Conference Proceedings

EuroSun 2014

Aix-les-Bains (France), 16 - 19 September 2014

First operation months of world's most powerful solar cooling system in the USA at Desert Mountain High School (DMHS), Scottsdale, AZ

Moritz Schubert[1], Christian Holter[1], Harald Blazek[1]

[1] all authors from SOLID GmbH, Graz, Austria

Abstract

In early 2014 the solar thermal cooling system with 1750 kW (500 tons) cooling power was commissioned at Desert Mountain High School (DMHS), Scottsdale, AZ. The collector gross area is 4865 m² of double glazed flat plate collectors. The lithium bromide absorption cooling machine works in combination with four existing compression chillers. Experiences of the start-up phase will be described and measurements of energy flows and use of auxiliary energy will be shown as well as seasonal energy efficiency ratios.

It is of special interest that electric COPs (kWh Cooling produced/ kWh electricity consumed) of the system up to 42 were reached for periods longer than one hour and daily average including all starting and stopping procedures in morning and evening reach COP_{el} between 25-30.

1. Boundary conditions and climate

Fig. 1: Overview collector fields from Google Maps (© www.google.com) and from a terrestrial photograph (© www.solid.at)

The buildings of the school for over 2600 students are 20 years old and were cooled by compression chillers. Air conditioned space in the buildings encompass 55.000 m². The school has no accommodation for students and thus little demand for domestic hot water.

The arid climate in this region requires approx. 12 months of cooling and approx. 3-4 months of space heating plus cooling per year according to the experiences with other solar thermal installations in the region. In these winter months, thermal loads typically start with heating demand in the morning and cooling demand around noon. As the heating demand itself is pretty low, a separate heating supply from the Solar System (which had been possible in theory) could not be realized economically.

Selection and/or peer review under responsibility of EuroSun2014 Scientific Committee
doi:10.18086/eurosun.2014.07.15 Available at http://proceedings.ises.org

From climate data, peak loads would occur during summertime but as big parts of the school are not used in holiday periods, only basic cooling services are provided during such phases which can be covered to 100% by the Solar Cooling System, avoiding the building to overheat.

Last but not least, experience during the installation period included all boundary conditions possible in AZ desert climate that can cause trouble for the installer: Starting from rattlesnakes or wild boars on the construction site, heavy flooding (30 cm water depth) of collector storage areas during heavy rain, frost in winter nights, over 40°C in summertime as well as a few sandstorms which are well documented on different video platforms in the web.

2. The solar thermal heating and cooling system

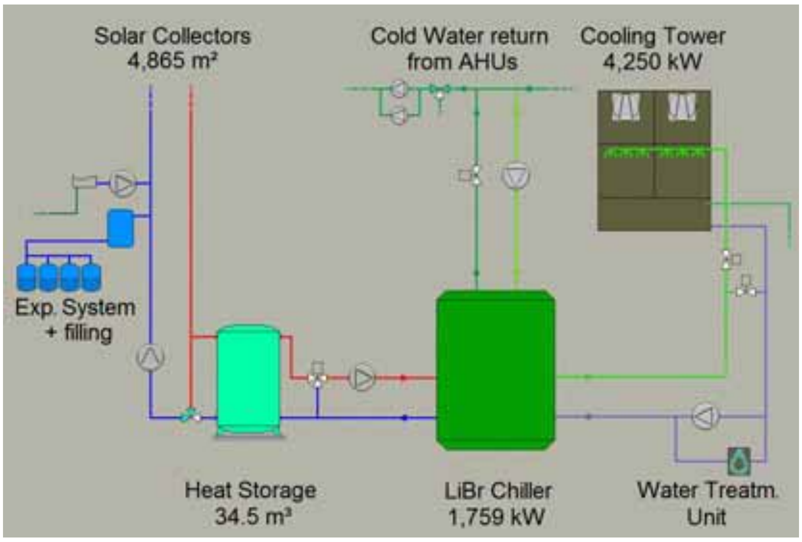

Fig. 2: Simplified system schematic

The collector field is distributed on different roofs of the sports complex of the school and on an elevated structure above the parking area. The collector field consists of 54 collector arrays, most of them of a size of 100 m² collector area with 8 large scale collectors of 12.5 m² gross area each. 2 different European collector producers were supplying collectors for this project.

Due to the mild climate no anti-freeze protection is needed and thus no heat exchanger between collector field, heat storage and chiller. In the very rare event of freezing during the night, small amounts of water from the storage tank are pumped around the collector field as freezing protection. Experience from other installations in the region show that this is only needed a few times in a 5 or 10 year period and therefore can be neglected in energy harvest considerations.

The single stage lithium bromide absorption chiller is supplied via a heat storage of 34.5 m³. When the solar pump is operating at 100%, this storage buffers approx. 30 minutes of solar heat production.

The designed cold water temperatures of the LiBr-chiller are 13°C return temperature and 7°C flow temperature. It is operating on full load during the hottest hours of the day, cutting down peak loads by pre-cooling the back flow from the air handling units. During morning or evening hours when the chiller is supplied with Solar Hot Water between 65-75°C it still delivers under partial load a relevant portion of the building’s cooling demand.

3. System performance and how actual performance was achieved

Experience from a couple of Large Scale Solar Thermal installations in the region justify the expectation that the collector fields will deliver 800 kWh of heat per m² gross area and year when producing hot water at average 80-85°C.

Thermal COPs of today's state of the art single stage LiBr absorption chillers are between 0.7 and 0.75. These values are reached by the DHMS system except on weekends where consumption behavior of the client still allows further system optimization.

The big step forward in this installation is to be understood on the side of the electric COP:
Coming from experiences from a 4000 m² Solar Cooling System in Singapore, SOLID has learned to run absorption chillers beyond nominal manufacturer's specifications:
All electric motors for pumps and ventilation fans do have speed controls and are remotely optimized for reducing energy consumption by minimizing flow rates and fan speed as far as possible while increasing temperature spreads between flow and back flow for maintaining needed thermal power values.

Optimization measures will continue for at least one full meteorological year in all different climatic conditions and the values reached until now are already extremely promising:

- Hourly COP_{el} reaches now values up to 42
- Daily COP_{el} incl. all starting and stopping losses in the morning and the evening reaches now constant values between 25-30.

Thermal measurements are taken on 3 different positions by calibrated heat meters:
From collector field to tank, from tank to chiller and from chiller to chilled water distribution.

Electric measurements are based on metering via the individual frequency converters of all motors today. A couple of calibrated electricity meters are already ordered in addition and will be installed asap for confirmation of today's metering results.

4. Outlook for the future

First of all, the values from today's metering results shall be validated by additional metering devices within the mentioned optimization period of a full meteorological year.

Second, the strategies developed in Singapore and Arizona shall be further refined and form the base for future installations all over the globe.

And last but not least: Coming from the fact that a state of the art Solar Cooling installation today can outperform a standard electric cooling system by a 5 or 10 times higher COP_{el} (or even more, when the electric system should be of older type) strategies how to use the cold water in the buildings shall also be adapted accordingly. Facility staff today still tends to shut down or minimize cold water distribution in periods of low usage of the buildings in the aim of saving energy cost but accepting temperature increase in the building on the other hand. This strategy needs to be re-evaluated when cooling can be provided at such lower operating cost.