Ground source heat pump (GSHP)

GSHPs are ideal heating systems for space heating and hot water provision in a substantial proportion of properties. The efficiencies are extremely good (300 to 450%) for heating and the heat pump unit could be installed easily inside the house or externally in an appropriately sized outbuilding. They are powered by electricity and take the heat energy from the ground (a ground collector) and transform it into usable heat, to run this system requires sufficient accessible land round a property.

As an example take a four bedroom modern house that is double glazed and reasonably insulated. The floor area could be about $180m^2$ and the whole house heated with a heat pump sized to meet the heating and domestic hot water (DHW) requirements at external ambient temperatures down to minus 5ºC. This would need a heat pump about 13kW output.

A heat pump absorbs heat energy from a low temperature source (8 to 15°C) and transforms it to a higher temperature (40 to 60°C) through a thermodynamic cycle similar to that which operates in a food freezer. Collecting heat energy from the ground – either from ground loops buried about 1.5 m below the surface or bore holes usually about 100m deep. The design of the collector loop and its integration with the heat pump is critical for life and performance as the ground properties and available space are key factors in determining the viability of GSHPs.

The ground collector can be either laid horizontally or in vertical boreholes, the former generally needs an open area significantly larger than the floor area of the building whilst the latter requires space for drilling boreholes. In the example above a $400m^2$ array would be required for a horizontal collector, this would be connected to the heat pump via flow and return pipes to the house running underground.

Boreholes could be considered as an alternative as they require less space, probably two at approximately 100m deep.

GSHPs are manufactured generally for single phase electricity for machines up to approximately 15kW output.

Installation and Space ~ there are three sub-systems associated with a GSHP installation, the heat pump unit, the ground collector and the heat distribution (under floor, radiators or warm air heating). The heat pump unit is generally about the size of an upright freezer and will need either a separate buffer tank or larger than standard water cylinder capable of transferring the heat output from the HP. The reason for this is to prevent rapid cycling on and off of the unit which could shorten the operating life.

Heat pumps operate at lower temperatures than conventional systems which has implications on the form of space heating distribution system installed. However the temperature of output water for under floor heating is 35°C - ideal for use with a heat pump offering high operating efficiency. They can however be used in conjunction with radiators although these would need to be larger than those installed in oil, gas or biomass systems due to the lower operating temperatures at 50 to 55^oC.

As mentioned above the ground space for the collector can be considerable depending on the type of ground conditions, generally for a horizontal collector array an area equivalent to 2 to 4 times that of the floor area of the property is required. Vertical boreholes require less area but if more than one are required the spacing between them should be 5m minimum. The relationship of costs between the two techniques is quite marked as there could be a difference of double the cost for boreholes for similar levels of heat absorption.

Savings and Costs ~ The indicative costs given here are based on the house requiring a 13kW system operating at 35°C (UFH) with DHW at 50°C. The capital investment is approximately £1000 to £1200/kW installed excluding ground works which could be undertaken by the client or at the time of laying in services if it is a new construction or extensive renovation.

There are certain factors that influence the time it takes to gain a financial benefit equivalent to the investment made that need to be considered before making a decision. The running costs of a heat pump are lower than other conventional systems to deliver the same heat input to a home. Simply this is the difference between the cost of electricity to run the heat pump and the cost of the alternative heat source e.g. oil.

In the example of the house mentioned earlier the comparison of costs could be £880 for electricity vs. £1350 for oil, £470 cheaper. This saving on its own would mean that the investment would be unattractive. The government has introduced an incentive scheme, the renewable heat incentive, (RHI), to make the adoption of renewable energy systems attractive to domestic users. The incentive is calculated based on the figures derived from a Green Deal Assessment which embraces an energy performance certificate (EPC). It is essential that anybody planning to pursue the RHI has an assessment and has an EPC.

The RHI for GSHPs is currently rated at 18.8p per kilowatt hour (kWh) for all renewable heat used (i.e. excluding the contribution from the electricity used). The RHI will probably yield a return of £3000 pa for the heat extracted from the ground. This will give a payback in the order of 5 years compared to oil heating.

The indicative annual CO_2 saving is 3000kg compared to oil heating.

Quality ~ the technology is mature as these systems have been in common use in central and northern Europe for decades. The majority of European manufactured units carry EU quality accreditation and are fundamentally reliable. Generally the life for this type of system is 20 to 25 years for the heat pump and 50 years for the ground loop. Servicing requirements are minor and vary from 1 to 3 yearly inspections.

Only accredited heat pumps installed by MCS accredited installers are eligible for the RHI.

Risks ~ There are no planning requirements for GSHP although where boreholes are being considered it is prudent to discuss the location with the Environment Agency. EA has knowledge of previous land usage which may reduce any risk associated with drilling. For large ground loop installations some authorities may require planning consent for “Engineering works”.

The technology is mature and as such represents no risk operationally or to the environment. The ground loop reliability is very good and risk of leaking is considered practically nil. Noise emission is low level (44 to 54 dB(A)) from the internal compressor and is not intrusive.

Benefits

- Reduced CO_2 emissions
- Highly efficient 300 to 450%
- Fuel energy cost saving.
- Easy to install in new buildings
- Well matched to under floor heating systems
- No fuel storage required.
- No combustion and CO emissions.
- No exhaust flue for combustion products.

Issues

- Low temperature system
- Can be complex to retrofit to an existing building
- Lacks flexibility for variable occupation buildings.

Must Do's

- Obtain a Green Deal Assessment
- Obtain an EPC
- Establish the full implications e.g. suitability of existing radiators, etc.
- Purchase an accredited product
- Use a MCS accredited installer
- Learn to get the best out of the system

Useful website

OFGEM ~ www.ofgem.gov.uk

RHI ~ www.ofgem.gov.uk/publications-and-updates/ domestic-rhi-essential-guide-applicants

Energy Saving Trust ~ http://www.energysavingtrust.org.uk/Take-action/Get-free-advice

Green Deal ~ https://www.gov.uk/green-deal-energy-savingmeasures/how-the-green-deal-works

EPC ~ https://www.gov.uk/buy-sell-your-home/energyperformance-certificates

MCS ~ http://www.microgenerationcertification.org

(All costs quoted in this article are based on prices in 2014)