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2016 Purdue Conferences
Compressor Engineering
Refrigeration and Air Conditioning
High Performance Buildings

Reduction Of Energy Consumption In Air Conditioning Systems Employing Direct Evaporative Pre-cooling Of Condenser Air

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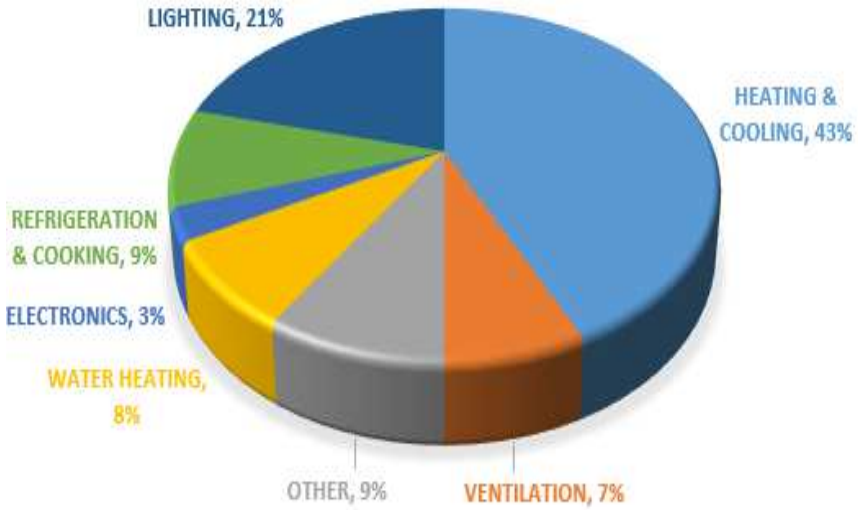
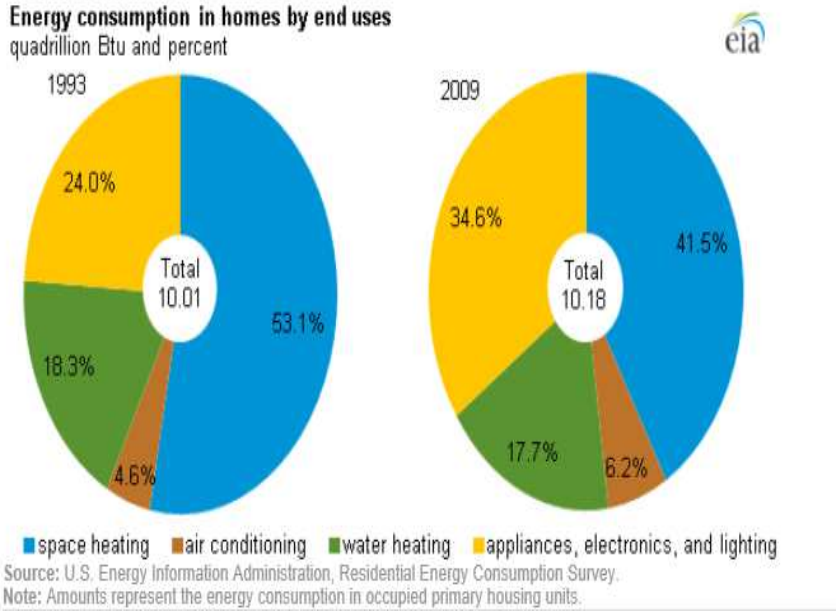
HVAC systems account for the largest use of energy by commercial and residential buildings in the US

Commercial building energy usage



Residential building energy usage

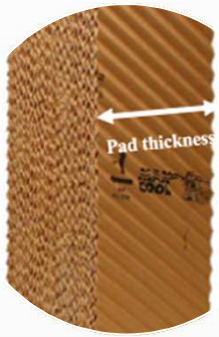


SOURCE: Energy Information Administration

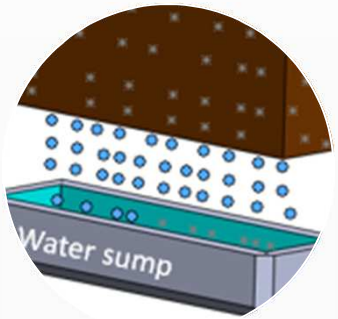
Objective

Improve the efficiency/ Coefficient of Performance(COP) of an Air Conditioning system

