Project 6: University of Valencia, Spain

Location, climate

UPV DEMO SITE is placed in the Polytechnical University of Valencia and is used for the air conditioning of the Applied Thermodynamics Department (UPV).This system was built under the frame of a R&D project titled GEOCOOL, supported by the European Union.

The Applied Thermodynamics Department is situated at the first floor of the 5J UPV departmental building as shown in the figure below:

Figure 1.- 5J UPV Building view and location.

The geographical location of Valencia is:

Latitude: 39,48º N
Longitude: 0,38º W
Altitude: 20 m

Climate Description

All climatologic information of the area of Valencia has been gathered in the “Atlas Climático de la Comunidad Valenciana” (Pérez Cueva, 1994). The region of Valencia is part of the Mediterranean Area, with moderate winters and fairly hot summers. The main characteristic of this climate is the clear dry period in summer.

In the western part of the Mediterranean area summers are somewhat cooler than in the central and eastern zones. Unlike the eastern Mediterranean Rim, precipitation is not only concentrated in winter but falls also in spring and autumn.

The next graph gives an overview of the medium temperature (T), the mean maximum temperature (TM), the mean minimum temperature (Tm), the absolute maximum temperature (MAXabs) and the absolute minimum temperature (MINabs).

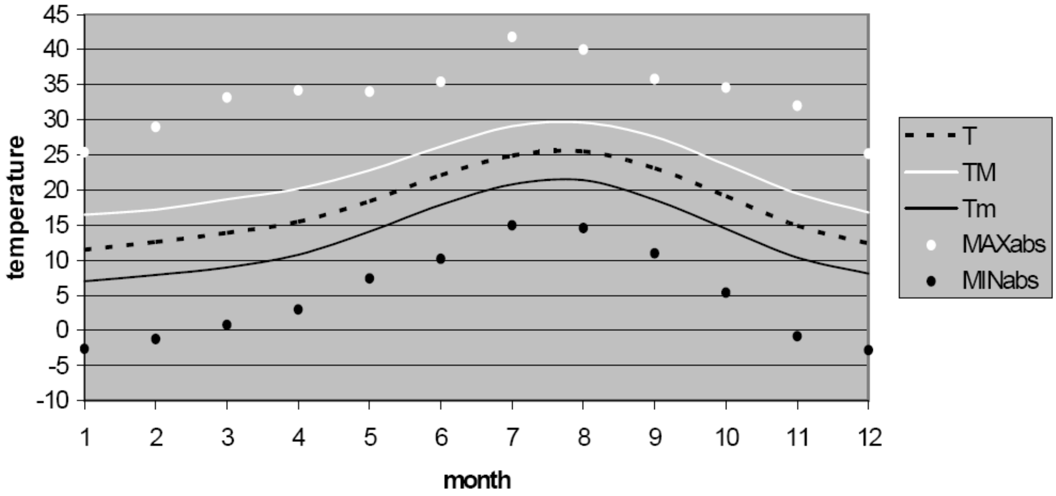


Figure 2.- Annual Temperatures in Valencia

The mean annual temperature for Valencia is 17,8 ºC.

The total average annual rainfall is 454mm.

