The Efficiency of Air Conditioning Energy Systems in the Iberê Camargo Contemporary Art Museum – Rio Grande Do Sul – Brazil

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The mechanical engineering project designed by the company GET – Gestão de Energia Térmica Lda. (url: www.get.pt) – not only encompassed the design of the most effective systems, in terms of energy, for responding to the thermal needs of the building arising from its envelope and its internal gains, but was also developed from an integrated perspective of energy streamlining while always maintaining good interior air quality.

The main objective defined for the HVAC project for the Iberê Camargo Museum was the implementation of an exemplary project demonstrating the use of efficient and environmentally friendly energy, with a view towards a decrease in consumption.

For this purpose, it was paramount at the design level to restrain the dimension (power) of the air conditioning systems so as to avoid excessive oversize by making a proper selection of the primary energy providing systems and Rational Utilization of Energy options, assessing their economic viability, and thus minimising the respective energy consumption.

Using these guidelines, therefore, a set of energy consumption rationalisation measures were taken, such as heat recovery from the chiller condenser to achieve terminal reheating of the batteries of the air treatment units for interior relative humidity control, the use of free cooling of the air treatment units, the use of variable flow and high energy efficiency pumps for distributing both heated and refrigerated water to terminal equipment, the use of radiant air conditioning in the outer circulation tunnels between floors, and the implementation of a centralised technical energy management system.

The treatment of ambient air is achieved by the air treatment units that ensure interior thermal comfort, although there is independent control of the blowing temperature for each space and there is provision for terminal reheating batteries fed by the chiller condenser water.

In addition to these measures, power splitting in refrigerated and hot water generating equipment was taken into account, as well as the use of more efficient electrical equipment (class A). In particular, the adoption of energy and environmental efficiency criteria was promoted in the purchase of the main energy-consuming equipment.

Free cooling is a technique based on the use of outside air to achieve cooling, in this way decreasing or eliminating cooling requirements.

An air free cooling system, like that installed in the air treatment units, recovers fresh air from the outside when its temperature and relative humidity (i.e., outside air enthalpy) are lower than the values selected for inside conditions.

Through the use of free cooling, energy consumption in the building is reduced, because the chiller is disconnected while the free cooling is working.

Thermal energy storage was used for ice storage cooling and good preventative maintenance practice was implemented.

Storage with ice is based on the high value of the latent heat of melting water, around 355 kJ/kg at 0 °C. A reduction in the accumulation volume is achieved of up to 25% of what would be necessary for accumulation with refrigerated water for the same amount of accumulated energy.

These systems require low evaporation temperatures in the refrigerating machine, on the order of −12° to −5 °C. It is normally necessary to use a glycol-based cooling fluid to prevent water freezing in the cooling circuits.

A solution with 25% "ethylene glycol" is a current solution for the secondary cooling fluid. Depending on the system's dimensions and usage, the use of an exchanger may be preferable so as to prevent glycol water from circulating throughout the whole distribution system.

The accumulation of thermal energy for ambient cooling consists, therefore, of the temporary storage of thermal

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energy at a low temperature during off-peak periods for later use in periods of higher energy cost.

Thermal storage technologies in general, under which thermal accumulation in support of cooling processes within HVAC installations falls, enable system operation during off-peak tariff times (night time), when electricity is cheaper, for later use during periods of higher energy cost, reducing the value of the power taken, essentially at peak times.

Thermal energy for ambient cooling is thus stored during this period and is later channelled into the building during working hours.

The accumulation of thermal energy for ambient cooling, in view of its technological features and operational methods, presents various advantages, as described below:

1. An increase in chiller efficiency due to preferential operation at rated speeds, which also contributes to the life span of the equipment.

On the other hand, the preferential operation of cooling machines during the night will enable their FOC to be increased, since they operate at lower condensation temperatures. In this way, and depending on the optimisation degree of the installation, it is possible to decrease energy consumption.

