Geothermal heat pump

Application using an existing water well

Introduction

The project includes the provision of space heating and cooling and domestic hot water for a single-family house of 190 m², by means of a geothermal heat pump, a reversing system to produce hot and cold water and a storage tank combining domestic hot water and space heating.

The design of the system includes an existing water well, to be used as thermal exchanger in a closed cycle, avoiding the need to perform bore holes or equivalent ground source devices.

The goal of this project is to replace the existing heating system, made up of a boiler with diesel oil burner. In the initial conditions, the system offered a thermal efficiency of 85%. The efficiency obtained using the geothermal system is stated to be of 460% in heating, and 600% in cooling the house, with a CO_2 emissions reduction equivalent to 0.33 Tm/year.

TECHNICAL DEFINITIONS

Bases used for the system calculation:

Outdoor minimum temperature:	-10 ºC
Outdoor maximum temperature:	45 ºC
Indoor temperature, winter:	20 ºC
Indoor temperature, summer:	24 ºC
Hot water temperature:	45 ºC
Supply water temperature:	15 ºC
Daily hot water consumption (average):	250 litres.
Thermal insulation of the house (estimated):	2 W/m ² K

Total power of the household's electric equipment: 3000 W, with a simultaneity factor of 0,6.

The sanitary hot water is obtained without any external energy support, just using the geothermal heat pump. The storage tank includes a 70 litres domestic hot water tank connected to the hot side of the geothermal heat pump, by means of a three-way valve with motor, and a storage tank of 200 litres capacity for space heating.

In summer, only small power contribution is required to heat the hot water storage tank, since the tank stores the heat extracted from the house.

Estimated power requirements:

In summer, the power of the system is considered in 9,5 KW, and the geothermal system acts like an energy absorbent, exchanging the surplus heat with the ground

In winter, the heat exchange system provides 86% of the required power, that is to say, 8.2 KW.

Power of the heat pump system:

A heat recovery factor of 30% superior to the thermal needs of the house is considered sufficient, so that a geothermal heat pump of 10.5 KW power output, made by NIBE - AB – Sweden, was selected.

Required electrical power

Maximum power output:	10.5 KW.
Coefficient of Performance (COP):	4.6 (heating), 6 (cooling)
Required electrical power:	2.28 KW.

System dimensioning

Underground characteristics:

Thermal conductivity: 1.4 W/*mK

Thermal power that can be transferred from the ground source: 65 W/m, taking advantage of the water as thermal conductor between the pipes used as intercooling system between the heat pump and the ground source.

Temperature measured to 60 meters depth : 17 ºC.

Depth calculation: L = P/60.

Length (l) of water well, in order to have a correct thermal exchange with the ground source:

L= 10.500 W / (65 W/m) = **161.5 m**

Considering that:

. The depth of the water well that can be used as intercooler is of 190 m

. Historically, the mean ground water level in winter is 8 m below ground level

. A free space of 5 m in the lower part of the water well must be respected, in order to install a water extraction pump, to use the water well as water source for garden irrigation.

In this case, the water column that can be used as intercooler is **177 m**

Due that the needs has been calculated at 161,5 m, and there are available 177m, the feasibility to use the water well as ground source is reasonable.

Calculation of the water volume that must circulate by the geothermal heat pump, in closed loop circuit:

Medium temperature of the well = 17 ºC. (Temperature at 60 m)

We use as hypothesis that in summer the water temperature send to the intercooler will be 29 ºC, while during winter it will be 9 ºC.

Summer

The contribution of energy to the ground is of 10.5 KW, that is to say, of 12,209 Kcal/h.

Thermal shift in summer = 29 -17 = 12 ºC. (dTest.)

Volume C, required for the intercooling Qest.= Kcal /h. it will be of:

Qest = C x dTest.

C = Qest/dTest; 12.209/12 = 1,017 l/h

Winter (the same power is considered)

Thermal shift in winter = 17 - 9 = 8 ºC. (dTinv.)

Volume C, required for the intercooling Qinv.= 12,209 Kcal /h. it will be of:

Qinv = C x dTinv

C = Qinv/dTinv: 12.209/8 = 1,526 l/h

SYSTEM GEOTHERMAL HEAT PUMP + INTERCOOLER

From the previous calculations we have:

Power (heating): 8.2 KW.

Power (cooling): 9.5 KW.

Number of meters available at the water well: 177 m

Ground source flow rate: 3.000 l/h.

Geothermal heat pump power output: 10.5 KW

The capacities of the system will be:

WINTER

Heating: 8.2 KW.

COP: 4,6

Electric power consumption = 1.78 KW/h.

SUMMER

Refrigeration: 9.5 KW.

COP : 6

Electric power consumption = 1.58 KW.

DISTRIBUTION OF THE HEATING / COOLING

The heating system will consist of the actually installed radiators, supplied with a water temperature up to 60ºC, while the cooling system will be done using two fan coils, with a water temperature of 6ºC.

PROJECT

Once carried out the described calculations previously, the house-owner agreed to realise the project, partly motivated by the power savings that the geothermal solution represents, but mainly motivated by the environmental aspects, reducing the emission of polluting agents down to zero.

The phases of the project settled down in three areas of work:

. The execution of the exchanger, taking advantage of the existing water well.

. The interconnection of the well with the engine room.

. The installation of the geothermal heat pump and the storage cell of ACS

INSTALLATION OF THE GROUND SOURCE HEAT EXCHANGER

The selected heat exchanger is a double cycle of polyethylene tubes DN20 , since the free space in the well did not allow to use a greater diameter.

The water extraction system of the well stayed as it was originally, since the well had to continue operating.

INTERCONNECTION WITH THE ENGINE ROOM

The water well is placed at 110 meters of the engine room. A trench of 40 x 50 cm, with sand base for better accommodation of the piping, allows to lead the pipes protected with insulating cover (K : 0,25)

INSTALLATION OF THE EQUIPMENT

The heat pump settled in the engine room where previously the diesel boiler was located, taking advantage of the connections to the existing circuit of radiators.

The ACS storage cell can reach 70ºC periodically to fulfil the present legislation on prevention of Legionnaire's disease.