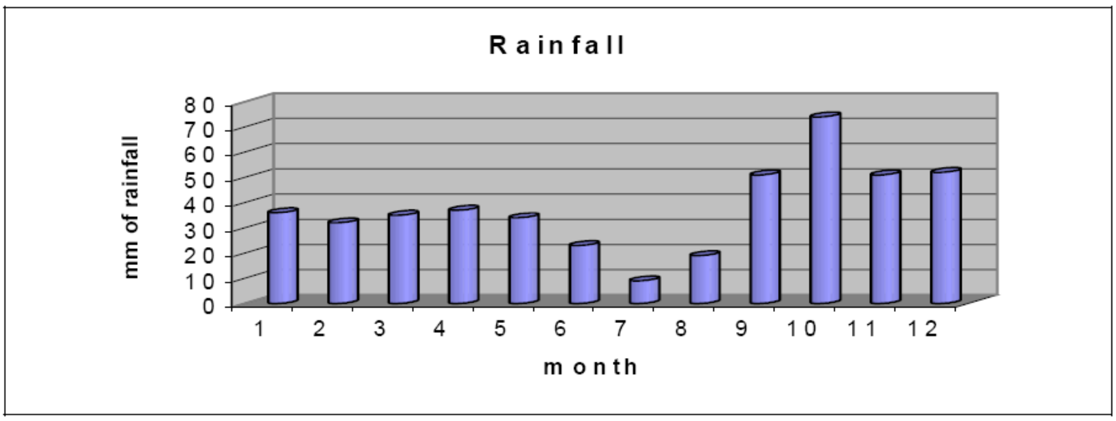


Figure 3.- Annual Temperatures in Valencia

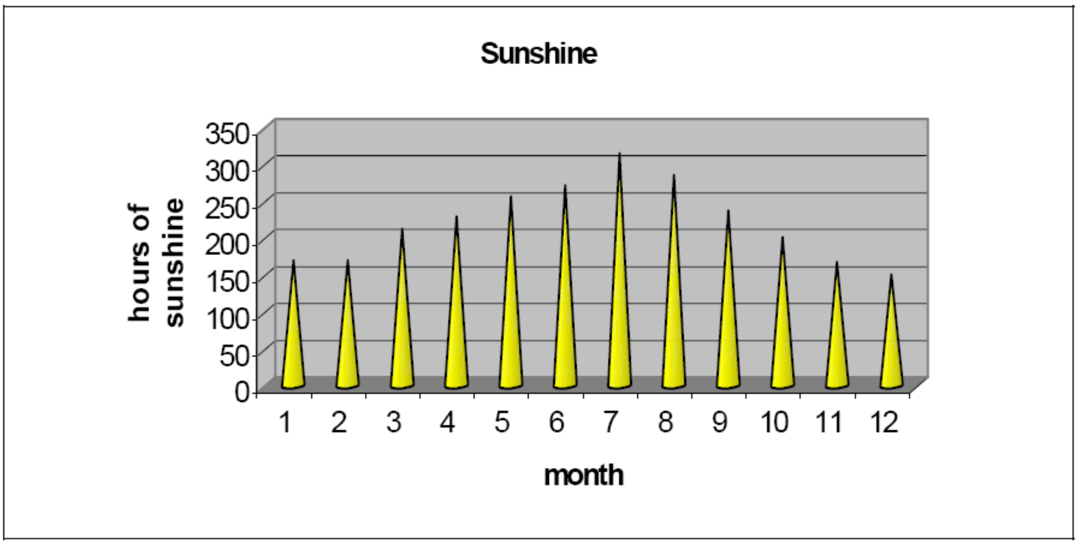


Figure 4.- Sunshine Average (time) in Valencia.

Description of the System:

The Air/Conditioning system, here in after referred as to as UPVAC, consists of:

1) An outdoor loop consisting of a ground source heat exchanger (here in after referred as GSHX), an external hydraulic group and the corresponding piping work. The loop takes the heat exchanged at the heat pump (cooling mode), and dissipates it to the ground.

   The external circuit loop consists of a circulating pump (Grundfos), a mass flow meter (Coriolis effect, Danfoss), manometers, expansion valves and several regulating and equalizing valves.

2) An indoor loop consisting of a series of 12 parallel connected fan coils, an internal hydraulic loop, a 157 litres storage expansion tank and the corresponding pipework. This loop serves and distributes the chilled/hot water (cooling/heating mode) produced at the heat pump to the fan coils.

   The internal circuit loop consists of a circulating pump (Grundfos), a mass flow meter (Coriolis effect, Danfoss), manometers, and expansion valves. It is located on the ground floor of the building and it is responsible for pumping the conditioned water to the network of fan coils situated on the first floor.

3) A water to water reversible heat pump, which uses propane (R290) as refrigerant. The experimental unit is a prototype manufactured by CIATESA with nominal cooling and heating capacities of 17 kW and 15 kW respectively.

   A new prototype will be manufactured by HIREF for UPV demo site with natural refrigerants as working fluid. It will be a ground source heat pump used for cooling and heating with possible simultaneous generation of sanitary hot water.

The old one won’t be removed at the moment and it may be used for comparing the performance of both heat pumps along the season. The distribution and the heat source system will remain the same.

The UPVAC system is schematically described in figure 5.

