



# *WaterFurnace Explains* Geothermal Heating and Cooling

WaterFurnace **geothermal heating and cooling** will save you money, reduce your energy use and keep the environment cleaner for your family and your community. It's the **most cost-effective, energy efficient and environmentally friendly** method of heating and cooling your home available today. This booklet will help explain how WaterFurnace can accomplish all this – and how you can **reduce your utility bills by up to 60%** today and for many years to come.

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# Geothermal Basics

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## **How does a Geothermal heating and cooling system work?**

Outdoor temperatures fluctuate with the changing seasons but underground temperatures don't. Four to six feet below the earth's surface, temperatures remain relatively constant year-round. A geothermal system, which typically consists of an indoor unit and a buried earth loop, capitalizes on these constant temperatures to provide "free" energy. In winter, fluid circulating through the system's earth loop absorbs stored heat and carries it indoors. The indoor unit compresses the heat to a higher temperature and distributes it throughout the building. In summer, the system reverses, pulling heat from the building, carrying it through the earth loop and depositing it in the cooler earth.

## **What makes a Geothermal system different from ordinary systems?**

Unlike ordinary systems, Geothermal systems do not burn fossil fuel to generate heat; they simply transfer heat to and from the earth to provide a more efficient, affordable and environmentally friendly method of heating and cooling. Typically, electric power is used only to operate the unit's fan, compressor and pump.

## **What are the components of a Geothermal system?**

The three main parts consist of the heat-pump unit, the liquid heat-exchange medium (open or closed loop), and the air-delivery system (ductwork).

## **How efficient is a Geothermal system?**

A Geothermal system is three to four times more efficient than the most efficient ordinary system. Because geothermal systems do not burn fossil fuels to make heat, they provide three to four units of energy for every one unit used to power the system.

## **Is the efficiency rating actual or just a manufacturer's average?**

All heating and cooling systems have a rated efficiency from a U.S. governmental agency. Fossil fuel furnaces have a percentage efficiency rating. Natural gas, propane and fuel oil furnaces have efficiency ratings based on laboratory conditions. To get an accurate installed efficiency rating, factors such as flue gas heat losses and cycling losses caused by oversizing, blower fan electrical usage, etc., must be included.

Geothermal heat pumps, as well as all other types of heat pumps, have efficiencies rated according to their coefficient of performance or COP. It's a scientific way of determining how much energy the system produces versus how much it uses. Most geothermal heat pump systems have COPs of 3-4.5 (WaterFurnace's E Series is rated up to 4.7). That means for every one unit of energy used to power the system, 3-4.5 units are supplied as heat. Where a fossil fuel furnace may be 78-90% efficient, a geothermal heat pump is about 400% efficient. Some geothermal heat pump manufacturers and electric utilities use computers to accurately determine the operating efficiency of a system for your home or building.

## **Do Geothermal systems require much maintenance?**

No. Geothermal systems are practically maintenance free. When installed properly, the buried loop will last for generations. And the other half of the operation – the unit's fan, compressor and pump – is housed indoors, protected from the harsh weather conditions. Usually, periodic checks and filter changes are the only required maintenance. (Note: WaterFurnace has developed a geothermal unit – the ES Split – that is so rugged and quiet, it can be placed outdoors when that's the best solution).

## **What does Geothermal mean for the environment?**

Geothermal systems work with nature, not against it. They emit no greenhouse gases, which have been linked to global warming, acid rain and other environmental hazards. WaterFurnace provides an earth-loop antifreeze which will not harm the environment in the unlikely event of a leak. And much of the WaterFurnace product line uses R-410A, a performance-enhancing refrigerant that will not harm the earth's ozone layer.

# **Geothermal Heat Pumps**

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## **Are all Geothermal heat pumps alike?**

No. There are different kinds of geothermal heat pumps designed for specific applications. Many geothermal heat pumps, for example, are intended for use only with higher temperature ground water encountered in open-loop systems. Others will operate at entering water temperatures as low as 25°F, which are possible in closed-loop systems. Most geothermal heat pumps provide summer air conditioning, but a few brands are designed only for winter heating. Geothermal heat pumps also can differ in the way they are designed. Self-contained units combine the blower, compressor, heat exchanger and coil in a single cabinet. Split systems (such as the WaterFurnace ES Split) allow the coil to be added to a forced-air furnace and utilize the existing blower.

## **How does a Geothermal heat pump work?**

Anyone with a refrigerator or an air conditioner has witnessed the operation of a heat pump, even though the term heat pump may be unfamiliar. All of these machines, rather than making heat, take existing heat and move it from a lower temperature location to a higher temperature location. Refrigerators and air conditioners are heat pumps that remove heat from colder interior spaces to warmer exterior spaces for cooling purposes. Heat pumps also move heat from a low-temperature source to a high-temperature space for heating.

