Swimming pools as heat sinks for air conditioners: Model design and experimental validation for natural thermal behavior of the pool

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1. Introduction

In California, where all the large electric utilities experience their peak power demand in the summer, space cooling accounts for 25% of the total peak power demand and approximately 40% of the residential peak demand [1]. This occurs in part because the COP for traditional air-cooled vapor-compression cooling equipment diminishes significantly at high outdoor temperatures, such that equipment efficiency can be at its worst when cooling demand is greatest. Thermodynamics for heat pumps dictates that the work required to transfer heat from a cooler source to a warmer sink increases with the temperature difference between the two. In practice, for a vapor-compression system, since heat exchange with the refrigerant at the condenser and evaporator is driven by the temperature differences between the refrigerant and the sink and source respectively, the overall temperature difference experienced by the refrigerant is significantly larger than the temperature difference between the sink and source. For this reason, a large fraction of cooling efficiency research has focused on techniques to reduce heat sink temperatures, and reduce the required temperature differences between the refrigerant and the source and sink. For example, rejecting condenser heat to water instead of air reduces the temperature difference that is needed for adequate heat transfer; air-cooled condensers typically require a refrigerant temperature that is 20 °C higher than condenser inlet air, while exchange with water only needs a 10 °C temperature difference.

The research presented in this paper provides a foundation for the design of cooling systems that reject condenser heat to swimming pools, a strategy that has been deployed successfully in many installations [2,3], but that has not been widely adopted. One reason for the lack of application is the lack of research, documentation and standardization. Our thesis is that a better understanding of the mechanisms that drive performance and savings could inform the development of guidelines for appropriate design of these systems, and could lead to more prevalent adoption, resulting in cost-effective energy and peak demand savings. The savings should come from three mechanisms:

1. Lower sink temperature since pool water is cooler than outdoor air during most cooling periods.
2. Improved heat transfer at the condenser since exchange with water is more effective than exchange with air.
3. Reduction of energy consumption for pool heating.