Sustainable Adsorption Cooling Systems with Direct Air Capture of Carbon Dioxide for Use in Classrooms in Universities

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A polluted indoor space is a serious problem for the occupants especially for students who require high attentiveness levels for effective learning in classrooms. Indoor pollutants reduce the student performance by increasing sickness risk and impairing cognitive abilities needed to make informed decisions. Typically, indoor air quality is improved by diluting indoor contaminants with fresh outdoor air. However, this solution is energy intensive due to the required treatment of outdoor air. Direct air capture of carbon dioxide (CO2) can be a solution to this problem. Recently, direct CO2 capture has become more promising due to the emerging of new generation of solid adsorbents, the metal-organic frameworks (MOFs). They can be produced to exhibit high capacity and affinity towards carbon dioxide and can be regenerated at low temperature energy such as solar and waste energy. Direct capture of carbon from air by adsorption reduces the ventilation load and the system size rendering the implementation of sustainable cooling more viable. In addition, water vapor capture from air using adsorption beds is well developed as a sustainable method for dehumidification of fresh air; a process inherent in all cooling systems operated with high latent load or humid climates. Thermal comfort is then achieved in the space, by sustainable adsorption cooling system that uses the same adsorbent.

In this proposal, a sustainable adsorption cooling system is suggested combined with adsorbent beds for CO2 and water vapor. A numerical model integrating the heat and mass transfer in the different adsorbent beds will be developed and validated experimentally. The validated model will be used to size the proposed sustainable cooling system for a case study in Beirut. The system operation will be optimized based on the intermittent load of the classroom. The energy cost reduction resulting from the implementation of the system is determined.