Kolloquium Energie- und Halbleiterforschung

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Development of Low Cost Renewable Cooling and Heating Systems for Residential Buildings in Egypt

The aim of this study is to investigate the potential of nocturnal radiative cooling systems for the Egyptian residential buildings. Egypt has been facing an exceeding energy demand since 2011. The cooling demand of the residential sector in Egypt is responsible for the recurrent electricity cut-offs in summer. Radiative cooling to the night sky represents a low-cost renewable energy source. The predominant dry desert climate of Egypt, with clear night skies, promotes radiative cooling applications. The system technology is based on plastic solar absorbers integrated with the building's hydronic system. With a different control strategy, the same system can be also used for heating applications during winter. The results of this research are simulation-based. The dynamic simulation program TRNSYS17 was used to simulate the transient behavior of the system. Three work-portfolios were considered in this thesis to develop a simulation model for the real system. Firstly, a number of plastic solar absorbers were tested in order to identify their performance parameters. The test was based on the quasi-dynamic test method of the international standard for solar thermal collectors EN ISO 9806:2013. Secondly, a building model, representing a typical residential apartment in Egypt, needed to be developed. For that purpose, a literature review was conducted on recent field surveys and other research-work for residential apartment buildings in Egypt. Finally, a control scheme was designed so that the whole system components collaborate in a proper operation. The analysis considered the three main different weather conditions in Egypt. Accordingly, the simulation was done for the cities of Alexandria, Cairo and Asyut. The more hot and dry weather conditions result in a higher cooling potential. In Asyut, higher levels of temperature difference could be achieved, and the highest cooling potential was also in Asyut. The simulated cooling power was 28.4 W/m^2 for a 70 m^2 absorber field. For a smaller field area of 10 m^2, the cooling power reached 109 W/m^2 in Asyut, but with humble temperature differences. Working in a hybrid system, as a supplementary part to the conventional AC units, a 10% reduction in the active cooling energy demand could be achieved, thanks to the radiative cooling system. This percentage reduction was nearly doubled when the thermal comfort set-point was two degrees higher (26 °C). The new Egyptian code for buildings was also investigated as part of the sensitivity analysis of this work. The simulation results proved that the new Egyptian energy standard can independently play a very important role in energy efficiency of buildings.