An Hourly Building Simulation Tool to Evaluate Hybrid Desiccant System Configuration Options

ASHRAE Summer Meeting

June 29, 2003

Hugh I Henderson, Jr. P.E.

CDH Energy Corp.

Cazenovia, NY

James R. Sand, PhD

Oak Ridge National Lab

Oak Ridge, TN

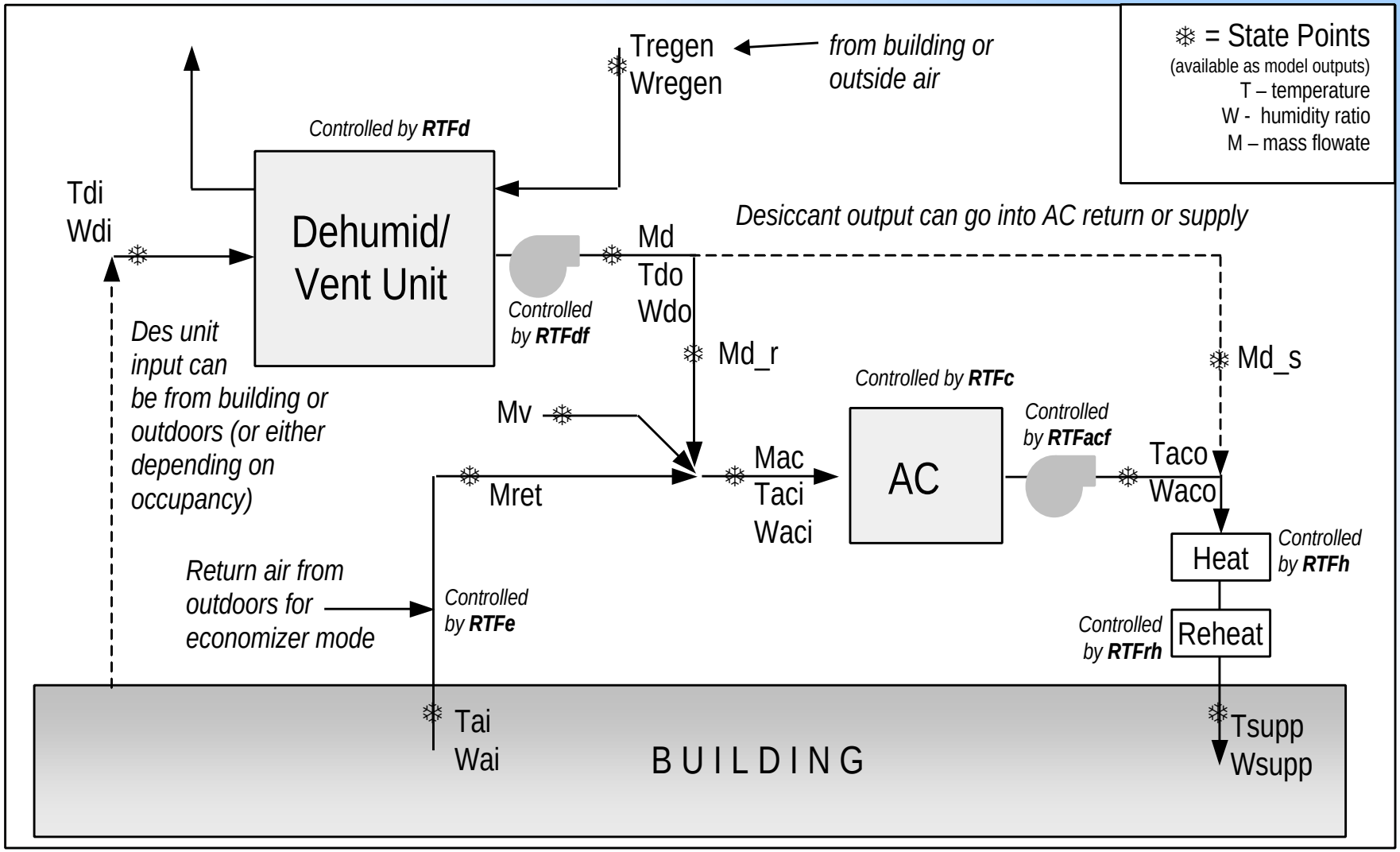
Overview

- Why the building model was developed
  - To compare various desiccant configurations to other HVAC systems
  - Develop software tool for “narrow” audience
- Simulation model details
  - Framework considers various desiccant system configuration options
  - Capture HVAC control and part load effects
- Simulation Results
  - Compare various desiccant and conventional AC options

