Case Study summary

IEA-ECBCS Annex 48

Heat Pumping and Reversible Air Conditioning

Italy Case Study N°1: Small building with surface water reversible HP for heating and cooling

Contribution of Politecnico di Torino

Introduction

The Brasimone research centre was established in the early 1960s by CNEN (National Committee for Nuclear Energy) – later to become ENEA (Italian National Agency for New Technologies, Energy and the Environment) - on the eastern shore of an artificial water basin, serving a nearby ENEL (National Electric Utility) hydroelectric power station. The Centre is located in the Appennine mountain range, halfway between Bologna and Firenze, at 846 m above sea level. In the mid 1980s, a small building (1.800 m^3) was constructed to promote communication to the public on the activities being conducted by the two organisms in the Energy field. In 2005, the HVAC system of the building has been completely renovated. This case study presents the results of the system monitoring campaign, carried out in its first summer of operation (May – September 2006).

Summary

- Location: Brasimone, Italy
- Building sector: Public building / Conference room
- Gross net area: 300 m²
- Heat pump nominal cooling capacity: 60 kW
- Heat pump nominal heating capacity: 68 kW
- U-value external walls: 0.5 W/(m²K)
- U-value windows: 2.3 W/(m²K)

Background

The AC system is of the air-and-water type (primary air and two-pipe fan coils). Hot and chilled water is produced with a water-to-water reversible heat pump, using treated lake water as the heat source / sink. A newly installed BEMS allows continuous monitoring of the main performance parameters of the system. Mechanical ventilation is provided to the conference room.

General concepts

The reversible water-to-water heat pump delivers water for cooling at 7°C and water for heating at 45°C. Condensation heat recovery in cooling mode is performed with a dedicated condenser. The heat exchanger of the primary circuit is of the shell-and-tube type, and is immersed in an inertial storage of 200 litres. The heat exchanger on the secondary circuit is of the brazed plate type; the heat recovery condenser is also of the brazed plate type. A water-glycol solution is used in the secondary circuit to avoid the risk of freezing. The existing oil boiler was maintained for emergency use.

Heat pump

Technical data of the system:

Heat pump:

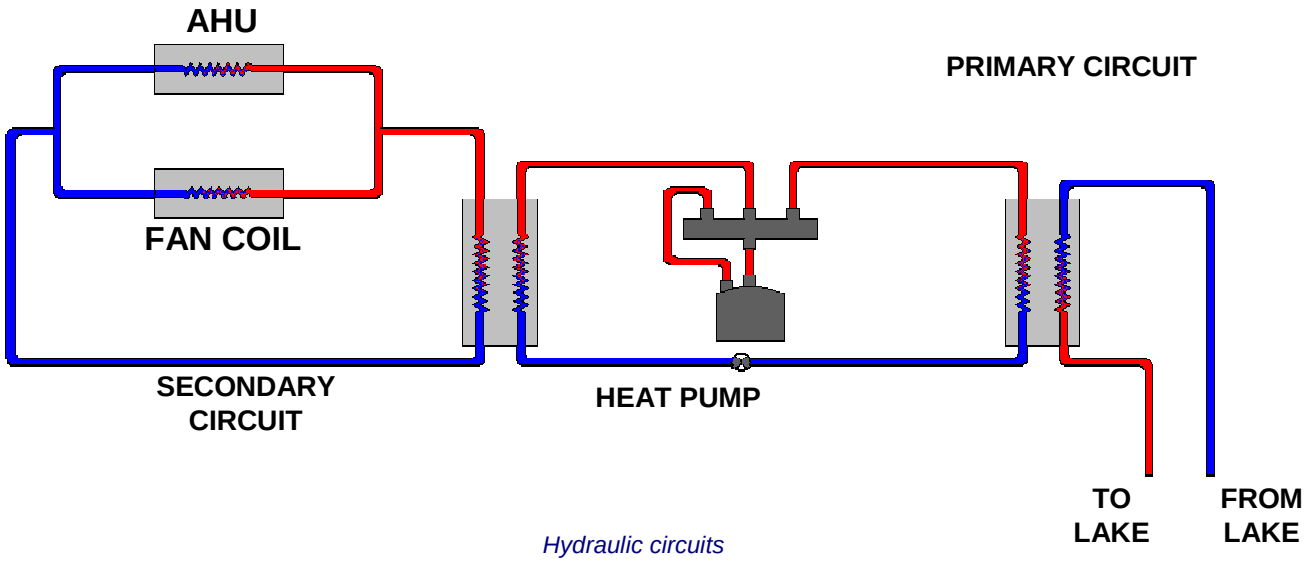
- Cooling power: 60 kW
- Heating power: 68 kW
- Screw compressors n°2
- Ref. fluid: R407C