Reduce the power consumption of an Air Conditioning system

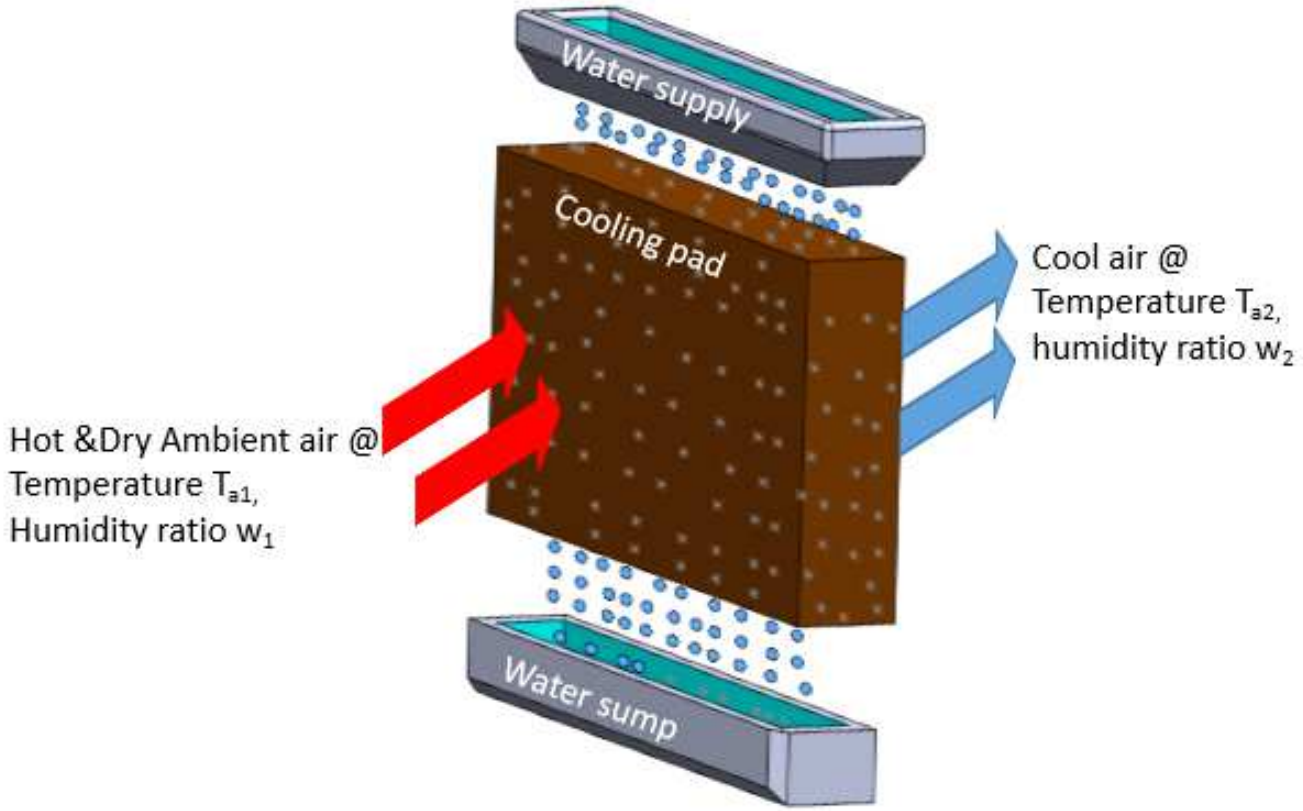


Investigate the influence of cooling pad thickness on the COP enhancement/ energy efficiency