The Need

- Need a hour building simulation model to make fair comparisons between systems
  - Accurately represent both conventional & innovative desiccant systems
  - Field testing showed controls & configuration matters
- Current models have hard-wired configurations
  - New equipment concepts difficult to incorporate
- User interface needs to be simple enough for use by “semi-experts”
  - Familiar with technology not simulation models
  - Fully-developed interface not required (and is too expensive to develop)

Model Framework



Model Approach

- Use TRNSYS with TRNSED interface
- Building is single-zone (Type 19) driven by hourly TMY2 weather data
- Use accurate equipment component models
- Properly integrate components considering part load effects (e.g., latent degradation)
- Add CO_2 balance to model ventilation performance
- Allow for simultaneous control of multiple set points (temperature, humidity, CO_2)
- Fan/ventilation control options

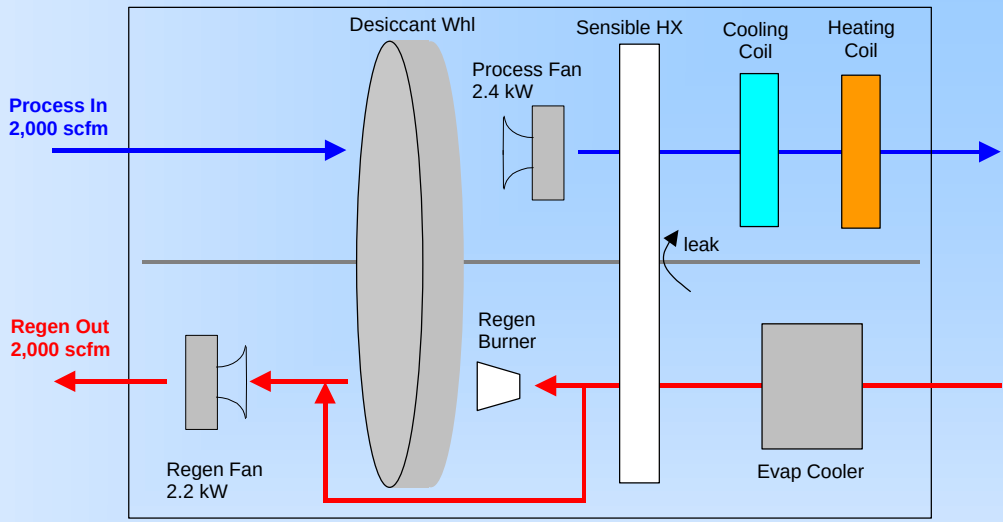
Equipment Options

- Conventional AC (w/ or w/o reheat)
- Economizer
- Desiccant Pre-conditioner
  - w/ or w/o sensible HX, evap cooler, DX coil
  - Makeup air, vent w/HR, recirculation
- Enthalpy Wheel
- DX Makeup-air Unit
- Demand-controlled Ventilation
- Other Options

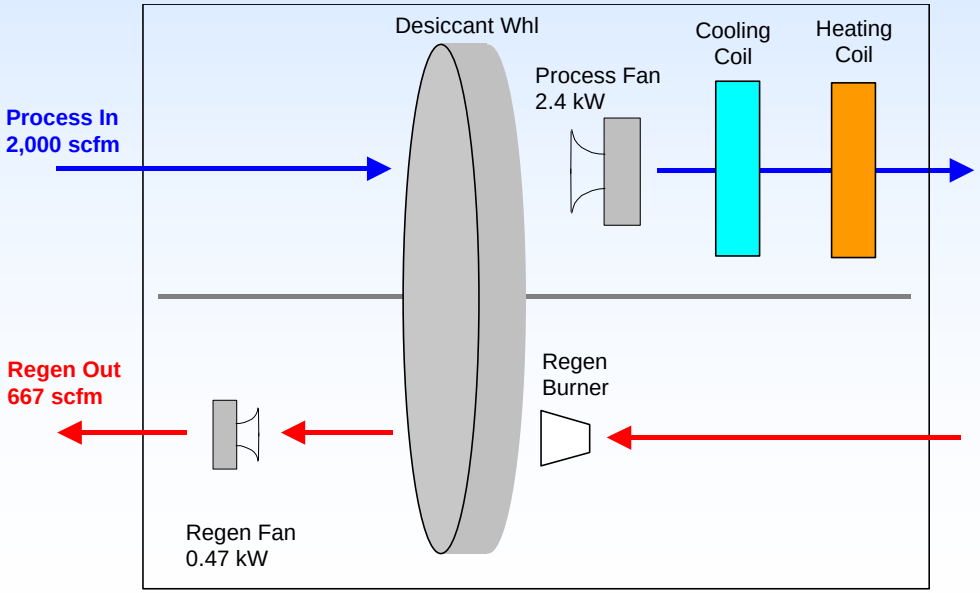
Desiccant Configuration Options "Inside the Box"

