Solar Liquid Desiccant Air-Conditioning

Chris McNevin and **Danial Salimizad**

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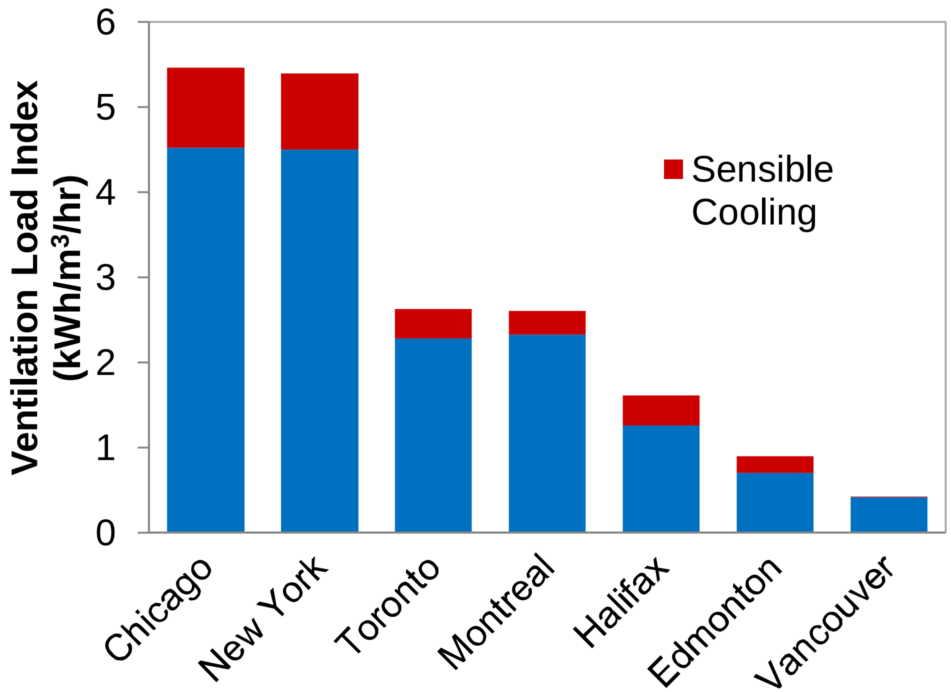
Solar Calorimetry Lab
Queen's University

Background

- Ontario peak electricity demand now in summer

- Solar desiccant A/C allows year-round use of collectors (heating in winter & cooling in summer)

- Latent cooling higher than sensible cooling in many climates



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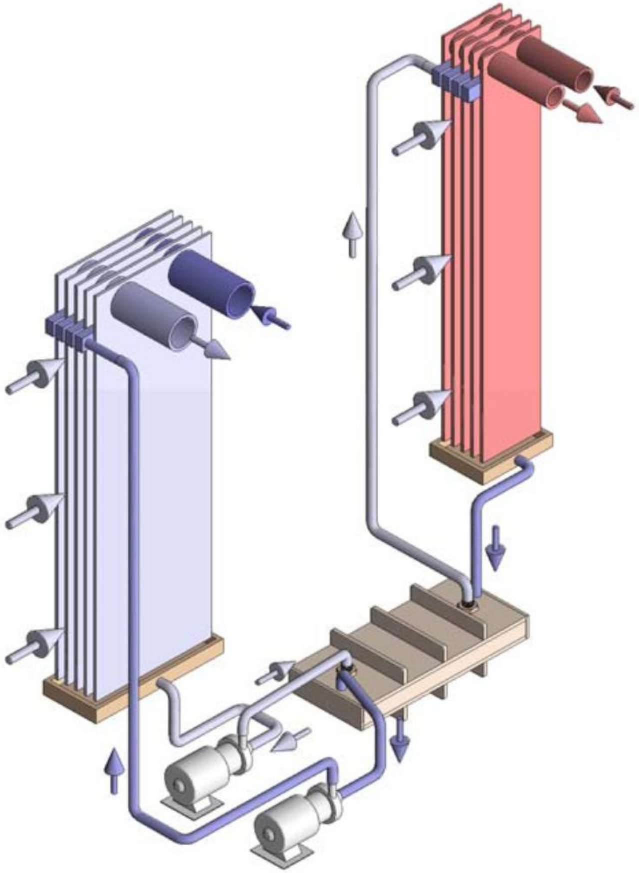