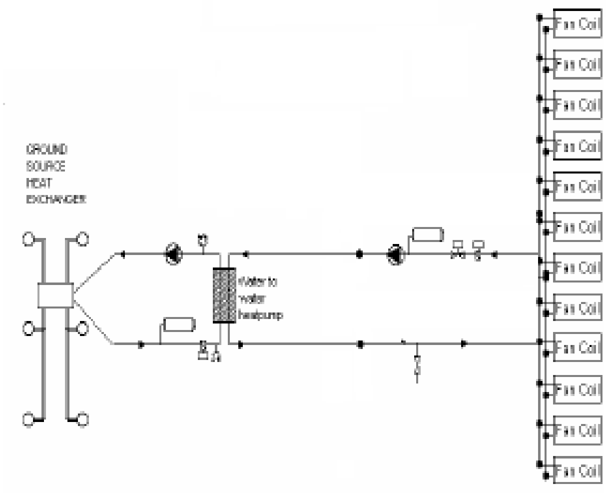


Figure 5- UPVAC System Scheme.

Air conditioned area: Fan coils

The total air-conditioned area comprises around 250 m^2 and includes a corridor, nine offices located on the East façade of the building, a computer room, and a room with photocopiers and a coffee dispenser. Each room is equipped with one fan coil except the computer room which has two fan coils installed and the corridor which is not conditioned. Figure 6 shows the fan coils distribution.

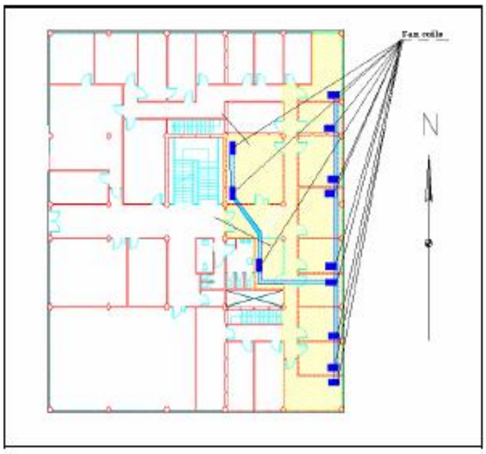


Figure 6- Fan coils distribution scheme.

The employed fan coil TYPE is model MAJOR – 329 CH from CIAT. Fan coils can be individually regulated by means of a thermostat. The comfort temperature and fan speed can be selected by the user.

The fan coils are connected in parallel to a supply and a return collector.

The control for each fan coil is governed by a three way valve that allows conditioned water to circulate through the fan coil or go directly to the return collector through a bypass.This valve is controlled by the thermostat of the room.

Ground Source Heat Exchanger Description

The GSHX consists of six boreholes connected in a parallel configuration. Each borehole is one hundred metres long, penetrates the earth by fifty metres and contains a polyethylene U (1'') tube (fifty metres upwards, fifty metres downwards) with a seven centimeter separation. The borehole diameter is 150 mm.

The six boreholes are arranged in a 2x3 grid (18m^2), with three meter distance in between boreholes.

The external hydraulic loop goes through three different caskets distributing and receiving the water from each borehole. Equalizing valves are located in each one of the circuits in order to balance the flow throughout the six boreholes.

Control components in the system

The operation of the heat pump is governed by an electronic controller which, depending on the water return temperature from the fan coils, switches on/off the compressor of the heat pump. The default values for the internal circuit return temperature are between 37ºC and 43ºC for heating mode, and between 12ºC and 15ºC for cooling mode.

The main electrical panel contains the protection switches for each part of the installation (heat pump, circulation pumps…etc.) as well as the relays that control the operation of these elements. The external circulation pump is controlled by the heat pump electronic controller. The external circulation pump is started up first and, a minute later, the compressor begins operation. When the compressor switches off, the pump is switched off one minute later.

There is a timer which controls the starting of the system, programmed so that it works from Monday to Friday from 7:00 am to 9:00 pm during the working days.

In order to be able to vary the flow circulating through the fan coils and the GSHX, two frequency inverters (OMRON SYSDRIVE 3G3MV) were installed, one for each circulation pump.

Data acquisition system

One of the main objectives of this work was to experimentally characterize the system performance. The UPVAC facility is fully instrumented and continuously monitored.

