Air Conditioning Solar Plant for a Small Office located in a Mediterranean Climate

Jordi Cadafalch[1*], Ricard Consul[1], Dani Carbonell[2] and Martín Iván Levi[2]

[1] Universitat Politècnica de Catalunya (UPC), Departament de Màquines i Motors Tèrmics (MMT), Institut Politècnic Campus de Terrassa (IPCT), Ctra. Nac. 150, km 14.5, 08227 Terrassa, Spain

[2] RDmes S.L., Institut Politècnic Campus de Terrassa (IPCT), Ctra. Nac. 150, km 14.5, 08227 Terrassa, Spain

[*] Corresponding Author, jcadafalch@mmt.upc.edu

Abstract

This work describes the air-conditioning solar driven system installed at the premises of the company RDmes, located in Terrassa (about 25 km inland from Barcelona). Main components that make up the system are a small-capacity adsorption machine of 8 kW, a solar field of flat plate single glazed collectors with a small buffer tank, a cold distribution system through a radiant ceiling and liquid-to-ambient heat exchanger as auxiliary temperature source.

The engineering of the plant has been carried out by using detailed transient modelling tools developed by RDmes. Sensors and hardware for detailed measuring and control of the plant have been installed in order to analyze the actual performance.

First measurements of the plant will be obtained during summer 2010. This work addresses details on the engineering and planning process.

1. Introduction

Large effort has recently been done on small capacity solar-driven air-conditioning plants and comprehensive material is now available from activities such as those carried out within the framework of the IEA (International Energy Agency) Solar Heating & Cooling Programme through "Task 25: Solar-Assisted Air-Conditioning in Buildings" and "Task 38: Solar Air-Conditioning and Refrigeration", see for example [1]. However, this technology still requires a large effort from planners in order to fit requirements of each plant according to meteorological conditions and demand profile.

Furthermore, many different technologies are available for solar energy collection (flat plate, evacuated tube...), for heat/cold distribution (radiant floor, radiant ceiling, convectors, standard radiators…), for heat exchange to the auxiliary temperature source (pool, geothermal holes, ambient…), and also different thermal driven machine technologies (adsorption, absorption..). This makes the planning process even more complicated.

As cooling demands and solar radiation in Mediterranean climates are very high, market potential for solar-cooling technology in this area is very promising. However, high humidity conditions and high summer temperatures make solar-driven machines work in adverse conditions resulting into lower performance. Therefore, if no accurate planning and engineering process is carried out, systems do not work properly.

In order to get further experience in the Mediterranean climate and to push this technology a step forward to the market, a solar heating and cooling showroom plant has been set-up at the premises of the company RDmes located 25 km inland from Barcelona, at the Institut Politecnic Campus Terrasa (IPCT), ctra. Nacional 150, km 14.5, in Terrassa.

Main components of the system are a solar collection field using single-glazed solar collectors with, a buffer to store energy collected from the sun, a low temperature driven adsorption machine of 8 kW, a distribution system through a ceiling roof and a liquid-to-air heat exchanger as the third temperature level source required by the thermal driven machine.

The site will be open to the public for technology dissemination purposes.

Additionally, the plant will also be used in the near future to test other RHC (renewable heating and cooling) configurations and devices in order to gain maximum experience in RHC technologies.

Engineering and planning has been carried out by using the detailed modelling tools developed by the company RDmes. In order to analyze the real performance of the plant, some sensors and hardware for detailed control and monitoring are used. Monitored data will be available on-line through the technical virtual office of RDmes at www.rdmes.com.

The plant will be commissioned by end of July 2010. Data available will be presented at the Eurosun 2010 conference.

2. Project FREDSOL

The showroom has been developed within a framework of a project called FREDSOL involving six different partners.

Research and technical development has been carried out by Universitat Politècnica de Catalunya (www.upc.edu), and RDmes (www.rdmes.com). RDmes is a spin-off from Universitat Politècnica de Catalunya focused on world-wide standardization of renewable energy engineering processes in order to asses maximum reliability at minimum costs, and that has developed a new on-line tool set for green technology engineering.