Conditioner

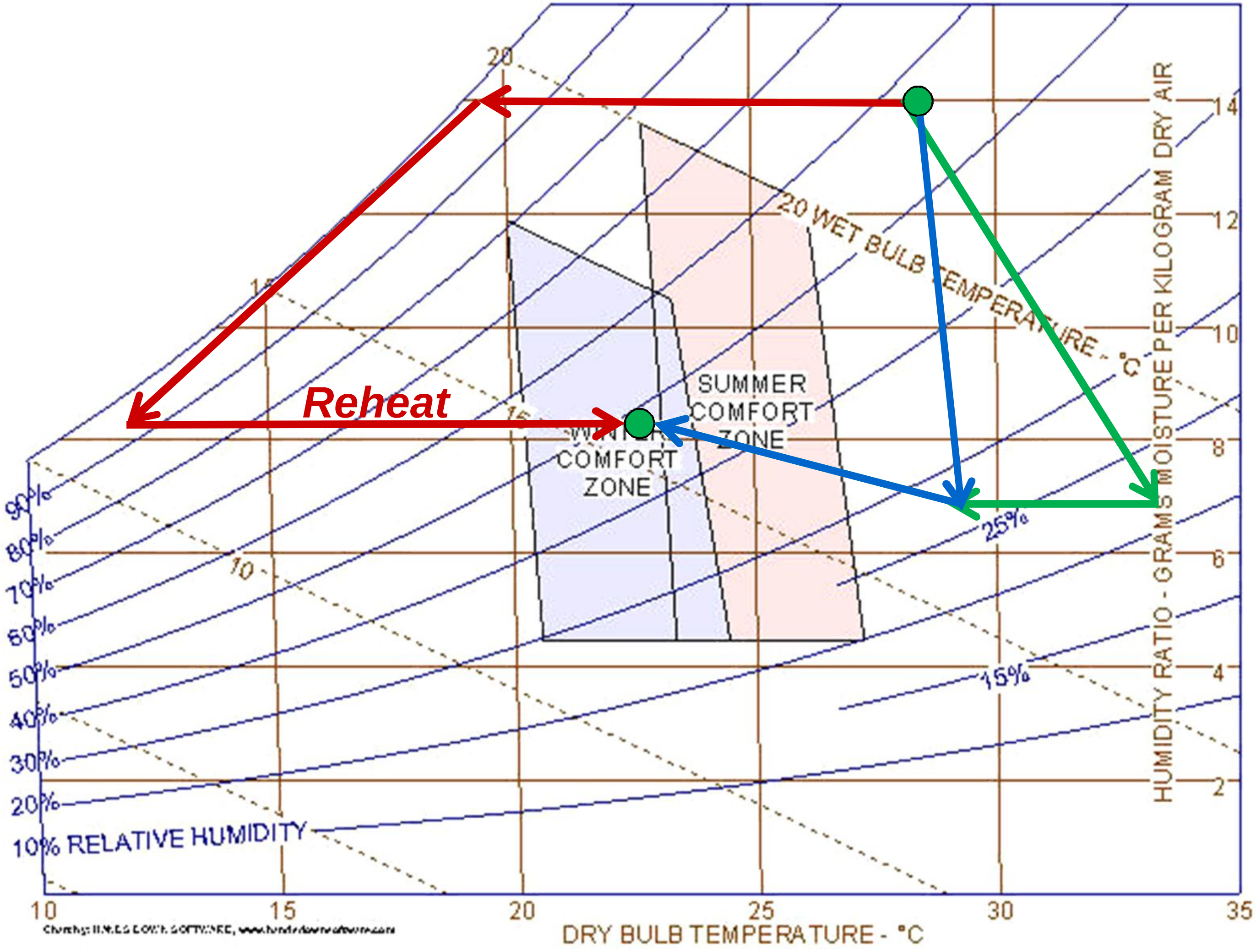
- Strong desiccant absorbs moisture from process air
- Cooling water removes latent heat of condensation

Regenerator

- Heating water added to re-concentrate desiccant
- Moisture in dilute desiccant desorbed to scavenging air stream

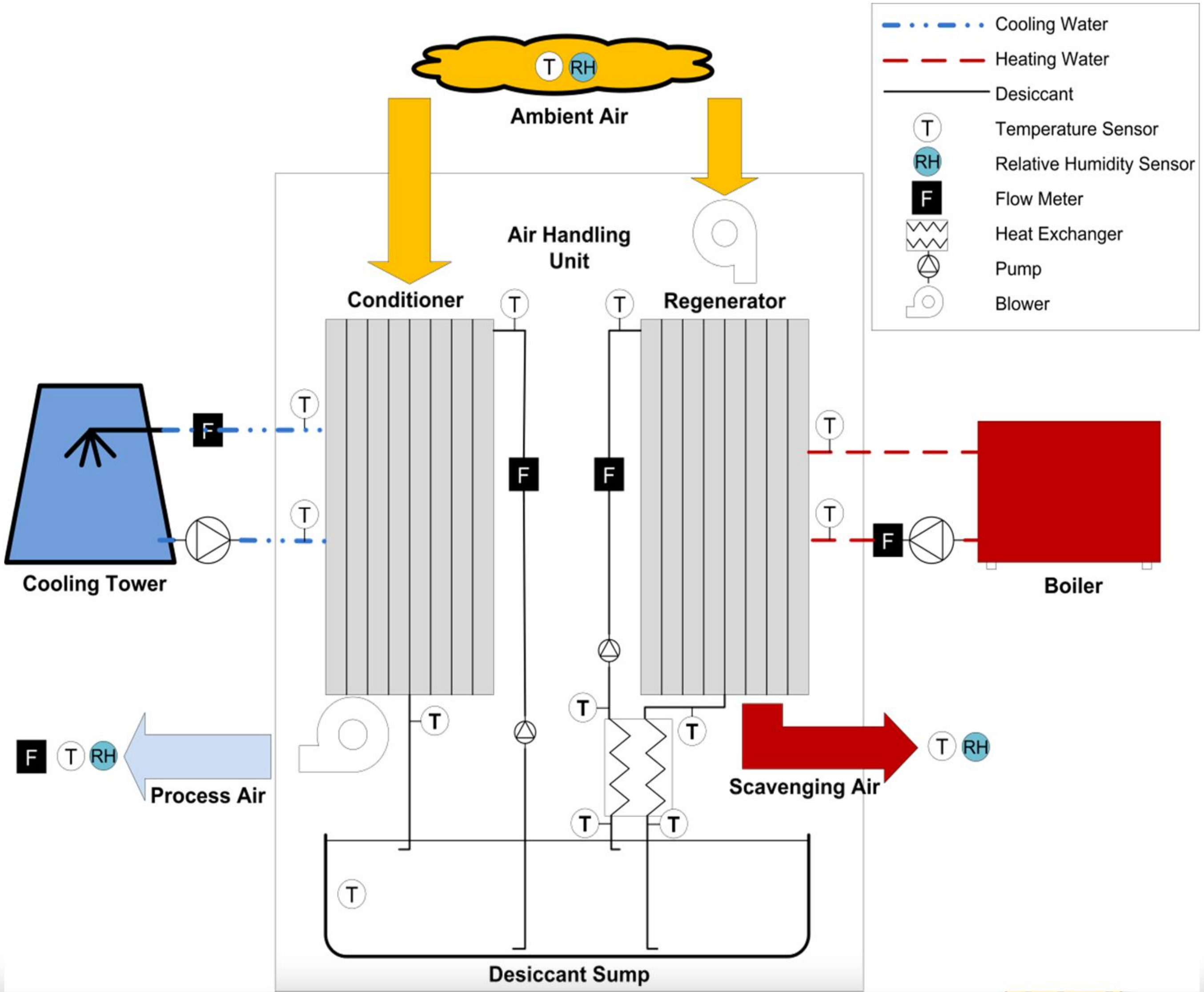
Novel low-flow configuration eliminates carry over, increases storage capacity