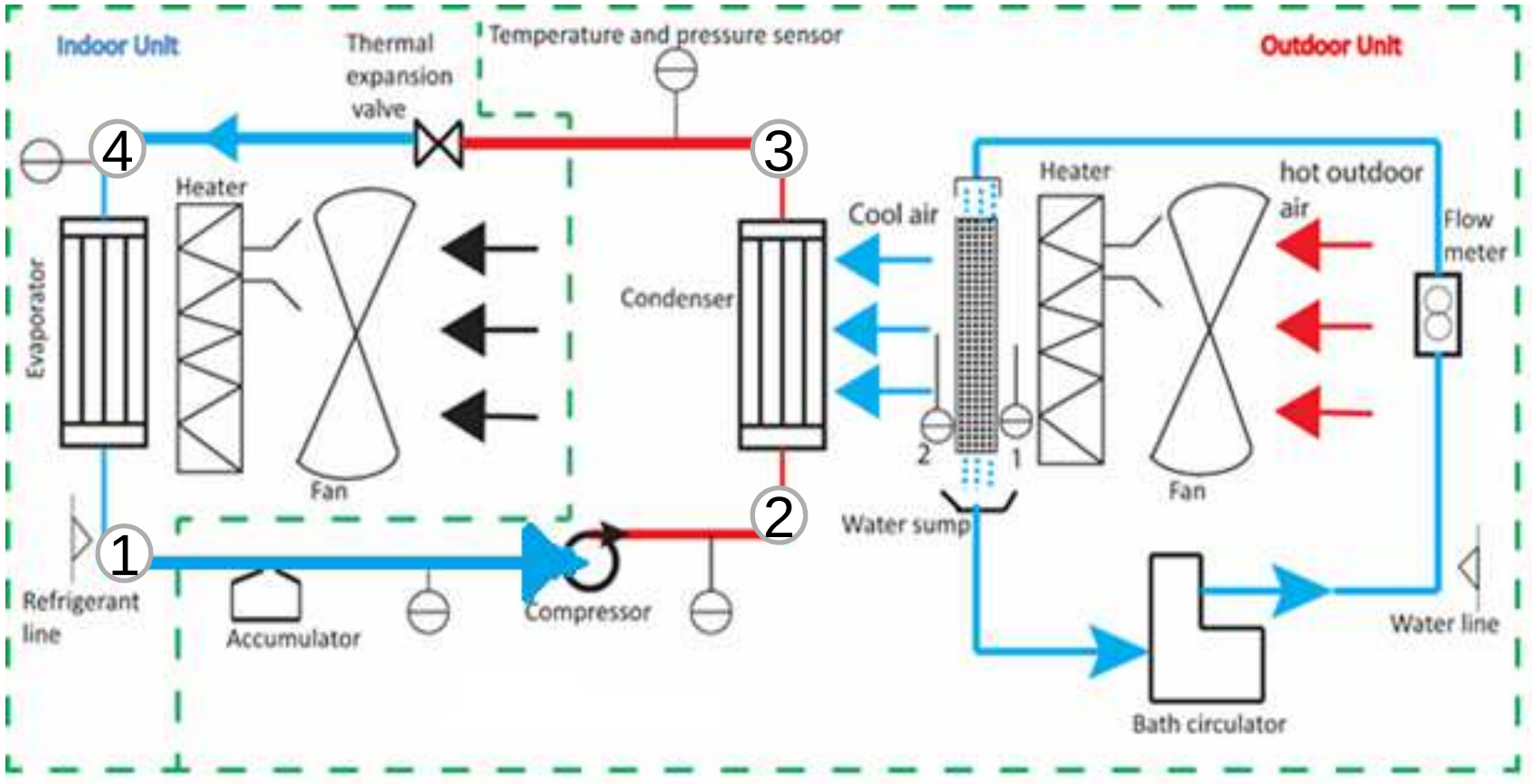


Examine the water consumption pattern of an air-conditioning system employing evaporative cooling at the condenser

Mechanism for evaporative cooling

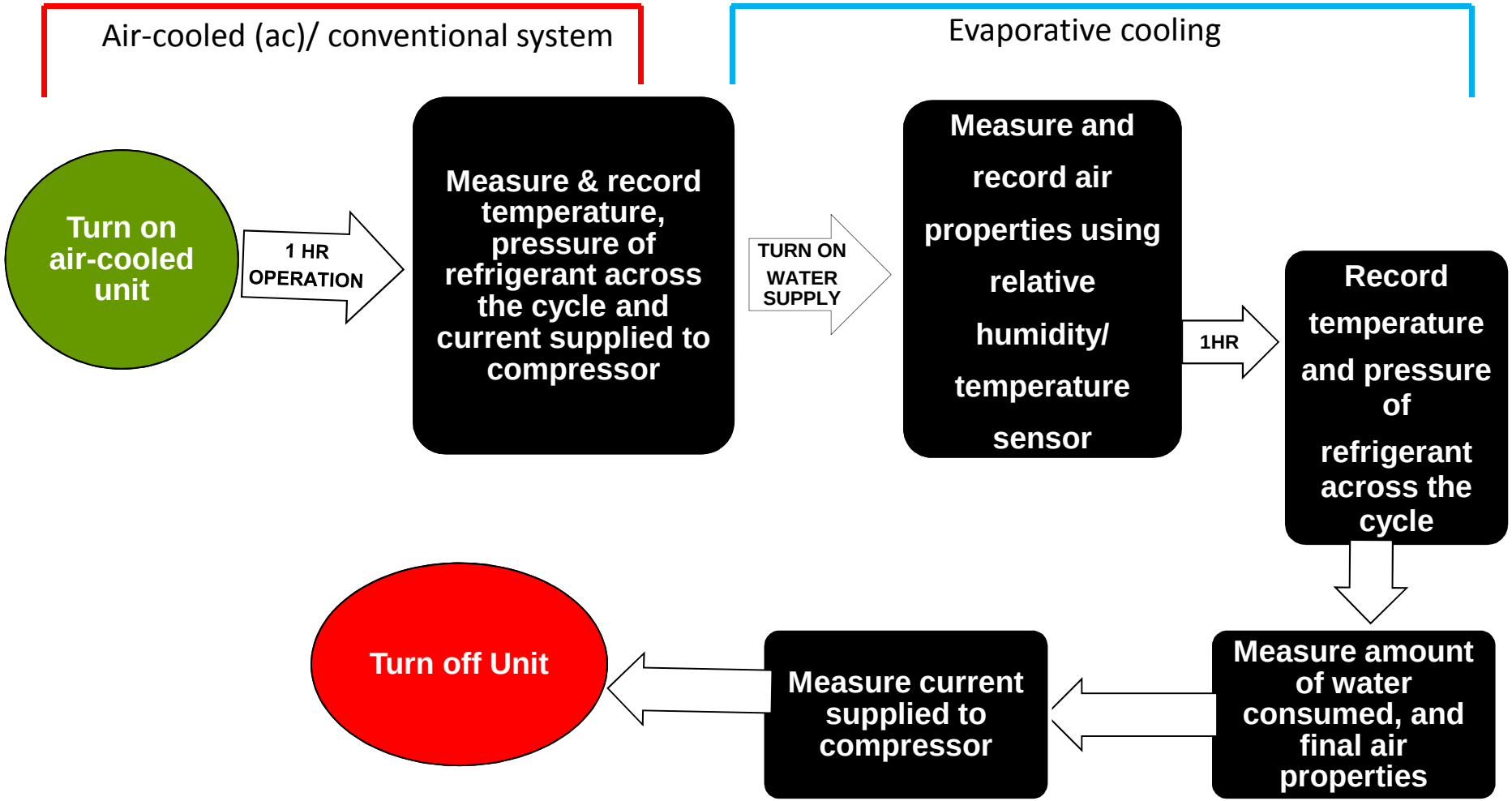


Experimental setup



Sensors 1 & 2 represents the relative humidity/ temperature sensors at the inlet and exit of the cooling pad

