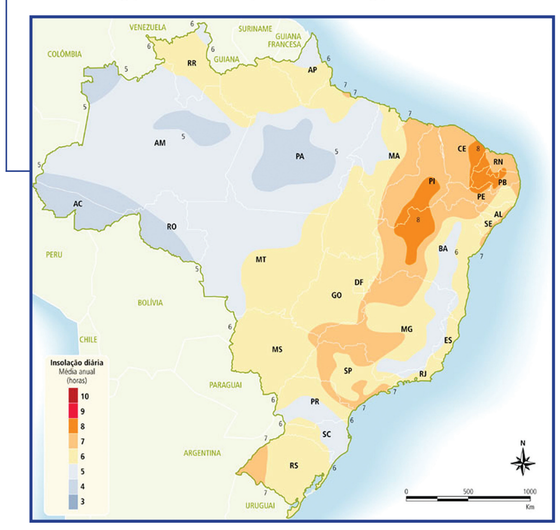
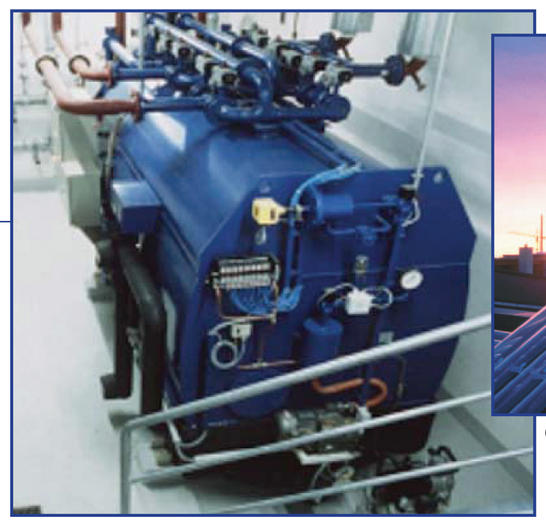
Solar Chiller: Zero-net energy for building air conditioning in hot climates

Introduction

The problem of global warming as a result of greenhouse gases emissions related with the growing world energy consumption and use of fossil fuels has concerned humanity. As a result, the use of renewable sources of energy has been increasingly considered. At the same time, an importance can be observed of considering buildings, especially office buildings, when searching alternatives to solve the problem. In fact, the office buildings have great importance on the issue especially because their air conditioning systems high energy consumption. Thus, knowing the great importance given to the solar energy as an alternative renewable energy source and taking into account that thermal loads increases with the intensity of solar radiation the alternative of using solar energy for air-conditioning systems is being considered a logical solution. Although many ways can be identified to convert solar radiation into cooling using air conditioning system, nowadays, the use of solar thermal collectors in combination with the absorption chiller is the alternative most commonly used. In fact, the alternative of utilizing solar water heating systems integrated with air conditioning systems, that is, using solar absorption chillers can be considered interesting for the future. It can be said due to these technologies progress and due to the fact that market is increasingly attractive to solar water heating systems. An advantage of this technology is that it greatly reduces the power consumption of the air conditioning system, replacing it with a renewable energy, in this case, solar energy.
In tropical regions such as São Paulo, where the solar resource is abundant and the radiation levels reach high values over the year, this alternative is even more interesting, as the great availability of solar radiation is compatible with the large office buildings thermal loads, especially in the usual glazed façade buildings. Thus, the problem of high energy consumption of air conditioning systems in these conditions would be mitigated if a technology assisted by solar energy is used.

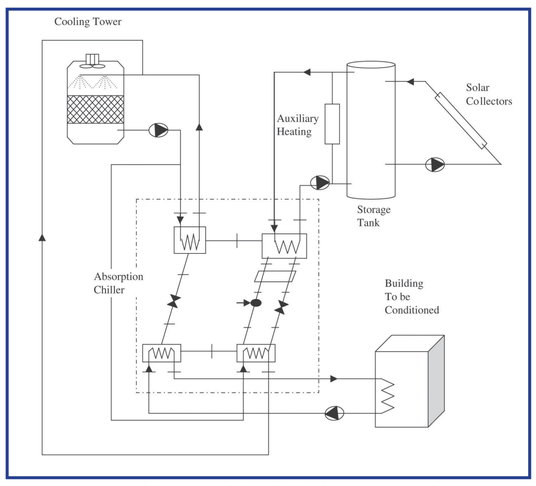


ATLAS Solarímetrico do Brasil.