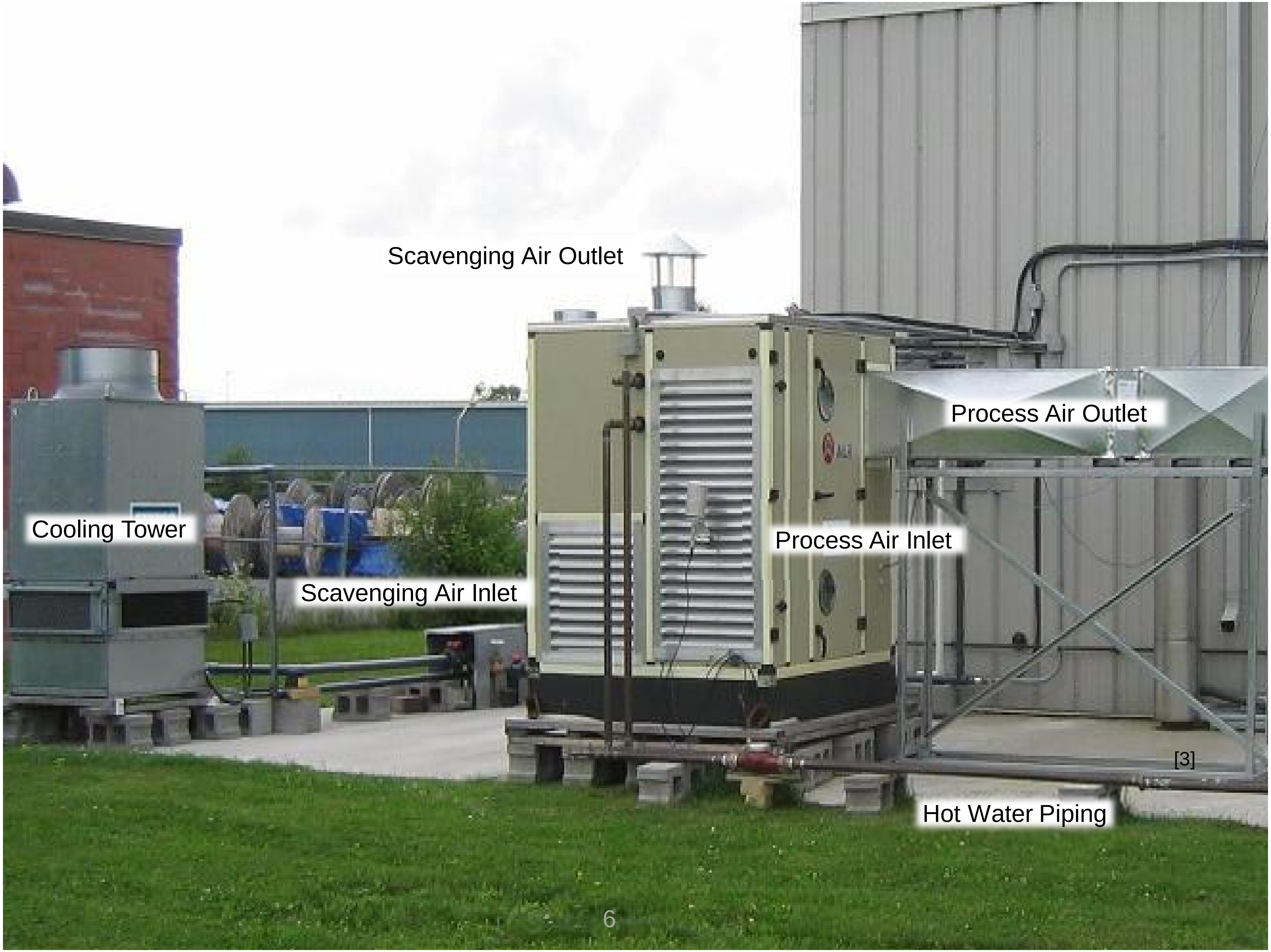
Background



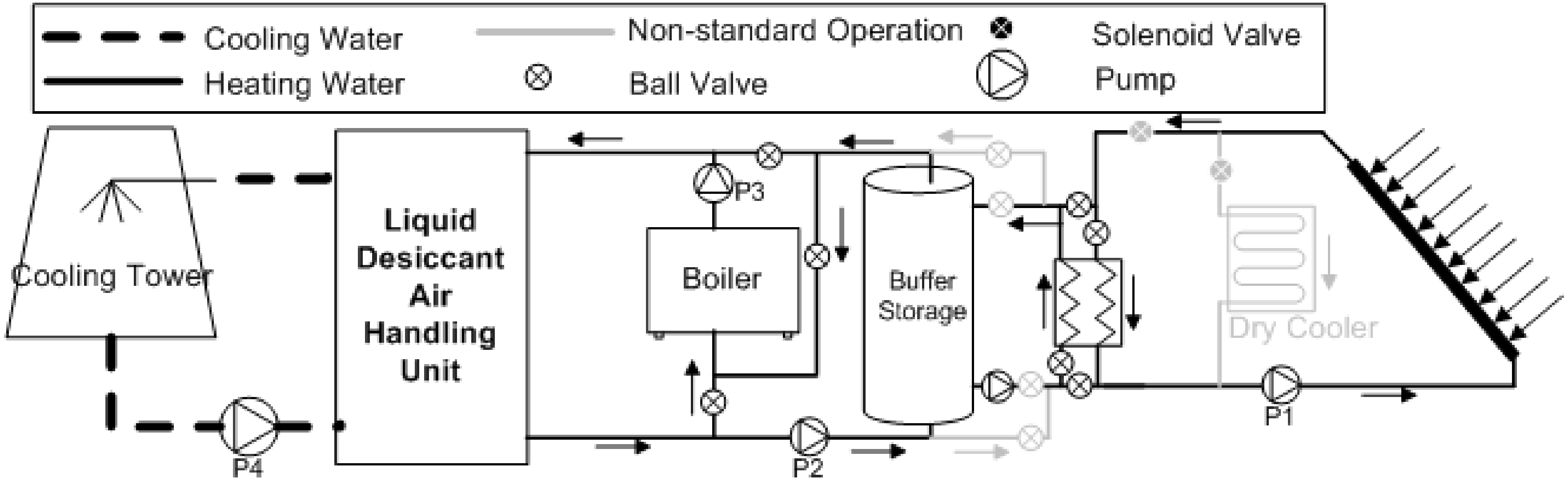
Psychometric Chart

LDAC system description

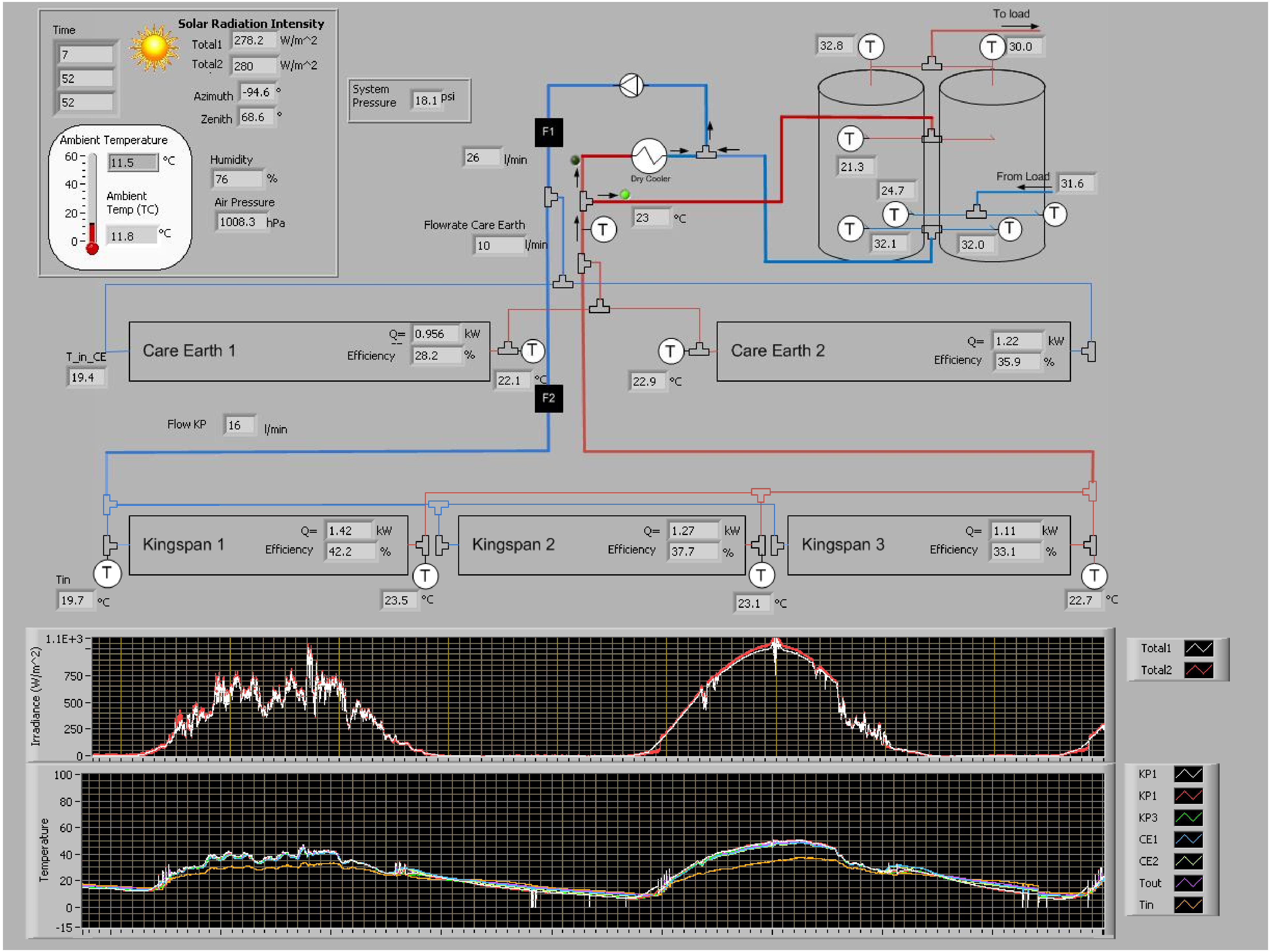



Scavenging Air Outlet
Process Air Outlet
Cooling Tower
Process Air Inlet
Scavenging Air Inlet
[3]
Hot Water Piping

Solar array description



Total Collector Area	95 m^2
Collector Absorber Area	61 m^2
Design Temperature Rise	10^0C
Total Collector Flow Rate	40 L/min
Buffer Storage Size	870 L
Pump Power	25-450 W
Dry Cooler Rated Capacity	56.5 kW

