Factsheet 6
Ground source heat pumps

What is it?

There are three different types of heat pumps:

- Ground source heat pumps (GSHPs);
- Air source heat pumps (ASHPs); and
- Water source heat pumps (WSHPs).

All of them work in a similar way, by extracting heat from their surroundings (from the ground, the air, or from water) and converting this into useful energy which can heat your home. They need some electricity to run, but because they are extracting renewable heat from the environment the energy output is much greater than the electricity input. This factsheet focuses on ground source heat pumps.

Why would I want to install one?

Reduce CO_2: Heat pumps will give out more energy as heat than the electricity they use to run. This means you reduce your CO_2 emission throughout the year.

Save money: As you are generating your own heat in a more efficient way, you could see a reduction in your energy bills.

Subsidies: GSHPs are eligible for the Scottish Government's Home Energy Scotland Loan scheme and the UK Government's Renewable Heat Incentive, although certain criteria apply.

All year heat: Since the ground stays at a fairly constant temperature, they work all year round.

What else do I need to know?

Larger radiators: As with other heat pumps, you may need to install larger radiators or underfloor heating to get the most out of your system.

Installation: You can only install a GSHP if you have a large area of accessible land. They cause a lot of disruption when being installed, as the ground must be dug up to form horizontal trenches or deep vertical boreholes, but once installed the ground can be re-landscaped so you don't notice the pipes are there. You may also need to install larger radiators or underfloor heating to get the most out of your system.

Insulation: With all heat pumps you need to insulate your home fully before installation. GSHPs give out a lower temperature of heat over longer periods. Insulation will keep the heat in for longer reducing energy bills and maintaining the ASHP's efficiency.

In this factsheet...

What are GSHPs?

Ground source heat pumps (GSHPs) use heat stored within the ground to heat people's homes. Long pipes are buried in the ground and absorb heat, which then passes to the heat pump. This low-level heat is collected over a very large area, and is then compressed to give higher temperatures which can be used for heating.

Because GSHPs need an electrical compressor, they do need some electricity to run. However, the energy needed to power the compressor is much lower than the energy usually needed to heat a home, so heat pumps help to reduce energy bills and carbon emissions.

Since the ground stays at a relatively stable temperature all year round, you can use GSHPs throughout the year.

Technical

How do GSHPs work?

GSHPs collect heat using a series of pipes, a 'ground loop', buried in the ground. These pipes are filled with a fluid (a type of anti-freeze) which is pumped around the ground loop.

The ground generally stays at a fairly constant temperature of 10 to 13°C all year round, so as the fluid moves through the ground loop it is gently warmed. This warmed fluid is then returned to the heat pump.

The heat pump itself is made up of an evaporator, a compressor and a condenser. In the evaporator, heat is transferred from the fluid to a refrigerant, which boils at very low temperature to create a vapour. The cooled fluid then returns to the ground loop to be reheated.

The evaporated refrigerant moves to the compressor, which compresses the vapour into a smaller volume. This causes the temperature to increase significantly. This hot gas then passes through a condenser, which turns the refrigerant back to a liquid. The heat released in this process is passed to a heat exchanger which powers the central heating system and produces hot water for a home.

Is a GSHP right for my home?

There are a few things to consider when looking at installing a GSHP:

Do you have sufficient space?

GSHPs are generally very large and need a large garden or area of land to be installed. This land will need to be dug up into trenches (which are then filled in) to allow the pipework to be laid, so the land needs to be accessible to digging equipment. You'll also need to consider whether there are any service pipes on your land which may restrict your ability to dig trenches.

If you have more limited space, it is possible to lay the pipework in vertical boreholes rather than trenches. However again this will need enough access for drilling and digging equipment, and you'll need to consider whether there are any buried service pipes which would be in the way of digging. If your land is near a river or coast line, the high water table may also affect your ability to drill a borehole. Vertical boreholes are also significantly more expensive than trenches.

As well as the ground loop outside, you will also need some space indoors for the heat pump unit. This is usually about the size of a fridge. The generator will create a low level humming sound, similar to an extractor fan or air conditioning unit. An installer will be able to advise on where best to place the unit to reduce this noise.

Is your home well-insulated?

Since GSHPs emit heat at a slightly lower temperature over a longer period than a traditional heating system, it's important to make sure your home is well insulated and draught-proofed before installation. Loft insulation, wall insulation and high performance double glazing will all reduce heat loss from your home; this will mean the heat produced by your ASHP will remain within the home much longer. Draught-proofing and sealing gaps around your home with sealant will also reduce heat loss but a lot prevent draughts from forming making you feel more comfortable and

This is important because if you home isn't well insulated you may well be using your ASHP a lot more increasing your energy bills and reducing its overall efficiency.

