feet below Earth's surface.

BENEFITS OF GEOTHERMAL

Various choices exist for heating and cooling systems. But there are a number of advantages to geothermal systems.

Longer Lifetime

Geothermal energy systems have a higher initial cost, but they last longer than traditional systems and save 30 to 70 percent of a building's heating bill, 20 to 50 percent of a cooling bill, and 50 percent of a water heating bill. The installation cost for a 2,200-square-foot home may be approximately $15,000 compared to approximately $6,000 for a conventional HVAC system. The initial investment can be reduced by 30 percent using available IRS tax credits. That brings the price tag down to $10,500. For example, if a homeowner of a 2,200-square-foot home pays $200 per month for utilities, he or she could save roughly $100 per month with a

DIGGING DEEPER...

UNCOVERING ADDITIONAL FACTS: Sharing the Power of Geothermal

The first modern district heating system was developed in Boise, Idaho. In the western United States, there are 271 communities with geothermal resources available. Modern district heating systems serve homes in Russia, China, France, Sweden, Hungary, Romania, and Japan. The world's largest district heating system is in Reykjavik, Iceland. Since the capital city of Iceland started using geothermal energy as its main source of heat, the once polluted Reykjavik has become one of the cleanest cities in the world.

Geothermal heat is being used in some creative ways in addition to providing indoor comfort and domestic hot water. Klamath Falls, Oregon, one of the largest U.S. district heating systems, pipes geothermal heated water under roads and sidewalks to keep them from icing over in freezing weather. New Mexico places rows of pipes carrying geothermal-heated water under soil, where flowers or vegetables are growing. This provides a longer growing season and faster growth of outdoor plants.

How can your community benefit from geothermal district heating? Conduct some research, and develop a proposal for your local Planning Department or a local developer. You should include the following elements: background; opportunities; benefits and obstacles; and suggested actions.

geothermal system. Using these figures, the geothermal system would pay for itself in less than four years.

Environmentally Friendly

Geothermal systems are a positive environmental choice. They produce four units of energy for every unit of electricity used to operate the system. Even the best of today's conventional HVAC systems provide a one for one tradeoff. Therefore, less fossil fuels will be used at the power plant, resulting in cleaner air. Geothermal is safer than conventional systems. No gas is involved, so there is no concern about carbon monoxide leaks or fires.

Comfort

Comfort is the third benefit. Geothermal systems are designed to provide steady warm air. Residents do not experience blasts of hot air followed by longer periods without air movement. Cooling with a geothermal system provides better dehumidification than traditional systems, which improves comfort.

Radiant Floor Heating

Many residential geothermal clients choose the comfort of radiant floor heating. **Radiant floor heating** is a system that consists of a series of tubes beneath the floor carrying hot water. Following the principle that heat always moves toward cold, the heat from the tubes radiates up to the floor and provides a comfortable and even blanket of heat.

FIGURE 1. Radiant heat adds comfort and eliminates cold toes.

COMPONENTS OF A GEOTHERMAL SYSTEM

The components of a geothermal system are piping, a water/antifreeze solution, an indoor heat pump, and an air distribution system.

Piping

The piping used in geothermal installations needs to be virtually indestructible because, once installed, it will be difficult to reach it for maintenance. **High-density polyethylene (HDPE)** is a closely packed structure with a high density and high chemical resistance rating. HDPE is the best choice for geothermal systems. Running through the pipes is a solution of water and antifreeze.

Solution

Piping carrying the liquid solution arrives at the heat pump, which contains a condenser and an evaporator coil. The evaporator coil contains a refrigerant, which is a gas. When compressed, the gas becomes much hotter. When allowed to expand, the gas becomes much cooler.

Heat Pump and Distribution

The heated or cooled air, depending on the season, is now directed into the building's duct work using a fan within the heat pump.

INSTALLING GEOTHERMAL ENERGY SYSTEMS

The factors influencing site selection of a geothermal energy system include the amount of land surrounding the building, whether there is a body of water nearby, and the thermal conductivity of the soil. A building will require a one ton geothermal system for every 550 square feet of building. Three distinct designs are used in geothermal systems: pond loop, horizontal loop, and Slinky™ loop. A vertical loop system is used in extreme circumstances.

