Residential: Geothermal heat pump and radiators

CASE STUDY

Renovated private home, Christchurch

Proper central heating helped combat heat loss from the the single glazed windows on this Christchurch home.

Challenge

The owners of this older home embarked on a significant renovation to the house which included adding insulation to external walls. However, whilst this improved the home's thermal performance the retained single glazing meant that the heat loss characteristics were inferior to those of a fully double glazed new home.

The owners wanted an efficient and effective heating solution that would ensure year round comfort, controllability and flexibility. A radiator-based system met all of these requirements.

Solution

The most efficient method of heat production for domestic installations is a geothermal heat pump. In this instance, Central Heating New Zealand installed a 3-phase DeLonghi WW-HT unit which harnesses the heat from inside the home's well water supply.

The principle of well water heating is the same as for in-earth ground source heat pump installations: the heat pump extracts a large amount of low temperature heat from the water and converts this to a smaller amount of high temperature heat output. The low variance in the temperature of the geothermal source (or well water in this case) ensures that the heat pump works within a small range, ensuring greater efficiency than air-sourced systems as air temperatures vary throughout the year. Geothermal heat pumps are capable of running at a coefficient of performance (COP) of 5.4, ie, for every kilowatt of energy consumed by the heat pump it is able to output 5.4kW.

Well water is pumped directly through the heat

System Performance: Dec '09 - Dec '10

Total Heat Delivered (kWh)	**28282**
Electricity consumption over period (kWh)	**8900**
COP (Coefficient of Performance)	**3.18**
Cost per kWh of actual delivered heat (Assuming power at 22c/kWh)	**6.92c**
Cost of Electricity consumed	**$615.88**

> A radiator system is a safe, stylish and healthy way to heat a home as there is no forced air draughts and they are not too hot to touch.
>
> *-CHNZ*

pump with its heat exchanger taking heat from the water. This cools the water which is then rejected into another well or soak pit. Heat can also be extracted from the ground using horizontal loops buried in the ground at about 1.8m depth or vertical bore holes containing pipe loops. Pipe loops are sealed with the water inside being continuously pumped round the system.

In this case, the water is heated to approximately 60°C, warm enough to supply the radiators throughout the home. With a maximum heating requirement of 24.3kW the house was fitted with 15 DeLonghi Ultimate radiators of various sizes.

As the water is heated to a lower temperature of 60°C rather than a more typical temperature of 70 to 80°C, the system had to be designed using radiators that were larger to counteract this. For example, a 600 x1800 radiator would typically produce an output of 3.2kW when used with a diesel boiler operating at an average of 70°C; with a heat pump operating at 60°C the output is reduced to 2.2kW. This also means that the coefficient of performance of the system is below that of a typical low temperature geothermal underfloor heating system.

Benefits

The high temperature heat pump heats radiators in every room in the house. When it is cold the radiators are heated to 60°C. The heat pump controller has an outside temperature sensor so that when it is not so cold outside the radiators can run at a lower temperature, making the heat pump run more efficiently, but still heating the house. This ensures the home stays warm and reacts to the changes in the weather.

Whilst geothermal systems running underfloor heating can attain a higher COP than an equivalent radiator system, the running times for radiator systems are shorter compared to underfloor where the heat pump must maintain floor slab temperatures all day long. Radiators, however, react much faster than underfloor heating systems and can be heated from cold in only a matter of minutes if required, thus perfectly suiting New Zealand's changeable climate.

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Following installation, Central Heating New Zealand installed equipment on-site to monitor power use and heat output of the system (see table below). Indoor and outdoor temperatures were also measured showing how warm the house was over the monitored period. Results show that the heating is not on 24 hours a day, only coming on in the morning and evening on week days. Indoor temperature dropping to 20°C overnight and sometimes during the day and rising to 24°C when the heating is on. The indoor temperature is a constant profile, only getting hotter on a couple of days towards the end of the heating season when the outside temperature is very high.

The results show the excellent efficiency of the system as well as its ability to meet the heat demands of a large home that is predominantly single glazed. Much of this can be attributed to the fact that the heating system control system doesn't waste fuel by overheating the house and adjusts the heat used according to the outside temperature. Shorter running times compared to underfloor ensures that costs are kept low despite the heat pumps lower COP than could have been achieved with underfloor heating.