An air-source heat pump, for example, extracts heat from outdoor air and pumps it indoors. A geothermal heat pump works the same way, except that its heat source is the warmth of the earth. The process of elevating low-temperature heat to over 100°F and transferring it indoors involves a cycle of evaporation, compression, condensation and expansion. A refrigerant is used as the heat-transfer medium which circulates within the heat pump. The cycle starts as the cold, liquid refrigerant passes through a heat exchanger (evaporator) and

absorbs heat from the low-temperature source (fluid from the ground loop). The refrigerant evaporates into a gas as heat is absorbed.

The gaseous refrigerant then passes through a compressor where the refrigerant is pressurized, raising its temperature to more than 180°F. The hot gas then circulates through a refrigerant-to-air heat exchanger where heat is removed and pumped into the building at about 100°F. When it loses the heat, the refrigerant changes back to a liquid. The liquid is cooled as it passes through an expansion valve and begins the process again. To work as an air conditioner, the system's flow is reversed.

### **Does a Geothermal system heat and cool?**

One thing that makes a geothermal heat pump so versatile is its ability to be a heating and cooling system in one. With a simple flick of a switch on your indoor thermostat, you can change from one mode to another. In the cooling mode, a geothermal heat pump takes heat from indoors and transfers it to the cooler earth through either groundwater or an underground earth loop system. In the heating mode, the process is reversed.

### **Will the minimum entering water temperature affect which Geothermal heat pump I buy?**

Yes. If you have an open loop system, your entering water temperatures (EWTs) may range from the 70s in the southern United States to the 40s in Canada. All heat pumps can handle temperatures in the moderate-to-warm range. A closed loop system, on the other hand, may encounter EWTs below freezing. Not all geothermal heat pumps will operate efficiently at those temperatures. It's important to know what EWTs at which your heat pump will operate most efficiently.

### **Can a Geothermal system also heat water?**

Yes. Some geothermal heat pumps can provide all of your hot water needs on demand at the same high efficiencies as the heating/cooling cycles. An option called a desuperheater can be added to most heat pumps. It will provide significant savings by heating water before it enters your hot water tank.

## **In The Loop**

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### **Do I need separate earth loops for heating and cooling?**

No. The same loop works for both. To switch heating to cooling, or vice versa, the flow of heat is simply reversed.

### **Does the underground pipe system really work?**

The buried pipe, or earth loop, was an important technical advancement in heat pump technology. The idea of burying pipe in the ground to gather heat energy originated in the 1940s. New heat pump designs and more durable pipe materials have been combined to make geothermal heat pumps the most efficient heating and cooling systems available.

## **What types of loops are available?**

There are two main types: open and closed.

## **What is an open loop system?**

An open loop system uses groundwater from an ordinary well as a heat source. The groundwater is pumped into the heat pump unit where heat is extracted and the water is disposed of in an environmentally safe manner. Because groundwater is a relatively constant temperature year-round, wells are an excellent heat source.

## **How much groundwater does an open loop system require?**

The water requirement of a specific model is usually expressed in gallons per minute (g.p.m.) and is listed in the unit's specifications. Generally, the average system will use 1.5 g.p.m. per ton of capacity while operating, but the amount of water required depends on the size of the unit and the manufacturer's specifications. Your contractor should be able to provide this information. Your well and pump combination should be large enough to supply the water needed by the heat pump in addition to your domestic water requirements. You probably will need to enlarge your pressure tank or modify your plumbing to supply adequate water to the heat pump.

## **What do I do with the discharge water?**

There are a number of ways to dispose of water after it has passed through the heat pump. The open discharge method is the easiest and least expensive. Open discharge simply involves releasing the water into a stream, river, lake, pond, ditch or drainage tile. Obviously, one of these alternatives must be readily available and have the capacity to accept the amount of water used by the heat pump before open discharge is feasible.

A second means of water discharge is the return well. A return well is a second well bore that returns the water to the ground aquifer. A return well must have enough capacity to dispose of the water passed through the heat pump. A new return well should be installed by a qualified well driller. Likewise, a professional should test the capacity of an existing well before it is used as a return.

## **Are there any laws that apply to open loop installations?**

All or part of the installation may be subject to local ordinances, codes, covenants or licensing requirements. Check with local authorities to determine if any restrictions apply in your area.

## **Does an open loop system cause environmental damage?**

No. They are pollution free. The heat pump merely removes or adds heat to the water. No pollutants are added. The only change in the water returned to the environment is a slight increase or decrease in temperature.

## **Can I reclaim heat from my septic system disposal field?**

No. An earth loop will reach temperatures below freezing during extreme conditions and may freeze your septic system. Such usage is banned in many areas.