Experimental Procedure



Calculations

$$COP = \frac{cooling\ capacity}{compressor\ work} = \frac{h_1 - h_4}{h_2 - h_1}$$

- Coefficient of Performance of the system (COP)/ Cycle efficiency

$$\varepsilon = \frac{COP_{dec} - COP_{cv}}{COP_{cv}} \times 100$$

- COP enhancement as a result of evaporative cooling

$$\dot{W}_c = h_2 - h_1 \mid W_c = I \times V cos\emptyset$$

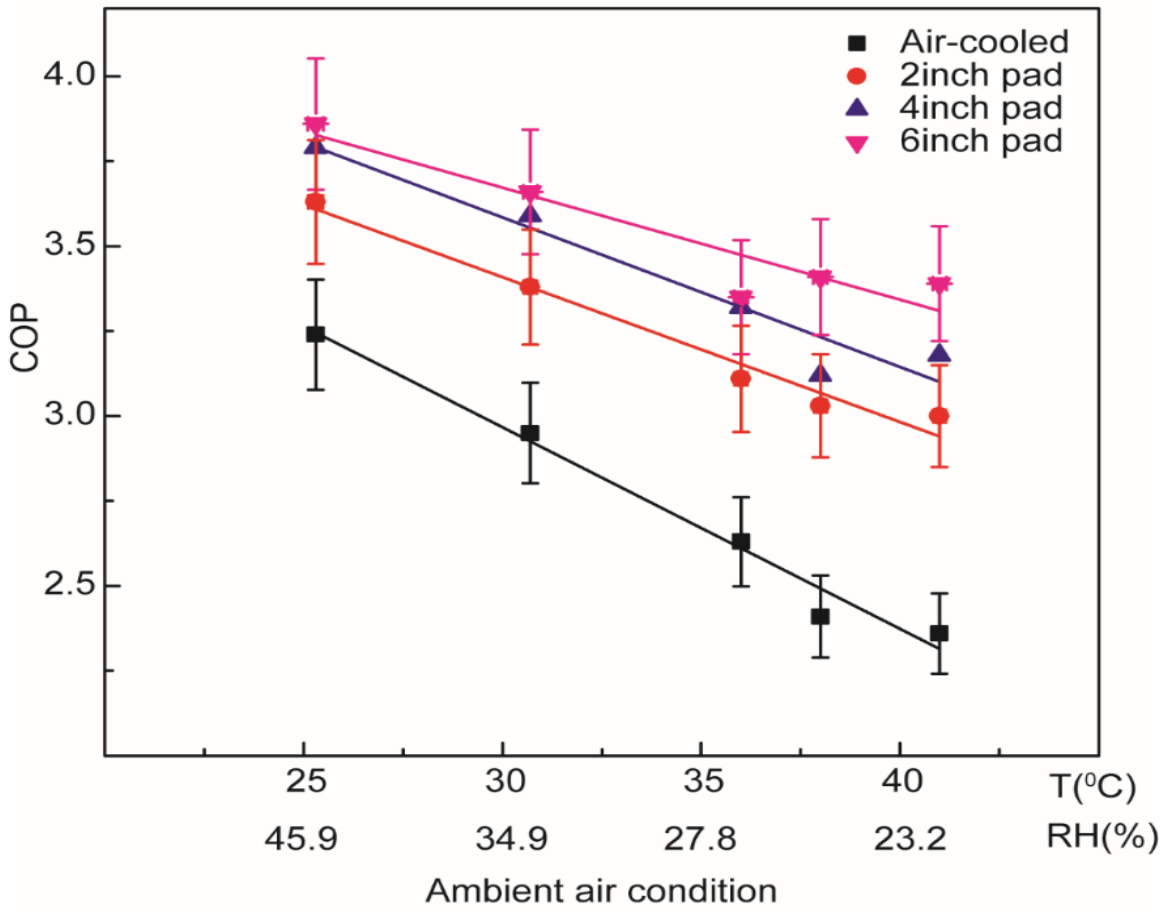
- Compressor work

$$m_R = \frac{I \times V\ cos\emptyset}{h_2 - h_1}$$

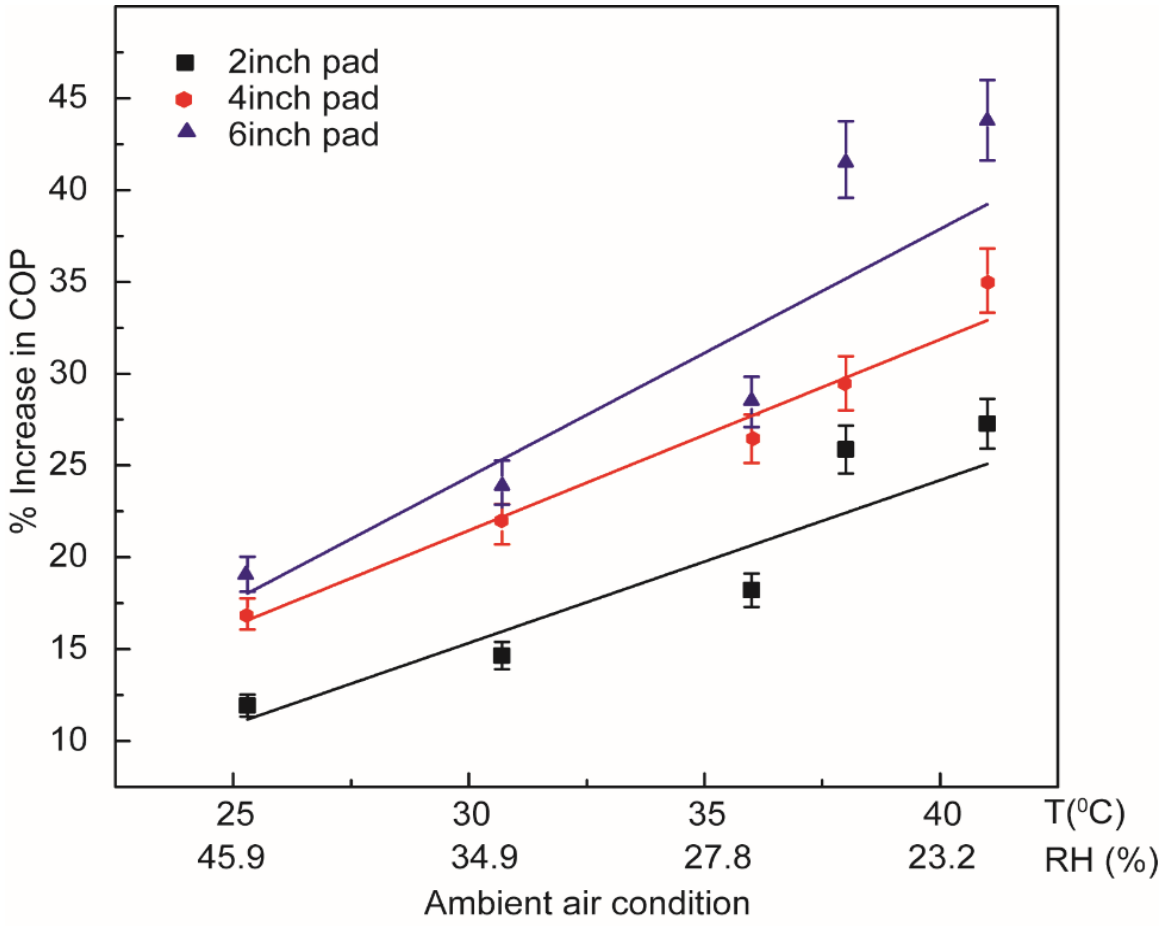
- Mass flowrate of the refrigerant

RESULTS & DISCUSSIONS

