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THESIS DEFENSE

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Solar Cooling and Heating Systems for Sustainable Buildings: Comprehensive Analysis and Solar Technology Improvement

Date :	**Monday, December 25th, 2023**
Time :	**10.00 am**
Location :	**Conference Room, ENSA - Tangier**

Committe Members		
Pr. Oulaid KAMACH	ENSA- Tangier	Chair
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ABSTRACT

The integration of renewable energy resources in building sector has been attracting more interest for reducing the energy consumption and alleviating the environmental issues. In particular, solar energy has been the focus of various research studies thanks to its tremendous potential that could cover the world's energy demand, in addition to its compatibility with a wide range of applications, such as space heating and cooling, and electricity production. Although, solar cooling and heating systems exhibit poor performance that varies depending mainly on their size, the used technologies and the climate conditions, making it hard for the practitioners in the field to discern the systems that could be supported for a greener energy transition. Thus, the present thesis aims to offer an exhaustive analysis of the most common solar cooling and heating technologies for a deeper understanding of their performance and potential in building sector. Moreover, the conducted work could contribute to the advancement of solar technologies by introducing novel and efficient solar collectors. In this research, a case study approach was conducted to investigate solar heating and cooling systems, from energy, exergy, economic, and environmental prospects, in residential and commercial buildings under various climate conditions. To tackle the research objectives, a dynamic simulation of the buildings' model was carried out, along with a mathematical modeling and optimization of different solar collector technologies based on the energy balance. The main solar cooling technologies were investigated including solar absorption and adsorption cooling systems, in addition to solar photovoltaic and photovoltaic thermal based cooling technologies. Besides, the most adopted solar collectors' types, such as flat plate, evacuated-tube, compound parabolic, parabolic trough, photovoltaic thermal, and concentrating photovoltaic thermal collectors, were considered for assessing their impact on the solar cooling systems' performance. For a further improvement of the solar technology, two novel configurations of concentrating photovoltaic thermal collectors were proposed; the first one involved the integration of inclined photovoltaic plates, while the second design introduced a semi-cylindrical receiver. These configurations were compared with those of literature and applied for sorption cooling systems. Then, the hybrid photovoltaic thermal collector was investigated for a trigeneration system based on adsorption chiller for space cooling and heating, along with electricity generation. The main findings revealed that the photovoltaic thermal cooling system exhibited the best solar cooling performance for almost all climate conditions. Meanwhile, solar absorption and adsorption cooling technologies performed better in hot climate regions, with high insolation and cooling demand, than the other weather conditions. Moreover, the economic feasibility analysis indicated that photovoltaic cooling system has the highest economic benefits compared to the other solar cooling technologies. Additionally, the variation of solar fraction proved that the highest the contribution of solar energy is, the highest are the economic and environmental performances of the systems. On the other hand, the proposed configurations of hybrid concentrating collectors were found to be advantageous from energy and exergy perspectives in contrast to the others collectors' technologies and configurations. Nevertheless, the resulted cooling cost was higher compared to the non-concentrating photovoltaic thermal system, unlike the life cycle climate performance that was more advantageous for the concentrating hybrid systems making them more environmentally iii friendly. Furthermore, when considering the application of hybrid photovoltaic thermal technology for trigeneration system, it was revealed that a considerable energy and cost savings can be attained contributing to the alleviation of environmental issues.

Keywords: Solar absorption cooling; Solar adsorption cooling; Solar heating; Solar thermal collectors; Photovoltaic thermal collector; Concentrating photovoltaic thermal collector; Energy metrics; Exergy analysis; Economic investigation; Life cycle climate performance