Energy efficient hospital design — technical installations

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Sustainability

Sustainability applies to the capacity that consumer society must acquire and maintain to prevent aggressive abuse, exhaustion or degradation of natural resources.

The definition of sustainability depends on the sector this concept is applied, currently referred to as:

- energy efficiency
- environment protection
- cost savings and competitiveness

Energy efficiency is the most recurrent issue, with buildings responsible for 40% of overall energy consumption - of this 50% is used for space heating and cooling.

The European Directive of December 2002 on Energy Performance of Buildings contains recommendations and general rules that members should apply with the common objective of energy savings.

Objectives

We have proposed the following objectives as guidelines of the Hospital of Mollet design, following the European Directive and assimilated national and local regulations:

- energy demand reduction
- use of renewable resources
- healthy environment
- equipment and systems efficiency
- energy savings
- patient wellbeing

Energy demand reduction

Energy demand is the responsibility of the building designer, as exposed by the architect Luis Moran when he describes the project scope of this hospital. This is influenced by:

- building orientation
- shape factor
- natural light
- the use of the light colors
- ventilated façade
- improved thermal insulation and inertia of windows, walls and roof
- special protection of glass windows against radiation

This is the first stage of all actions to save energy in buildings.

Use of renewable resources

Rain water

Water is a scarce resource therefore the use of rain water for non sanitary applications is a strategy for sustainability. This system requires the separation of pipework for rain, drainage and for non potable residual water. The rain water coming from the roof is collected in a 150 cubic meter storage tank for gardening, cleaning outlets, toilets, and other not sanitary applications. For the Mollet project about 2000 m3 of water savings per normal year are achieved, representing about 5 to 7% of total water consumption.

Daylight

Architecturally designed windows opening to patios and the roof skylight form the basis of the modern hospital concept. A large number of windows provide daylight to the interior spaces of the Hospital of Mollet.

An engineered lighting system has a PLC for mixing of daylight and artificial light, providing sensors and automatic programs to optimize its use and save energy.

Solar

High efficiency vacuum tube solar panels covering 240 m2 are installed on the flat roof and will contribute up to 70% of hot water requirements, estimated as 455,000 kWh per year. One 470 kW natural gas boiler boosts the solar system as required.

Photovoltaic panels will cover the rest of the roof, an area totaling 3000 m2. This is an independent installation, still under development, and will be privately financed investment under an outsourcing contract with a private investor.

Air

All air handling units are designed to optimise energy consumption by controlling the outside air enthalpy for free cooling with the exhaust passing through sensible heat exchangers to recover energy.

Healthy Environment

Low and clean combustion emissions are a key objective so the design consists of using heat pumps to generate the water for space conditioning, instead of the traditional boilers. The same applies to the sanitary hot water, generated in a first stage by means of the solar panels and heat pumps.

The 470 kW boiler will operate only when the maximum load is needed in peak winter heating conditions, or when raising the sanitary hot water temperature to the safety limits as specified. The boilers will be fuelled by natural gas for a clean combustion.

The European Directive on Energy Performance of Buildings recommends heat pump systems be used instead of boilers, when the conditions allow, as a strategy for sustainability and efficiency improvement.

The heat pumps designed for the Hospital of Mollet are a four tube system to take advantage of the simultaneous demand of hot and chilled water that we have in many circumstances and places in the hospital energy profile. 50% of the heat pump equipment is of the geothermal earth source (ground source hat pump) type, with a COP above four, as described later.

A key objective of the project is to optimise the energy performance of the equipment and systems to produce the thermal energy demand, but avoid the installation of cooling towers and similar equipment with the associated risk of contamination and infection by Legionella.

Domestic hot water is another problematic source of Legionella colonies. One essential strategy is the careful design of pipework to avoid dead legs and to assure a high terminal temperature and the installation of thermostatic mixing valves.

Air dehumidification will be achieved by utilising Lithium Chloride (Li Cl) in patient areas. In conjunction with radiant panels, the air handling units for the primary ventilation air will be equipped with a desiccant device based on moisture absorption by a Li Cl solution. The desiccant material attracts moisture due to the difference in vapour pressure. The desiccant system consists of a drying process air path and a regeneration air path. The desiccant solution that is in the process air path has been prepared to have a lower vapor pressure than the air passing over it. Thus the moisture in the air is transferred onto the desiccant.

As the desiccant vapor pressure increases due to the moisture that it has attracted, the desiccant solution is transferred to the regeneration part, where hot air is passed over the desiccant, the moisture being transferred to the hot air stream that now is exhausted. The dry air leaving the desiccant process is then passed over a conventional cooling coil to lower its temperature before entering the air handling unit attached. To produce the heat for the reactivation process and the cooling for refreshing the air leaving the desiccant device, there is a small built-in heat pump that supplies the required heat at a high performance.

This desiccant equipment replaces the cooling coil of the air handling unit, eliminating the problem of condensation in air handling units that could be a source of Legionella contamination if not well maintained. One important advantage of the system is the biocide property of the Li Cl, with a high efficiency against airborne bacteria and microorganisms, resulting in a high quality air supplied to patient care areas

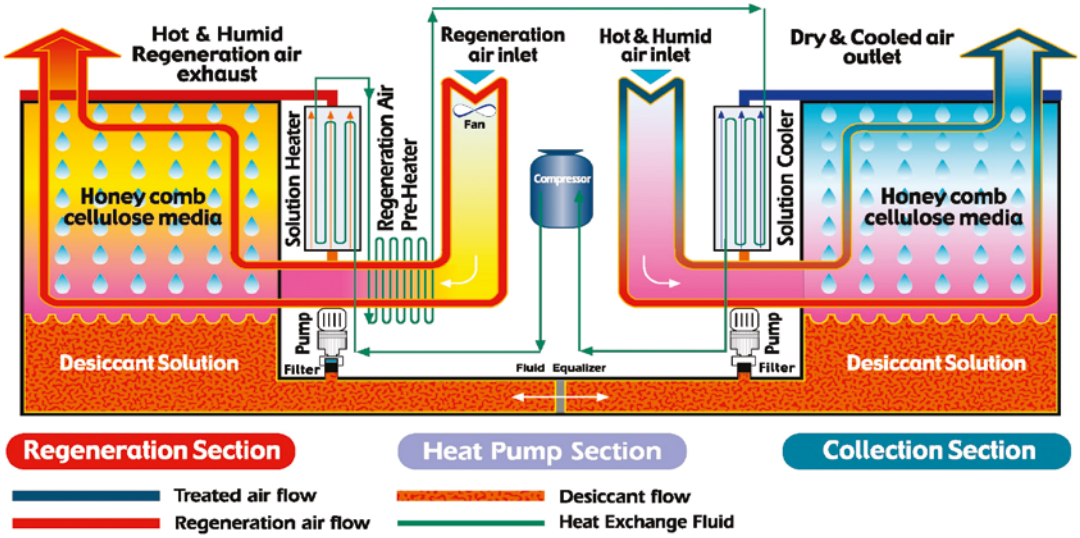
Thermal production

According to the detailed calculations, zone by zone, of the thermal loads and losses, the thermal load of the Hospital of Mollet can be summarised as follows:

Total cooling loads 2,745 kW
Total heating loads 2,637 kW

The simultaneous peak demand has been estimated as:

Peak cooling load 2,196 kW
Peak heating load 1,980 kW



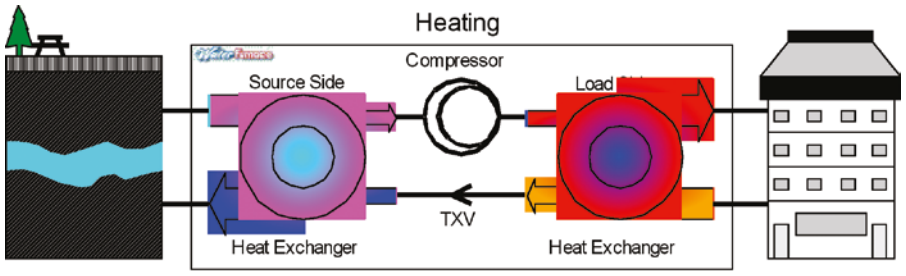
The thermal energy will be produced by the following equipment:

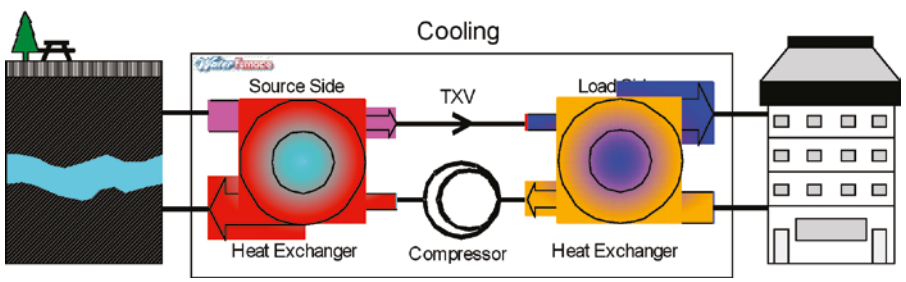
Quantity	DESCRIPTION	Cooling power (KW)	Heating power (KW)
	Geothermal Heat Pumps GHP EWK130 from Water Furnace		
10	Furnace or equivalent. ***First priority***	1030	1200
	Heat Pump four tubes ERACS-Q/LN 2422		
2	Climaveneta or equivalent. ***Second priority***	1022	1090
	Chiller FOCS 26002 /B Climaveneta or equivalent.		
1	***Only for peak demand in summer***	529	
	Hot water boiler WIESMANN or equivalent,		
1	***Third priority***		470
	TOTAL	2581	2760

Geothermal heat pumps

The European Directive 2002/91 on Energy Performance of Buildings defines heat pumps as equipment or system that uses heat from the air, from the water or from the earth, moving it to the building. All heat pumps are based on the principle of the Carnot cycle.

In the case of the geothermal heat pumps (GHP), they use the ground as a heat sink in the summer and a cool source in the winter. The system designed for the Hospital of Mollet is a closed ground loop vertical system, made of underground pipes in deep boreholes, to transfer heat to and from the ground. The ground temperature stability at about 13 to 14 degrees is important to get a high performance in the GHP operation, with COP over four.

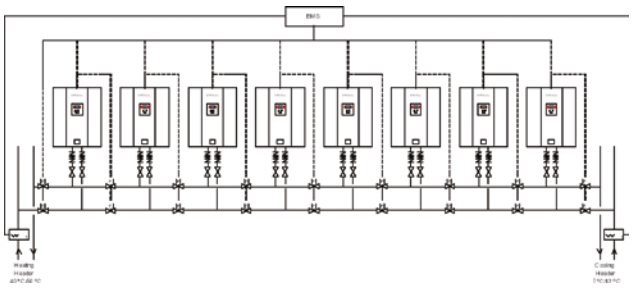


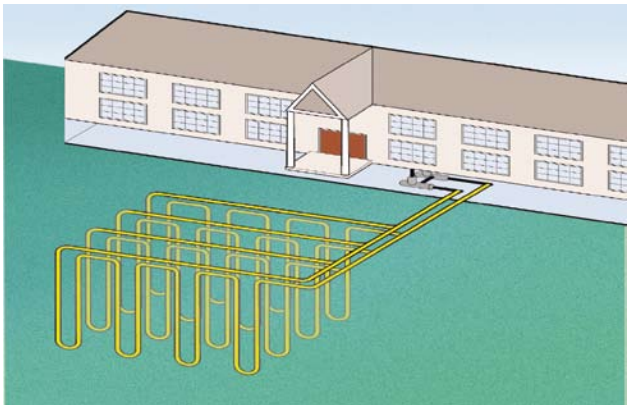


The equipment layout is composed of 10 units of about 120 kW each. The GHP supply the four tube system for space heating (45ºC to 50ºC) and cooling (12ºC to 7ºC). Two of the GHP will be regulated to supply water at more moderate temperatures (18ºC to 12ºC for cooling and 30ºC to 35ºC in heating) supplying the radiant panels, thus improving the COP of this system by one point, and saving energy again.

In normal operation, some of the GHP's will operate in heating mode and others in cooling mode. Thus, some units will give heat to the source while the others are absorbing heat. As a result, the temperature of the ground loop will vary along with the COP of the system.

The operation of the group of ten units as a master-slave will be controlled by a PLC coordinated with the central building management system. All data will be transmitted and analysed for general performance ratios. The balance of energies transferred to the ground is also controlled to keep the temperature variation of the ground under a limit of 2ºC in 30 years of operation.



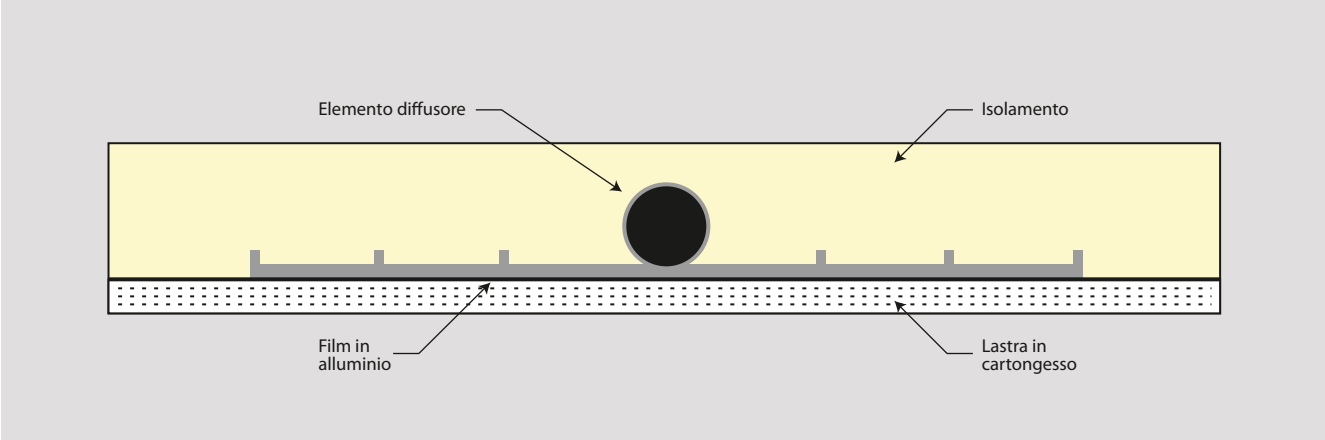


Geothermal loop

The capacity of the system has been limited by the availability of convenient space for the bore holes.

The geothermal closed ground loop has been designed with 180 bore holes (18 x 10) of 111m deep and 145 mm diameter at a five metre spacing. The holes have two 32 mm diameter high density polyethylene pipes fully compacted by bentonite and sand material to improve the transmission coefficient to the earth.

The temperature of the ground in the zone of Mollet is 13.9 ºC. The balance of energies transferred do not produce a rise in temperature of the earth, more than 1.9 ºC, in 30 years of operation.



BMS Energy Savings

The Building Management System consists of automatic control by means of integrated monitoring and management of the equipment, systems and subsystems. The BMS aims to intelligently control plant operation in order to use energy only when it is required and only in the amount needed, in three main areas;

- heating, ventilation and air conditioning
- electrical installations
- other technical systems in the hospital.

The BAS should improve reliability of plant operation, energy savings, maintenance efficiency and cost performance of systems. The system will be connected to the LAN of the Hospital so that any PC of the structured network could be used as a point of supervision. The supervision software will have the performance of a web server for a remote connection via Internet. In all cases the security of the access will be ensured.

Priority is given to the Geothermal Heat Pumps due to the better coefficient of performance. The last equipment to enter the system will be the boiler to cover peak requirements, and the chiller for peak demand of refrigeration.

The central BMS will integrate the PLC of the GHP as well as the PLC controlling the conditions of the areas with radiant ceiling.

The alternative of space conditioning by using radiation elements, to provide sensible heating and cooling loads, instead of all air systems, is gaining supporters.

One of the features of the Hospital of Mollet project is the application of radiant panels for conditioning patient areas, improving comfort and air quality.

The objective of the radiant panel system is to obtain a higher comfort due to the quiet and uniform radiation at comfortable temperatures, reducing the amount of air in movement. The zones with radiant panels avoid the traditional fan-coil with the associated maintenance problems.

Radiant panels provide sensible heat, but the latent heat/humidity should be eliminated by the primary ventilation air, calculated to comply with local standards and regulations.

The radiant panel modules are made of plasterboard integrating a small pipe circuit and a diffuser piece so the water is regulated to a comfortable temperature as well as controlling the dew point to avoid any condensation on the cooled surfaces. The sophisticated control includes sensors and software to ensure the performance of the system.

Air handling units with sensible heat exchangers and Li Cl desiccant devices provide primary ventilation air in patient care areas. The advantage of a chemical drying system is that the Li Cl is an effective biocide, purifying the supply air.

Patient wellbeing

We might expect that well designed hospitals would increase the level of satisfaction in patients, and indeed they can and do. However, evidence is growing rapidly that buildings are part of the healthcare system and contribute significantly to it. With about 700 pieces of research on this subject, the evidence shows that the patient health outcome and the efficiency of the staff can be significantly improved through a good design that takes into account the environment values. Moreover, this evidence has recently led to an appreciation of the overall contribution of the built environment to both the cost and the performance of the healthcare system.

Architectural design, daylight, outside views, privacy, contact with nature, accessibility, clear signage, construction materials, furniture and decoration all produce a good environment for patient and staff wellbeing.

A key lesson is that building designs and care models must go hand in hand to create a more effective, more efficient, and far more pleasant, healthcare environment.