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Demonstration of
Ground Source Heat Pumps
in Mediterranean Climate

One-family house in Sasso Morelli

In 2007 in Imola (near Bologna) a new wooden family house with new energy efficiency techniques has been built. The heating/cooling system is a geothermal heat pump, while the hot water system is a solar panel with a back-up gas condensing boiler. Heat pump and solar panel startet operation in late June 2008. The area to be cooled/heated is about 150 m^2.

General Description

Country	Italy
City	Imola (BO)
Client name	Private citizen
Application area	Building sector
Building type	One-/two-family house
Year of construction	2007
Heated/ cooled building area	150 m²
Heat source/sink	Brine/Water
Heat pump type	Electric heat pump
Year of installation	2008
Purpose	Heating and cooling
Heat source system	Borehole heat exchanger (vertical)
Distribution system	fan coil units
Design heating temperature	supply: 0°C return: 0°C
Design cooling temperature	supply: 0°C return: 0°C
Operation mode	Bivalent
Refrigerant	R410A
Alternative/ complementary heating system	gas condensing boiler thermal solar
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Project description

Building, overall energy concept

In Imola (near Bologna) a new family house with new energy efficiency techniques has been built *(Photo 1)*. It is a wooden structure with 9 cm of insulation material all around the building. The heating/cooling system is a geothermal heat pump, while the hot water system is a solar panel with a condensing boiler to support it in the winter season. The house and the thermal and hydraulic circuits have been completed in 2008 and the heat pump and the solar panel startet operation in late June 2008. The area to be cooled/heated is about 150 m^2.

The ground source heat pump is linked to a centralized fan coil system, which is managed by an electronic control panel, that can be programmed manually. There are 11 fan coils inside the house that work only when temperature in the single room is below a certain value given by the external air temperature and by customer decisions. The fan coils work always at the lowest speed, because of the high insulation of the house. In this way, there are no energy losses (the power is always about 1-2 kW/fan coil) and the running temperature is about 30-35°C, so that the efficiency of the heat pump is similar to the same heat pump linked to a radiant panel system.

A "Riello" solar panel of 2.35 m^2, located in the south of the roof, at about 30°C inclination, provides the hot water for domestic purposes. Because the one solar panel is insufficient for providing enough of hot water in witertime, there is a "Immergas" condensing gas boiler to support it. The condensing boiler could also be used to support the heat pump system, but, until now, it never happened.

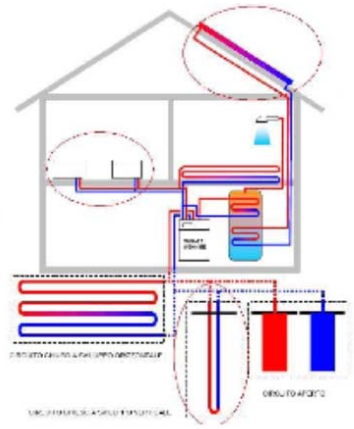

Figure 1: Funtional scheme of the GSHP heating/cooling system

Heat pump system

Two 80 m borehole heat exchangers are linked to a water-to water electric heat pump. They are single U tube PE 100 DN 40 PN 12. Each borehole is completely sealed. The two hydraulic circuits are then linked in one larger PEAD DN 40 PN 12 circuit, consisting of two tubes (in/out), which are connected to the heat pump.

WSHN-EE 17 - 121 (R-410A)		
GRANDEZZE	Raffreddamento [kW]	Riscaldamento [kW]
17	5,97	6,58
21	6,40	7,17
31	7,82	8,90
41	10,4	11,6
51	13,1	15,7
61	16,1	18,1
71	20,0	23,6
81	22,1	25,3
91	25,6	29,5
101	29,0	34,7
121	32,4	39,3

Figure 2: Cooling and heating capacity of the Clivet heat pump

Because of the high level of the COP (5.18), due to the low temperatures of the fan coils, the power exchanged by the two boreholes is about 6 kW.