The temperature is measured at the entrance and exit of the heat pump in the Indoor and the Outdoor loops, at the entrance and exit of every borehole, at several depths in the ground inside three of the boreholes, and inside each office. In order to have the highest accuracy in the estimation of the heat transferred, only RTD PT-100 are employed.

The flow rates through the Indoor and Outdoor loops are measured with two Coriolis Effect mass flow meters (Danfoss Massflow 2000).

The power consumption is measured by two GMC A2000 power meters. One of them measures the total consumption of the outer circuit: heat pump compressor and external circulation pump. The other measures the total consumption of the inner circuit: fan coils and internal circulation pump.

An elaborate strategy of data acquisition allows the system to distinguish the consumption of the pumps, the fan coils and the heat pump individually.

At 7am the internal circulation pump is switched on. This allows the measurement of the power consumption of the internal circulation pump from the power meter reading. After five minutes, the power supply for the fan coils is switched on. Therefore, the fan coils consumption which is variable throughout the day can be estimated from the power meter reading by subtracting the pump consumption.

In order to measure the power consumption of the external circulation pump, it is important to mention that there is a delay of 1 minute approximately between the switch on/off of the heat pump and the external circulation pump. It’s during this period of time when the power consumption of the external pump can be measured.

Climatic data is registered in a meteorological station located on the building roof. Twenty four parameters such as temperature, humidity, wind speed or irradiation are recorded every five minutes.

The system energy performance throughout the second year of the installation operation was analysed from the instantaneous experimental measurements recorded in the data acquisition system and led to the conclusion that the use of the ground source heat pump enables the achievement of considerable energy savings, around 40% in heating and cooling mode with respect to a conventional system such as an air source heat pump working in analogous operating conditions [Urchueguía et al. 2008].

Publications:

1. Mathematical modelling and analytical solution for workpiece temperature in grinding, D.L.Skuratov, Yu.L. Ratis, I.A. Selezneva, J.Pérez, P. Fernández de Córdoba, J.F. Urchueguía, Applied Mathematics Modelling (in press)

2. Comparative energy performance between a geothermal heat pump system and an air-to-water heat pump system for heating and cooling in typical conditions of the European Mediterranean coast, J.F. Urchueguía, M. Zacarés, J. Jiménez, J.M. Corberán and J. Martos Energy Conversion & Management (in preparation)

3. Test performance and oil circulation rate of commerical reciprocating compressors of different capacitites working with propane (R290) as refrigerant, Navarro, E., Urchueguía, J.F., Gonzálvez, J. and Corberán, J.M. International Journal of Refrigeration, 28/6 (2005) 881-888.

4. Etude comparative expérimentale des rendements de compresseurs alternatifs de différentes tailles utilisant le R-290 et le R-407C, Navarro, E., Urchueguía, J.F., Gonzálvez, J. and Corberán,J.M. Froid, 1052 (2005) 34-40.

5. Optimized design of a heat exchanger for an air–to–water reversible heat pump working with propane (R290) as refrigerant: Modelling analysis and experimental observations , Blanco, J., Urchueguía, J.F., Corberán, J.M. and Gonzálvez, J. Applied Thermal Engineering, 25(14-15) (2005) 2450-2462.

6. Comparative energy performance between a geothermal heat pump system and an air-to-water heat pump system for heating and cooling in typical conditions of the European Mediterranean coast, J.F. Urchueguía, M. Zacarés, J. Jiménez, J.M.

Corberán, J. Martos Congreso: ECOSTOCK 2006, The Tenth Internacional Conference on Thermal Energy Storage. 31 May - 2 June2006.

7. Transient Numerical Solution for the Heat Equation. Application to Ground Source Heat Pump Systems L. Patiño, I. Orquín, J. Urchueguía, P. Fernández de Córdoba, F.R. Villatoro y A. Montero Proceedings of the 8th IEA Heat Pump Conference, Las Vegas (USA), 2005.

8. Comparative Study Between a Geothermal Heat Pump System and an Air-to-Water Heat Pump System for Heating and Cooling in Typical Conditions of the European Mediterranean Coast G. Romero, J. F. Urchueguía, H.Witte,W. Cambien, T. Magraner

Proceedings of the World Geothermal Congress 2005, paper nr. 1471, Antalya (Turkey), May 2005.