Will it work with your existing heating system?

GSHPs tend to work best with underfloor heating systems or with oversize radiators. This is because they tend to produce slightly lower water temperatures than a traditional boiler, so as the water circulates through your central-heating system it needs a large surface area (such as large radiators or the floor) to release heat over. This means you might need to replace your current radiators or central heating system – an installer will be able to advise you on what's best for your home.

The heating system you are replacing will also be important in deciding whether a heat pump is cost effective for your home. Heat pumps will be much more cost-effective if replacing a coal or electric heating system but they usually aren't a cost-effective replacement for a gas central heating system, although they do have lower carbon emissions.

Will you need planning permission or building warrant?

GSHPs are classed as 'permitted developments' in the planning system, meaning in most cases you can install a system without applying for planning permission, as long as it's within the boundaries of your land. However, there are some restrictions on permitted developments, so it's worth contacting your local authority to check whether you need planning permission **before** you install a system.

If your home is a listed building, in a conservation area, or in a World Heritage Site, you will almost certainly require planning permission from your local authority.

You can find full details on planning permission for WSHPs in the Scottish Government's microgeneration planning legislation. If you are not sure, it's best to contact your local authority to check whether a system in your home would meet the conditions.

You will also need to make sure your installation keeps to Scottish Building Regulations, in Section 3 Environment of the Scottish Building Standard's Technical Handbook 2016.

What type of GSHP would be best for me?

There are several different types and sizes of GSHP. The type most suitable for you will depend on your home's heating needs, the space you have, and your ground conditions.

Sizing

An installer will be able to advise you on the size of heat pump suitable for your home, depending on your heating needs. This will depend on the size of your home and the level of insulation, so it's important to make sure your home is fully insulated before installing. If you have a lower heating requirement, your ground loop can be smaller. You'll also want to check whether the heat pump will heat your hot water as well as your central heating – this depends on the model of heat pump you choose.

It's important not to oversize your heat pump – too large a heat pump will provide more heat than your home needs, meaning you will not be able to leave it running continuously. 'Stop-start' heating with a heat pump is more energy intensive, so will increase your running costs.

Efficiency

Different models of heat pump vary in efficiency and so it is important to check the manufacturers' details and at what temperature below 0ºC they will operate. Efficiency is often described as the Coefficient of Performance (CoP). This is the ratio of electricity into the system to the heat produced by the system, for example a CoP of 3.0 means that for every 1 unit of electrical energy used by the heat pump you will get 3 units of heat energy produced. The CoP may vary slightly throughout the year, since the efficiency will be lower in colder temperatures. For a GSHP, the CoP won't vary too much since the temperature of the ground stays fairly constant.

The Seasonal Performance Factor (SPF) is another term used to measure efficiency of heat pumps. This takes into

account how well it works at low and high temperatures, so gives a better idea of how efficient a heat pump will be on average. To be eligible for Renewable Heat Incentive (RHI) payments, a GSHP must have an SPF of at least 2.5 and be on the Product Eligibility List. You will also need to make sure that your heat pump has an EU energy related products label (ErP) if you want to claim RHI payments.

Types of GSHP

Horizontal and spiral coil

These coils are laid in trenches across the ground. The earth must be dug into trenches, the pipes laid, and then the trenches filled in. These systems need a large area of land. They will cause a lot of disruption while being laid, but once in place the soil can settle and the grass can grow back. These systems are 'closed-loop', meaning they are an entirely sealed network of pipes through which fluid is pumped. The fluid doesn't interact with the surrounding area, so unless there is a leak there should not be any effect on the environment.

Vertical coil

Vertical coils are used where there is less space available. They are placed in deep vertical boreholes (rather than horizontally across the ground). A specialist installer should be able to advise you on whether your local area is suitable for drilling. Or you may want to pay for a geological survey. You can contact the British Geological Survey for more information. If you live in an ex-coal mining area, it's also worth asking your installer to consult the Coal Authority to check whether your property is above any mines, as this may affect the efficiency of the system. Vertical coils are also 'closed loop' systems and have a significantly higher cost.

Open-loop systems

Open-loop systems use ground water as the fluid for the heat pump, rather than a sealed-off anti-freeze fluid. Water is taken from a borehole and, after passing through the ground loop, either re-injected into the aquifer (a layer of water underground) or released into a nearby watercourse. Open-loop systems have a direct effect on the ground source water, and can affect surface water, so may have some effect on the environment. These systems will need an environmental permit from the Scottish Environment Protection Agency (SEPA). You can find more information on this on the SEPA website.