- Many options have greatest impact at peak load conditions
- What is annual benefit?
- Part load conditions need to be considered

With Sensible HX, DX Coil, & Evap Cooling

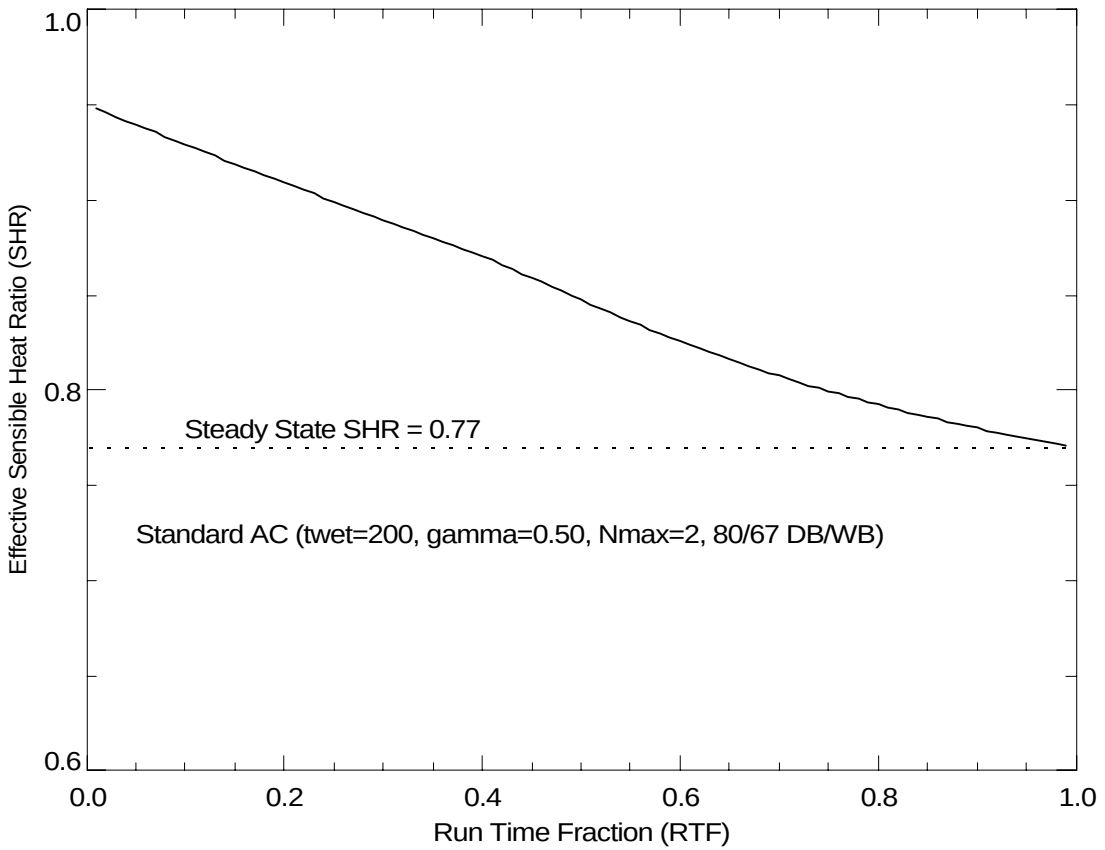


With DX Coil Only