9. Design analysis of a finned tube heat exchanger for an air to water reversible heat pump working with propane (R290) as refrigerant J. Blanco, Javier F. Urchueguía, Jose M. Corberán, J. Gonzálvez

10. Effect of climatic conditions on the performance of an air-to-water reversible heat pump using R290 as refrigerant: seasonal system performances evaluation by means of experiments and modelling J. Blanco, G. Romero, Javier F. Urchueguía, Jose M. Corberán, Jose Gonzálvez Congreso:Proceedings of the 8th International Energy Agency Heat Pump Conference - Global Advances in Heat Pump Technology, Applications and Markets, Las Vegas (EEUU), June 2005.

11. Modelado de la Conducción del Calor Transitoria en un Intercambiador Enterrado L. Patiño, J.F. Urchueguía, I. Orquín, M. Zacarés y P. Fernández de Córdoba

VI Jornadas de Matemática Aplicada. Universidad Politécnica de Valencia. Valencia, Spain, 1 to 3rd of September 2005.

12. Seasonal system performances for vertical ground coupled heat exchanger and comparison with air-to- water heat pump system

G. Romero, J.F. Urchueguía, H.Witte,W. Cambien, T. Magraner y M. Zacarés. Congreso: 8th International Energy Agency Heat Pump Conference, Las Vegas, Nevada (USA), Junio 2005.

13. Current situation and evolution of standards upon the use of Hydrocarbon Refrigerants on A/C, heat pump and refrigeration equipment

Corberán, J. M.; Gómez Martinez, B.; Gonzalvez, J.; Urchueguía, J. F.; Segurado, J.

IIR International Conference on Commercial Refrigeration / Thermophysical Properties and Transfer Processes of Refrigerants Vicenza (Italia), 2005.

14. Comparative Experimental Investigation of Oil Behaviour in a Hermetic Piston Compressor using Propane (R290) as Refrigerant Navarro, E.; Urchueguia, J. F.; Gonzalvez, J.; Corberan, J. M. Proceedings of the IIR-Gustav Lorentzen Conference

on NaturalWorking Fluids at Purdue, Glasgow, United Kingdom, August 2004, pp. 45-49. I.S.B.N.: 2-913149-34-0

15. Estudio experimental de un intercambiador enterrado horizontal I. Orquín, J.F. Urchueguía, G. Romero, W. Cambien, Mohammed Ait Bahajji. Proceedings of the XVI Congreso Nacional de Ingeniería Mecánica, León (España), 2004

16. Modelado y solución numérica de la conduccion de calor transitoria en el subsuelo. Aplicación a intercambiadores de calor enterrados L. Patiño, I. Orquín, J.F. Urchueguía, P. Fernández de Cordoba, F. R. Villatoro. Proceedings of the XVI Congreso Nacional de Ingeniería Mecánica, León (España), 2004

17. Rendimiento estacional de un intercambiador enterrado vertical y comparación con un sistema equivalente de bomba de calor aire-agua G. Romero, J.F. Urchueguía,W. Cambien, T. Magraner Proceeding of the XVI Congreso Nacional de Ingeniería Mecánica, León (España), 2004 32 3.1. Workpackage Area D – Dissemination of results and promotion

Web links:

www.geocool.net

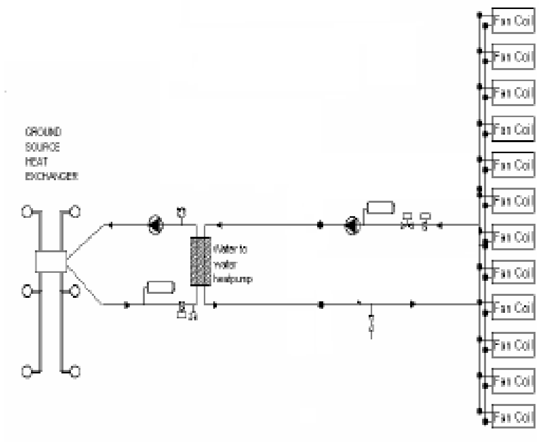
Photos:

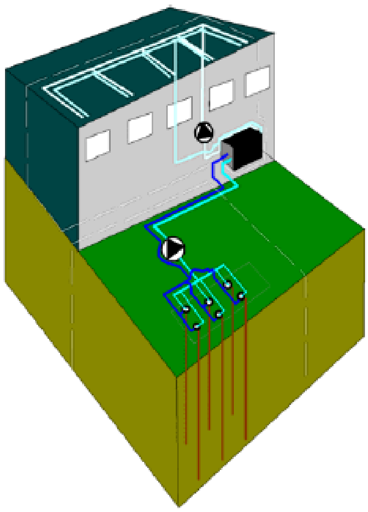
OUTSIDE VIEW OF THE BUILDING

HEAT PUMP INSTALLED:

Nominal capacity = 17 kW. Manufacturer: CIATESA. Refrigerant: Propane. Scroll compressor .Brazed plate heat exchangers.

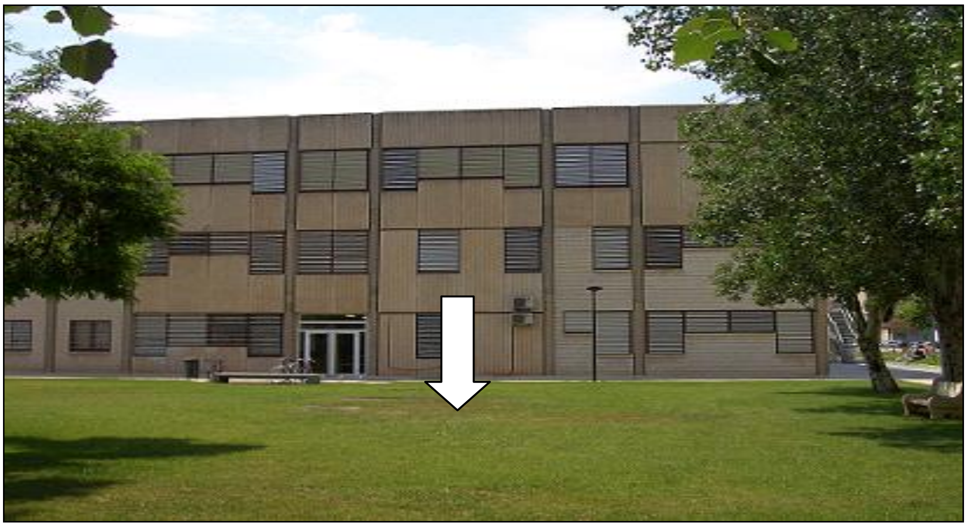
UPV DEMO SITE SYSTEM SCHEME:



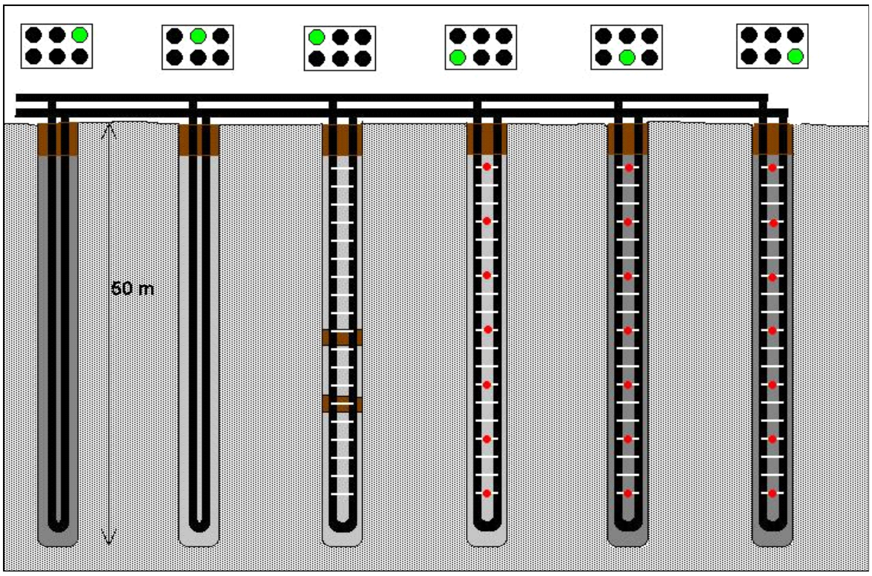


BOREHOLE HEAT EXCHANGERS:

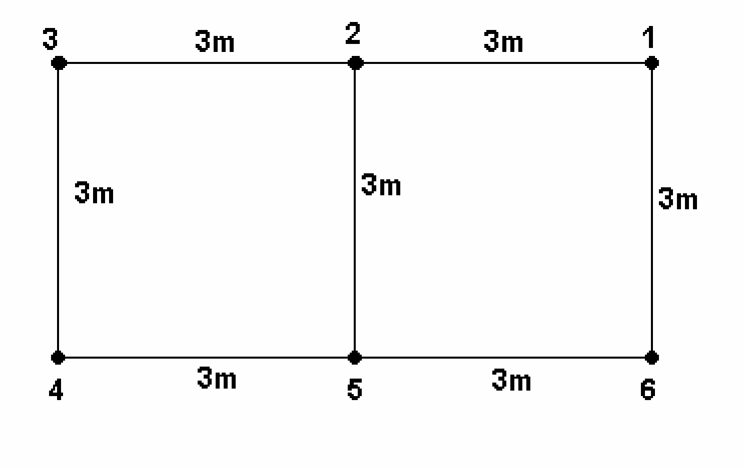
LOCATION:

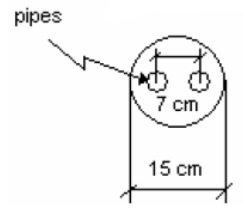


CONFIGURATION: DOUBLE U TUBE OF 1 INCH DIAMETER.