Hybrid heat pumps

In a well-insulated property, GSHPs can provide all your heating needs by themselves. However, in older properties where it is not possible to insulate to a high enough standard for heat pumps to be fully effective on their own, you can have another heating system in place alongside the heat pump, usually a fossil fuel boiler. This set up is called a bivalent system or hybrid heat pump. With these systems, most of the time the heat pump will provide all your heating needs and the fossil fuel boiler will be switched off. However, when outdoor temperatures are very low and your heating demand high, the heat pump may not be able to provide enough heat on its own. At this point, the fossil fuel boiler turns on. The system can either be set up so that the heat pump then switches off, allowing the boiler to provide all your heat, or it can be set up for both systems to run at the same time. This will depend on the design of your particular system and which set-up is likely to be more cost-effective for you.

High temperature heat pumps

High temperature heat pumps use different fluids for transferring heat from the ground loop to your home (a different refrigerant is used in both the evaporator and compressor). This allows the water in your heating system to be raised to higher temperatures, meaning the heating system work more effectively with normal sized radiators as a direct replacement for your current heating system. However, these systems have lower efficiency than a normal heat pump, so may cost more to run. There are relatively few high temperature heat pumps on the market at the moment, but the technology is developing.

Solar assisted heat pumps

Solar assisted heat pumps combine a solar thermal panel with a heat pump. The solar panel is used to collect heat which is then transferred to the heat pump. The panel is usually (though not always) placed outside on a south-facing roof to capture heat from the sun. A fluid passing through the panel absorbs heat from the sun's rays and from the ambient air. This heats the fluid, causing it to evaporate and turn into a gas. The gas is then passed to a heat pump, which amplifies the heat and transfers it to your heating system (in the same way as a standard HP), where it can be used either to heat

your home or to provide hot water. Some systems use a 'hybrid' solar panel, which uses the sun's rays to generate electricity as well as heating the fluid to pass to the heat pump. This electricity can then be used to power the heat pump itself. At the moment, the Microgeneration Certification Scheme only certifies solar-assisted heat pumps which provide hot water, not those which also provide space heating for your home.

What maintenance do GSHPs need?

GSHPs will usually last for 20 years or more, and need relatively little maintenance. We recommend you carry out a yearly check and have a more detailed check by a professional every three to five years. Your installer should leave written details of any maintenance checks needed, and you should contact the heat pump supplier for exact maintenance requirements before you install. Your yearly checks are likely to include pre-heating season checks of the water pump and the external pipework to check there are no leaks.

Heat pumps usually come with warranties of two or three years, which can often be extended for a fee. Workmanship warranties are often longer, up to 10 years.

Are there any financial schemes available in Scotland?

There are two schemes you can take advantage of for GSHPs, the UK Government's Renewable Heat Incentive (RHI) and the Scottish Government's Home Energy Scotland Loan scheme.

The RHI gives you cash payments every three months over seven years and the amount you receive will depend on a range of factors. To be eligible for the RHI, the heat pump installed must be on the Ofgem's Product Eligibility List and installed by a Microgeneration Certification Scheme (MCS)-certified installer. The heat pump also must have a Seasonal Performance Factor (SPF) of at least 2.5.

You could also get an interest-free loan through the Home Energy Scotland Loan scheme to cover up to 100% of the cost of the heat pump (up to a maximum amount of £10,000). The repayments can be spread over a number of years (up to a maximum of 12 years).

For more information, please see our *Financial support for renewables systems* factsheet.

How do I get a GSHP installed?

Find an installer certified under the Microgeneration Certification Scheme (MCS)
The MCS is a quality assurance scheme supported by the UK Government, which certifies products and installers. To be eligible for government funding, your installer must be MCS-certified. You can search for an MCS installer in your area on the Renewables Installer Finder and read customers reviews, or alternatively search the full list on MCS website.

You should try to find an installer who is also listed on the Competent Persons Register. Registered installers are able to self-certify that their work complies with building regulations, and will give you a certificate of compliance when the work is complete so you do not need to submit a building notice.

Check which approved consumer code the installer is registered with and what other protection/guaranties they can offer you.

work out the appropriate size for the system, and help you decide what model of GSHP would work best for you and what sort of trenches or boreholes will need to be dug.

You should choose a system which is MCS-certified, see MCS website.

You should also check that your chosen system is on the RHI Product Eligibility List (PEL).

