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Solare Klimatisierung



Solar Assisted Air Conditioning

Demonstration Unit

FGK - Working Group
Desiccant Air Conditioning



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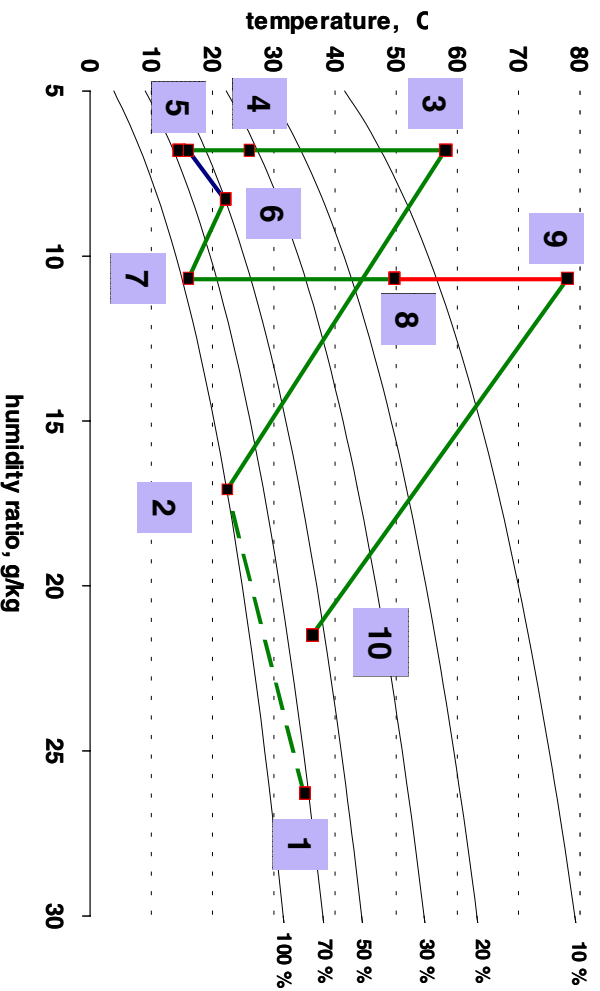
Solar Assisted Desiccant Air Conditioning System for hot-humid climates

General Concept:

Depending on outside weather conditions, dehumidification of the fresh air rate is significant for energy consumption of air conditioning systems. Conventional air conditioning systems need low temperatures on cooling coil surface to achieve the comfortable dry air inside the buildings with a typical water vapour of 7 - 8 g per kg of dry air. Chilled water temperature of about 4 - 6°C is usually needed in air conditioning systems for the purpose of dehumidification.

A solar assisted desiccant air handling unit splits the cooling and the dehumidification process. The conventional process is replaced by a cascade of several process steps:

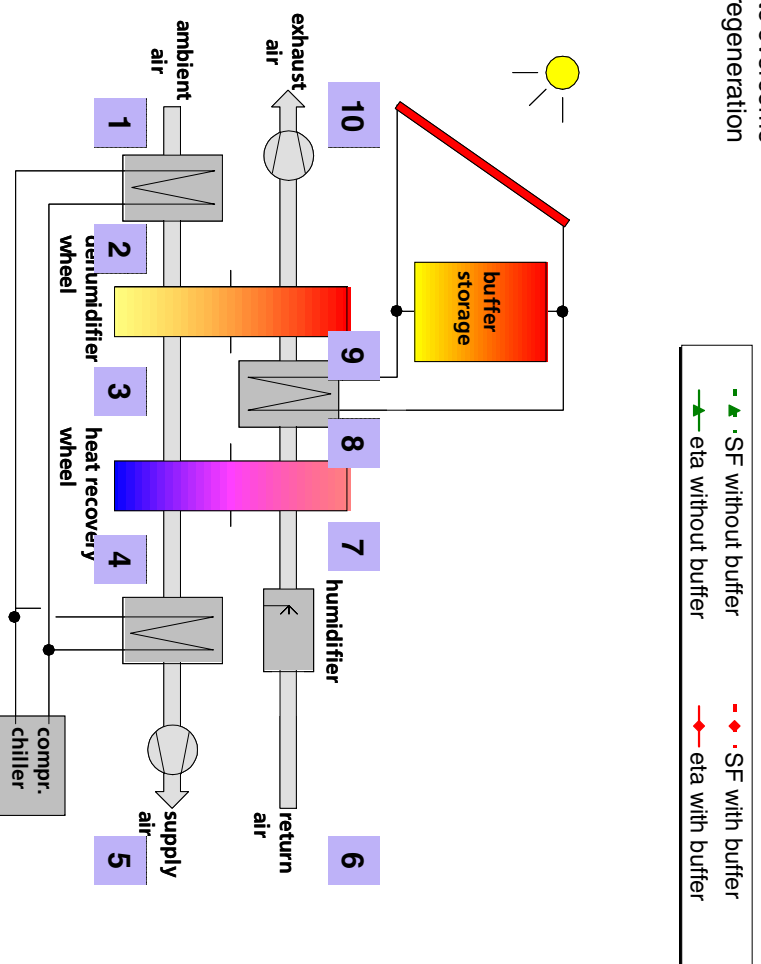
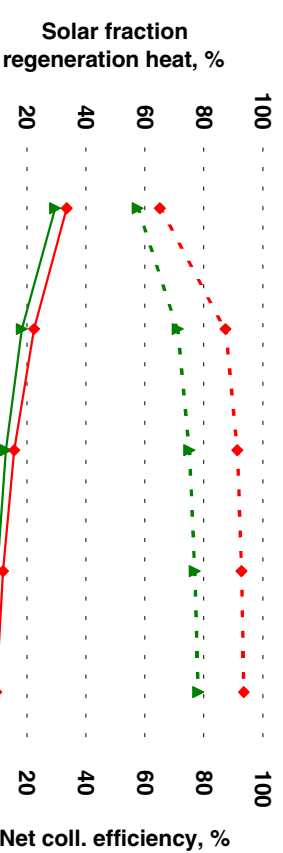
- Pre-cooling and -dehumidification
- Desiccant dehumidification
- Heat/cold recovery
- Secondary cooling



In comparison to a standard air handling unit the desiccant system needs driving heat input for regeneration of the sorption material (e.g. silica gel, lithium chloride). This heat can be produced using a solar thermal collector which transforms solar radiation into heat. For this process any kind of solar collector can be used:

- flat plat collector (heating water)
- evacuated tube collector (heating water)
- solar air collector (direct air heating)

A buffer storage can be installed in order to overcome mismatches between required heat for regeneration and available solar heat.



Key advantages of this design:

- Pre-cooling and pre-dehumidification at a high surface temperature on cooling coil. Chilled water temperature of approx. 12°C.
- Desiccant dehumidification to comfortable 7 g/kg dry air. Low temperature regeneration of sorption wheel (70 - 80°C) is ideal for the use of solar energy.
- Solar fraction for regeneration up to 80%.
- Evaporative cooling in return air (condensate from precooling can be used)
- Heat recovery to reduce cooling energy
- Secondary cooling without dehumidification to a comfort supply air temperature at a high temperature level of chilled water (12 - 14 °C).
- High chiller COP
- No reheating for room temperature control and no reheating to reduce draft.
- Reduction of electric consumption at design conditions up to 40 %

Design example:

Results of a draft system design are shown in the illustrations opposite. The results are valid for a typical office building with office hours from 8 a.m. to 6 p.m. from Monday to Friday and 8 a.m. to noon on Saturday. Meteorological data from Abu Dhabi were used for the simulations.