The Sasso Morelli subsoil is formed by an alluvial terrace and the boreholes meet a lot of ground water, divided into 4 aquifers, but with no strong Darcy flow. For this reason, the thermal power exchanged by the ground was supposed of about 40 W/m, resulting in two boreholes with a depth of 80 metres.

ELEVATA EFFICIENZA PER IL MASSIMO RISPARMIO ENERGETICO ED IL MINIMO IMPATTO AMBIENTALE

EFFICIENZA ENERGETICA					
Impianto lato sorgente	Impianto lato utilizzo	funzionamento	Temperatura di ingresso lato sorgente	Temperatura di mandata lato utilizzo	COP in riscaldamento / EER in raffreddamento (media di tutte le grandezze 17-121)
Sonda geotermica (circuito chiuso)	Fan coil / radiatori	riscaldamento	0°C	50°C	**2,61**
	Pannelli radianti		0°C	35°C	**4,03**
Acqua di falda (circuito aperto)	Fan coil/ radiatori		10°C	50°C	**3,45**
	Pannelli radianti		10°C	35°C	**5,18**
Sonda geotermica o Acqua di falda	Fan coil	raffreddamento	30°C (*)	7°C	**5,12**
	Pannelli radianti		30°C (*)	18°C	**6,51**

Figure 3: Operational characteristics of the heat pump

Operation experiences

Before starting the operational process of the heat pump eight thermometers have been installed inside the thermal systems which measure the following temperatures:

- Temperature of the water/glycol mixture in the "borehole - heat pump" circuit
- Temperature of the water/glycol mixture in the "heat pump - borehole" circuit
- Temperature of the water in the "heat pump-fan coils" circuit
- Temperature of the water in the "fan coils-heat pump" circuit
- Temperature of the ground at the bottom of one borehole (-80 m)
- Temperature of the external air
- Temperature of the internal air
- Temperature of the hot water from the solar panel

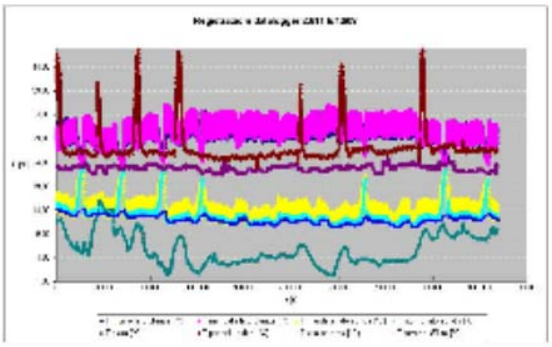

Figure 4: Utilization of the system in winter

A data logger registers all measurements in real time and registers the power sent to the fan coils every 15 seconds.

Photo 2: The geothermal heat pump (left) and the monitoring system

To watch the real time data of the working system, click the following link:

http://www.casa-geotermica-brt.dyndns.org/www.Casa-geotermica-brt.dyndns.org

Costs, economic efficiency, incentives

The "Sasso Morelli " building is a new house, so Italian state did not give any incentive to build it according to energy efficiency rules.

The savings are very high, not only because the geothermal heat pump system saves a 50% of money compared to a traditional boiler system, but also because the house insulation permits the fan coils (and consequently the heat pump) to work only in the "hard seasons", in summer and in winter. In addition, the request of energy is allocated into the rooms, so that the eleven fan coils do not work all together but only when and where it is really needed.

References

Francesco Tinti, *Geotermia per la climatizzazione*, Applicazioni - Tecnologia - Analisi costi - benefici. 2009, Dario Flaccovio Editore.

Characteristic values, performance data

	Design value	Measured data
Year	2008	2009
Heating capacity (kW)	7.17	-
Cooling capacity (kW)	6.40	-
COP (Heating, appliance)	5.18	-
EER (Cooling, appliance)	17.67	-
Annual heat delivery (kWh/year)	1 000	2 210
Annual cooling delivery (kWh/year)	800	269
Annual CO_2 emissions (kg CO_2/year)	250	307

Contacts, Links

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