Borehole arrangement: RECTANGULAR GRID 2X3

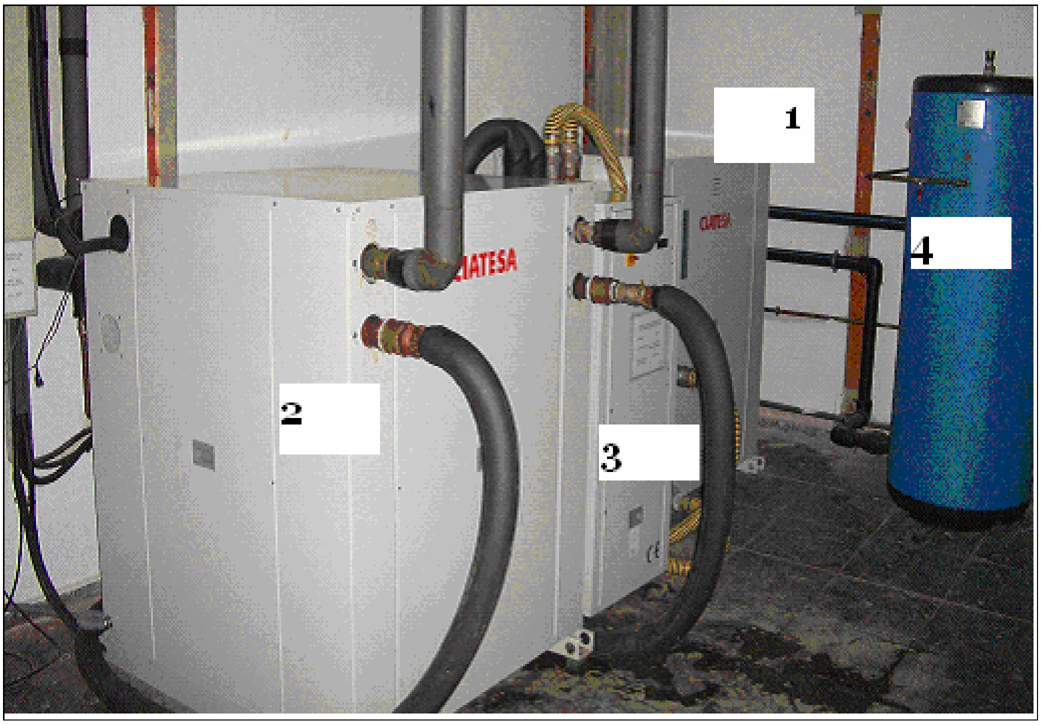




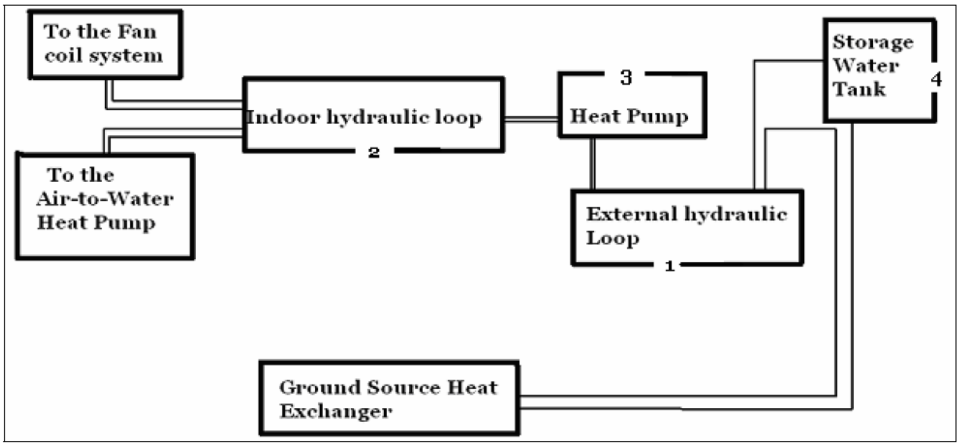
MACHINERY ROOM

Components located at the machinery room are listed below:

- External loop hydraulic group. (1)
- Internal loop hydraulic group. (2)
- Water to Water reversible heat pump. (3)
- External loop water tank. (4)

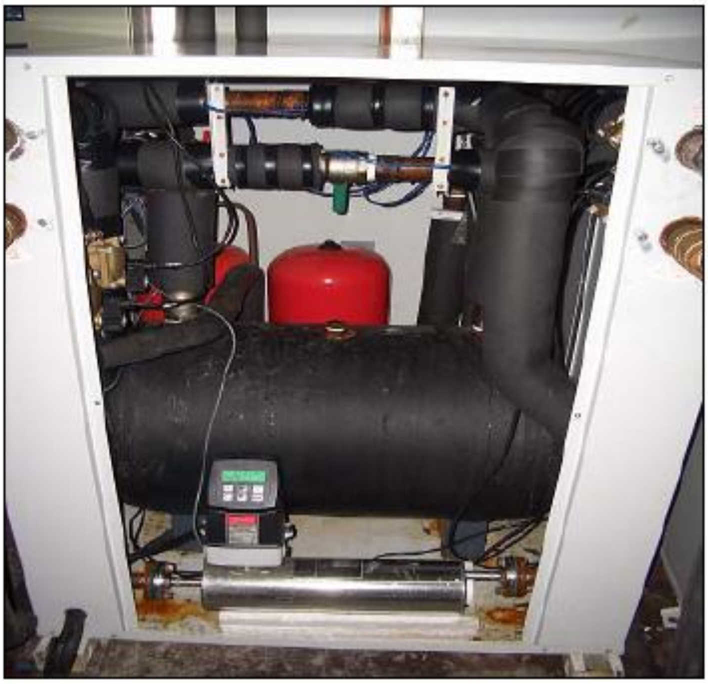


SCHEME OF THE INSTALLATION

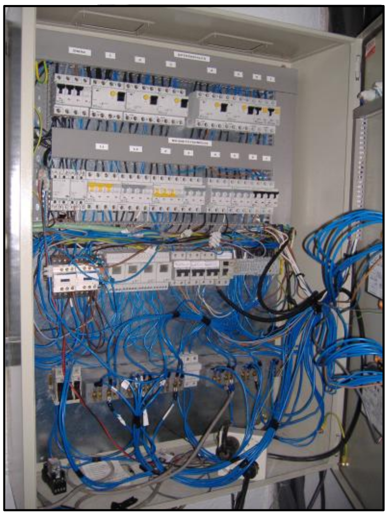


OUTDOOR HYDRAULIC GROUP

INDOOR HYDRAULIC GROUP



ELLECTRICAL PANNELS FOR CONTROL AND MEASUREMENTS



Frequency inverters for water circulation pumps of the internal and external circuits.

Controller of the heat pump: