Results of DEC Unit Assisted by Solar Energy in Lisbon

João Farinha Mendes, Rui Rodrigues, Iván Vázquez Pérez

LNEG – Laboratório Nacional de Energia e Geologia, IP
Estrada do Paço do Lumiar, 22, 1649-038 Lisboa, Portugal
Telf: +351210924768 Fax: +351217127195 farinha.mendes@lneg.pt www.lneg.pt

ABSTRACT

The Air Handling Unit (AHU) with Desiccant Evaporative Cooling (DEC) technology, assisted by solar energy, is in operation at LNEG (former INETI) since 1999, ant it has some features in its design, resulting from local constraints of the building and from design decisions taken at that time with the purpose to investigate different solutions.

This unit has a conventional auxiliary back-up cooling unit, an heat pump, to assist the DEC AHU on cold production in heavy summer load conditions, that guarantees the comfort conditions of the 12 offices, but does not permit an high solar fraction in summer due to the role of its condenser. So, to limit the time operation period of the heat pump, was recently introduced a new humidifier in the air admission section.

In this paper we make a description of this AHU and we report the results obtained so far after those modifications, in a qualitative way, and we begin the discussion of using the performance figures, adopted in the framework of IEA SHC Task 38, to this unit.

Key-Words: *Air handling unit, desiccant evaporative process, solar energy, solar fraction, performance figures.*

1. INTRODUCTION

In central and north part of Europe, building heating loads are predominant on energy consumption for a long time ago, but in the last years also the south Europe is giving attention to the heating load, due to new requirements on comfort that is also responsible for a strong increase on the market of the small compression air conditioning units, that are able to cover also the cooling loads. In consequence the electricity consumption is increasing everywhere, summer and winter, being responsible for the black-out already occurred in some cities of South Europe. Fig. 1 shows such evolution on electricity consumption in Portugal along the last years, which is obliging to increase the power capacity of the country.

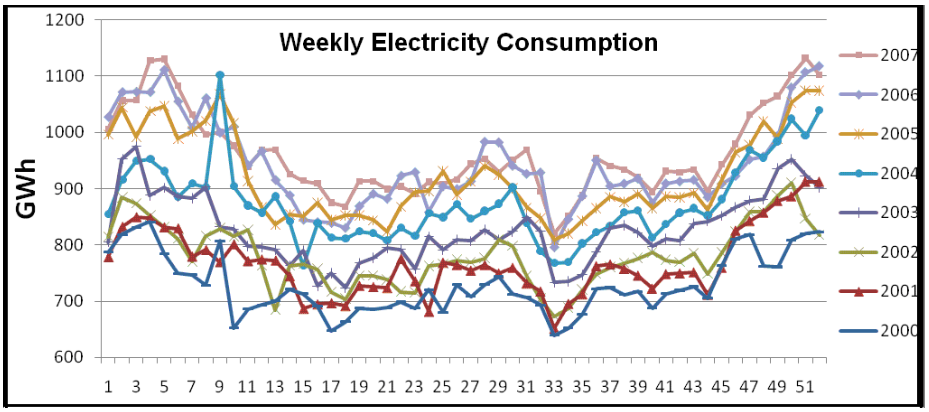

Fig. 1 – Evolution of electricity consumption in Portugal (Source: REN).

In counterpart and like in other countries of the region, the annual sunshine conditions is a natural energy source, to be captured by solar thermal collectors to use in thermal driven cooling machines in summer or to heat the air in winter, facilitating the economic viability of solar systems for space conditioning allied to domestic hot water preparation.

The solar thermal driven cooling systems, to be competitive in terms of primary energy ratios require high solar fractions [1], but an auxiliary thermal energy source is always necessary. The gas is particularly suitable to that purpose and this combination can also contribute to eliminate the seasonal fluctuations on the network gas distribution.

This work will be addressed to the solar desiccant evaporative cooling technology, through the presentation of the Demonstration AHU installed at LNEG (former INETI) [2], which has a CPC type solar collector system.

In operation since 1999, the most recent modification of the initial design will be reported, as well the results obtained so far: the quality (comfort conditions) and the quantitative results (performance figures), which will be discussed in the framework of the initial proposal of IEA SHC Task 38.

2. DESCRIPTION OF THE AIR HANDLING UNIT

The unit was designed to promote the air conditioning of 11 offices of building G at LNEG campus (former INETI) in Lisbon. This building was not prepared to accommodate the air ducts size required by the desiccant evaporative cooling technology – the design flow rate was 10 m3/h and it has to be reduced to half of this value. Then an auxiliary heat pump (HP) was introduced to decrease the process air temperature and the traditional humidifier on the process air duct of the AHU was removed. The main characteristics are:

AHU global dimensions : 1290 x 1315 x 7060 mm

Air flow rate: 5000 m3/h (8 renovations/hour)

Power: 2.2 KW (fans); 7.5 KW (Heat pump); 1 KW (pumps and wheels)

Solar system: 48 m2 CPC type collectors with 2 m3 water tank.

AHU design conditions: 28.6 kW cooling power needing 38.2 kW thermal power.

The condenser of the HP was placed in the exhaust air duct before the solar heat exchanger which became not useful each time the HP works and leading by this way to low solar fractions in summer time. This solution was however correct in terms of comfort conditions which were preserved all the time according to the results. The whole is being monitorised since the beginning of its operation and the results of this 1st phase of operation were reported in the framework of Task 25 - Solar Assisted Air Conditioning of Buildings of the Solar Heating and Cooling Program of IEA and elsewhere [3].

According to those results there is however a large number of periods, out of the heavy summer temperature and humidity conditions, where it would be possible to keep the comfort conditions, without HP operation and if one humidifier was introduced in the process air duct of the AHU. The idea is to reduce the number of hours of HP operation, increasing by that way the solar fraction. This modification was introduced last year, but the necessary control adaptation only recently was possible to begin its adjustment, reason why is only partially implemented.

In Fig. 2 is shown the hydraulic scheme of the whole system showing the coupling of solar system with AHU and showing also the new humidifier, located after HP evaporator. The two will work in an alternative way.

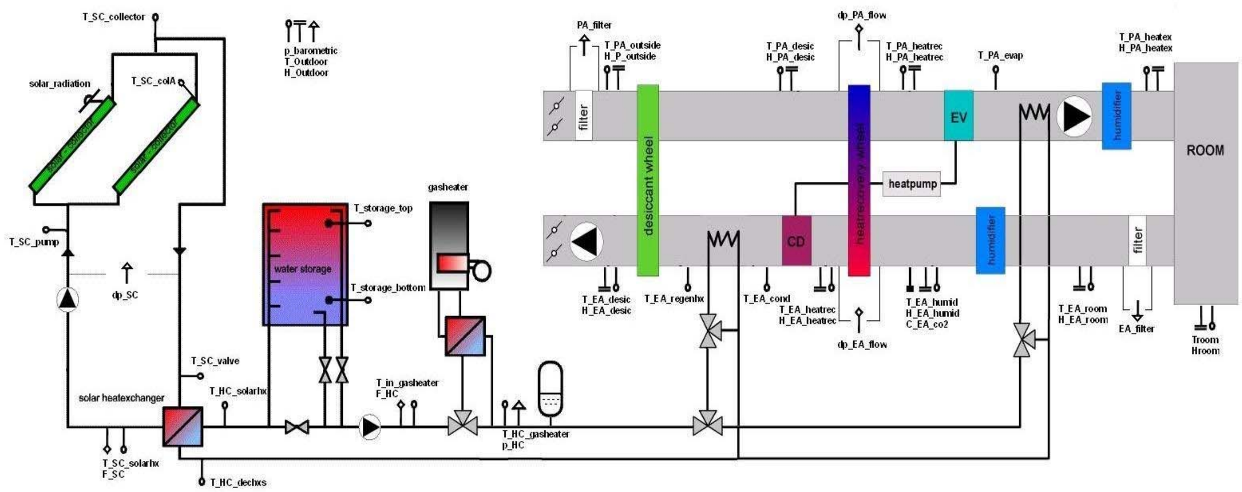

Fig. 2 – Hydraulic scheme of the whole system.

3. RESULTS

After introduction of the new humidifier there is not yet a whole summer season to make sense the presentation of the most important performance figures, showing its performance on the accorded standardized way. Anyway a discussion on this point will be done below.

Maintenance with repair and substitution of some components also impeach the system operation during May and June of this year and after that, the back-up cooling heat pump was stopped, to force an intensive use of the two humidifiers.

The result obtained until now is positive which is also due to the mild summer of present year, with comfortable room temperatures, achieved without HP back-up contribution.

Due to the limited period with available data until now, we chosen one recent day, characteristic of the period, where the evolution of some important parameters are presented in the next four graphs.

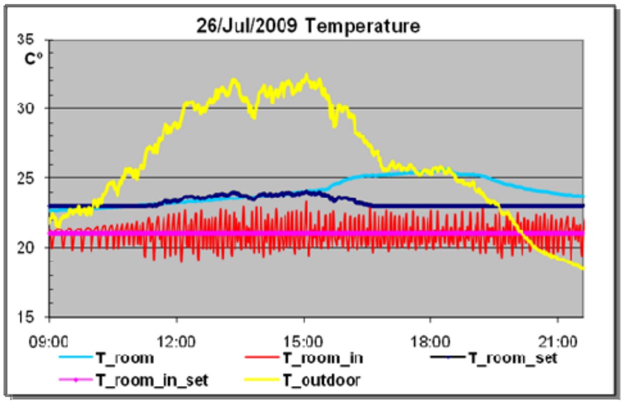

Fig. 3 – Temperature values.

