

# Geothermal Networks: System Components & Benefits

A geothermal network is a system of interconnected ground-source heat pumps that uses the stable temperature of the earth to deliver local, affordable, renewable, and non-combusting heating and cooling to buildings. Geothermal networks are deployed in street segments and interconnect with additional systems, growing over time to serve entire neighborhoods, municipalities, or territories. As the system grows, energy efficiency increases. This utility-scale infrastructure requires centralized management, whether by an existing utility or other entity.



Systems should be designed not for the maximum heating and cooling need of each building, but for the combined needs, known as loads. An optimal system design balances the loads, so that while some buildings are drawing heat, others are shedding heat. This “load canceling” allows systems to be designed at approximately 80% of peak load, which means lower installation and operating costs.

## System Components

**A single horizontal, closed loop of pipe** is installed in the street below the frostline, where the ambient temperature is typically in the 50s (°F) year round. The pipe, which lies in the right of way and connects all the buildings on the system, is filled with water or a mix of water and glycol. The water is the heat exchange medium and carries thermal energy as it circulates through the loop.<sup>1</sup>

**Vertical boreholes** go down several hundred feet into the bedrock. U-shaped pipes are installed in these holes and tie into the horizontal loop. Boreholes can be located in the right of way of the street or adjacent spaces, such as parking lots. Additional thermal sources and sinks (such as data centers, supermarkets, office buildings, or municipal sewage lines) can be used as needed or available.

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<sup>1</sup> While some district heating systems, especially in Europe, use a two-pipe system—one for hot water and one for cold—these systems have just one large, continuous, closed loop of pipe. Two-pipe systems rely on external sources of energy to heat and cool the water. The advantage of single-pipe systems is they use only the ambient temperature of the ground, which is much more efficient and cost effective.



The boreholes serve two main functions:

1. They give the system access to additional thermal energy, beyond what the horizontal loop can provide.
2. They allow the transfer of excess heat from the horizontal loop into the bedrock, which acts like a big thermal battery. Excess heat shed from buildings in hot weather is not wasted, but rather stored in the bedrock for use in the winter. (A percentage of that energy dissipates, but much of it is available for the system to access weeks or even months later.) This thermal storage is one reason geothermal networks are so efficient.

**A circulating pump powered by electricity** moves the water through this closed-loop system, maintaining a temperature between approximately 40°–90° Fahrenheit, the range in which ground-source heat pumps operate most efficiently.

**A ground-source heat pump** in each building is plumbed to the horizontal loop and delivers heating and cooling to meet the customer's desired temperature through the building's distribution system.

**Sensors** monitor the water temperature as it circulates, and a **main control panel** receives all of the data from the sensors. The data is used to optimize system performance.

**A backup heater and cooler** can be attached to the system or to individual buildings as needed to in the case of an unusual heating or cooling event.

## System Benefits

**No fuel:** This means no reliance on leak-prone fossil fuel pipelines, as well as the avoidance of spikes in fossil fuel prices driven by geopolitical and market forces. In addition, the environmental degradation from fracking and drilling for gas and oil is reduced as system adoption grows.

**Energy security:** Although in recent years the U.S. has become a net exporter of natural gas, we continue to depend on foreign energy. Geothermal networks break this dependence through entirely local generation. In addition, because geothermal networks are highly segmented and locally controlled, they are less susceptible to deliberate system breaches.

**Non-intermittent energy:** Geothermal energy is always available and does not require external storage through batteries or other systems. In fact, the circulating water is its own form of thermal storage; even if electric power goes out, the system can continue delivering heat or cooling for several hours.



**Safety:** Thermal energy is non-combusting. This means no explosions, and no harmful byproducts of combustion emitted into homes.

**Minimal above-ground footprint:** The horizontal loop is installed in the street, using the existing right of way. Boreholes can be drilled with a minimal footprint in parking lots or similar areas.

**Efficiency:** Because customers on the system use heating and cooling at different times (load canceling), waste heat is reused. This means the overall energy use is lower than the sum of individual building needs.

**Reduced cost and electric grid impact:** As greater diversity of energy use results in increased system efficiency, less backup heating and cooling and fewer linear feet of boreholes are needed, thus decreasing the cost of installed infrastructure. Load canceling also significantly reduces the electric grid peaks that would result from conventional building electrification.

**Essential public service and jobs:** Utilities are uniquely suited to build geothermal networks because they can leverage their capital financing model, which amortizes up-front costs over decades and across the entire customer base. The approach allows gas utilities to continue delivering an essential public service as the use of natural gas declines, as well as continue providing good jobs to their existing workforce with minimal retraining.

**Affordability and equity:** An unmanaged transition to building electrification risks leaving renters, low- to moderate-income populations, and environmental justice communities out in the cold, unable to afford the high cost of new equipment and building retrofits *and* left paying higher and higher gas prices as fewer customers are forced to pay for the entire gas system. A planned, utility-scale gas-to-geo transition alleviates this risk by having the utilities shoulder up-front costs and prioritize the inclusion of otherwise marginalized populations.