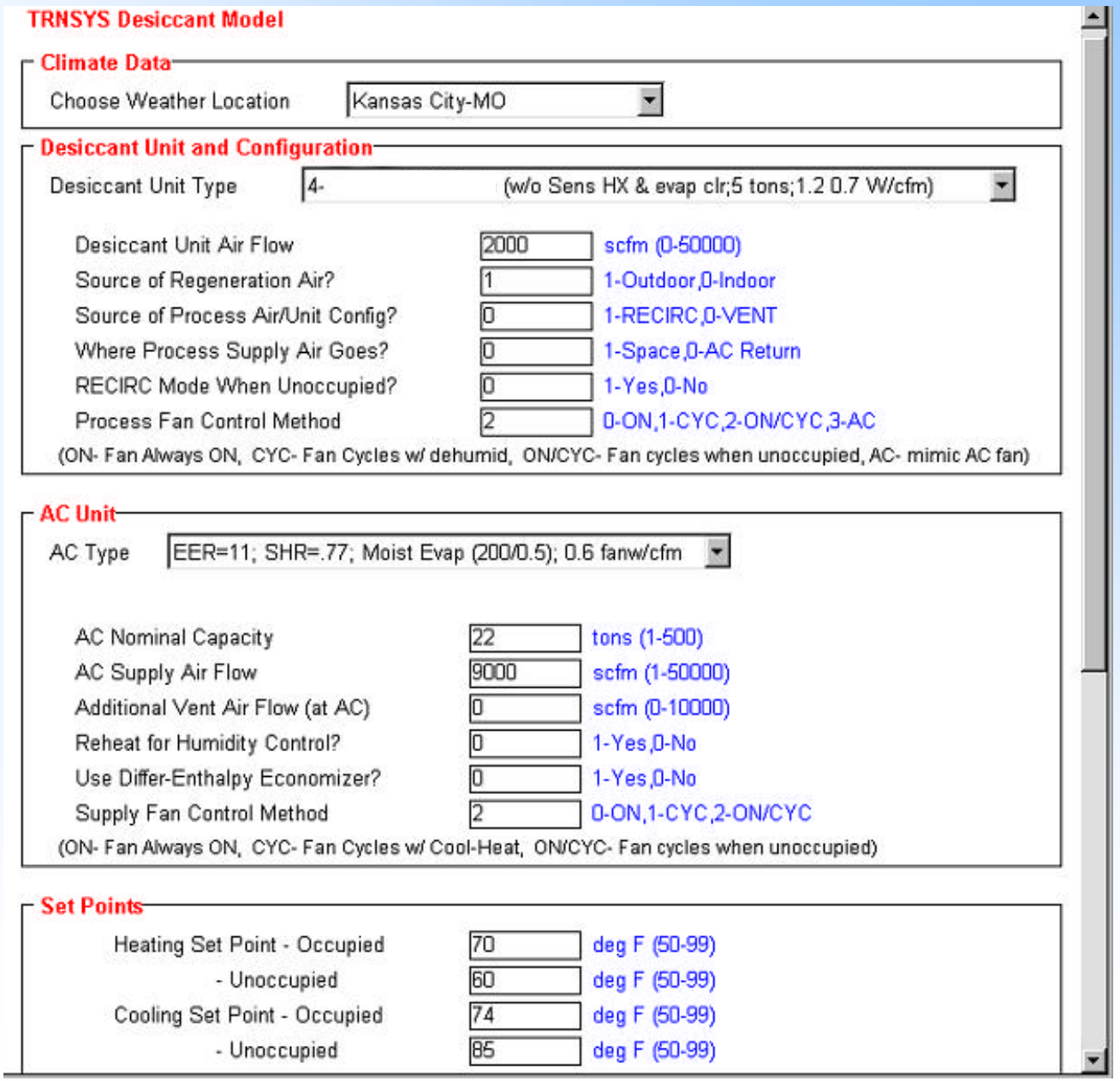


Part Load Effects

- Building model considers moisture capacitance
- Latent degradation of cooling coil at part load (plus interactions with fan control)
- Setpoint as RH or dew point