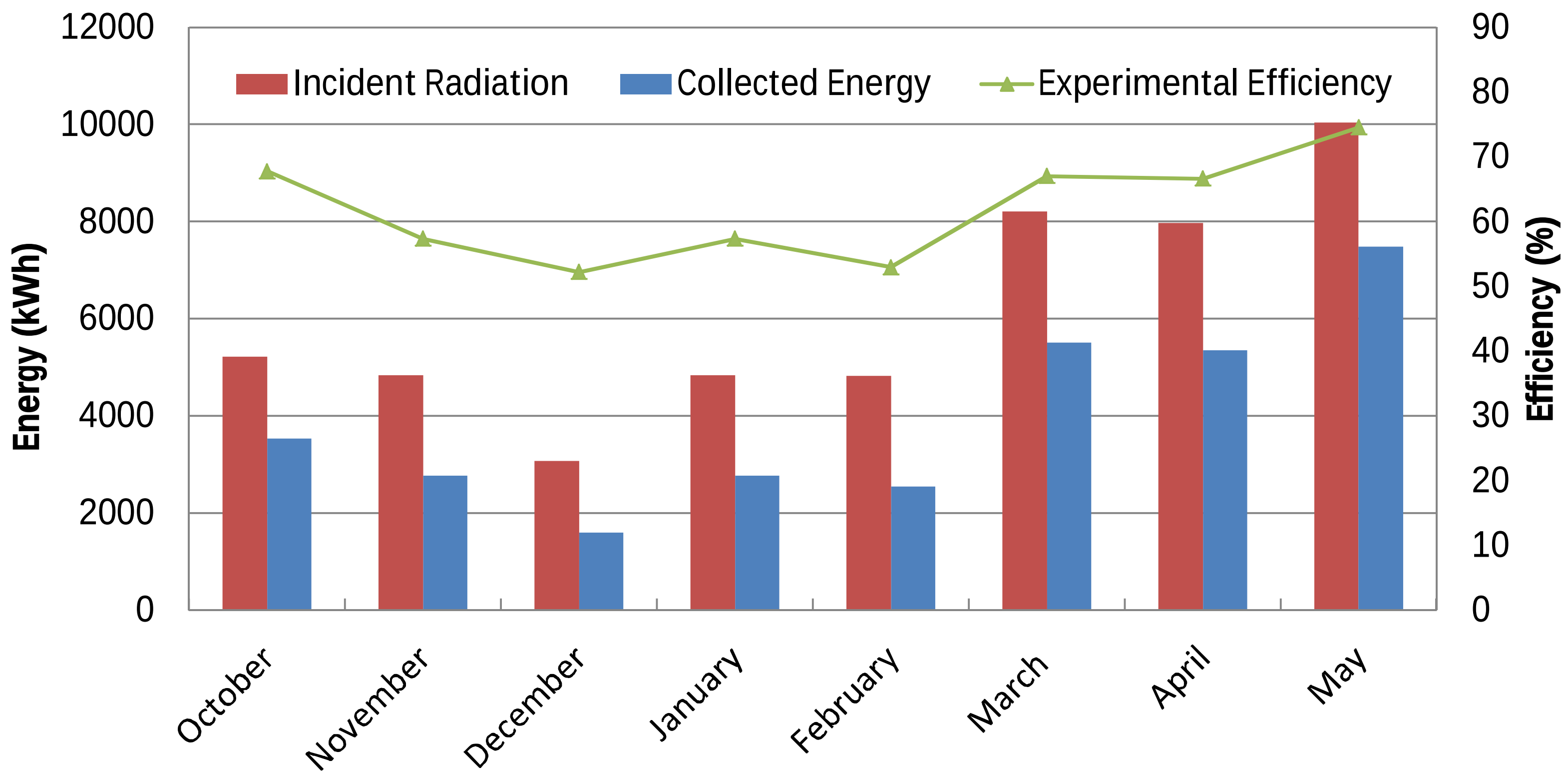


Time
7
52
52
Solar Radiation Intensity
Total1 278.2 W/m^2
Total2 280 W/m^2
Azimuth -94.6 °
Zenith 68.6 °
Ambient Temperature
11.5 °C
Ambient Temp (TC)
11.8 °C
Humidity
76 %
Air Pressure
1008.3 hPa
System Pressure 18.1 psi
26 l/min
F1
Dry Cooler
23 °C
Flowrate Care Earth
10 l/min
To load
32.8
30.0
21.3
24.7
From Load
31.6
32.1
32.0
T_in_CE
19.4
Care Earth 1
Q= 0.956 kW
Efficiency 28.2 %
22.1 °C
F2
Care Earth 2
Q= 1.22 kW
Efficiency 35.9 %
22.9 °C
Flow KP 16 l/min
Kingspan 1
Q= 1.42 kW
Efficiency 42.2 %
Kingspan 2
Q= 1.27 kW
Efficiency 37.7 %
Kingspan 3
Q= 1.11 kW
Efficiency 33.1 %
Tin
19.7 °C
23.5 °C
23.1 °C
22.7 °C
Irradiance (W/m^2)
Total1
Total2
Temperature
KP1
KP1
KP3
CE1
CE2
Tout
Tin

