Consumer Guide to Geothermal Heat Pumps

Geothermal heat pumps are among the most efficient and comfortable heating and cooling technologies available because they use the earth's natural heat to provide heating, cooling, and often, water heating.

HOW GEOTHERMAL HEAT PUMPS WORK

Using a heat exchanger, which is a mechanical unit that moves fluids of different temperatures past each other, a geothermal heat pump transfers heat from one space to another. In summer, the geothermal heat pump extracts heat from a building and transfers it to the ground for cooling. In winter, the geothermal heat pump takes natural heat from the ground and transfers it to the home or building for heating.

Installing a geothermal heat pump system can be the most cost-effective and energy-efficient home heating and cooling option. Geothermal heat pumps are a particularly good option if you are building a new home or planning a major renovation to an existing home by replacing, for example, an HVAC system.


Geothermal heat pump systems, consisting of the heat exchanger (left) and the heat pump (right), heat and cool a home by transferring heat to and from the earth.

About Geothermal Heat Pumps

While many parts of the country experience seasonal temperature extremes – from scorching heat in the summer to sub-zero cold in the winter – a few feet below the earth's surface the ground remains a relatively constant temperature. The natural ground temperature is cooler than the natural air temperature in summer, and warmer than the natural air temperature in winter. While the margin of variation is small, seasonal changes in ground temperature give geothermal heat pumps a dependable and permanent wintertime heat source and summertime heat sink.

Geothermal heat pumps—also known as ground-source heat pumps—take advantage of the earth's stable temperature and represent one of the most efficient and durable options on the market to heat and cool your home.

Many heating, ventilation, and air conditioning systems use some sort of heat pump for heating and cooling.

Geothermal vs. Air-Source Heat Pumps

While geothermal heat pumps operate similarly to the far more common air-source heat pump (ASHP), geothermal heat pumps are substantially more energy-efficient than even ASHPs because they take advantage of the relatively consistent ground temperatures, which are far more uniform than air temperatures. Because they are anchored deep in the ground on your property and better able to access stable temperatures, geothermal systems can reduce energy consumption anywhere between 25% to 50% compared to air-source heat pump systems. Geothermal heat pumps reach high efficiencies (300%-600%) on the coldest of winter nights.

As with any heat pump, geothermal heat pumps are able to heat, cool, and, if so equipped, supply the house with hot water. Some models of geothermal systems are available with two-speed compressors and variable fans for more comfort and energy savings. Relative to ASHPs, they are quieter, last longer, need little maintenance, and do not depend on the temperature of the outside air.

A dual-source heat pump combines an ASHP with a geothermal heat pump. These appliances simultaneously provide the consumer with a more efficient alternative to the ASHP, and a more affordable alternative to the geothermal heat pump. Dual-source heat pumps have higher efficiency ratings than air-source units but are not as efficient as geothermal units. The main advantage of dual-source systems is that they cost much less to install than a single geothermal unit and work almost as well.

Types of Geothermal Heat Pumps

Geothermal heat pumps come in four types of systems that "loop" the heat to or from the ground and your house. Three of these – horizontal, vertical, and pond/lake – are closed-loop systems. The fourth type of system is the open-loop option. Choosing the one that is best for your site depends on the climate, soil conditions, available land, and local installation costs at the site.

Closed-Loop Systems

- **Horizontal:** This type of installation is generally most cost-effective for residential installations, particularly for new construction where sufficient land is available. It requires trenches at least four feet deep.
- **Vertical:** This is often used for larger-scale geothermal systems (such as in commercial buildings) where land is limited, or where the soil is too shallow to bury horizontal loops in trenches and some form of drilling into bedrock is necessary. Vertical-loop systems can be more expensive, but they use less land and also minimize disturbance to the existing landscape.
- **Pond/Lake:** If the site has an adequate water body, this may be the least expensive option. A supply line pipe runs underground from the building to the water and coils into circles at least eight feet under the surface to prevent freezing. The coils should only be placed in a water source that meets minimum volume, depth, and quality criteria.

Open-Loop System

This type of system uses well or surface body water as the heat exchange fluid that circulates directly through the geothermal heat pump system. Once it has circulated through the system, the water returns to the ground through the well, a recharge well, or surface discharge. This option is practical only with an adequate supply of relatively clean water, and if all local codes and regulations regarding groundwater discharge are met.

Energy Efficient and Cost Effective

Although installing a geothermal heat pump system is more expensive than installing an air-source system of the same heating and cooling capacity, you can recoup the additional costs in energy savings in 5 to 10 years. An average geothermal heat pump system costs about $2,500 per ton of capacity. If a home requires a 3-ton unit, then it would cost about $7,500 (plus installation and drilling costs). A comparable ASHP system with air conditioning would cost about $4,000, but the energy costs could easily equate to the extra cost of installing a geothermal heat pump. Additionally, geothermal heat pump systems may be eligible for tax credits or other incentives. See the Financial Incentives box for more information.

Geothermal heat pump systems have an average 20+ year life expectancy for the heat pump itself and 25 to 50 years for the underground infrastructure. Additionally, they move between three and five times the energy they consume between a building's interior space and the ground.

To determine the energy efficiency of a geothermal heat pump, look for: the Energy Efficiency Ratio (EER), and the Coefficient of Performance (COP). The cooling capacity is indicated by the EER while the heating capacity is indicated by the COP. To find current ENERGY STAR requirements and ratings, please see the ENERGY STAR link below.

FURTHER READING

Energy Saver: Geothermal Heat Pumps
energy.gov/energysaver/heat-pump-systems

ENERGY STAR Geothermal Heat Pumps
energystar.gov/products/energy_star_most_efficient_2020/geothermal_heat_pumps

Financial Incentives
Tax credits, incentives, and rebates may be available in your area. Please visit energystar.gov/about/federal_tax_credits/geothermal_heat_pumps for more information.

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