The main figures for the design of a solar system are:

solar fraction (SF) which defines the fraction of regeneration heat that is delivered by the solar system in order to provide a constant regeneration temperature of 85°C

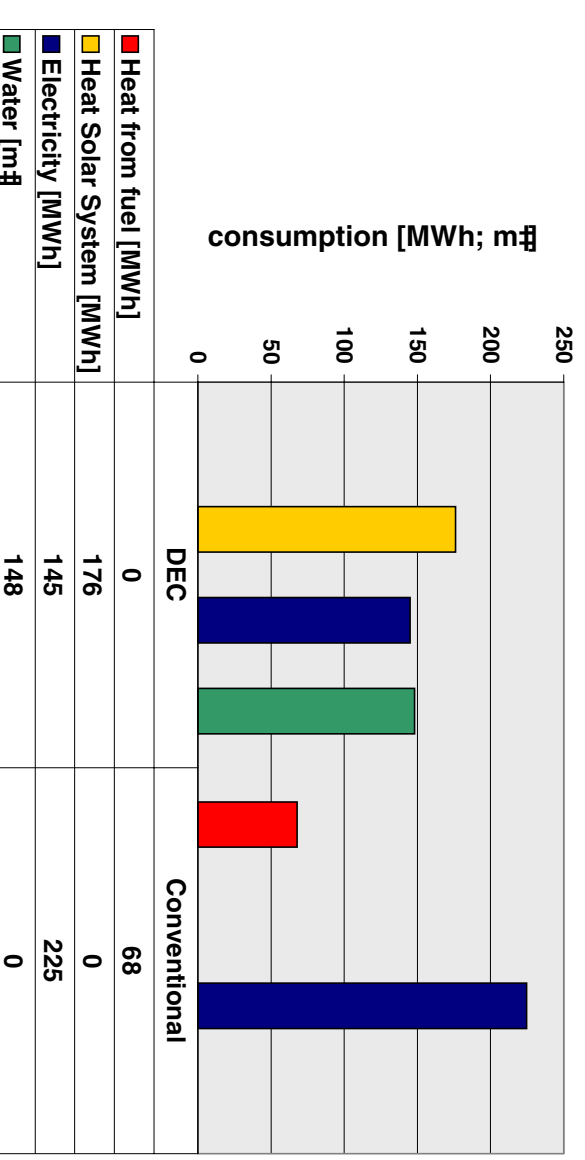
net collector efficiency (eta) which defines the final useful solar heat referred to the radiation incident on the solar collector.

The figure on the top is valid for a typical flat plate collector. The x-axis denotes the collector area normalized to the air volume flow (m² of collector area per 1000 m³/h of nominal air volume flow of the air handling unit). The bigger the collector the higher is the solar fraction but the lower the net collector efficiency. A second major influence is due to the installed buffer storage. Using a buffer storage increases both the solar fraction and the efficiency.

With a flat plate collector system of 60 m² per 1000 m³/h of size of the air handling unit a solar fraction of more than 85 % is achieved, if a buffer storage is installed. Using an evacuated tube collector the same result is achieved with a smaller collector of about 30 m².

Annual performance related to energy and water consumption is shown on the bottom figure. The annual electricity consumption can be reduced by more than 35 % due the installation of a solar assisted desiccant system. Another advantage of this technology is that no heat source beside the solar collector is needed, since in case of low solar gains the chiller serves as backup. It should be noticed that the water needed for evaporative cooling can be delivered from the pre-cooler condensate.

Energy and Water Consumption



Description of the process:

- 1 - 2 Pre-cooling and pre-dehumidification of ambient air at a high temperature level of chilled water. Chilled water supply temperature at 12 - 14°C improves chiller coefficient of performance (COP) and reduces energy cost for chilled water about 15 - 20%
- 2 - 3 Desiccant wheel realises the dehumidification to the target of approx. 7 - 8 g/kg dry air (20°C; 50%).
- 3 - 4 Cooling of warm and dry air in high efficient heat recovery system
- 4 - 5 Secondary cooling without dehumidification to the required supply air temperature. Chilled water supply temperature of 12 - 14°C with high chiller COP
- 5 - 6 Thermal room loads
- 6 - 7 Evaporative cooling (condensate delivered from process step 1 - 2 can be used)
- 7 - 8 Pre-heating of return air for regeneration of sorption wheel with heat recovery system (corresponding to 3 - 4)
- 8 - 9 Solar heating of regeneration air volume flow to achieve the necessary temperature for sorption wheel. A regeneration temperature of ~70 °C is suitable for most available solar collectors (flat plate, vacuum tube, air collector)
- 9 - 10 Regeneration of sorption wheel (corresponding 2 - 3).