Live Data Feed Website

http://130.15.73.102:8000/SolarCoolingDAQ_DEC.html

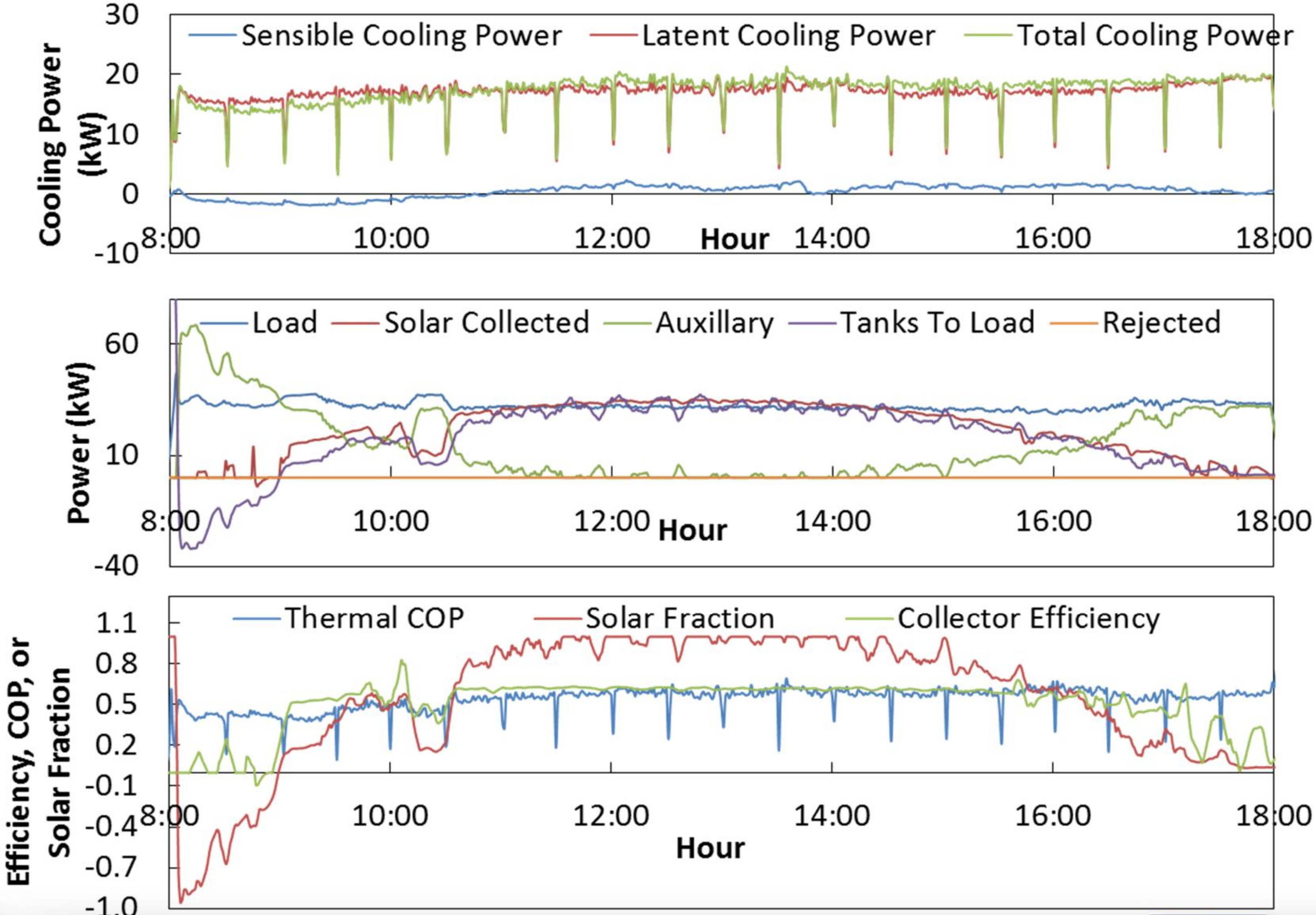
Solar Array (Winter Heating Results)



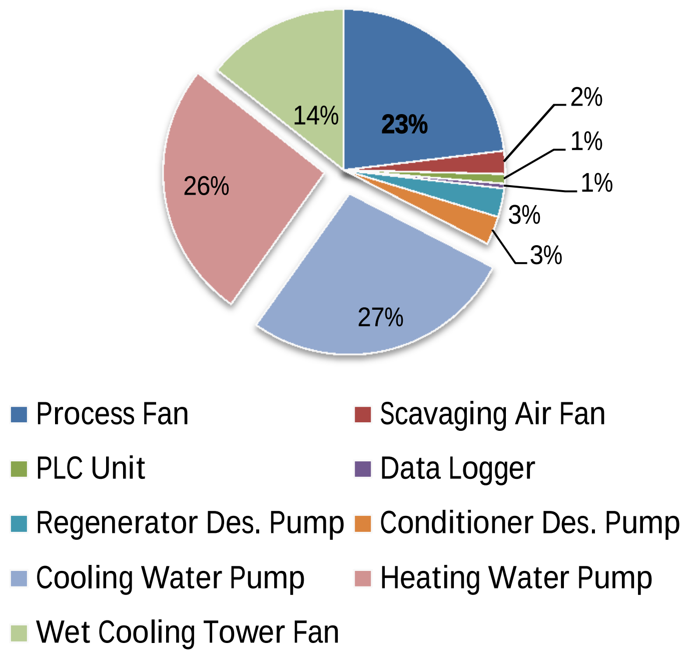
In total, 18800 kWh collected and 61% collector efficiency

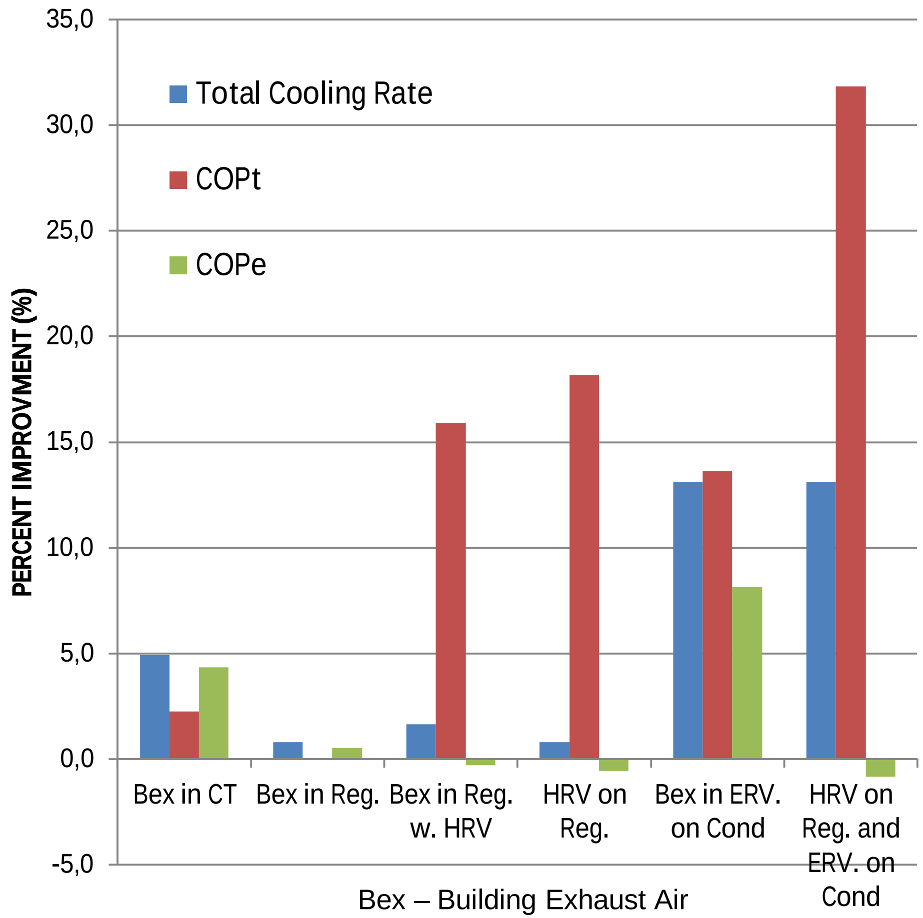
Experimental Results – July 17th (Sunny, Hot, Humid)