Pond Loop

The **pond loop** is a design with a grid comprised of coiled HDPE piping that is sunk in a body of water. Approximately 300 feet of HDPE is used for each coil. A grid may include 12 to 14 coils. Spacers are used to separate the HDPE to increase the surface area within the loop, allowing the water to come in contact with more of the piping. The grid or grids are elevated on concrete blocks, floated out onto the pond, and sunk. An underground trench, about 6 feet deep, is then dug from the pond to the building to connect the system. This system is often the most cost-effective. A one-acre pond will power approximately a 50-ton system. This could serve more than 12 home of the 1,200-square-foot size. But the pond must be at least 10 feet deep at the lowest level.

FIGURE 2. A one-acre pond can be the source for a geothermal district heating system.

Horizontal Loop

If the site does not have access to a pond or lake, but it has soil or clay-based soil and a reasonable area of land available, a horizontal loop system may be appropriate. A **horizontal**

loop is a system in which HDPE pipes are run horizontally underground from the house, approximately 100 to 500 feet out. The pipes form a U-shaped configuration. A backhoe is used to dig the trench and backfill the soil.

Slinky™ Loop

A **Slinky™ loop** is a system design modification based on the horizontal loop, but it requires less horizontal space. Pipes are looped, much like a flattened slinky, and they are laid flat in a deep trench. This design saves one-third to two-thirds of the space and is, therefore, more economical.

Horizontal and slinky loop designs require between 400 and 600 feet of piping per ton of system. Soil characteristics will affect sizing. Therefore, the geothermal installer must first conduct a core sample.

FIGURE 3. Installing a horizontal loop geothermal system.

Vertical Loop

If the building site is extremely rocky, is in an extreme climate, has limited land available around the structure, or has mature landscaping, a vertical loop system would be chosen. A **vertical loop** is a system comprised of 150- to 300-foot holes filled with hairpin-shaped loops comprised of HDPE pipe. A drilling company is required to drill the holes. Vertical loop designs require between 300 and 600 feet of piping per ton of system. This is slightly less than horizontal loops because Earth's temperature is more stable at depth. Soil characteristics will affect sizing, so a core sample will be required. In the case of vertical loops, there may be local ordinances involving aquifers.

FIGURE 4. Vertical loop systems are used when space is limited, soil is rocky, climates are extreme, or landscaping is mature.

Summary:

Geothermal energy can provide clean, efficient, and comfortable heating, cooling, and domestic hot water for buildings of all sizes. In addition, it can be used as the basis for a district heating system providing conditioned air for a number of buildings.

Geothermal systems consist of piping sunk in a body of water or the ground through which a water/antifreeze solution flows. The solution picks up the heat from the ground, which is a constant temperature 4 to 6 feet below Earth's surface.

Geothermal systems in the ground are placed horizontally or vertically, depending on the site constraints. Piping carrying this solution is directed into a heat pump where the solution passes by an evaporator coil containing a refrigerant in gaseous form. The gas is compressed to create heat or is allowed to expand, which causes it to cool. A fan moves this heated or cooled air throughout the building.

Checking Your Knowledge:

1. Describe the benefits of a geothermal system.
2. Identify and describe the various system configurations.
3. Explain how the heat pump uses the heat from the Earth to heat or cool a building.
4. What is HDPE, and why is it used instead of other materials?
5. What is the best type of system to use on rocky ground?

Expanding Your Knowledge:

Interview someone who lives in a geothermal home. Be prepared with a series of questions related to comfort, affordability, and ease of operation. If he or she has lived in homes with other types of systems, ask how geothermal compares.

Web Links:

Renewable Energy Sources in the United States
http://www.nationalatlas.gov/articles/people/a_energy.html

Geothermal Maps
http://www1.eere.energy.gov/geothermal/maps.html

Geothermal District Heating System Philip, South Dakota
http://geoheat.oit.edu/bulletin/bull24-2/art6.pdf

Case Studies
http://www.geothermalallianceofillinois.org/category/consumer-news/case-studies-consumer-news/