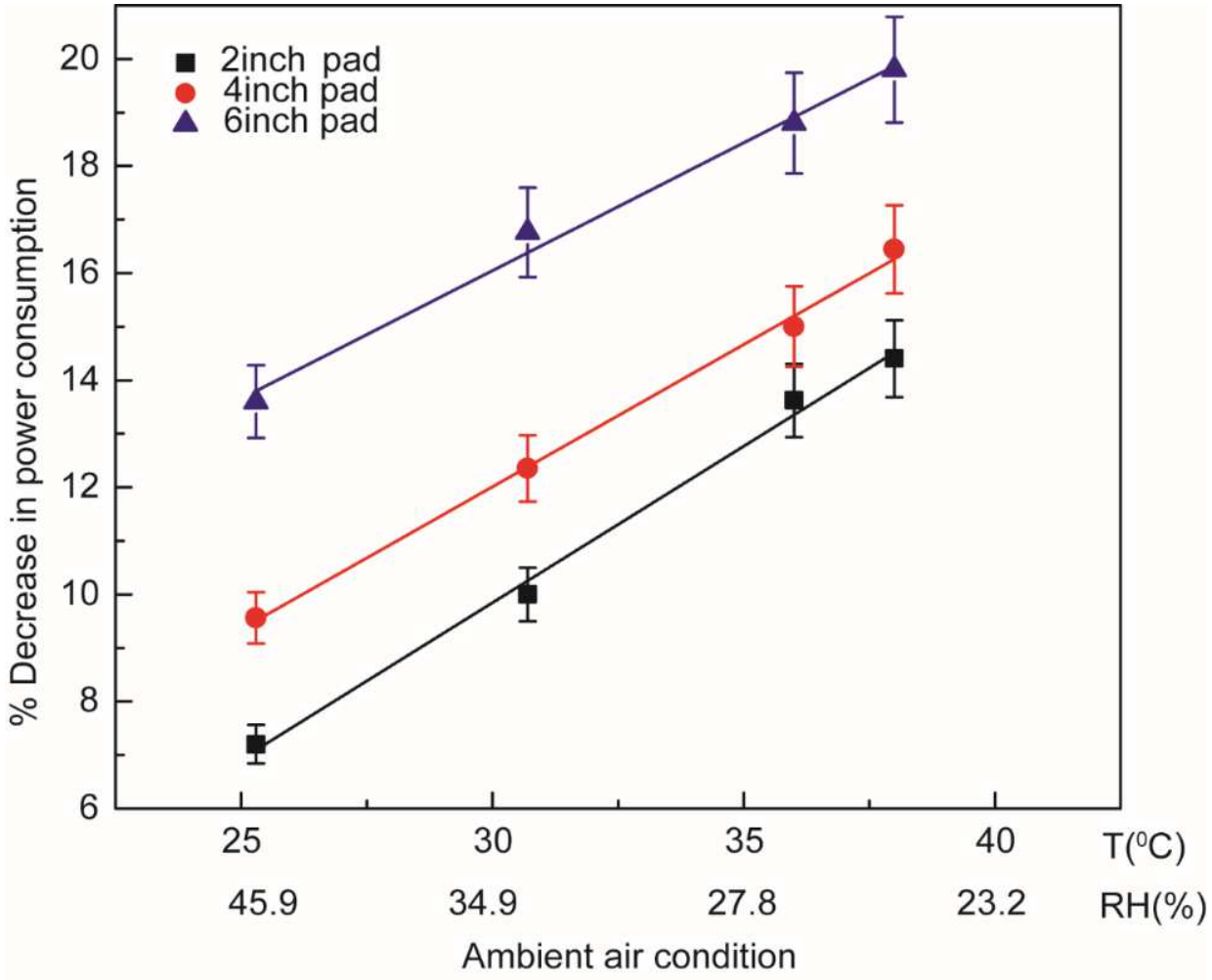
COP decreases with increase in ambient air temperature and increases with pad thickness



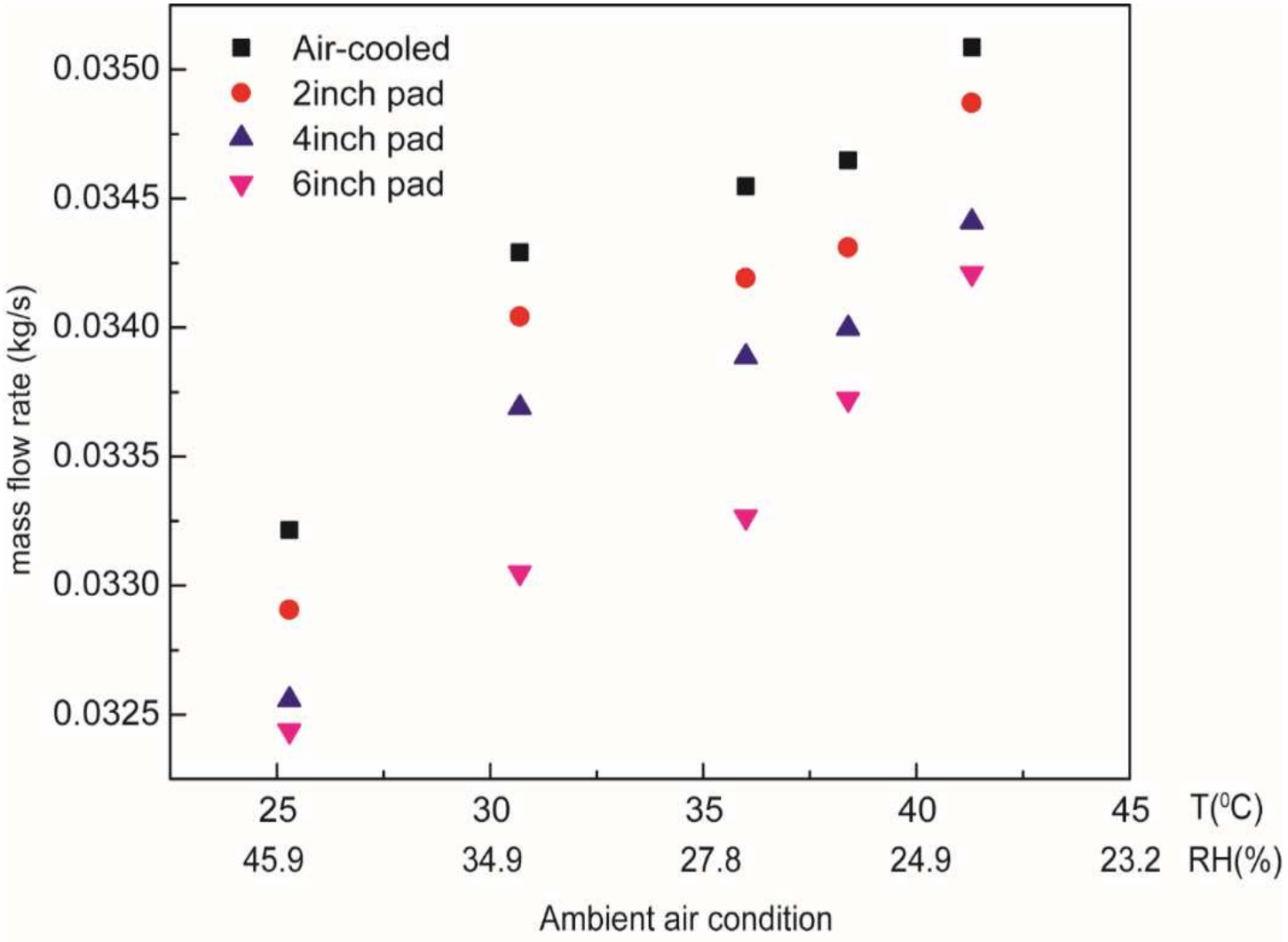
Effect of evaporative cooling on the COP is more pronounced at higher ambient temperature and in a thicker pad