$COP_T = 0.53$, $\eta_{coll} = 56.2\%$, $SF = 0.52$

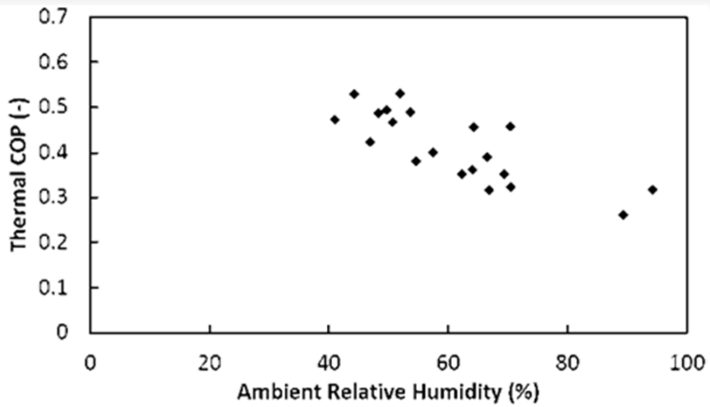


Energy recovery simulations

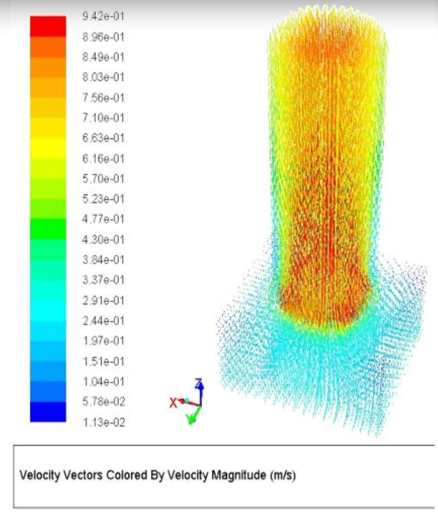




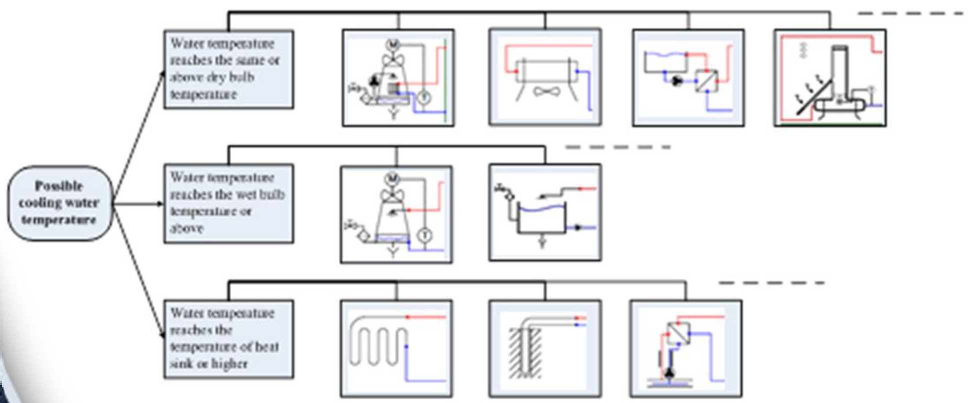
The effect of cooling water temperature on the system performance



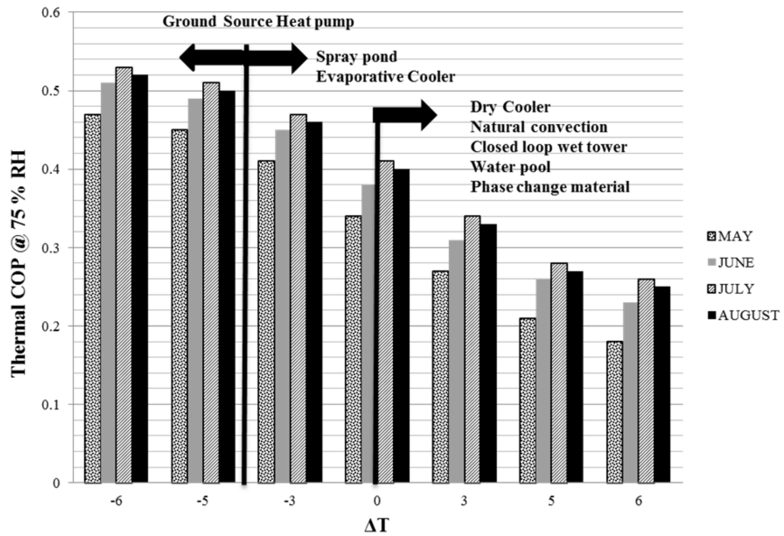
2012 Experimental results showing the effect of ambient relative humidity on COP_T