Simple User Interface

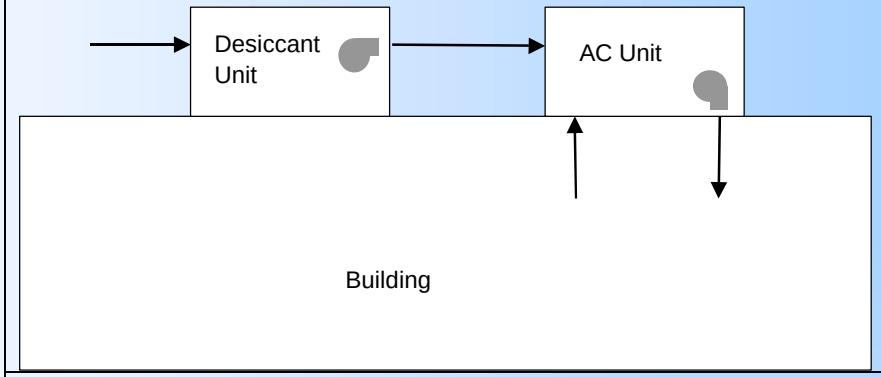


Compare Model to Test Data

- Elementary school in Olathe, KS where desiccant unit was field tested
- Pretreated ventilation air for area with 6 classrooms
- Model compared well to measured data

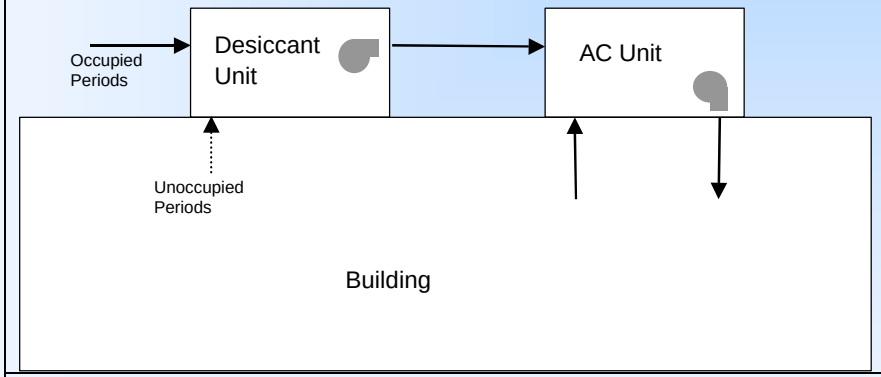
System-Level Configuration Options for School

Desiccant Ventilation Pretreatment System (System #2)



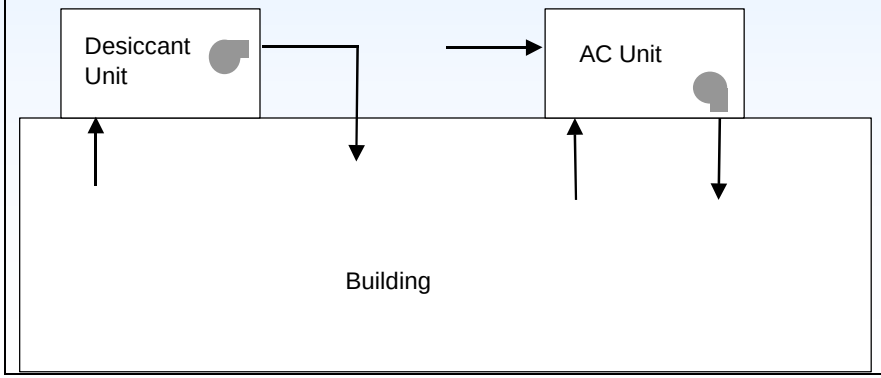
AC supply and desiccant process fan operate continuously during occupied period. AC supply fan cycles on/off with heating when unoccupied.

Desiccant Ventilation Pretreatment System (System #3) (recirculation when unoccupied)



AC supply and desiccant process fan operate continuously during occupied period. AC supply fan cycles on/off with heating when unoccupied. Desiccant process fan (and AC supply) cycles on/off with desiccant when unoccupied.