2. A decrease in the power of refrigerating equipment and lower simultaneous operation with other equipment, contributing to a decrease in the power taken by the installation.
3. The possibility of use of high ΔT, which will allow for lesser flows, with a resulting reduction in load losses and smaller duct dimensions.
4. A reduction in the electricity bill, in terms of both power taken and energy consumed, since the power taken decreases and, with it, the power contracted can also be reduced. The energy component decreases as well, due to energy consumption shifting from peak times to off-peak times.
5. Reduction of noise levels produced due to higher operational stability;
6. In the case of the use of iced water tanks, these may also be used as a water reservoir for fire fighting;

This solution, therefore, enables electric energy consumption to be reduced because the energy costs of system operation are lower, also leading to a reduction in the cost of power, thanks to the operational time-shifting of refrigerated water generating plants.

The disadvantages of these systems are essentially concentrated in higher start-up costs and the need for available space in which to install the ice storage tanks.

However, this increase in cost is normally recouped within reasonable periods of time due to the resulting savings.

In this way, this technology applied in support of the large air conditioning system installed at the Iberê Camargo Museum represents an interesting solution that was envisaged by the designers and the directors of the building.

The adoption of the use of more efficient artificial lighting equipment and bulbs was promoted, through the accrual of a credit, by demonstrating the utilisation of the most efficient categories of these energy consumers, according to the respective energy labelling certificates.

An estimate of the building's energy consumption was made using detailed computer methods, which enabled its global consumption to be predicted, under the anticipated rated operating conditions of the building, with the main aim of ensuring that the building's consumption does not exceed figures that are considered excessive.

However, energy consumption at the Iberê Camargo Museum depends on many factors that go beyond the detailed energy simulations carried out during construction, amongst which are the level of visitor flow, the behaviour of energy-consuming installations, the periodicity of maintenance work, etc.

One of the places where innovative measures were required was the radiant air conditioning system designed for cooling and heating (if needed) of the circulation tunnels between floors that are visible on the building's façade.

In view of the high thermal load of the envelope of the tunnels/corridors visible on the building's façade, for circulation between floors, and the reduced space for installing an all-air-type ambient cooling system, a radiant air conditioning system was favoured, using polypropylene grids rebated into the walls and ceiling of the top floor.

Radiant heating and cooling systems are more energy-efficient than traditional convection systems.

In environments where air speed is low, as is the case with interior spaces, radiant heating and cooling has the advantage that most of the heat transfer from the surfaces of a human body occur in the form of a radiant interaction with the surrounding surfaces.

In the case of these circulation spaces, heating and cooling thermal loads mostly originate through their exterior envelope and structure, whose surfaces, directly exposed to exterior conditions, reach extreme temperatures.

Radiant heating and cooling, i.e., a radiant air conditioning system, is able to maintain a thermal equilibrium inside these corridors of the building through a radiative interaction with the inside surface of the outside walls, allowing them to maintain a constant temperature closer to that for desired interior comfort.

Heat flowing directly onto the radiant surfaces can be immediately absorbed by them, merely increasing the circulation of water flow in them without altering their surface temperature and without requiring the flow or the temperature of the air renovation of the space to be changed.

In view of the high values of both the mass heat and the volume mass of the water, heat is transferred to or from the interior of the building, consuming only about 1/5 to 1/10 of the electric energy that would have been required to achieve the same heat transport by air, due to the glitch energy required to feed ventilators and hydraulic pumps.

Radiant cooling follows the same principles as radiant heating. The heat transfer that is achieved between the space to be cooled and the radiant panels is due to a difference in temperature.

However, unlike in radiant heating, the refrigerated ceiling absorbs thermal energy, radiated by people and objects or a neighbouring apparatus.

The greatest difference between refrigerated ceilings and cooling by traditional convection systems (all-air systems) lies in the heat transport mechanism.

Traditional all-air systems only use convection, whereas refrigerated ceilings use a combination of radiation and convection.

In the case of refrigerated ceilings, the amount of heat transfer by radiation is about 55%, with only the remainder being transferred by convection.

With the refrigerated ceiling system, heat transfer by radiation is achieved through emission of electromagnetic waves from warmer people or objects and apparatuses to the refrigerated ceiling.

Since convection starts by cooling the air in the space, due to contact with the refrigerated ceiling and walls, convection currents are created in their interior that achieve heat transfer from generating sources to the refrigerated ceiling and walls that absorb it.

The Iberê Camargo Museum is a fine example of a low energy consumption building.