HENNING, H.M. (2007, Solar assisted air conditioning of buildings – an overview, p.1742)

(2007, Solar Thermal Action Plan for Europe , p.22)



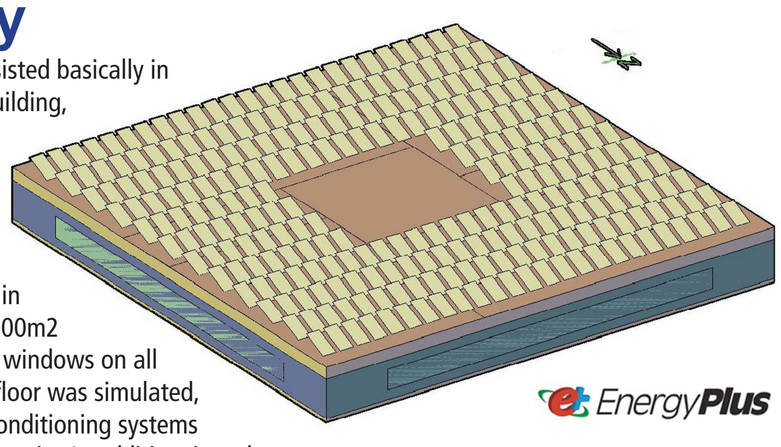
BARGHOUTHI, M. et al. (2007, Feasibility of solar absorption air conditioning in Tunisia, p.4)

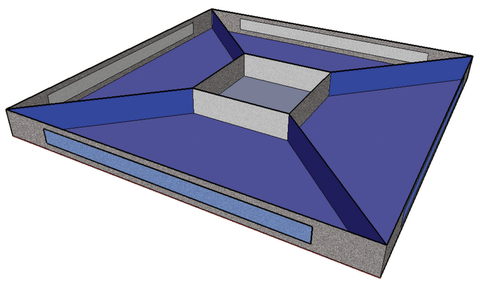
Objectives

This work aims to present and discuss the possibility of utilization of solar air conditioning systems in office buildings as an alternative for sustainable construction in hot climates, particularly in the region of Sao Paulo, Brazil. Thus, this work proposes using solar thermal systems (flat plate collectors) as a heat source for solar absorption chillers reducing significantly air conditioning electric consumption. The electric consumption not met by solar systems (auxiliary heating, pumps and fans) would be supplied by PV panels integrated in the façade so that the air conditioning system can achieve a net zero energy goal.

Methodology

The methodology of this work consisted basically in obtaining the model of an office building, carrying out computer simulations using software *EnergyPlus* and, finally, collecting and discussing the results. The office building original model aimed to represent the office buildings typically found in the region, with floors of about 1,000m2 with a central core, four zones and windows on all façades. Only the building ground floor was simulated, taking into account that solar air conditioning systems usually do not exceed 100kW of capacity. In addition, in order to take advantage of well deployed flat plate collectors in these regions, the system works with water up to 100 C and therefore use single effect absorption chillers with COP around 0.7. Three simulations were carried out aiming net zero energy air-conditioning:



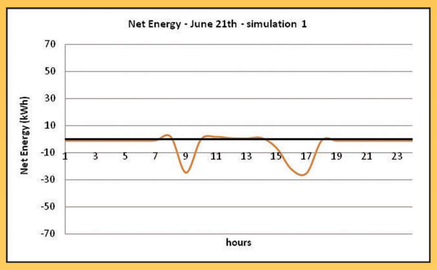


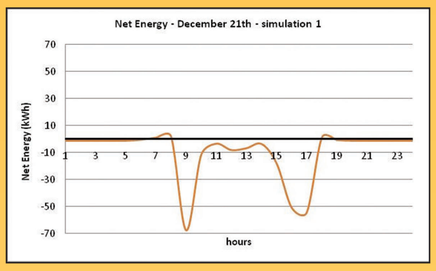
- the original model (simulation 1);
- the simulation 1 model, with the adoption of passive architecture techniques (simulation 2);
- the simulation 2 model, with the improvement of PV cells (simulation 3).