## **What problems can be caused by poor water quality?**

Poor water quality can cause serious problems in open loop systems. Your water should be tested for hardness, acidity and iron content before a heat pump is installed. Your contractor or equipment manufacturer can tell you what level of water is acceptable. Mineral deposits can build up inside the heat pump's heat exchanger. Sometimes a periodic cleaning with a mild acid solution is all that's needed to remove the build-up.

Impurities, particularly iron, can eventually clog a return well. If your water has high iron content, make sure that the discharge water is not aerated before it's injected into a return well.

## **What is a closed loop system?**

A closed loop system uses a continuous loop of buried polyethylene pipe. The pipe is connected to the indoor heat pump to form a sealed, underground loop through which an environmentally friendly antifreeze-and-water solution is circulated. A closed loop system constantly re-circulates its heat-transferring solution in pressurized pipe, unlike an open loop system that consumes water from a well. Most closed loops are trenched horizontally in areas adjacent to the building. However, where adequate land is not available, loops are vertically bored. Any area near a home or business with appropriate soil conditions and adequate square footage will work.

## **What if I don't have room for a horizontal loop?**

Closed loop systems also can be vertical. Holes are bored up to 250 feet per ton of heat pump capacity, depending on where you live. U-shaped loops of pipe are inserted in the holes. The holes are then backfilled with a sealing solution.

## **How long will the loop pipe last?**

Closed loop systems should be installed using only high-density polyethylene pipe. Properly installed, these pipes will last for many decades. They are inert to chemicals normally found in soil and have good heat conducting properties. PVC pipe should never be used.

## **How deep and long will my trenches be?**

Trenches are normally four to six feet deep and up to 400 feet long, depending on the number of pipes in a trench. One advantage of a horizontal loop system is being able to lay the trenches according to the shape of the land. As a rule of thumb, 500-600 feet of pipe is required per ton of system capacity. A well-insulated 2,000-square-foot home would need about a three-ton system with 1,500 - 1,800 feet of pipe.

## **How are the pipe sections of the loop joined?**

Pipe sections are joined by thermal fusion. Thermal fusion involves heating the pipe connections and then fusing them together to form a joint that's stronger than the original pipe. This technique creates a secure connection to protect from leakage and contamination.

## **Will an earth loop affect my lawn or landscape?**

No. Research has proven that loops have no adverse effect on grass, trees, or shrubs. Most horizontal loop installations use trenches about 24 inches wide. This, of course, will initially leave temporary bare areas, but they can easily be restored with grass seed or sod. Vertical loops require little space and result in minimal lawn damage.

## **I have a pond nearby. Can I put a loop in it?**

Yes, if it's deep enough and large enough. A minimum of six feet in depth at its lowest level during the year is needed for a pond to be considered. The amount of surface area required depends on the heating and cooling load of the structure. You should opt against using water from a spring, pond, lake or river as a source for your heat pump system unless it's proven to be free of excessive particles and organic matter. They can clog a heat pump system and make it inoperable in a short time.

## **Can I install an earth loop myself?**

It's not recommended. Good earth-to-coil contact is very important for successful loop operation. Nonprofessional installations may result in less-than-optimum system performance.

# **What Every Owner Should Know**

## **How do I know if the dealer and loop installers are qualified?**

Don't be afraid to ask for references from dealers. A reputable dealer or loop installer won't hesitate to give you names and numbers to call to confirm his capabilities.

## **Can a Geothermal heat pump be added to my fossil fuel furnace?**

Split systems easily can be added to existing furnaces for those wishing to have a dual-fuel heating system. Dual-fuel systems use the heat pump as the main heating source and a fossil fuel furnace as a supplement in extremely cold weather if additional heat is needed.

## **Is a geothermal heat pump difficult to install?**

Most units are easy to install, particularly when they replace another forced-air system. They can be installed in areas unsuitable for fossil fuel furnaces because there is no combustion, thus no need to vent exhaust gases. Ductwork must be installed in homes that don't have an existing air distribution system. The difficulty of installing ductwork will vary and should be assessed by a contractor. Another popular way to use geothermal technology is with in-floor radiant heating, in which hot water circulating through pipes under the floor heats the room.

### **I have ductwork, but will it work with this system?**

In all probability, yes. Your installing contractor should be able to determine ductwork requirements and any minor modifications if needed.

### **If a home has ceiling cable heat or baseboard heat, do air ducts need to be installed?**

Not always. It may be desirable to install geothermal heat pump room units. For some small homes, a one-room unit would handle the heating and cooling needs. Ceiling cable or baseboard units could be used for supplemental heat if desired.

### **Do I need to increase the size of my electric service?**

Geothermal heat pumps don't use large amounts of resistance heat so your existing service may be adequate. Generally, a 200-amp service will have enough capacity and smaller amp services may be large enough in some cases. Your electric utility or contractor can determine your service needs.

