How to implement guide on ground source heat pumps

If you have the available space, a ground source heat pump (GSHP) can reduce the energy and costs associated with heating and cooling your buildings. This guide takes you through the early stages of installing an effective GSHP system.

Introduction

Heat pumps can provide a low carbon alternative to electric heating and cooling systems. In winter these devices use electricity to move heat from the ground into a building for heating. In summer they move heat from the building into the ground for cooling.

Heat pumps can produce up to four times more heating or cooling than the energy it takes to drive them. Heat pump efficiency depends on the temperature of the source from which it draws the heat. By using the relatively constant temperatures found underground as the heat source, it is possible to achieve high heat pump efficiencies all year round.

GSHPs typically use pipework buried in the soil as the heat source in winter or heat sink in summer. Under some circumstances, surface or underground waters are used as the heat source.

The Business Case

GSHPs cost more to install than traditional heating and cooling systems due to the pipework or bore holes necessary to collect the heat. However, operational cost savings can mean that they pay back their capital investment relatively quickly.

For example, a new 20kW thermal capacity GSHP system installed to replace an equivalent electric heating system costs £15,000. Based on 2,000 operating hours, the heat pump will save 30,000kWh per year. At an electricity price of 9p/kWh you would save £2,700 per year and recoup your investment costs within five years. The payback periods associated with replacing a gas heating system with a GSHP can by much longer than this due to the relative costs of gas and electricity.

Depending on the size, type and efficiency of the GSHP installed, you may be eligible for payments under the Government's Renewable Heat Incentive scheme, which may make the installation of a system more attractive from a financial perspective.

The Technology

Heat pump technology is based on a simple principle. Heat is collected from a plentiful source; either the earth a couple of metres below ground level, a deeper borehole or a water volume. This energy is transferred to space heat a building's interior.

The process is usually reversed to provide cooling in summer which replenishes the heat in the source ready for winter heating.

Ground source heat pump technology is particularly useful when the outside air is very cold because the earth will be at a higher temperature. This "low grade" heat energy is sufficient to heat a building when it is transformed to a higher temperature.

Heat energy from the ground can be collected or dissipated using either horizontal or vertical collector systems in an open or closed loop configuration.

Horizontal closed loop ground collector systems are laid typically at a depth of 1m to 2m. Vertical closed loop boreholes vary in depths of 15m to 25m or sometimes more. Ground collectors are best laid in ground that is relatively free of boulders and hard rocks.

Horizontal ground collectors are usually laid in helix wound configurations known as 'slinkies'. These require a large land area to extract enough heat for a building. This can be a costly exercise when it involves a large amount of excavation. Often it is better to lower the building's heating requirement by improving insulation before finally sizing the GSHP.

Vertical ground collectors are better suited to situations where limited land is available. A borehole will need to be dug and the ground collector inserted. Boreholes can be located almost anywhere on a site providing ground conditions permit, and there is adequate spacing between them. They can also be built on or landscaped over, providing access is maintained.

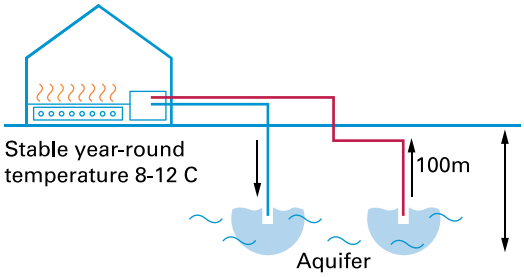
Open loop collectors pump water from an underground or surface water source to the heat pump and then return it to source.

The length of collector pipe is directly related to the amount of heat required to be extracted. Also, the amount of heat that can be extracted is related to the surface area of the collector pipework and the thermal properties of the ground.

Sufficient space inside a building is required for the heat pump equipment. Often heat pumps are installed in plant rooms with conventional systems such as boilers retained for meeting peak heating demands and as a back-up system.

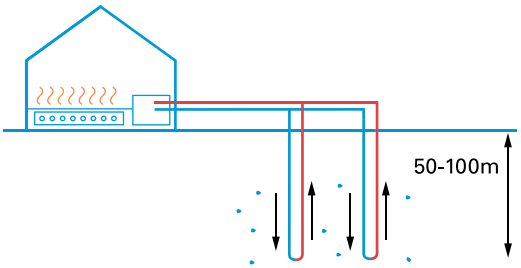
What is a ground source heat pump?

Ground source heating and cooling systems exploit the stable temperature of the ground or groundwater beneath a site and use it as a source of heating and/or cooling. We look at three types.



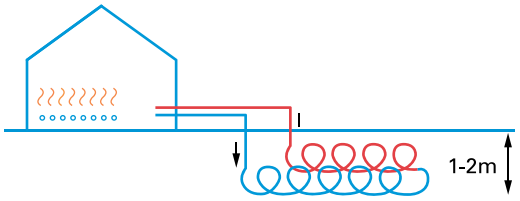
Open loop system

- Groundwater is extracted from and returned to a suitable aquifer below the site
- Output is dependent on how much water can be extracted
- More efficient than closed loop systems, so less boreholes are needed
- Generally more cost efficient than a closed loop system
- Can use cooling effect of groundwater without running a heat pump.



Closed loop vertical system

- A heat exchange fluid is circulated through pipes laid vertically in boreholes in the ground
- Can be used in most ground types in the earth or in ground water
- Output is fairly predictable
- Less efficient than an open loop system so more boreholes are required
- Generally less cost efficient than open loop systems – but up-front investigations are less.



Closed loop horizontal system

- A heat exchange fluid is circulated through pipes laid horizontally in trenches in the ground
- A large area of ground is required – larger than vertical systems.

Applications

The biggest application for GSHPs is for newly constructed buildings needing space heating and cooling. This is because heat pumps are most efficient when producing low output temperatures, from 35°C to 50°C and many existing buildings have heating systems designed to work at higher temperatures. GSHPs are normally connected to either low temperature radiators or an under-floor heating system in buildings with a high degree of thermal insulation. All of these are costly to retrofit, and may not be economically viable.

Although GSHPs can be used for domestic hot water supply, water temperatures above 60°C are necessary to prevent Legionella growth. This reduces the overall efficiency of the heat pump or may require additional heating.

Reversible GSHPs are increasingly being used to condition incoming air for ventilation systems, providing pre-heating in winter and pre-cooling in summer when the distribution systems with the building allow.

GSHPs are most economically viable when installed to replace both heating and cooling systems.

Specification checklist

The following is a list of items to consider when specifying a GSHP:

- Is there a need for heating in winter and cooling in summer? Avoid using heat pumps for only heating or only cooling as efficiency will fall significantly over time.
- What is the best type of ground collector for your system? See Technology section for guidance.
- Make sure the ground collector is correctly sized to meet the requirements of the system. An oversized collector is an unnecessary cost and an undersized system will result in heating and cooling conditions not being achieved.
- Check that the ground conditions are suitable for installation of a ground collector.
- Are the existing heating and cooling systems installed within the building suitable for the relatively low temperatures produced by heat pumps, or do they need to be replaced?
- Is there an opportunity to install a GSHP that is matched to the heating and cooling base load of the building (a level of demand that remains constant throughout the heating/cooling season), with other technologies used to meet the peak demands? This will ensure that the heat pump is operated for longer periods of time, making the system more economical over its entire life-cycle.
- Make sure that the ground being used for the collector is free from drains, pipes, electrical services and other buried services which could disrupt the installation.

Commissioning procedure

The four things to commission are:

- the bore holes/trenches and accompanying pipework
- the heat pumps and internal distribution pipework
- the overall system controls
- the metering.

Ensure that a suitably qualified contractor is used for all stages.

Common Problems

There are not a lot of moving parts on GSHPs and therefore there is not much to go wrong. However, they do often require seasonal adjustments to ensure they are operating efficiently over both the heating and cooling periods.

Finding a supplier

Ground source heat pumps come under the Government's Enhanced Capital Allowances Scheme. You can see a list of ECA approved sequence controls at http://etl.decc.gov.uk/etl

Specification and installation should be carried out by a specialist controls contractor. For more advice contact The Ground Source Heat Pump Association www.gshp.org.uk

A buyer's guide to heat pumps – Energy Saving Trust

Getting warmer: a field trial of heat pumps – Energy Saving Trust

Additional information

A buyer's guide to heap pumps - Energy Saving Trust

Getting warmer: a field trial of heat pumps - Energy Saving Trust