Results

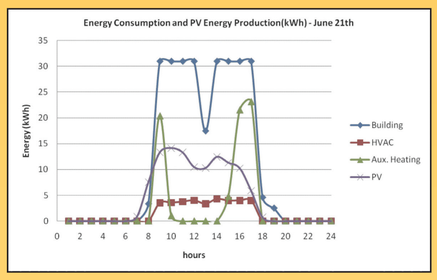
After modeling the building and the system and carried out simulations in *EnergyPlus*, the following results were obtained:

Simulation 1



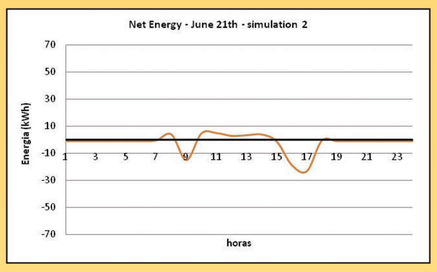


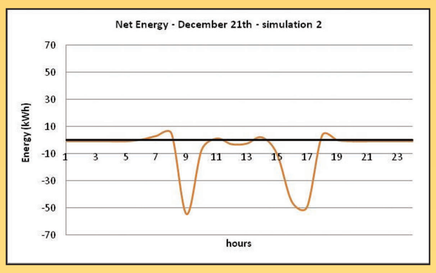
In the first simulation (original model), were obtained net energy values for June 21th (winter) and December 21th (summer) for each hours of the day. As a result, the PV energy production was lower than air conditioning energy consumption, as can be observed in the graphics below, with negative values of net energy. The main cause was the high consumption of auxiliary heating especially in times of lower solar radiation, that is, at the beginning and the end of the day.



Simulation 2

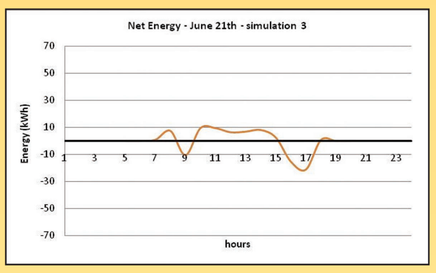
Adopting passive architectural techniques (east and west windows removed, roof thick doubled and windows north and south with double glazing), the net energy was considerably reduced but did not reach the net zero goal yet.

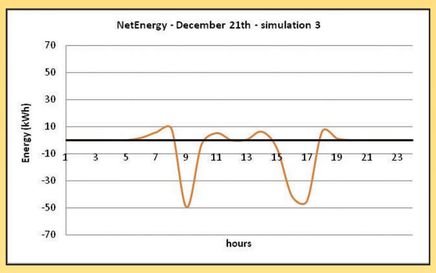




Simulation 3

Increasing PV efficiency (from 13.5% to 20%), the net zero goal was achieved in winter.

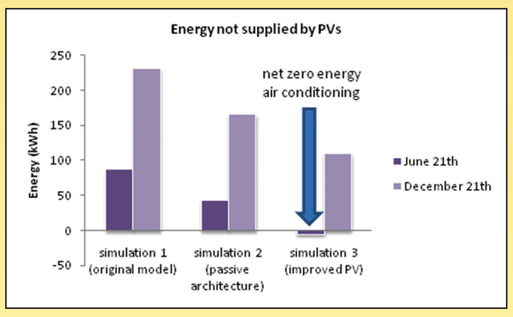




In all simulations, was observed that summer represents the critical period related to net energy, outlining that the increased solar energy production in the summer is not as significant as the increased air conditioning demand.

Conclusion

The following points can be concluded from this work:



1) The net zero energy air conditioning goal can be achieved only in winter in these regions, by associating solar thermal systems with absorption chillers and feeding the energy surplus with PV panels only if passive architectural techniques and high efficiency PV panels were adopted.

2) In order to increase the possibility of achieving the net zero energy goal for air conditioning systems, especially at an annual base, the following points should be taken into account:

- using solar collectors that work at high temperature such as ETC, CPC or PTC so that double or triple effect absorption chillers with high COPs can be used.
- developing solar chillers that work at lower temperatures so that the auxiliary heating energy consumption can be reduced.

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