Technical consultancy and components have been provided by the industrial partners Modulo Solar (www.modulo-solar.com), manufacturer of solar collectors, Sortech (www.sortech.de), manufacturer of adsorption chillers, and Giaccomini (www.giacomini.com/es), manufacturer of heating, cooling and regulating products and systems.

Technical consultancy and system installation has been carried out by Abast Energia Natural (www.abastenergia.com), which main activity is based on planning, engineering, installation and maintenance of solar thermal systems.

3. Description of the plant

The solar plant is installed at the office of RDmes located in (IPCT) Institut Politècnic Campus Terrassa, approximately 25 km inland from Barcelona. The system is designed for only solar-air-conditioning of a total area of 100 m^2, with no additional backup. As the solar system will not be able to supply 100% of air-conditioning demand, some degree of discomfort will be accepted.

The building where the office is located is old and with low-quality construction materials, resulting into high cooling loads.

Energy from the sun is collected in an array of 15 single-glazed flat plate collectors from Modulo Solar, model Maxol 2.0S with a total absorber area of 27.6 m^2. Solar energy is stored in a buffer tank with 1000 l of capacity and with an internal serpentine heat exchanger (tank from Modulo Solar model MS 100 Vs1) to provide thermal inertia to the system.

Solar energy is then used as driving energy for an adsorption chiller ACS08 from Sortech with a nominal cooling capacity of 8 kW.

Cold water produced by the chiller is distributed to the conditioned area through a radiant ceiling from Giacomini with an active area of about 75 m^2. Cooling power of the Giacomini radiant panels in nominal conditions (cold water at 14 ºC, ambient temperature at 26 ºC) is 111 W/m^2 resulting in a total cooling capacity between 8 and 8.5 kW. When required, office air is dried by low power domestic dehumidifier devices.

Energy introduced at the adsorption chiller from the solar loop (high temperature) and the conditioned space (low-temperature) is dissipated to the ambient through a liquid-to-air recooler RCS08 from Sortech. The recooler is equipped with a low-consumption water spray system only activated in critical conditions to increase dissipation power. In parallel to the RCS08 recooler, actions are being taken to install a geothermal collector to increase dissipation rates in the near future.

In order to minimize parasitic electrical demand low consumption fans are used in the recooler, and Wilo Stratos series pumps are used.

The site will be commissioned by end of July 2010. First results obtained will be presented at the EUROSUN conference in October 2010.

The following pictures show main components and parts of the site. They were taken during the installation process.

Fig. 1. Air conditioning solar plant. Left: Collector field composed by 15 Maxol 2.0 S units. Right: RCS 08 SorTech re-cooling system.

Fig. 2. Air conditioning solar plant. Left: radiant ceiling. Right: radiant ceiling distribution kit.

Fig. 3. Air conditioning solar plant. Technical room (in progress). Left: SorTech ACS 08 Adsorption chiller and buffer. Right: Buffer and hydraulics.

4. Critical analysis of the plant

In order to analyze plant performance and to develop best-practices for an immediate dissemination of the technology to the Spanish market, the plant has been equipped with a monitoring system. Additionally, the transient modeling tools from RDmes have been upgraded in order to be able to model in detail the system under different boundary conditions. Expected improvements of the systems will arise from a critical evaluation of monitored data and theoretical performance from the models.

The heat flows of the chiller are measured in detail using energy counter units. Additional temperature sensors will also be installed in order to obtain other data of interest for critical analysis purposes. From the energy measured and the measurement of the parasitic electrical consumption, seasonal performance factors are analyzed.

Measured data is processed and stored at the RDmes servers, and accessible on-line through the technical virtual office of RDmes. Data will be open soon to the general public.

References

[1] H.M. Henning, (2004). Solar-Assisted Air-Conditioning in Buildings, A Handbook for Planners, Springer Wien New York.