You can visit a home on the Green Homes Network to see a system in action in a real home and speak to the homeowner about their experiences. Go to www.greenhomesnetwork.org.uk

Check your land is suitable
Check whether there are any service pipes running under your land which may affect your ability to dig trenches or drill boreholes. If you go for a vertical borehole GSHP, get a geological survey done to check the suitability for drilling, and check with the Coal Authority if you live in an ex-mining area.

Check whether you will need planning permission or building warrant
GSHPs are usually classed as 'permitted developments' which do not need planning permission, but you should check with your local authority

Decide what type of heating system you need
Installers will be able to advise on what is best for your home. You may need to install new radiators or underfloor heating to get the best out of your heat pump

Get at least three quotes
We recommend that you get at least three quotes from three different installers to make sure you get the best deal. Make sure you understand exactly what each installer is quoting for to make sure they cover all aspects of the installation. Also check if the installer will manage the whole installation and coordinate any drilling or digging work, as this could make the process much easier for you.

You should also check any conditions in the quote about costs of trenching or drilling – often quotes will contain caveats around extra costs if the ground is not suitable for drilling. Check whether the drilling will be subcontracted or not. Often it will be up to you to contact a specialist borehole drilling company or trench-digging company.

You should also check whether the heat pump installer will contact installers of any new heating system – it's important that these two systems are designed to work together.

Apply for a HES Loan
If you would like to apply for Scottish Government's Home Energy Scotland Loan, you will need to request an application form by calling Home Energy Scotland on 0808 808 2282. You will then need to return the form to the Energy Saving Trust along with your chosen quote from an installer and some supporting documentation. You need to apply and have written confirmation of your loan before commencing with installation. For more information on how to apply and how much you could receive, see our *Financial support for renewables*

Load checks
Before installation, you will need to check with your local electricity board that it is ok to install a heat pump of a certain size. Your installer will be able to provide you with technical details on the heat pump model, such as the starting current, maximum operating current and heating load. Some heat pump models have a 'soft start' mechanism, meaning the heat pump will start up gradually and so require less electricity in one go. It's worth checking this with your installer so you can inform the electricity board.

The network operator will then perform a 'load check' to ensure the local electricity network is capable of supplying enough electricity at peak times when the heat pump is working at full capacity. Sometimes remote properties will require an electrical upgrade.

You should inform your electricity board as far in advance as possible, as it may take a few weeks for them to schedule a check.

Install, apply for the RHI and claim your Home Energy Scotland Loan if relevant
Once the installation is complete, your installer should provide you with an MCS compliance certificate. They should also register your installation within 10 working days on the Micro-generation Installation Database and provide you with a separate MCS commissioning certificate. You will need these certificates if you wish to apply for RHI.
You have 12 months from the commissioning date of your system to apply for the RHI.
If you've been offered a loan, you will need to claim your loan before the expiry date on your loan offer letter.

How to get the most out of my GSHP

Electricity tariff

If you did not previously have electric heating, you will find your electricity usage goes up after installing a heat pump. Because of this, you may want to change to a different tariff. You should discuss this with your installer – heat pumps work over 24 hours, so a tariff with a large number of off-peak hours such as Economy 10 may be most appropriate.

Some off-peak tariffs are only available to people with heat pumps, so it's worth telling your energy supplier that you are installing a heat pump to see what tariffs are available.

Electricity monitoring

You can keep on top of the amount of electricity your heat pump and your home is using by buying an electricity energy monitor. These simply can be clamped on to your existing electricity meter and be bought online. They will show the amount of electricity you are using through an in home display, you can also add in your tariff rates so you can see an estimated cost.

Understanding your controls

Using your heat pump correctly will be important to make sure it works at its most efficiency. Heat pump controls usually include a controller and a thermostat:

Controller

Your installer should programme your controller based on their calculation of your heating requirements. Monitor your energy bills, and if they are close to what the installer predicted, you should not need to change the settings on the controller.

The controller decides when the heat pump turns on and off, what temperature the water flows at (separately for heating and hot water, if your heat pump provides both), and displays any error messages.

Thermostat

The thermostat monitors the temperature in the home and communicates with the heat pump to turn on if the room temperature is too low.

Thermostatic radiator controls (TRVs)

These individual radiator controls can be set to different temperature levels (usually 0-5). This will allow you to heat only the rooms you use regularly and then set the amount of heat used. This will reduce your energy consumption saving you energy and money.

Useful links

- Renewable heat incentive calculator at https://www.gov.uk/renewable-heat-incentive-calculator
- Green Homes Network (to see case studies of people who have installed renewables or talk to people about their experiences) at http://greenhomesnetwork.energysavingtrust.org.uk/
- Renewables Installer Finder Scotland at https://rif.est.org.uk/