GROUND SOURCE HEAT PUMPS

Harnessing the warmth of the earth, ground source heat pumps are a popular choice to heat homes in North America and Europe. A handful of home owners in Australia have also embraced the technology.

WORDS SARAH ROBERTSON

Ground source heat pumps work by exchanging heat energy with the earth at depths of one to 100 metres, using a loop field which can be installed horizontally or vertically. Images courtesy Geo Climate Systems and WaterFurnace (left) and Dr Donald Payne (right)

Ground source heat pumps are an extremely efficient form of space heating and cooling. They use little energy, have a long lifetime and they need little maintenance. They can also provide hot water. They do, however, require a significant upfront capital investment and with a payback period of anywhere from five to 15 years, they are not a viable option for everyone.

Also called geo exchange systems and popularly known as geothermal heat pumps, ground source heat pumps (GSHPs) are fairly common throughout North America and Europe. GSHP technology is not new but their use is relatively new to Australia, with systems mainly installed in commercial applications over the last 20 years. It has only been in the last few years that GSHPs have been more commonly used for residential purposes.

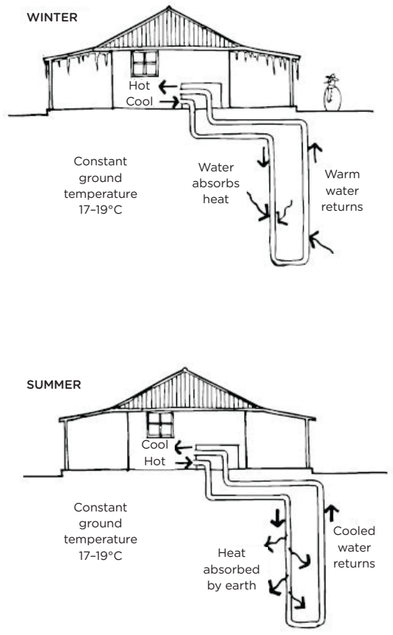
To understand geo exchange or GSHP systems, it's helpful first to know that GSHP systems used to heat, cool or provide hot water for a home or other building are different to the more commonly understood geothermal electricity. Both geo exchange systems and geothermal energy systems for electricity and direct use make use of heat energy stored underneath the ground. However, geothermal energy typically refers to the use of heat from much deeper – up to five kilometres – below the earth's surface. To generate electricity, this heat is brought to the surface in the form of water or steam and moved through turbines to generate electricity. A GSHP system, on the other hand, simply exchanges heat energy with the ground at much shallower depths of between one and 100 metres below the surface.

HOW THEY WORK

Exchanging heat energy with the ground, GSHPs move heat into, or out of, a building. They work just like a refrigerator, which uses a circulating refrigerant and a compressor to move heat from inside the fridge out into the room, lowering the temperature inside the fridge. All GSHPs consist of a loop field, a compressor and refrigerant. This system then connects to a heating, cooling and/or hot water system of choice.

Paul Ledwith runs Melbourne heating installation company Geo Climate Systems and says GSHPs are much more efficient than virtually everything else on the market.

The key to this efficiency lies in the GSHP's exchange of heat energy with the ground as opposed to the air exchange that takes place in traditional heating and cooling systems. GSHPs make use of the fact that the temperature some metres below the earth's surface is fairly constant over the whole year. In Melbourne, Sydney and Canberra, for example, this temperature remains between about 15 and 18 degrees Celsius throughout the year, between 22 and 23 degrees in Brisbane, approximately 14 degrees in Hobart and 31 degrees in Darwin. A GSHP is such an efficient heating and cooling option, therefore, because it only has to work to bridge the temperature gap between the generally comfortable ground temperature and the desired temperature inside a house. This means that to heat a home to 19 degrees Celsius on a five degree winter's night in Sydney, for example, a GSHP takes the constant ground temperature of about 17



A ground source heat pump uses the relatively constant ground temperature to warm the system's circulating liquid in winter, and cool it in summer. It's then used for functions like heating and cooling the home and providing hot water. Image courtesy *Your Home Technical Manual*

degrees as its starting point and only has to work to heat the air within the house by two to four degrees. A conventional electric heat pump (such as reverse cycle air-conditioning) in the same house, on the other hand, would take the outside air temperature of five degrees Celsius as its starting point and would need to work harder, using more electricity, to heat the air within the house by 14 degrees to have the same effect.

With this reduced workload, GSHPs achieve significant energy savings, reducing electricity bills and carbon dioxide emissions.

Dr Donald Payne is Scientific and Policy Director with ground source heat pump supplier and installer Direct Energy and an Australian Geothermal Energy Group representative. He says that while the amount of electricity used by GSHPs varies greatly between households because of different usage habits, electricity use savings are typically 30 to 70 per cent on the amount of electricity that would be used by an air-source system.

He explains in more detail that the energy savings achieved with a GSHP are about 50 per cent compared to an electricity-driven conventional refrigerated air conditioner; about 70 to 80 per cent compared to heating with LPG; about 30 per cent compared to heating with natural gas; and about 70 per cent compared to the traditional delivery of electric hot water.

GSHPs, however, do require a serious upfront capital investment. System installation costs vary depending on the type and size of the system. As a rough guide, the initial cost for the loop field and heat pump of an average-sized (14 kW) direct exchange system starts at about $10,000 to $15,000 beyond the cost of a typical reverse-cycle air-conditioning system. Because drilling is the major cost in a GSHP system, deeper drilling depths or greater system sizes will increase this cost.