Greater reduction in power consumption is achieved at high ambient air temperature and in a thicker pad

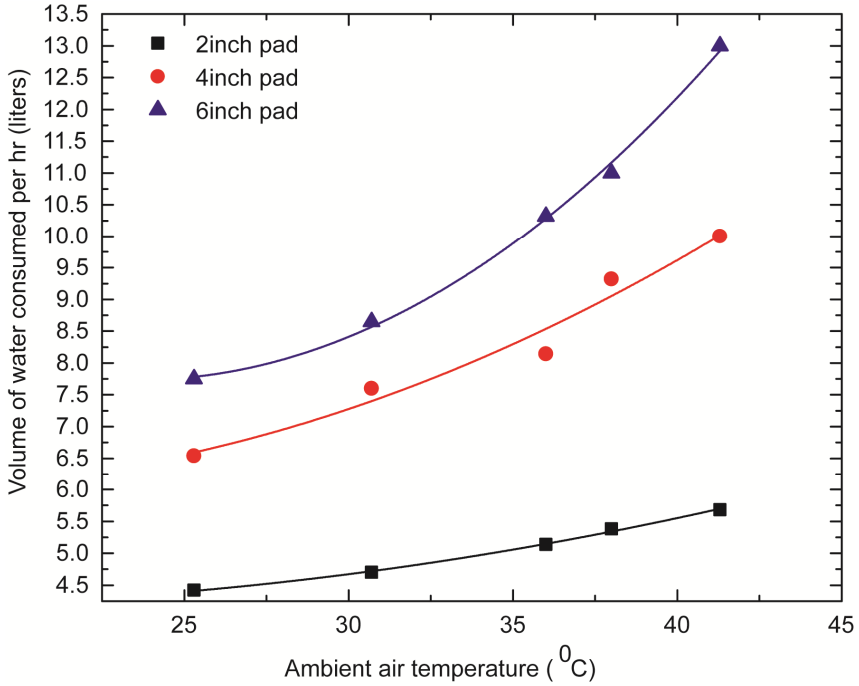


Increase in ambient air temperature causes an increase in mass flowrate of the refrigerant

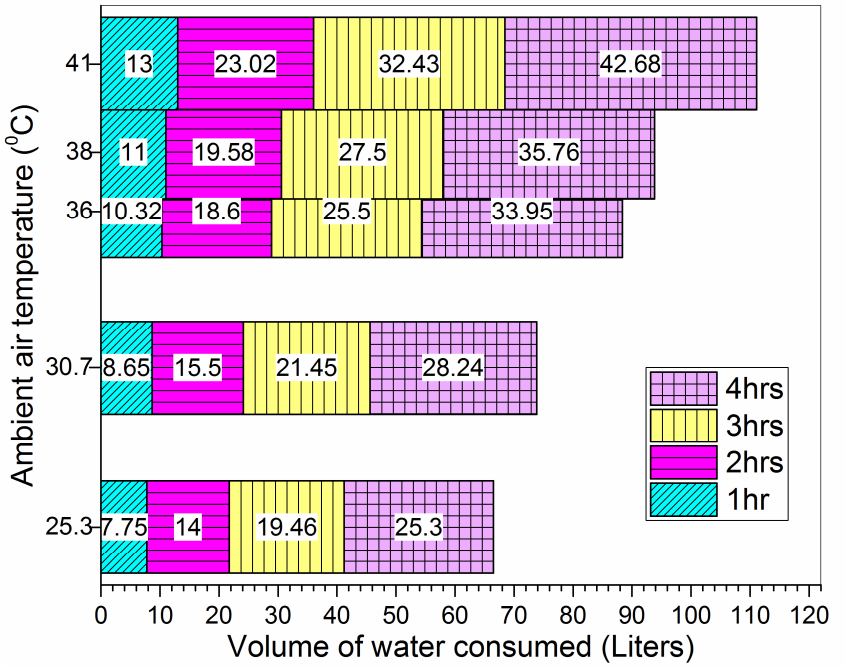


Water consumed increases with ambient temperature, and pad thickness, but does not increase proportionally with time

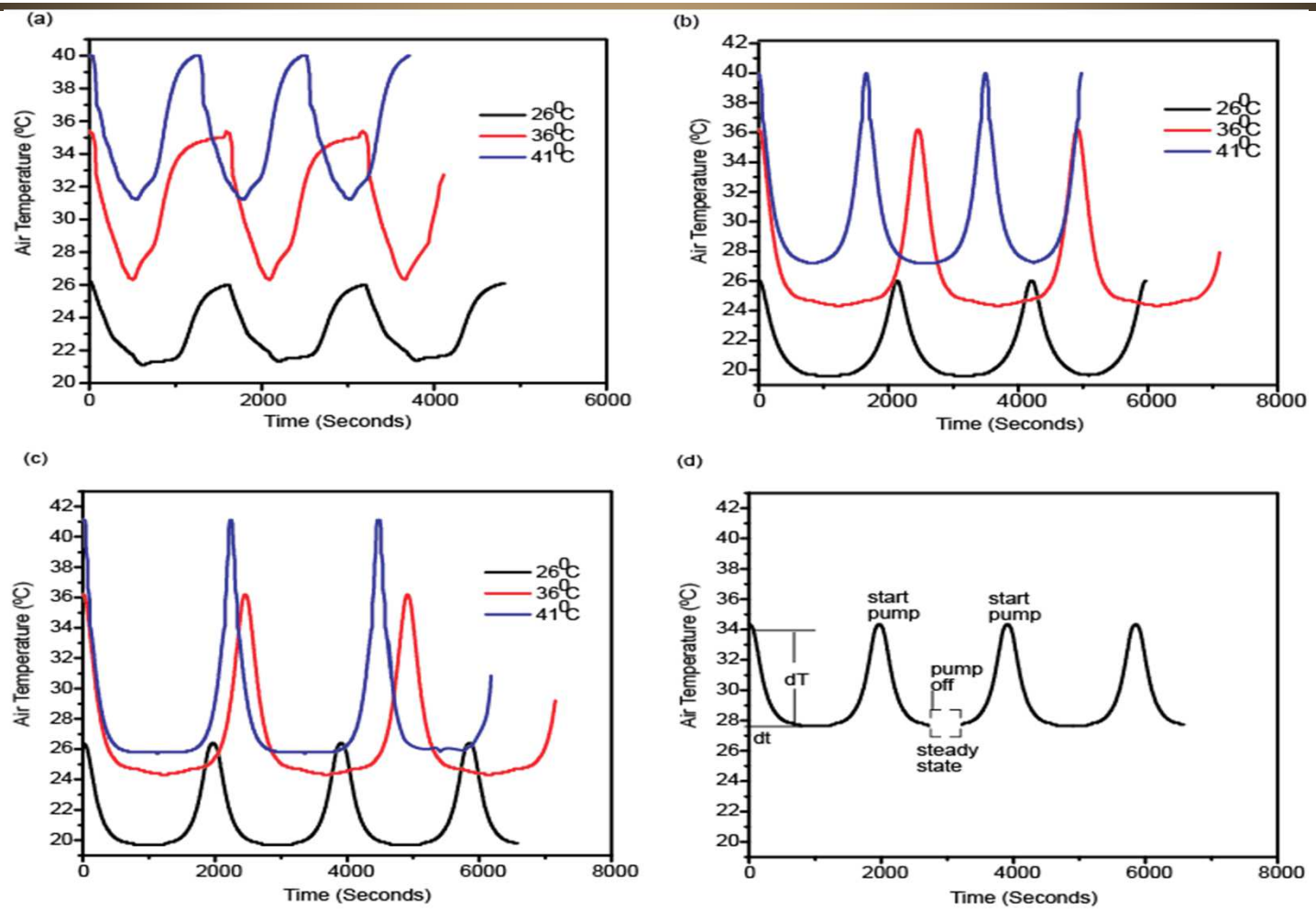
Water consumed in 1hr in the 2, 4, and 6inch pads



Water consumption over time in the 6inch pad



Water-pump can be operated intermittently to avoid unnecessary recirculation, without hindering performance



(a) 2inch pad- 6mins/hr of operation, energy saving of 10% (b) 4inch pad- 8mins/hr of operation, energy saving of 14% (c) 6inch pad- 12mins/hr, energy saving of 20% (d) optimization technique

Conclusion

- By taking advantage of evaporative cooling, the COP of an air-conditioning system can be enhanced by up to 44% and power consumption reduced by up to 20%
- The volume of water consumed does not increase proportionally with time
- The total annual saving depends on the region, and the number of hours evaporative cooling is employed.
- Water pump doesn't need to be in continuous mode of operation

THANK YOU!!

U.S. DEPARTMENT OF ENERGY