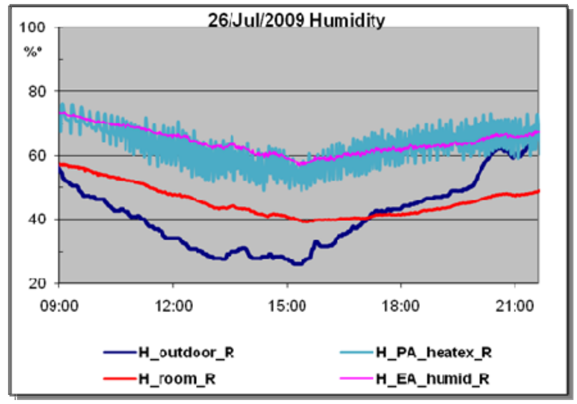

Fig. 4 - Humidity values.

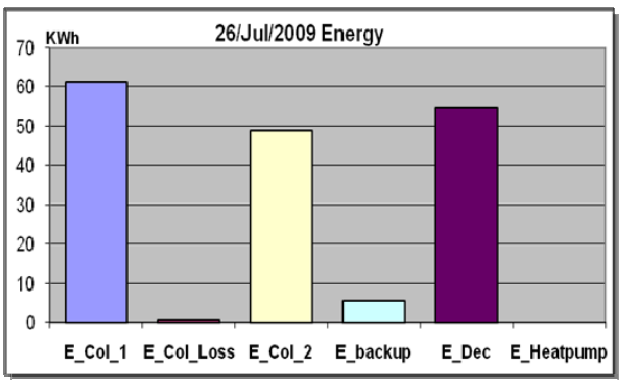

Fig. 5 – Daily energy totals.

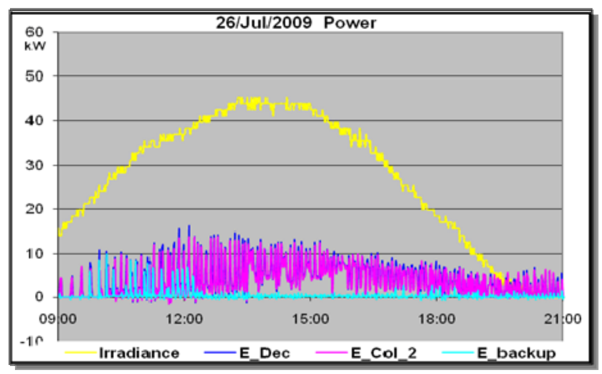

Fig. 6 – Available and used solar power.

The presentation of the performance figures, accorded within SHC Task 38, for the three levels of instrumentation, when applied to this system in the present operation mode – desiccant evaporative cooling with humidifiers in both AHU paths and without back-up cooling from HP - showed that some adaptations on the initial template have to be done. The two first levels were already exploited and in the first level, when trying to calculate PER, in the present case the value Q10 has to be substituted by Q6, because it's the one that represents the energy added to the unit to get the cooling effect, which physical process occurs inside the AHU without addition of no more energy, besides power to movable parts. Doing it by this way we get, for the characteristic day above, where there is no DHW (Q4) or SH (Q3) consumptions, the value PER= 0.12 . And when going to the PERref an additional problem comes because of separated value Q10 on denominator

which can not be calculated as an input – chilled water for instance - but only as output – stream of cooled air. Alternatively we can miss it and consider just the input Q6 given by a boiler, besides the electricity input. By this last way we get PERref= 0.75 .
The second level is more pacific and showed no problem of implementation.

4. CONCLUSIONS

Some representative days have been analysed in a qualitative and quantitative way. The system is operating to give the comfort conditions and that can be confirmed by the comments of occupants as well as by data analysing. Anyway the limited data acquired until now with the system operating in the new configuration, is not totally conclusive in regard to our expectations, but it shows that it is reasonable to wait, in the whole season, for such positive results.
When applying the methodology decided in the framework of IEA SHC Task 38, to calculate the relevant performance figures of first level, some modifications have to be done in the initial template, if we want to consider all the operation modes of DEC systems.
As a demonstration system, this unit is being visited by a number of students, professionals and managers giving a good contribution to the dissemination of solar thermal driven systems.

REFERENCES

[1] - “Solar-Assisted Air Conditioning in Buildings – A Handbook for Planners”, coordinated by Hans-Martin Henning in the framework of IEA SHC Task 25 work, and edited by Springer-Verlag/Wien, 2004.

[2] – CODEC Project : Contract JOR3 - CT95 - 0003 (EU DGXII) .

[3] – J. Farinha Mendes, Rui Rodrigues, M. João Carvalho **–** *“Air Handling Unit Based on Desiccant Evaporative Technology and Assisted by Solar Thermal Energy*” - ISES Solar World Congress 2003, June 14-19, Goteborg, Sweden.