Effect of heat injection on bouncy forces and rate



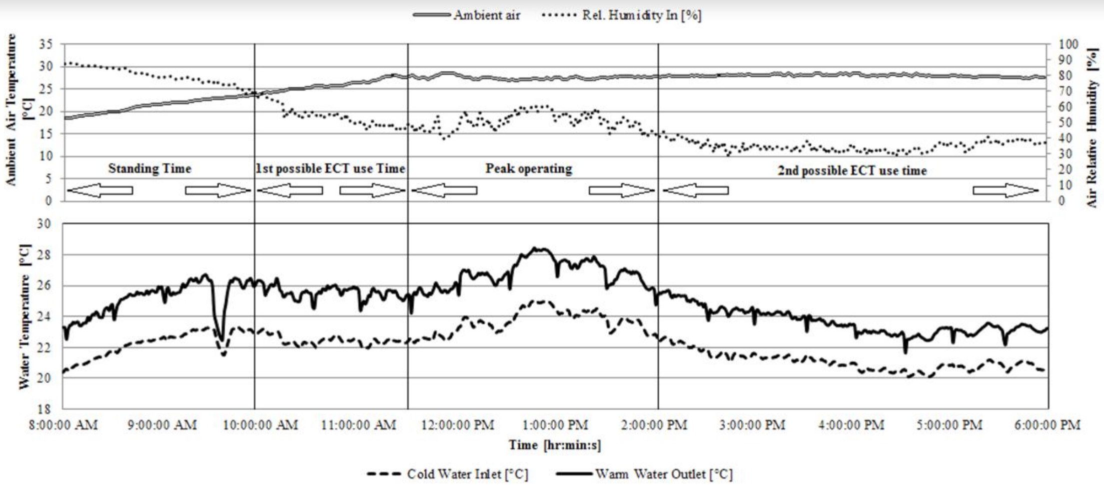
Possible cooling techniques



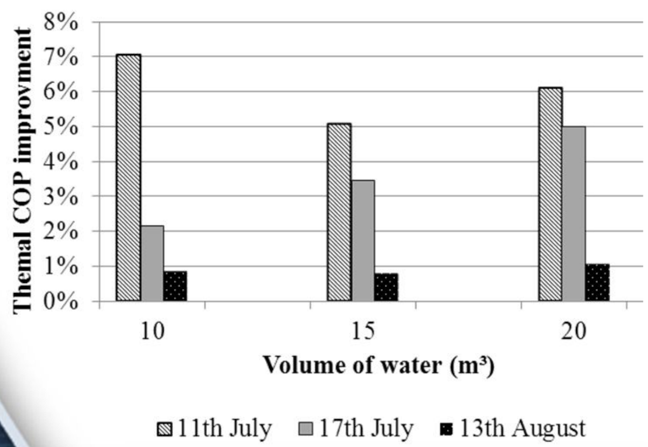
Simulated average COP_T from May-August in Toronto

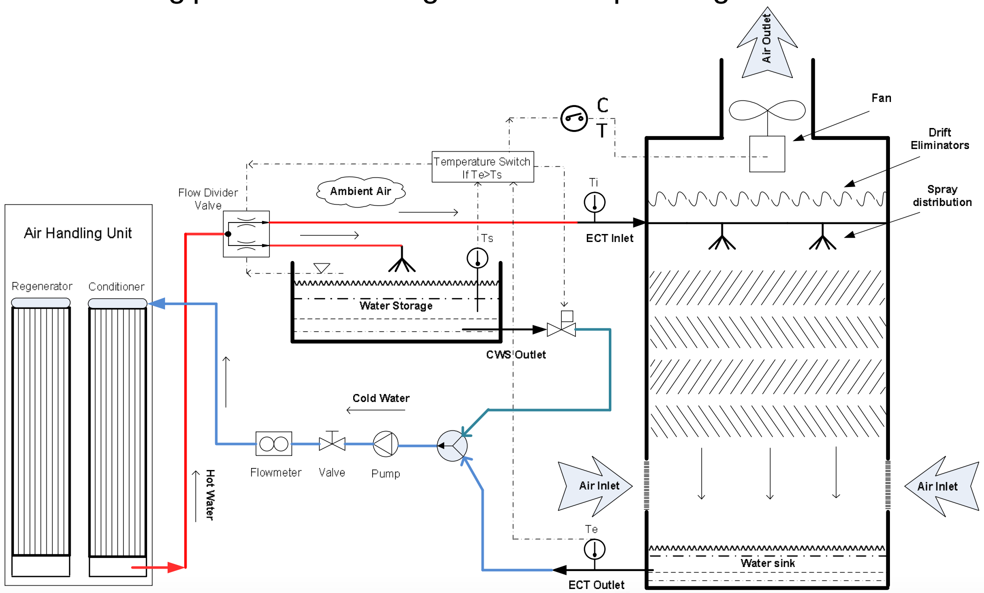
Evaluation of cooling water storage integrated with cooling tower

- Up to 16 % improvement in COP_E
- Up to 6 % improvement in total cooling rate
- Smaller gains in COP_T and solar fraction were also found in the simulation results



Cooling pattern of cooling tower and operating conditions





References

1. Harriman, L., Plager, D., & Kosar, D. (1997). Dehumidification and Cooling Loads from Air. *ASHRAE Journal*, 37-45.
2. Lowenstein, A., Slayzak, S, and Kozubal, E. (2007). "A Zero Carryover Liquid-Desiccant Air Conditioner for Solar Applications," 2006 International Solar Energy Conference, ISEC2006, American Society of Mechanical Engineers, pp. 397-407.
3. Jones, B.M. (2008). “Field Evaluation and Analysis of a Liquid Desiccant Air Handling System,” M.Sc. Thesis, Queen’s University, Kingston, Ontario, Canada
4. Andrusiak, M., Harrison, S.J., Mesquita, L., (2010). Modelling of a solar thermally-driven liquid desiccant air-conditioning system. *American Solar Energy Society Conference*, Pheonix USA.
5. Lisa Crofoot,(2012). Experimental evaluation and modeling of a solar liquid desiccant air conditioner, MSc Thesis, Department of Mechanical and Materials Engineering, Queens University.
6. Chris McNevin and Stephen J. Harrison (2014). Performance improvements on a solar thermally driven liquid desiccant air-conditioner, Submitted to CSME 2014 International Congress
7. Danial Salimizad, Chris McNevin and Stephen J. Harrison (2014) Evaluation of Evaporative Cooling Tower for Liquid Desiccant Air Conditioning System, ASME 2014 International mechanical engineering congress, date of submission 24/Feb/2014.
8. Danial Salimizad and Stephen J. Harrison, (2014) Performance of Liquid Desiccant Air-Conditioning- Part III: Heat Rejection, Draft paper for International ENERGY Journal
9. Ahmed Abdel-Salam, Chris McNevin, Lisa Crofoot, Stephen Harrison, Carey Simonson, (2014) Field study of a low solution flow rate internally cooled/heated liquid desiccant dehumidification system under different outdoor air conditions, Draft paper for Energy Journal

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