Advantages

- High and almost constant COP during the whole year

Drawbacks

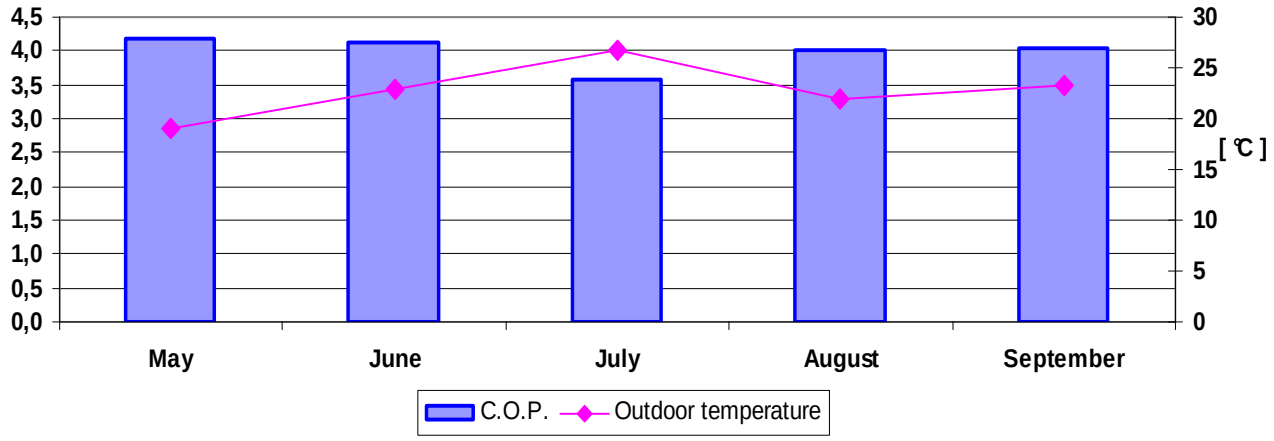
- Higher installation cost than traditional HVAC system
- Presence of accessible surface water and official authorization to use it



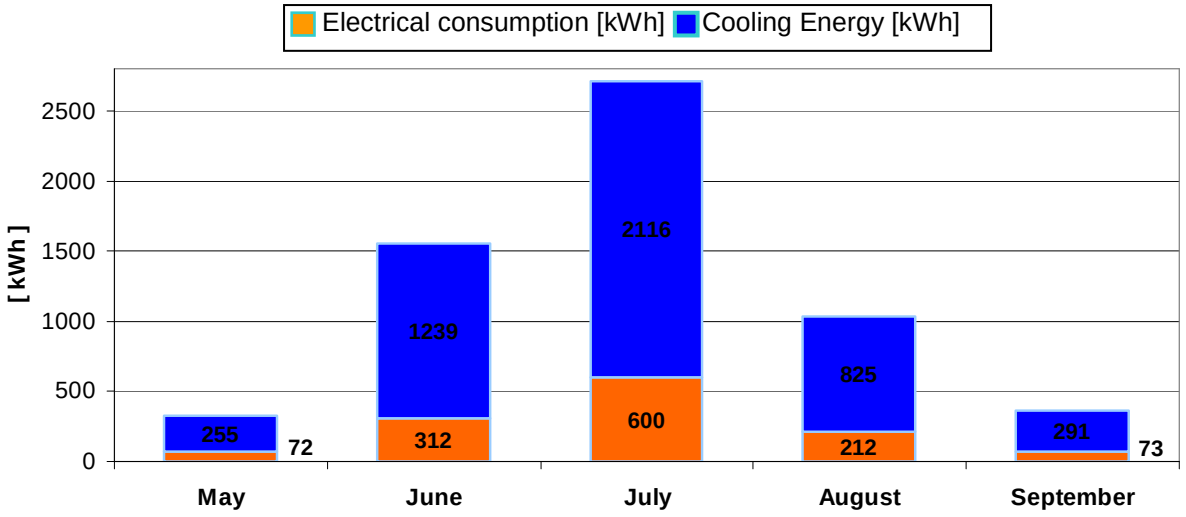
Hydraulic circuits

Performance data

The monitoring campaign carried out in the summer of 2006 provides data for further evaluations. Monthly average COP was computed from the measured data of delivered cooling energy and compressor electrical consumption; the seasonal average COP turned out to be 3.9.