### **What is the BTU size of the furnace that's being proposed?**

Furnaces are designed to provide specific amounts of heat energy per hour. The term "BTUH" refers to how much heat can be produced by the unit in an hour. Before you can determine what size furnace you'll need, you must have a heat loss/heat gain calculation done on the structure. From that, an accurate determination can be made of the size of the system you'll need. Most fossil fuel furnaces are substantially oversized for heating requirements, resulting in increased operating cost and unpleasant temperature swings.

### **Should I buy a Geothermal heat pump large enough to heat with no supplemental heat?**

Your contractor should provide a heating and cooling load calculation (heat loss, heat gain) to guide your equipment selection. Geothermal heat pumps typically are sized to meet your cooling requirements. Depending on your heating needs, a geothermal heat pump will supply 80-100 percent of your design heating load. Sizing the heat pump to handle your entire heating needs may result in slightly lower heating costs, but the savings may not offset the added cost of the larger heat pump unit and larger loop installation. Also, an oversized unit can cause dehumidification problems in the cooling mode, resulting in a loss of summer comfort.

### **How long is the payback period for a Geothermal system?**

To figure this accurately, you must know how much you'll save each year in energy costs with a geothermal system as well as the price difference between it and an ordinary heating system and central air conditioner.

As an example: If you'll save \$700 per year with a geothermal system and the price difference is \$2,000, your payback will be less than three years. If you install a geothermal system



in a new home, the monthly savings in operating costs generally will offset the additional monthly cost in the mortgage, resulting in an immediate positive cash flow.

## Learn More

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### How can I learn more about Geothermal systems?

You can call us at 800-GEO-SAVE, or visit our website at [www.waterfurnace.com](http://www.waterfurnace.com). Our comprehensive site offers a wide variety of information on geothermal technology. It also will help you find an independent WaterFurnace dealer in your area. Most electric utilities have information about geothermal systems. Get in touch with the experts and start saving on your utility bills right away!

## Glossary

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**BTU (British Thermal Unit):** The amount of heat needed to raise the temperature of one pound of water one degree Fahrenheit. Btu is used to signify the heating and cooling capacity of a system and the heat losses and gains of buildings and homes.

**BTUH:** The number of BTUs produced in one hour.

**Closed loop system:** A heat pump system that uses a loop of buried plastic pipe as a heat exchanger. Loops can be horizontal or vertical.

**COP (Coefficient of Performance):** The ratio of heating or cooling provided by a heat pump (or other refrigeration machine) to the energy consumed by the system under designated operating conditions. The higher the COP, the more efficient the system.

**Compressor:** The central part of a heat pump system. The compressor increases the pressure and temperature of the refrigerant and simultaneously reduces its volume while causing the refrigerant to move through the system.

**Condenser:** A heat exchanger in which hot, pressurized (gaseous) refrigerant is condensed by transferring heat to cooler surrounding air, water or earth.

**Cycling losses:** The efficiency of a heating or cooling system is reduced due to start-up and shut-down losses. Oversizing a heating or cooling system increases cycling losses.

**Desuperheater:** A device for recovering superheat from the compressor discharge gas of a heat pump or central air conditioner for use in heating or preheating water.

**Evaporator:** A heat exchanger in which cold, liquid refrigerant absorbs heat from the low-temperature source (fluid from the ground loop).

**Fossil fuel:** Combustible fuels formed from the decomposition of organic matter. Examples are natural gas, propane, fuel oil, oil, and coal.

**Geothermal heat pump:** A heat pump that uses the earth as a heat source and heat sink.

**Heat exchanger:** A device designed to transfer heat between two physically separated fluids or mediums of different temperatures.

**Heat Pump:** A mechanical device used for heating and cooling which operates by pumping heat from a cooler to a warmer location. Heat pumps can extract heat from air, water, or the earth. They are classified as either air-source or geothermal units.

**Heat sink:** The medium – air, water or earth – which receives heat rejected from a heat pump.

**Heat source:** The medium – air, water or earth – from which heat is extracted by a heat pump.

**Open loop system:** A heat pump system that uses groundwater from a well or surface water from a lake, pond, or river as a heat source. The water is returned to the environment.

**Payback:** A method of calculating how long it will take to recover the difference in costs between two different heating and cooling systems by using the energy and operating cost savings from the more efficient system.

**Supplemental heating:** A heating system used during extremely cold weather when additional heat is needed to moderate indoor temperatures. May be in the form of fossil fuel or electric resistance.

## Conversion Table

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U.S.	(Equals)	Canadian
1 gallon	=	.8 gallon (3.78 liters)
1 foot	=	.304 meter
1,000 feet	=	304.8 meters
1 BTU	=	252 calories (grams)
Fahrenheit	=	Celsius = $(F - 32) \times 5/9$
(Example: 40 F)	=	(4.44 C)