Seminar 14 – Desiccant Enhanced Air Conditioning

Desiccant Enhanced Evaporative Air Conditioning

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Learning Objectives

- Explains how liquid desiccant based coupled with an indirect evaporative cooler can efficiently produce cool, dry air.
- Explains how a liquid desiccant membrane air conditioner can efficiently provide cooling and dehumidification without the carryover problems of previous generations of liquid desiccant systems.
- Provides an overview to a liquid desiccant DX air conditioner that can efficiently provide cooling and dehumidification to high latent loads without the need for reheat.
- Explains how liquid desiccant cooling and dehumidification systems can outperform vapor compression based air conditioning systems in hot and humid climates
- Explains how liquid desiccant cooling and dehumidification systems work.
- Describes a refrigerant free liquid desiccant based cooling system.

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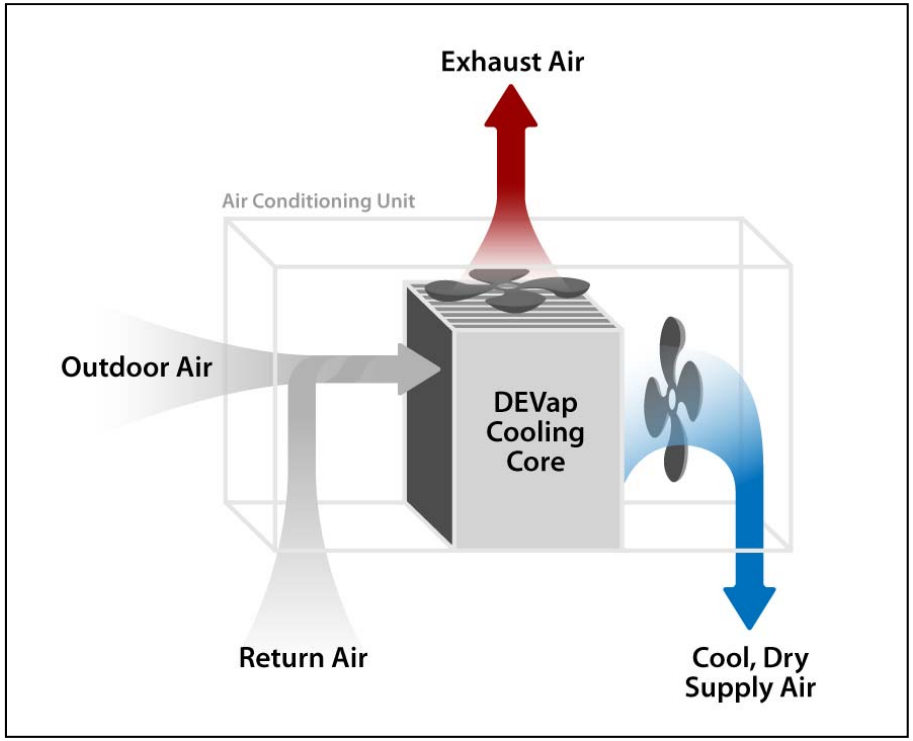
Agenda for Session

- Technical description
- Benefits
- Laboratory testing

“Desiccant Enhanced Evaporative” (DEVAP) Air Conditioning

Desiccants:
WARM / DRY air

Indirect evaporative cooling:
COOL / Dry air



What Problems Does DEVAP Air Conditioning Address?

- Vapor compression:
  - Uses a lot of energy

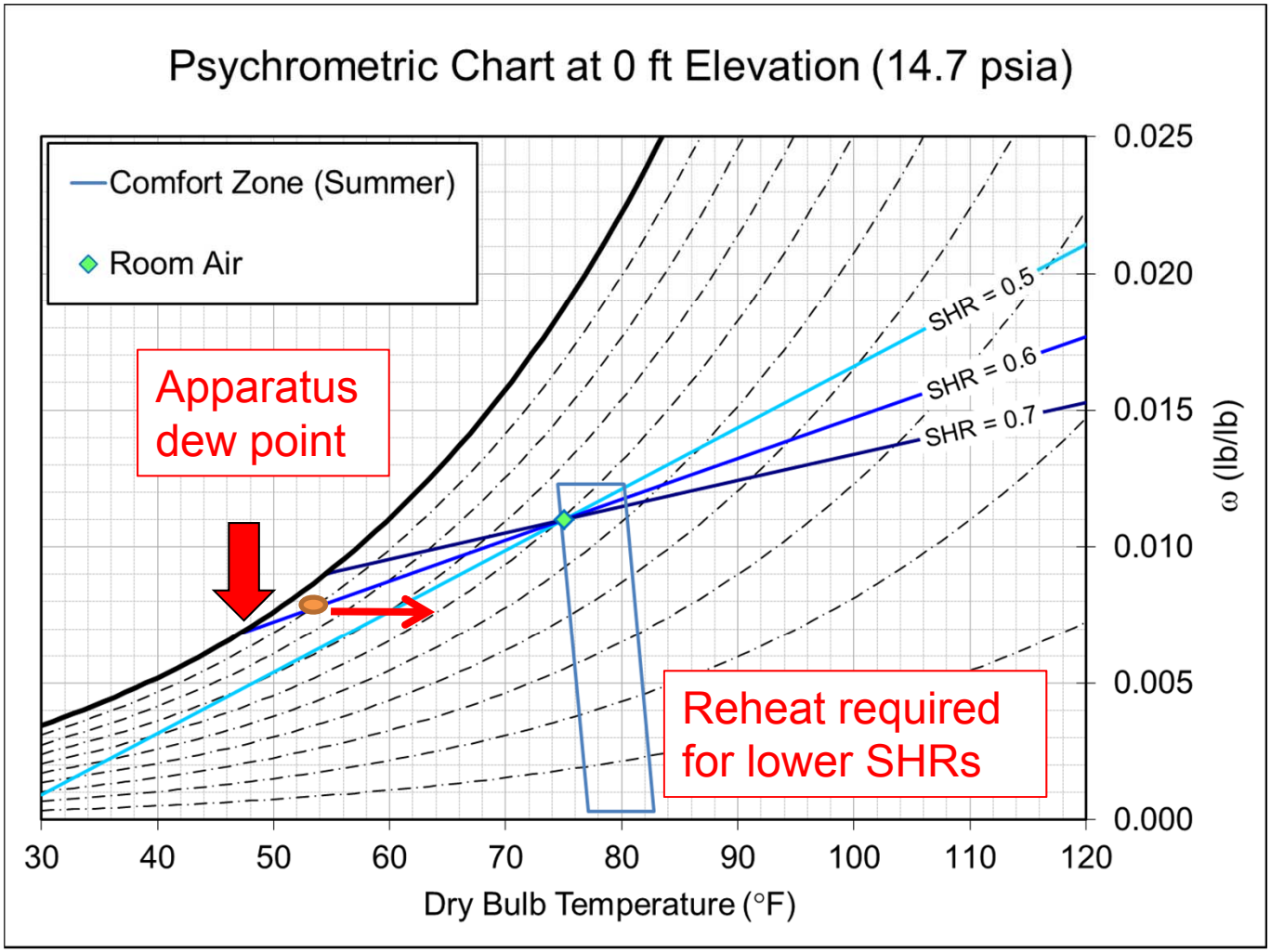
    In the US, ~15% of annual electric generation [1]
  - Major contributor to peak power

    up to 50% in western states [2]
  - Often inefficient at humidity control
  - Uses environmentally harmful refrigerants

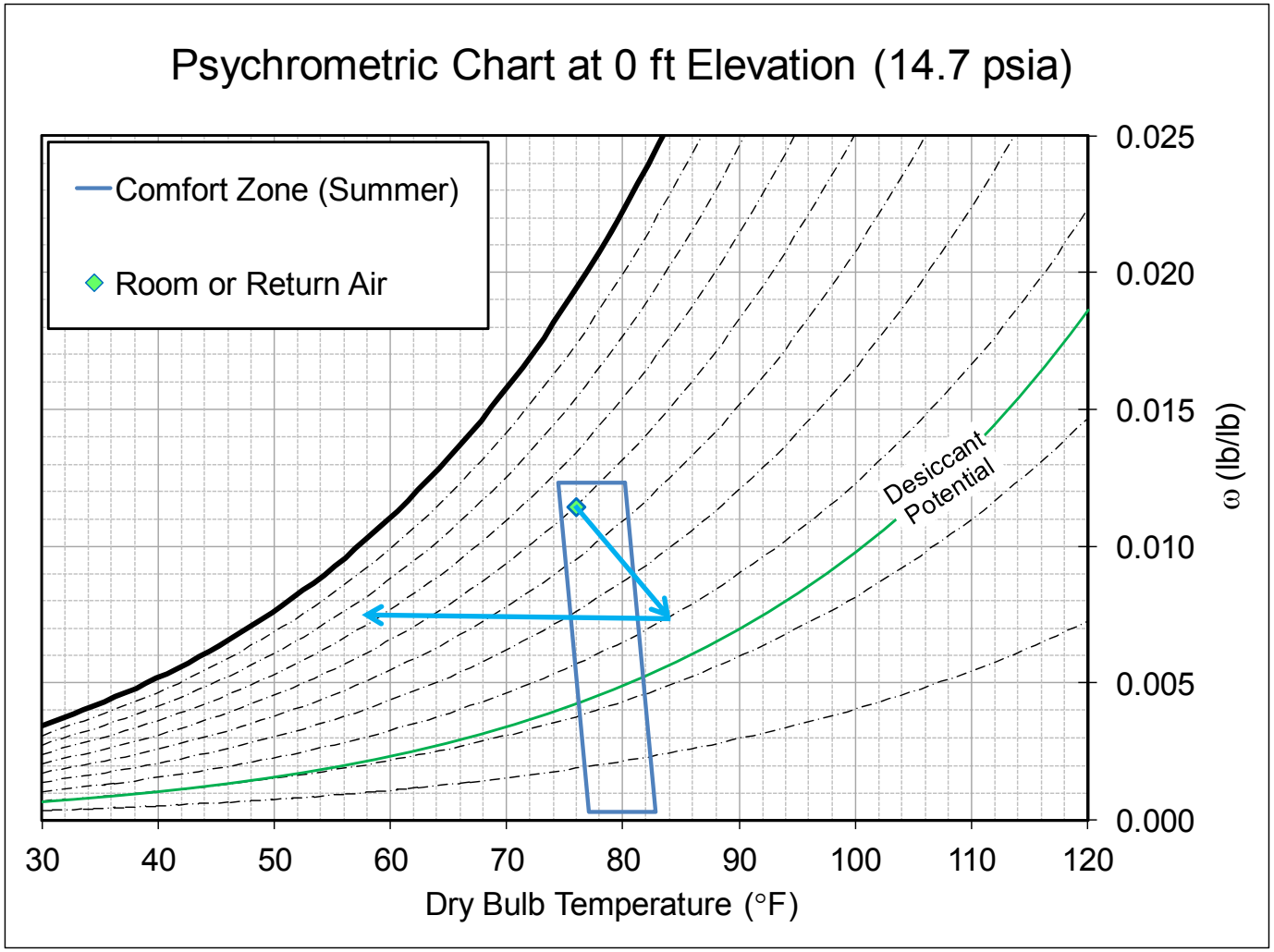
Credit: Wikipedia user Wknight94 [3]

1. DOE Buildings Energy Data Book - http://buildingsdatabook.eren.doe.gov/
2. Western Cooling Efficiency Center – http://wcec.ucdavis.edu
3. http://en.wikipedia.org/wiki/File:Big_Bend_Power_Station.jpg

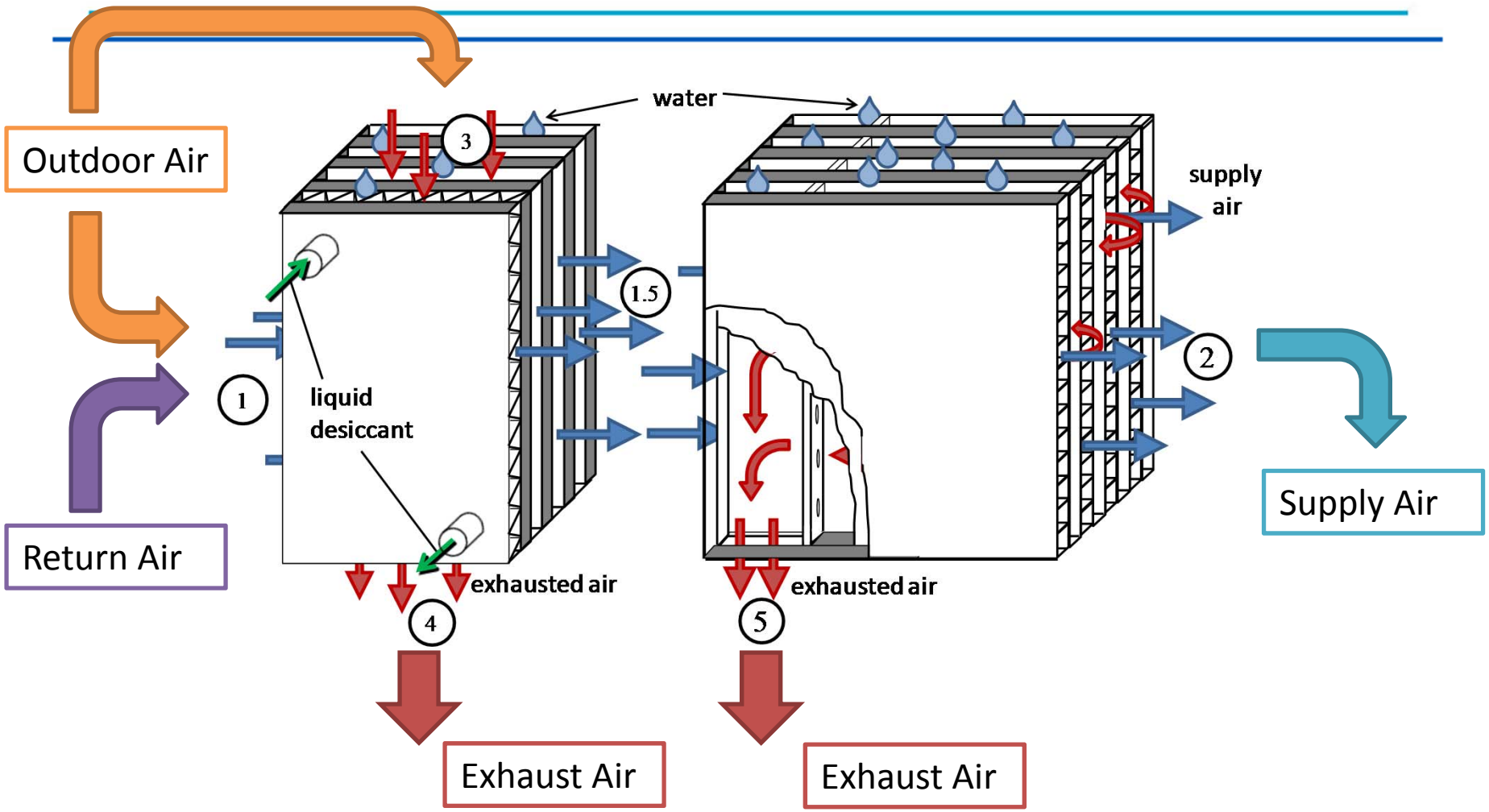
Sensible and Humidity Control with Vapor Compression



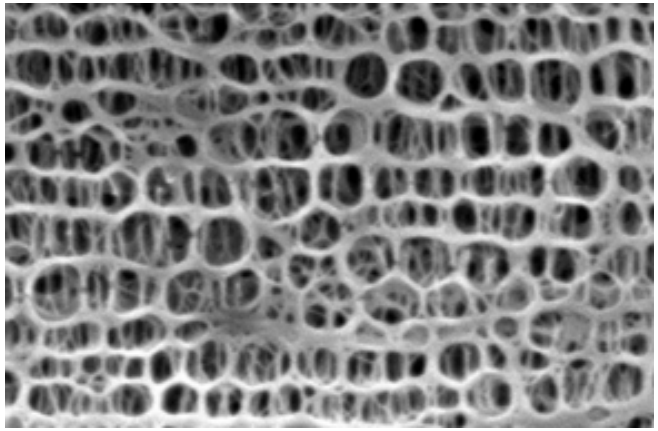
DEVAP Cooling Process
(Using Liquid Desiccants)



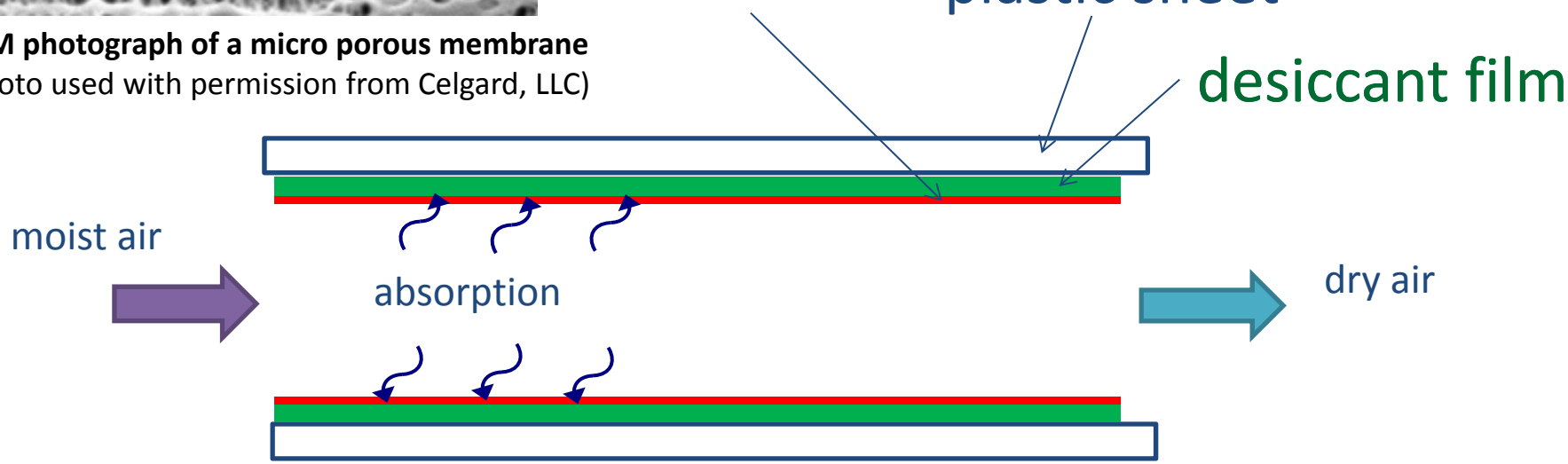
DEVAP Heat and Mass Exchangers



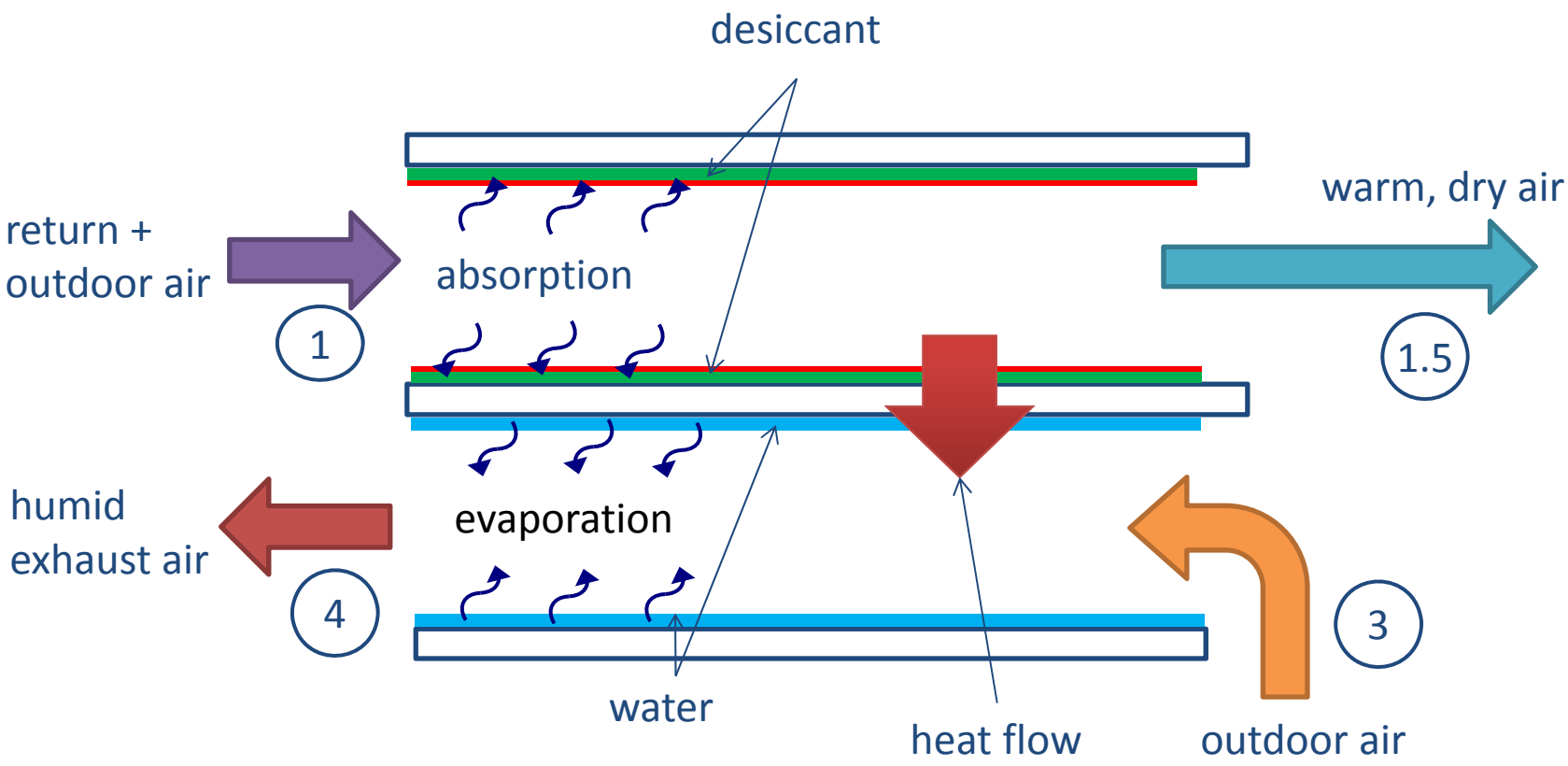
Membrane Contained Liquid Desiccant



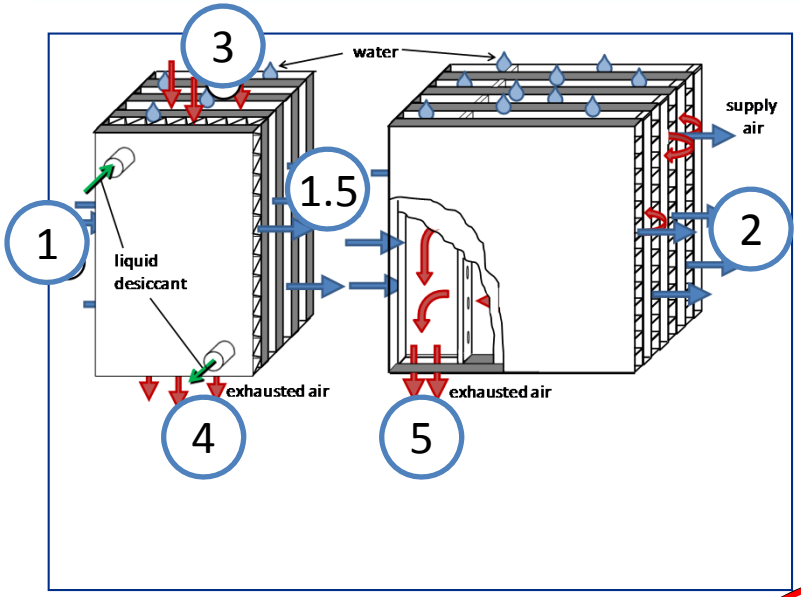
SEM photograph of a micro porous membrane
(Photo used with permission from Celgard, LLC)

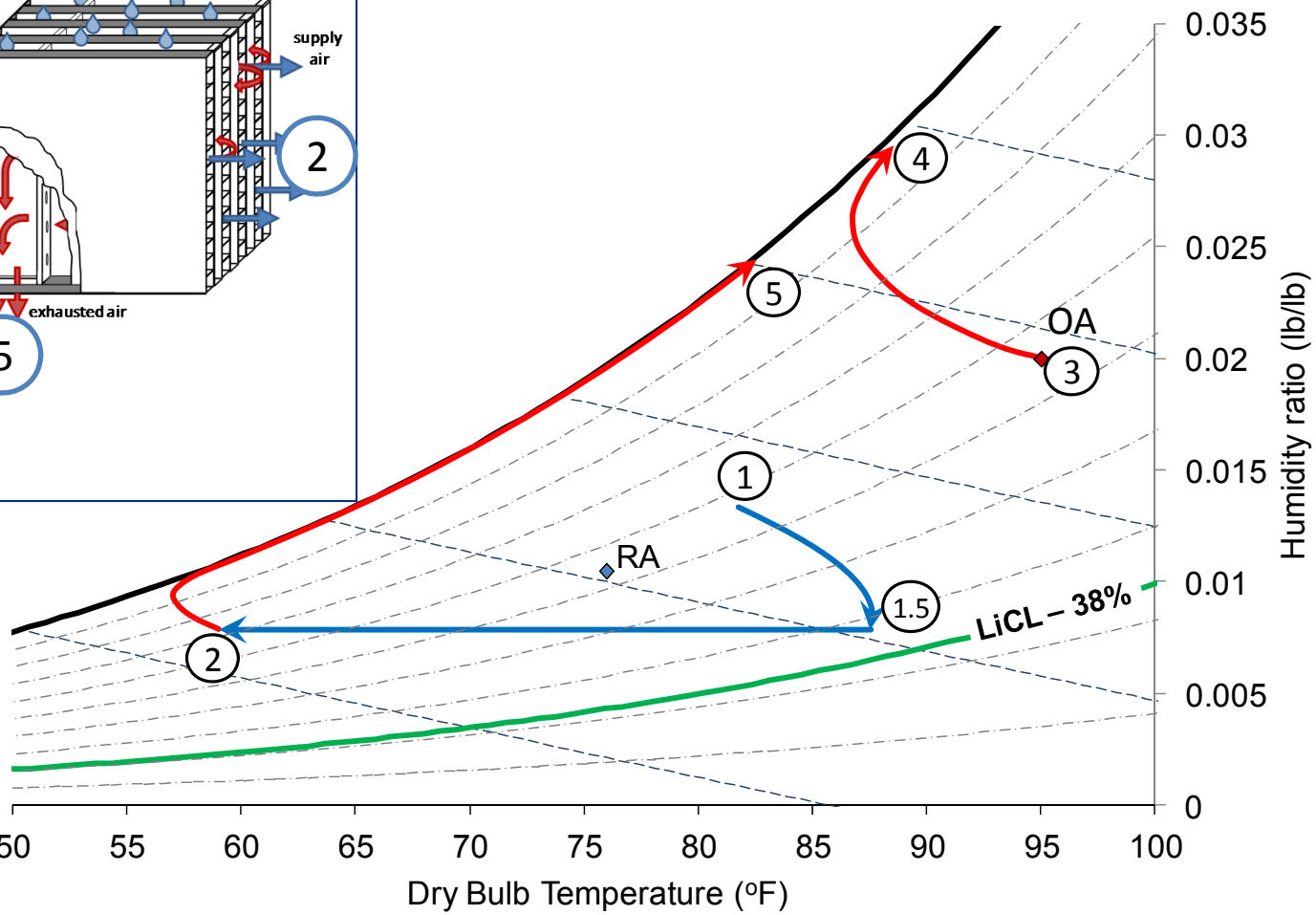


Dehumidifier Fluid Flows
(In one channel pair)

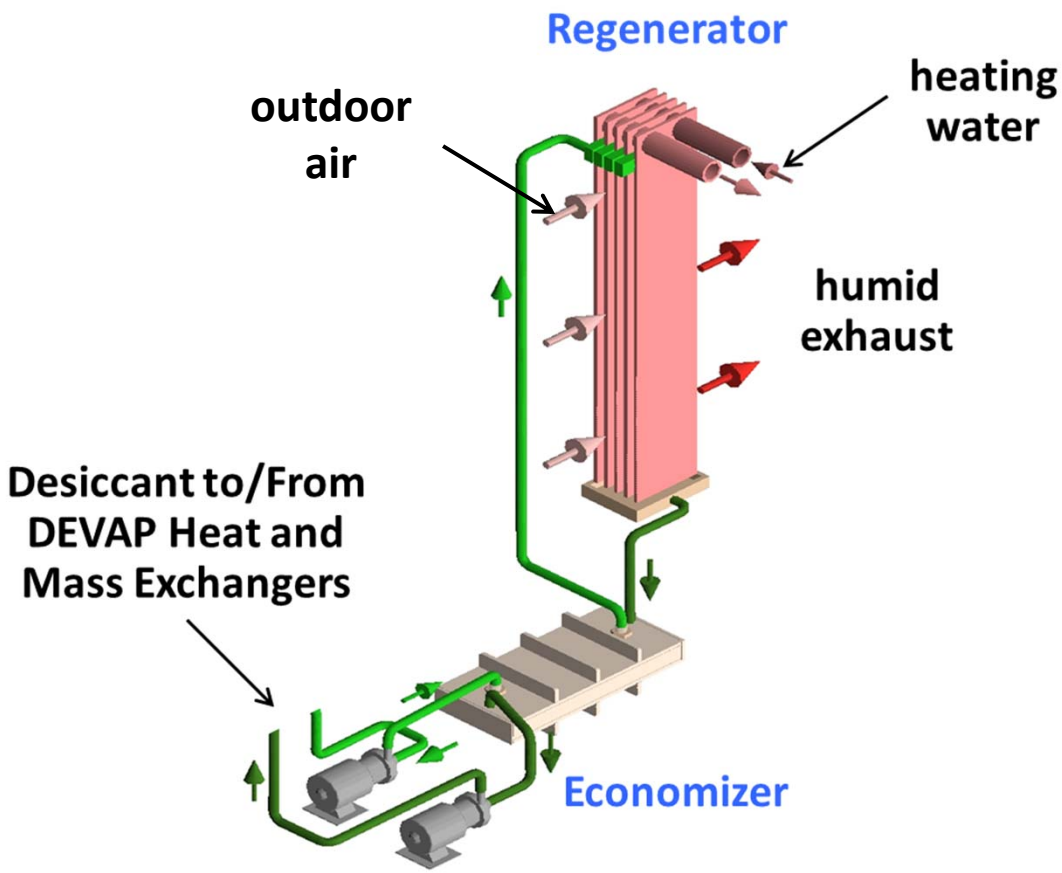


DEVAP Cooling Process





Heat and Mass Exchangers for Desiccant Regeneration



Credit: Andrew Lowenstein

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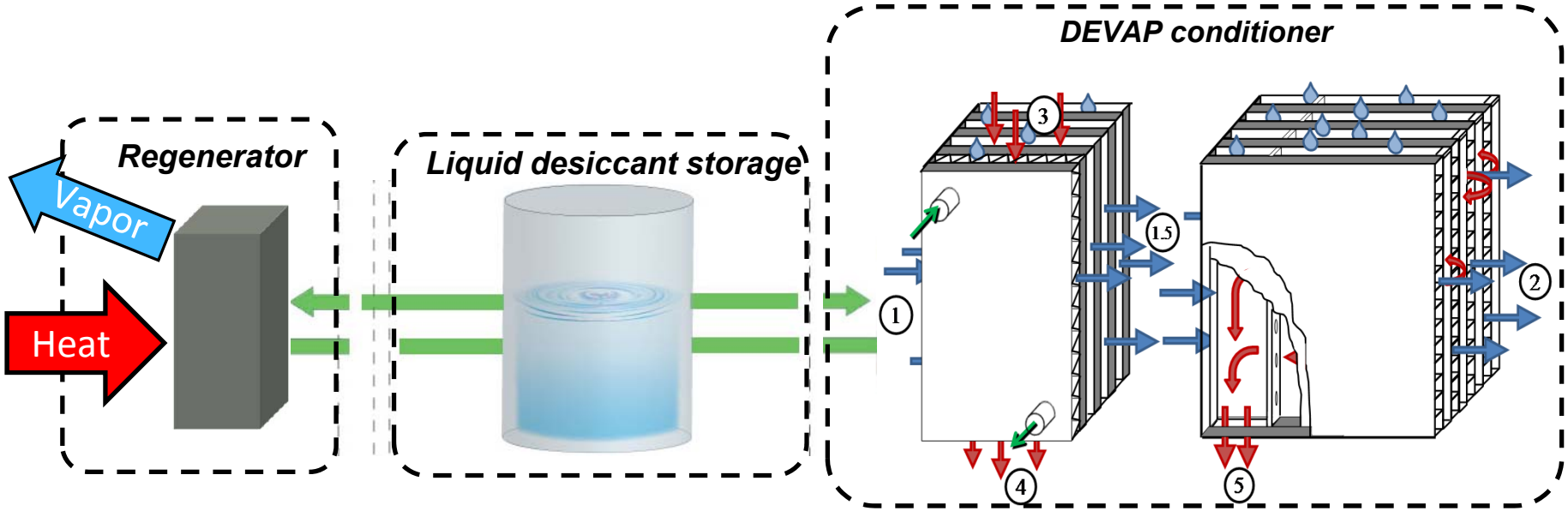
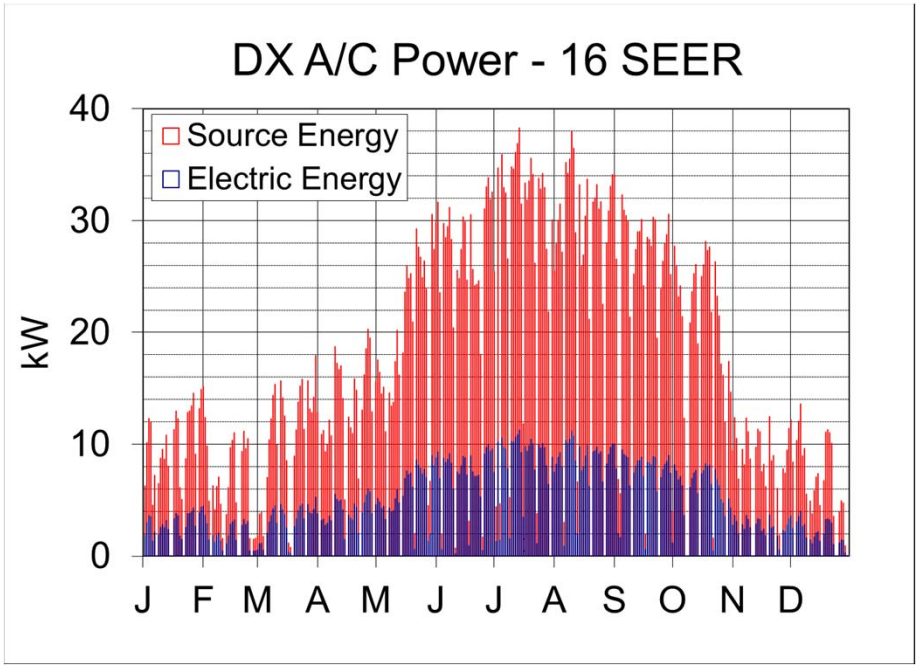
DEVAP System Diagram

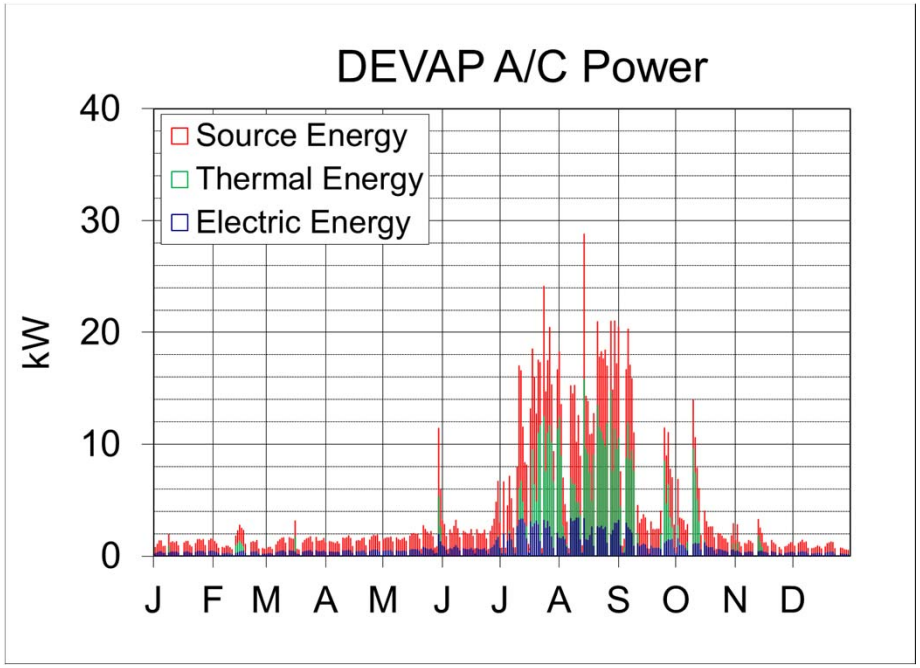


- Electricity (fans and small liquid pumps) < 0.2 kW/ton
- Thermal Energy (natural gas, waste, or solar heat) depends on latent load

Annual / Hourly Commercial Building Energy Simulation - Phoenix, AZ

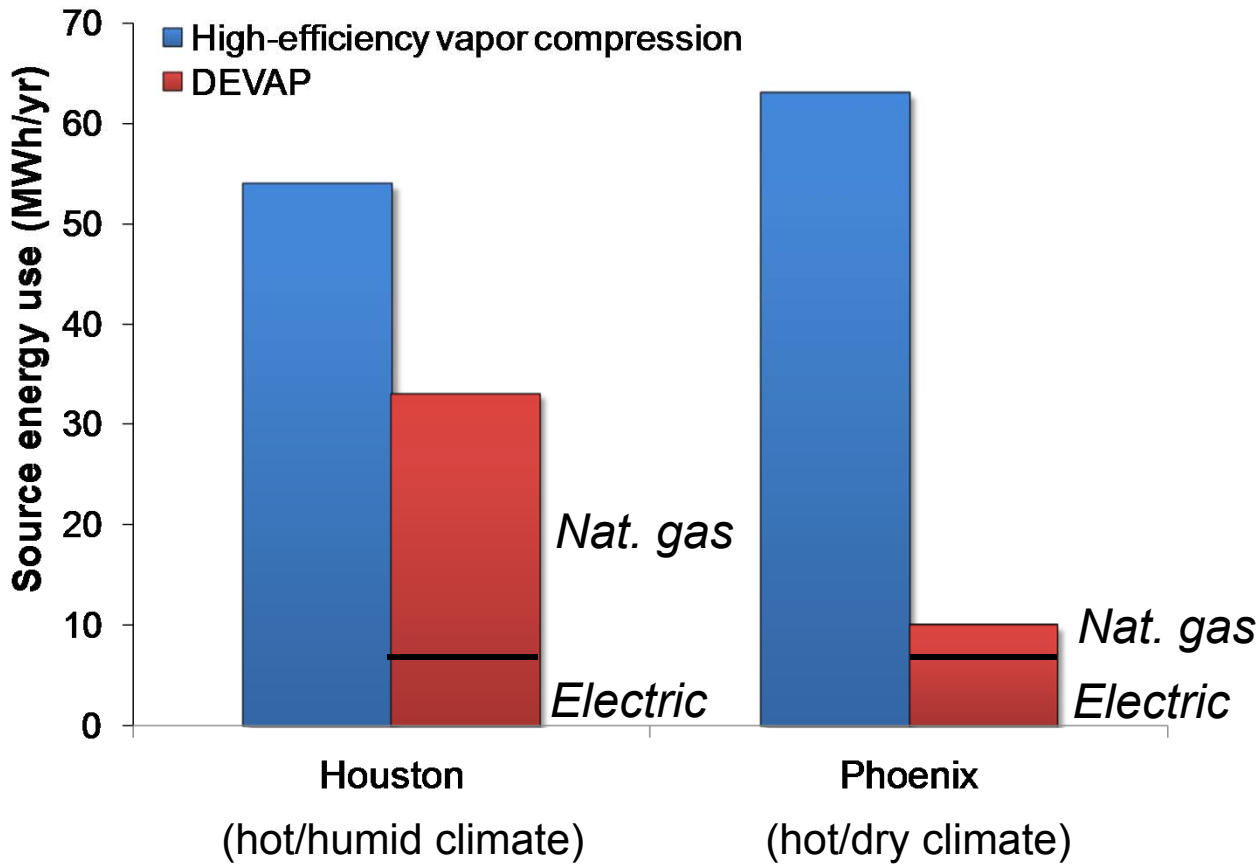
(Using a 2-stage regenerator & natural gas as thermal source)





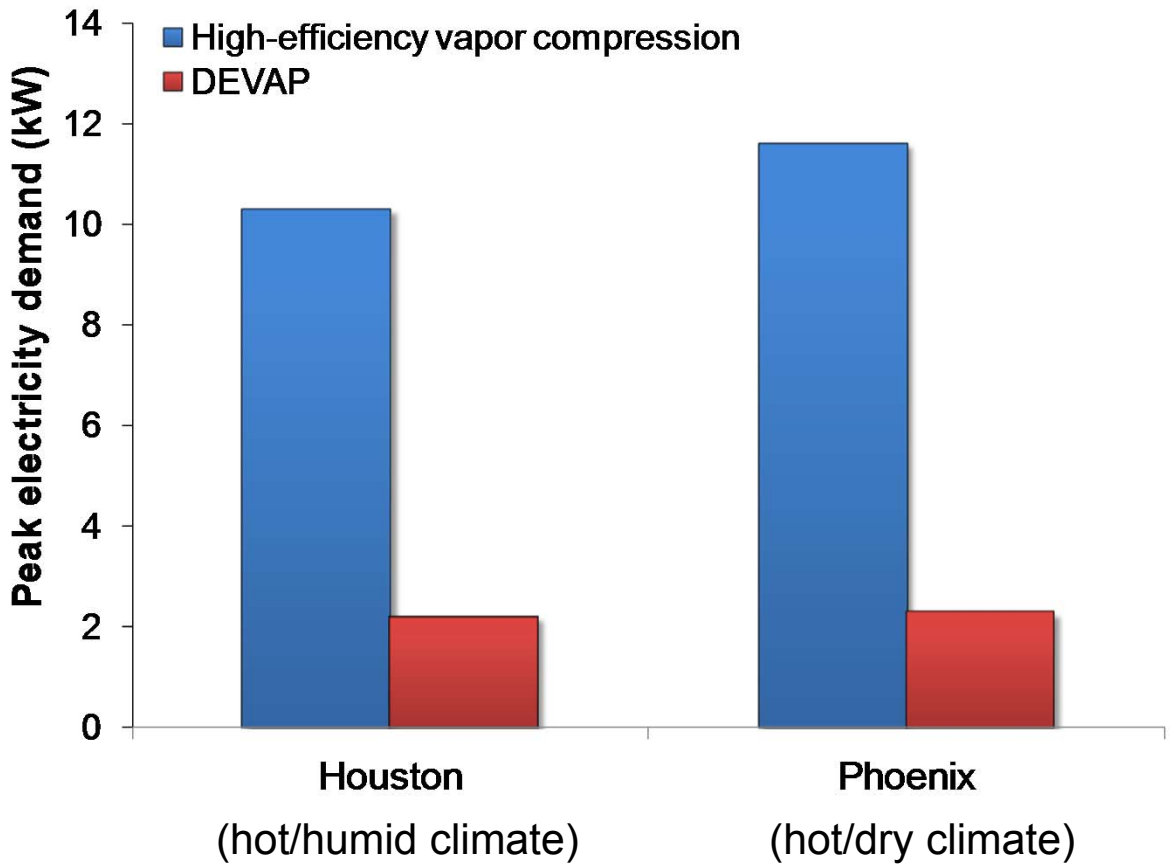
- EnergyPlus used to generate loads with a small office benchmark building model (10,000 sqft)
- DEVAP simulation follows hourly sensible and latent loads

Model Estimate: 40%-80% Source Energy Savings



Note: DEVAP a/c model matches hourly sensible and latent cooling from E-Plus “small office benchmark” simulation. Results for different building types will vary.

Model Estimate:
80% Peak Electric Demand Savings



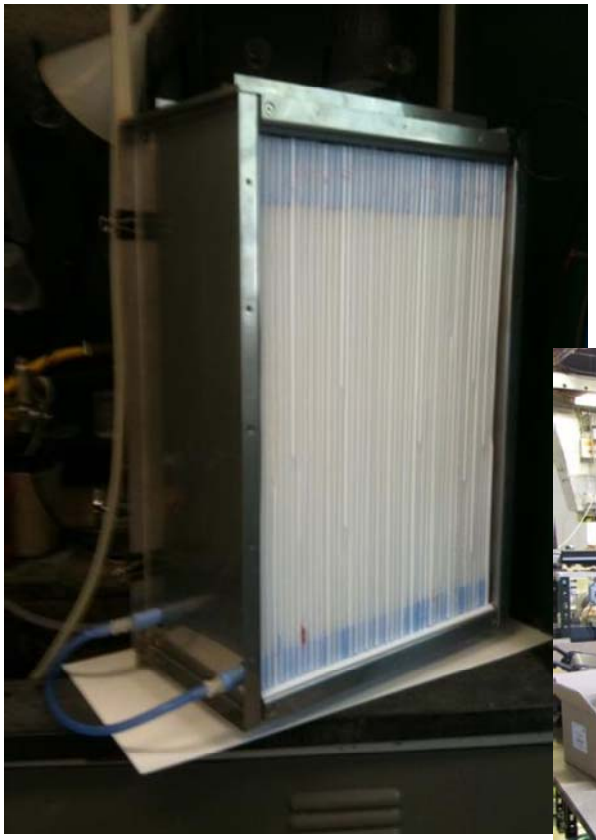
Note: DEVAP a/c model matches hourly sensible and latent cooling from E-Plus “small office benchmark” simulation. Results for different building types will vary.

Laboratory Testing (Fall 2011)

Credit: Warren Gretz

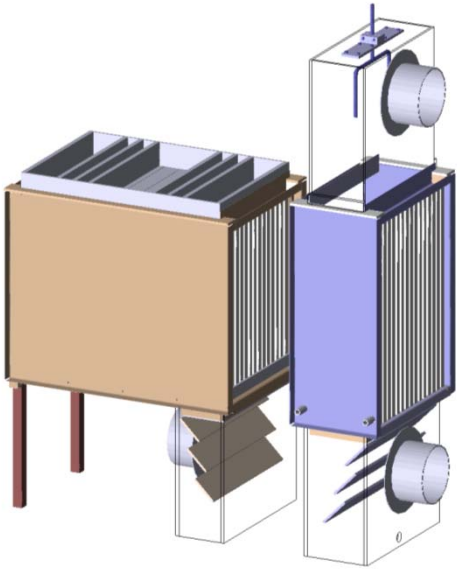
Prototype Unit #1

First Stage



Credit: Andrew Lowenstein

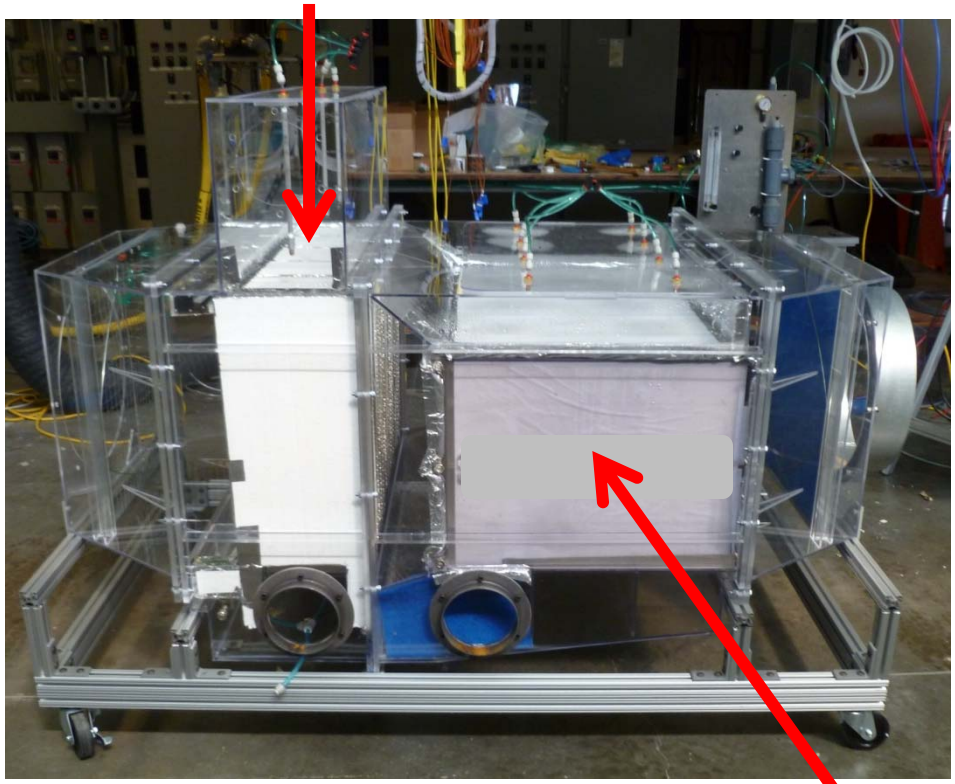
Second Stage



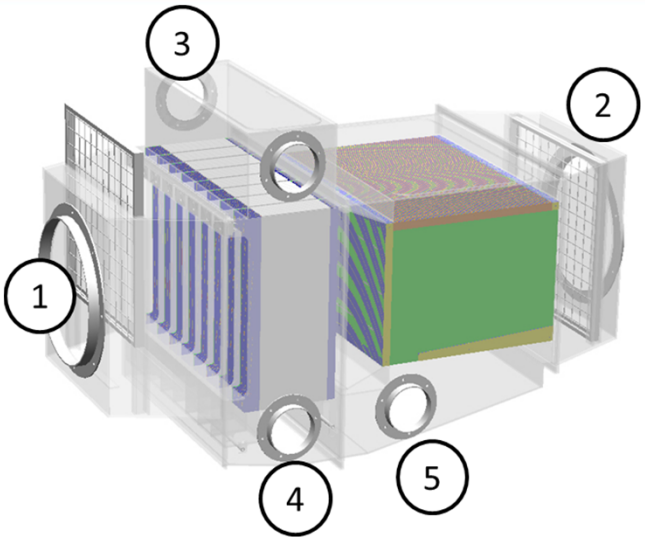
Credit: Andrew Lowenstein

Prototype Unit #2

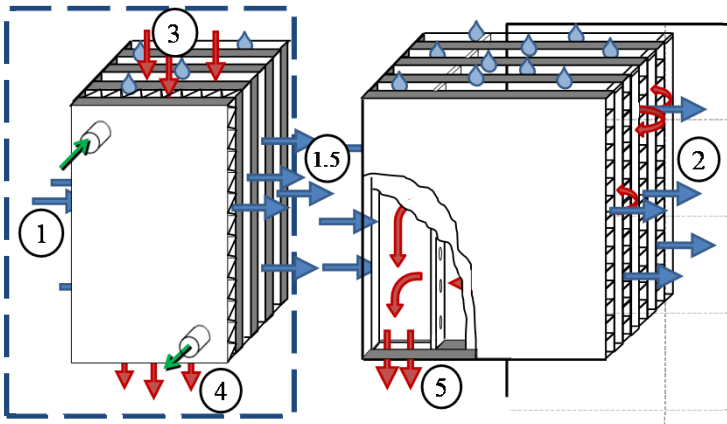
First Stage



Second Stage



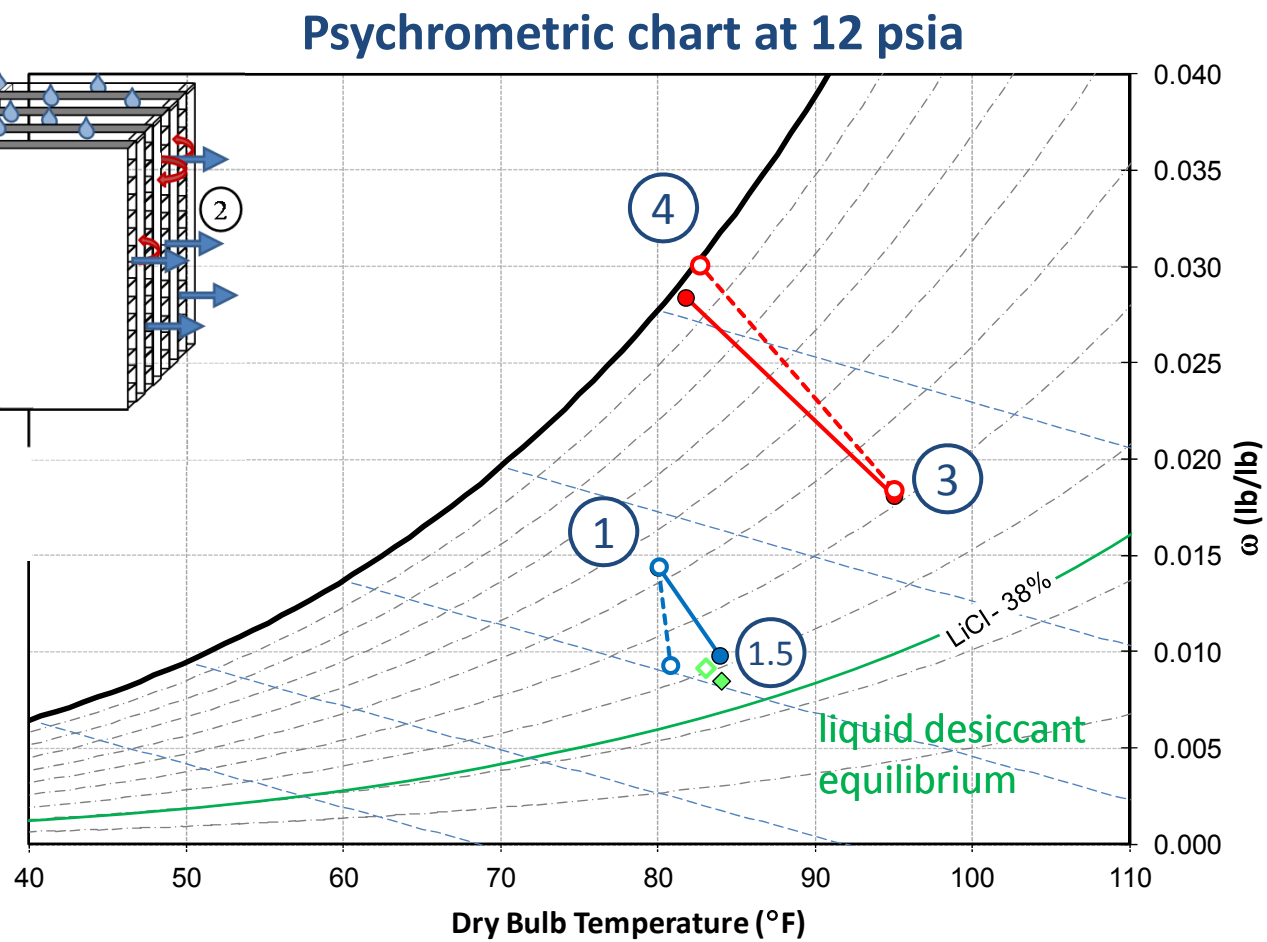
AHRI conditions (1st Stage Only)



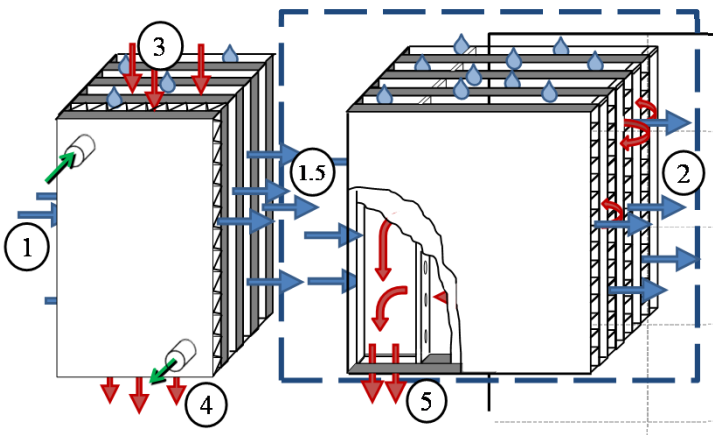
Lab test Model

Unit #1

Unit #2



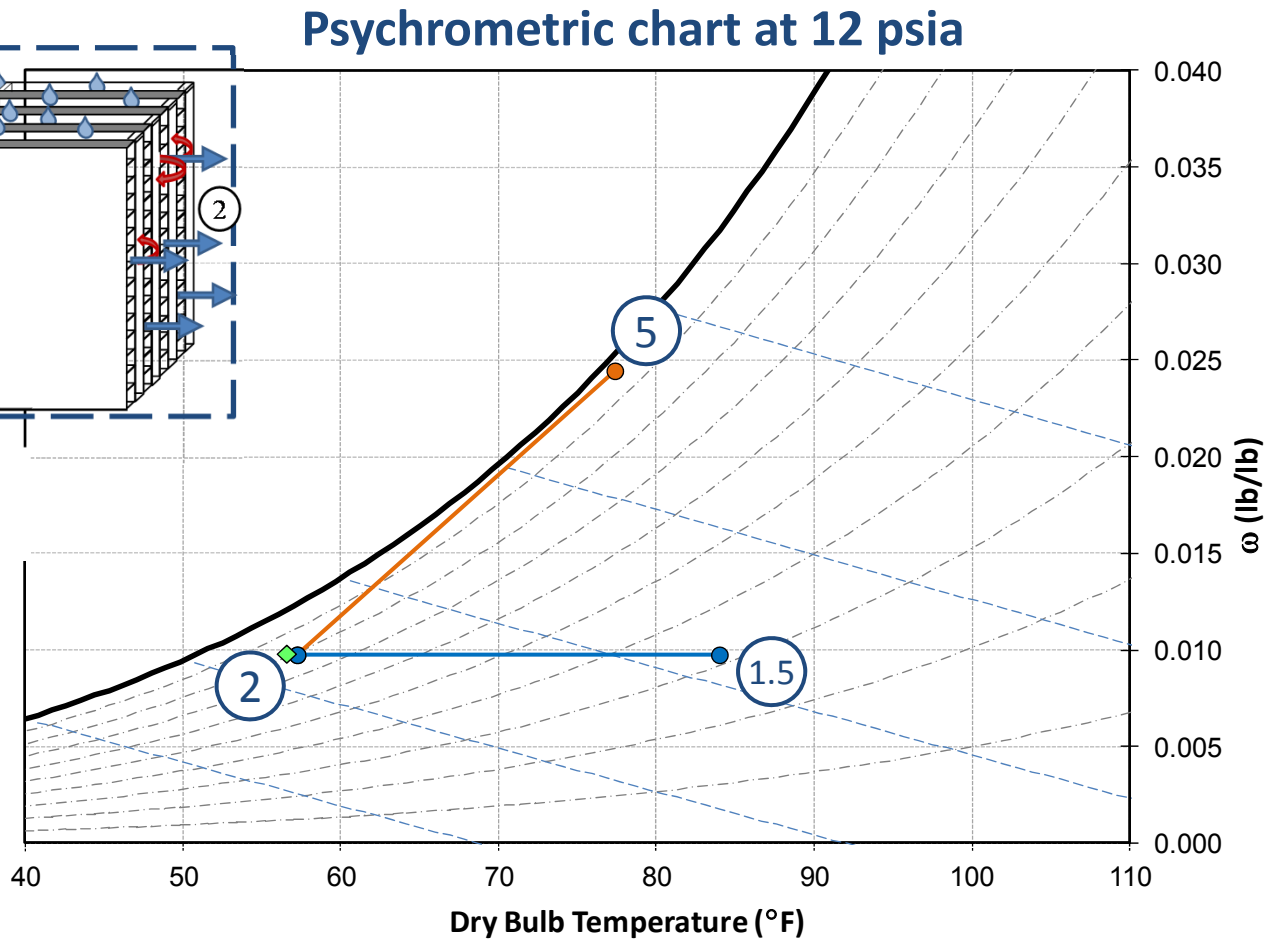
AHRI conditions (2nd Stage Only)



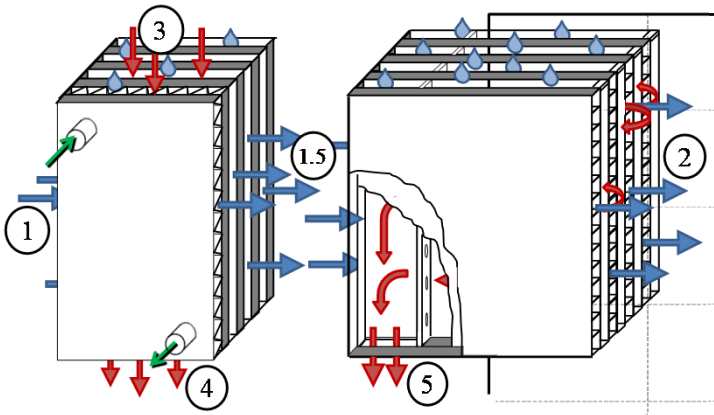
Lab test

Model

Unit #1



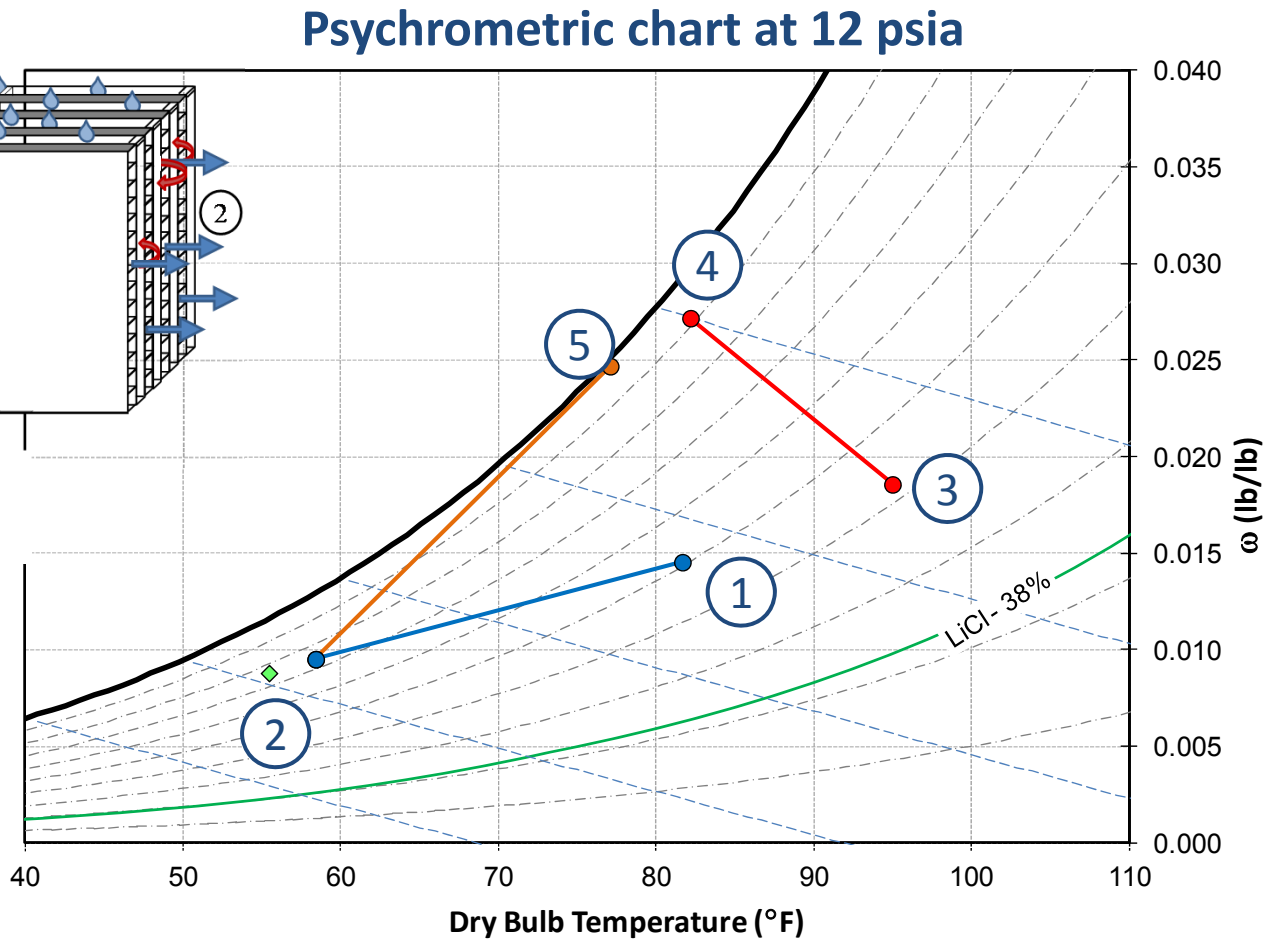
AHRI conditions



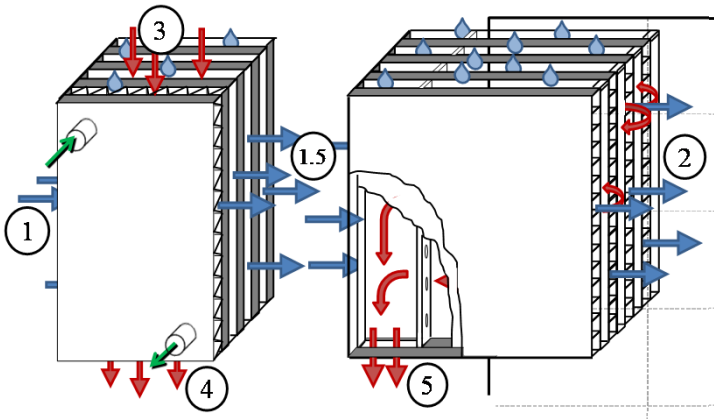
Lab test

Model

Unit #1

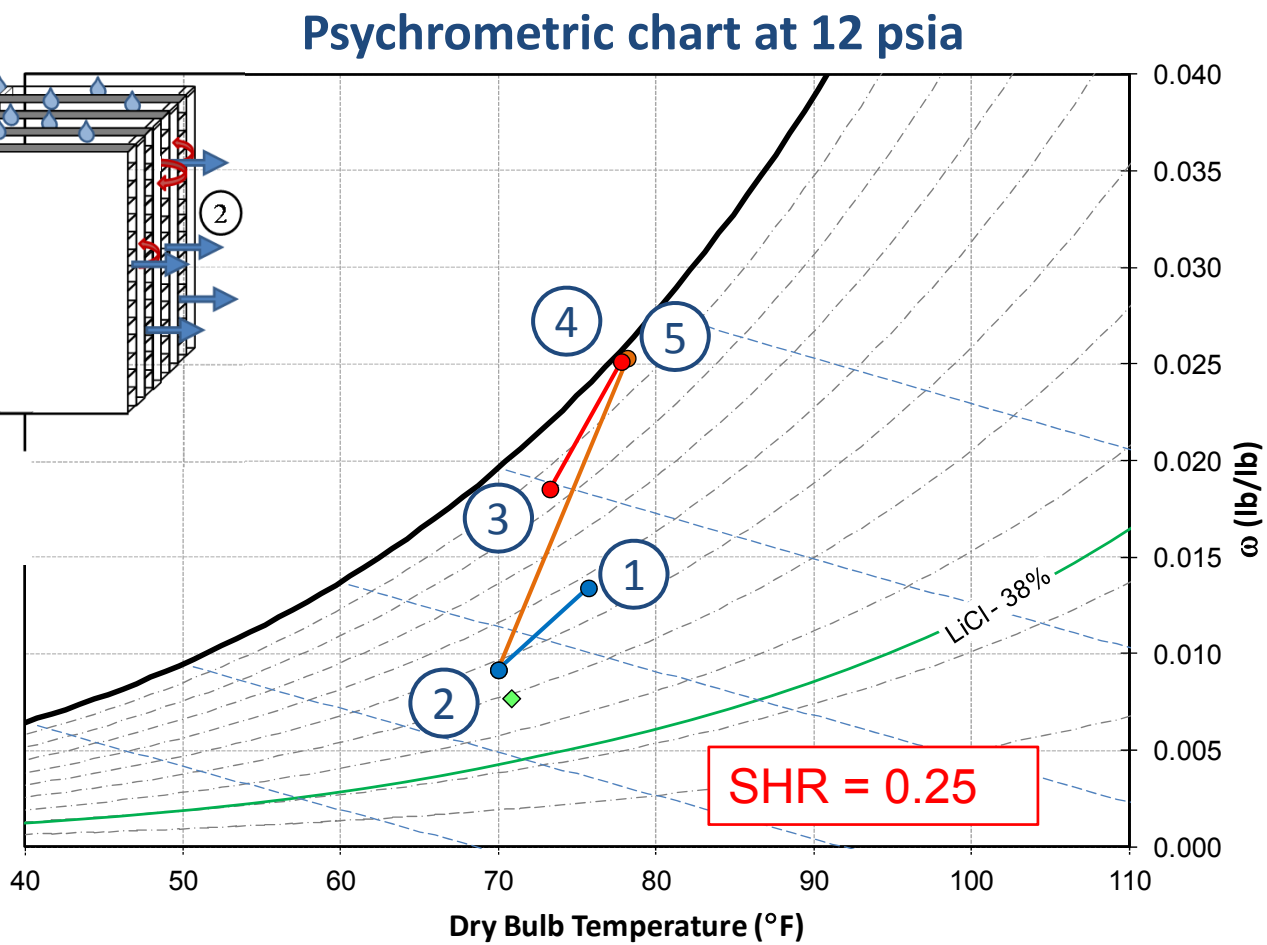


Rainy Day:
High Latent, Low Sensible

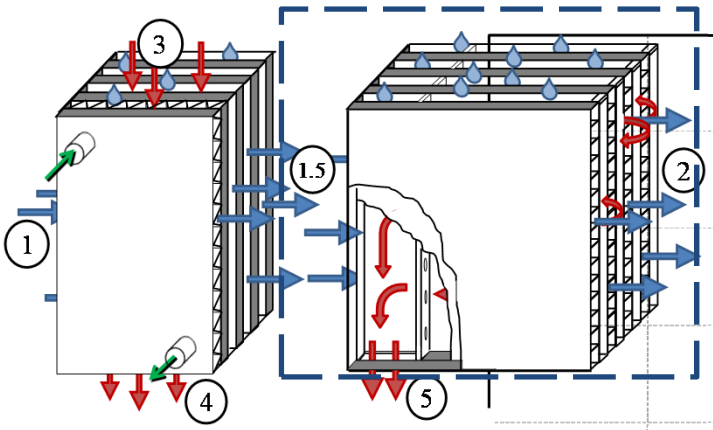


Lab test Model

Unit #1

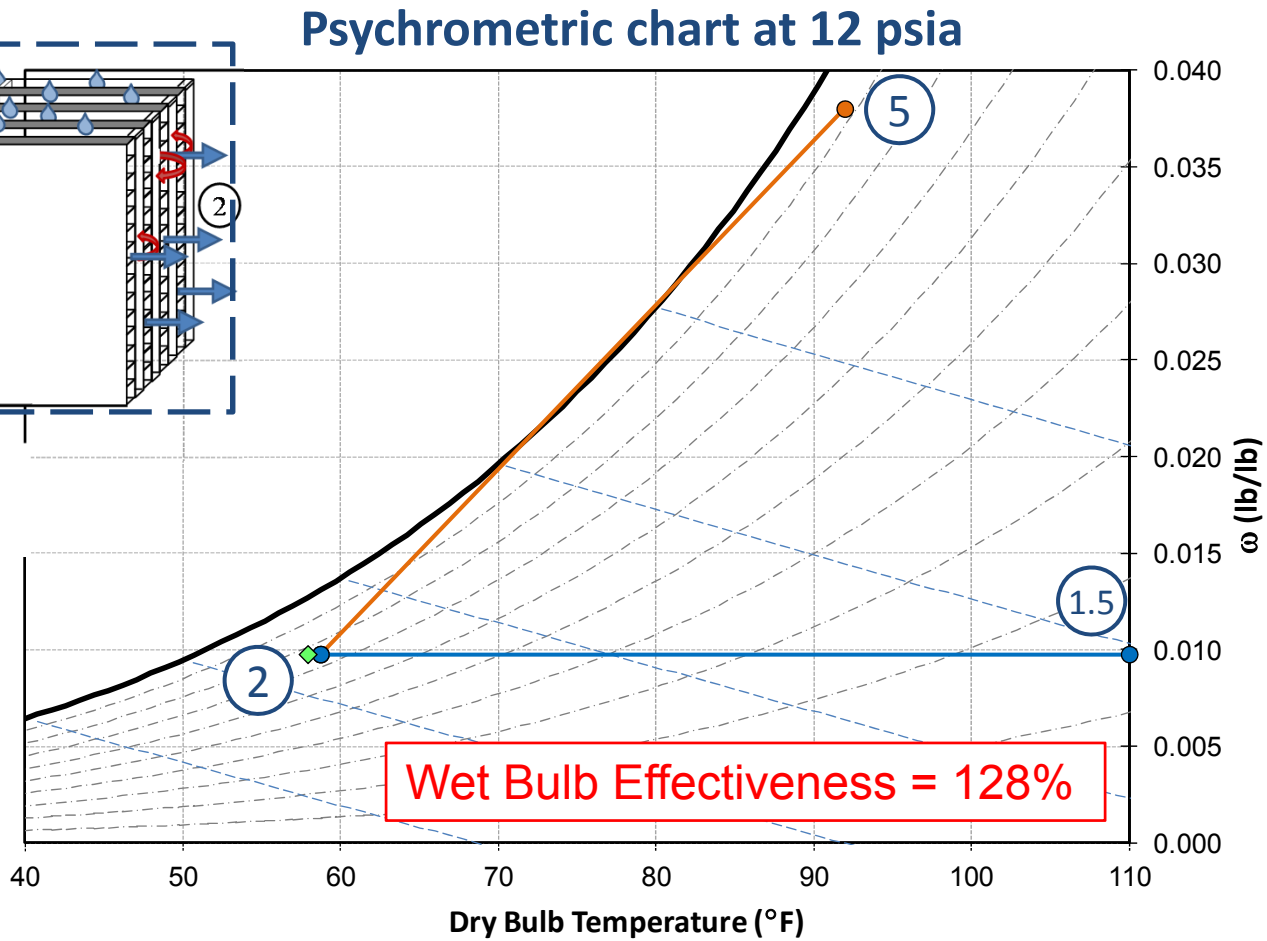


Hot-dry
High Sensible, Low Latent



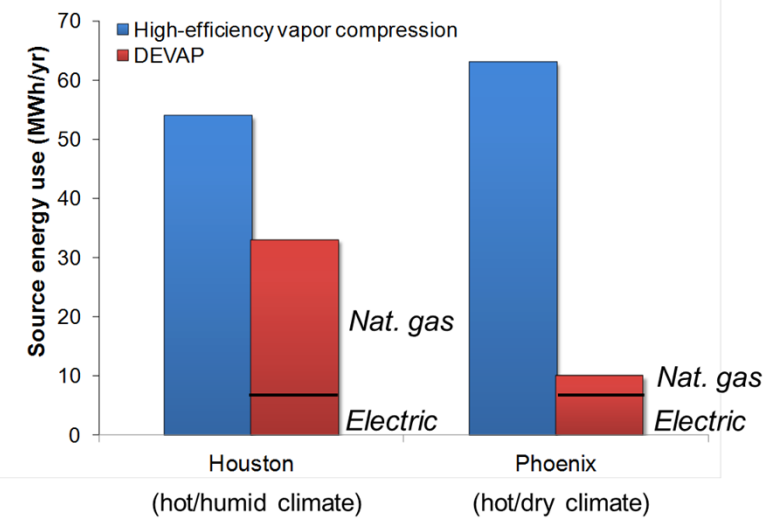
Lab test Model

Unit #1



Benefits: Desiccant Enhanced Evaporative Air Conditioning

- Estimated savings (commercial buildings):
  - 40%-80% energy
  - 80% peak power
- Controls temperature and humidity separately
- No harmful refrigerants
- Natural gas or waste heat



Bibliography

- Information at:

  www.nrel.gov/publications

  Search keyword: **Desiccant Enhanced Evaporative**

Acknowledgements

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Questions?

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