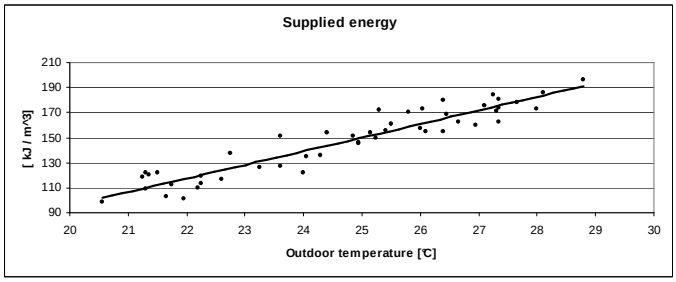
Monthly average C.O.P. and outdoor temperature



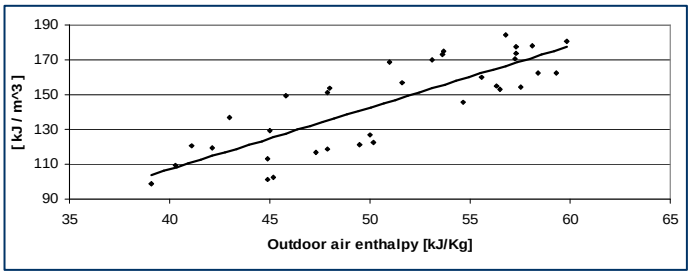
Heat pump electrical consumption and cooling energy delivered to the HVAC system

Data analysis

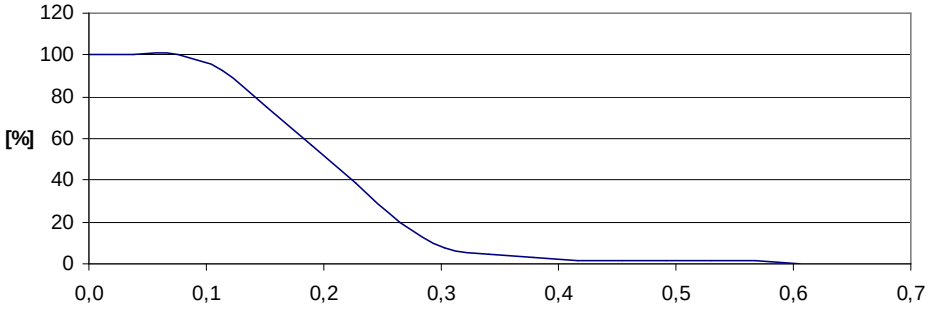
A correlation analysis was performed to investigate the dependence of delivered cooling energy (AC system thermal load) on outdoor climate. The best correlation is obtained when air temperature is considered. This fact may be explained by considering that, during the period of investigation, the AHU fans were generally switched off (the conference room was mostly unoccupied): the AC cooling load was therefore primarily determined by solar and conduction gains, which are fairly well correlated with outdoor dry-bulb air temperature.



Energy signatures of HVAC system, cooling season. The x values are represented by external temperature



Energy signatures of HVAC system, cooling season. The x values are represented by external air enthalpy



Cumulative value of Heat Pump load factor

HP load factor

The heat pump load factor was determined by analysing the compressors duty cycle. The capacity control is in fact on-off: therefore, the heat pump load factor can be determined by measuring the time fraction for which the each compressors are on.

Conclusion

This case study was aimed at analysing the performance of a water-to-water reversible heat pump. The presence of a BEMS makes it possible to monitor and record the main system operational parameters: water temperatures and flow rates, electric energy consumption, outdoor air temperature and humidity, etc. Based on the above data, the daily performance of the heat pump was analysed in the April – September 2006 period. The seasonal average COP was equal to 3.9 and a good correlation between daily cooling energy and outdoor dry-bulb air temperature was identified. The statistical distribution of heat pump load factor was also considered, which turned out to be quite low, mainly because of the limited utilisation of the conference room in the investigated period.

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Literature

IEA-ECBCS Annex 48 website: http://www.ecbcs-48.org

Article: Masoero, M and Silvi, C. 2007. A proposal for an energy conservation opportunities (ECO) list in auditing of air conditioning systems. Proc. Climamed 2007. Genova, 5-7 settembre 2007, pp. 897-912.