Once a system is installed, either in a new building or retrofitted into an existing building, both Dr Payne and Ledwith say little maintenance is required. They add that there is very little that can go wrong with a GSHP. Perhaps as a testament to this, systems generally have warranties of 20 years and the ground infrastructure is built to last decades.

Dr Payne says the significant reduction in peak-load power delivered by a GSHP is the key driver for their popularity overseas. It is also a key driver among policy makers in Australia. He says a good way of characterising GSHPs and the industry's development is by comparing it to solar photovoltaic technology about 10 to 15 years ago. There are currently no government rebates or subsidies available for GSHPs. However Dr Payne says that over the next 10 to 15 years, rising electricity and gas prices and greater awareness of the efficiencies and effectiveness of GSHPs, as well as better economies of scale, should bring their cost down.

TYPES OF GSHPS

GSHP systems differ mainly in the type of loop field they employ (the pipes and their configuration), and the liquid circulating through it.

The loop field can be a vertical ground loop or a horizontal loop field placed about 1.5 metres below the ground or in a body of water.

Standard vertical water loop geo exchange systems circulate water through high-density polyethylene pipes underground. These are the most prevalent systems around the world as they were the first GSHPs to be commercialised. They require digging holes down to about 100 metres.

In direct exchange systems, refrigerant circulates directly through copper pipes underground. Typically, these systems involve digging holes down to about 30 metres.

Depending on the heat pump's design, both the standard and direct exchange systems can perform more than one function, such as heating, cooling, and/or hot water. David Manoni from Geothermal Western Australia explains that one of their direct exchange systems can perform two functions at any one time, where fan-forced heating and cooling is one function, hydronic heating is another, and domestic hot water is another. So the system might provide fan-forced heating and cooling as one function and hot water as the second function. Alternatively, the system could provide fan-forced air-conditioning as one function and hydronic heating as its second function.

Manoni adds that in cooling mode, a desuperheater device can be added at relatively small cost to supply "free" hot water. This hot water is free, he says, because while a heat pump compressor is working to cool a building by extracting heat from within it, instead

Installing a horizontal loop GSHP can be cheaper than the extensive drilling required for a vertical loop field, but it does require more land. Image courtesy Geoexchange

of disposing of this waste heat outside, the desuperheater uses it directly to heat water.

GSHP systems that perform multiple functions are slightly more expensive than single function ones; however, Dr Payne says using a GSHP system to multitask is where it becomes most cost effective.

"If you can do multiple applications out of that one set of ground loops then you start to get a more attractive payback and life cycle on the GSHP," he says.

"The other thing that will, over time, factor into these costs is the price of natural gas and electricity over the next few years. That will substantially impact on the economics," he adds.

With most of the cost of a GSHP being the drilling, vertical loop field systems are generally more expensive than horizontal ones. However, horizontal systems do require a larger amount of land.

GSHPS IN THE HOME

In early 2008, Callum Ingram retrofitted his old Californian bungalow in an eastern suburb of Melbourne with an 8.7 kW direct exchange GSHP system. While they had some installation troubles early on, he says these were resolved when a different contractor took over and they now use less energy, the heat pump is quiet and provides very comfortable heat and cooling.

An early suburban GSHP installation, the system cost just under $10,000 more than a conventional heating and cooling system. However, Ingram says they recognise it would cost more now as the systems are much more sophisticated. Today he says the system runs "very smoothly" and they get it serviced once or twice a year.

"We did have a number of issues early on," he explains, "but these all related to the installation of the system rather than the system itself."

In Western Australia, Dermot O'Keeffe's family is building a green home in Peppermint Grove. Their new home will be 80 per cent self-sufficient in terms of electricity and water with a greywater system, water tanks totalling 40,000 litres, a five kW solar system and a GSHP.

Geothermal Western Australia have drilled nine 30 metre holes for the 21 kW direct exchange system that will run a conventional air-conditioner and a hydronic water module heat exchanger for under-floor heating.

O'Keeffe says he would recommend the system to others. "It's not cheap, the upfront cost. And the government, of course, gives you nothing, which is pretty disgraceful really. But we've got to get away from using coal, there's no question about that and I think if you can combine running your geothermal system off solar panels, you're kind of getting there," he says.

In north eastern Victoria, Geo Climate Systems is installing a standard geo exchange system to heat the Mace family's newly bought Victorian brick home.

Michelle Mace says they wanted to help change the perception that old brick homes are difficult to heat. With drilling about to begin, the heat pump and under floor insulation has been installed and windows are double gazed.

Mace says they have moved to the town for the long term so the ten to 15 year payback is not a problem. She says the system will be significantly more economical than burning LPG or wood but adds that if the town had access to natural gas they might not have researched geothermal heating so thoroughly.

"It's going to be a blessing," says Mace. "And we just thought, it's a one-off big cost but once it's in, it's going to be a dream to run."

MORE INFORMATION

- For more information about GSHPs, see *ReNew* 107 and *ReNew* 112. **www.renew.org.au**
- Geo Climate Systems **www.geoclimate.com.au**
- Direct Energy **www.directenergy.com.au**
- Earth to Air Solutions **www.earthtoair.com.au**
- Geoexchange **www.geoexchange.com.au**
- Geothermal Western Australia **www.geothermalwa.com.au**
- Alternative Technology Association **www.ata.org.au/projects-and-advocacy/ground-sourced-heat-pumps/**
- International Ground Source Heat Pump Association **www.igshpa.okstate.edu**