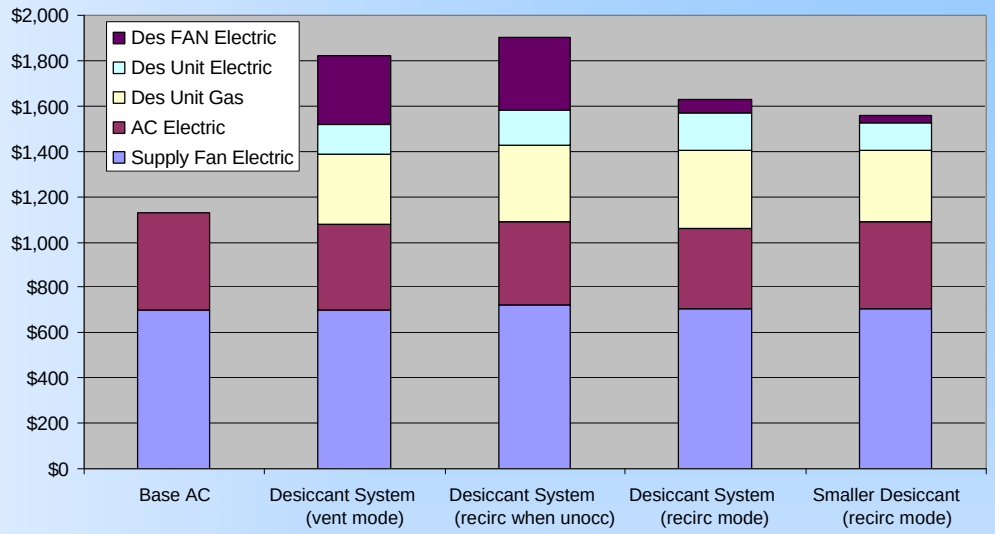
Desiccant Recirculation System (System #4 & #5)

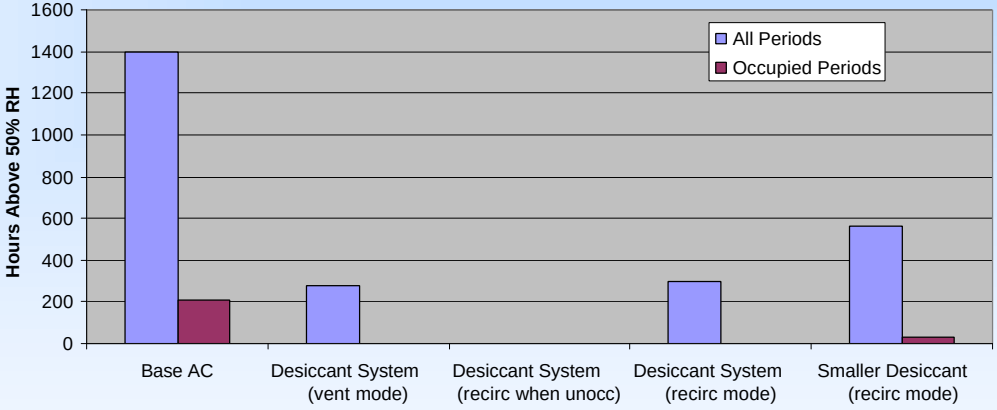


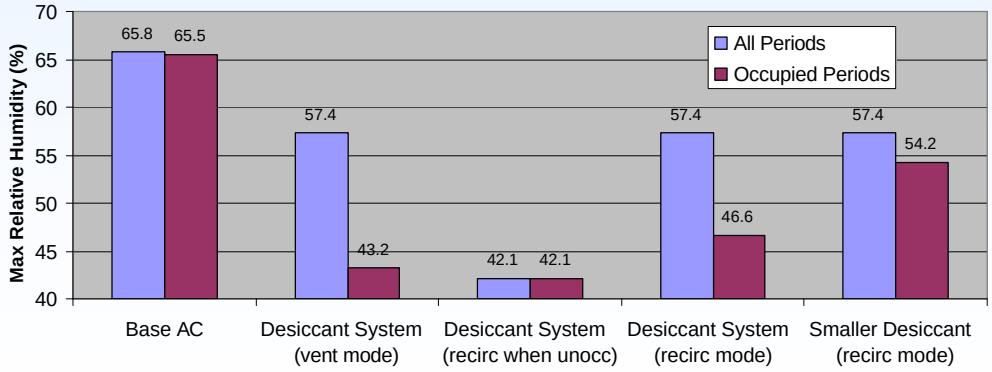
AC supply fan operates continuously during occupied period. AC supply fan cycles on/off with heating when unoccupied. Desiccant process fan cycles on/off with desiccant during all periods.

School Results

- Des System in vent mode was installed at site (61% higher costs than base AC)
- Recirc mode in summer improved humidity control
- Year-round recirc mode had lower costs (more gas, less fan)







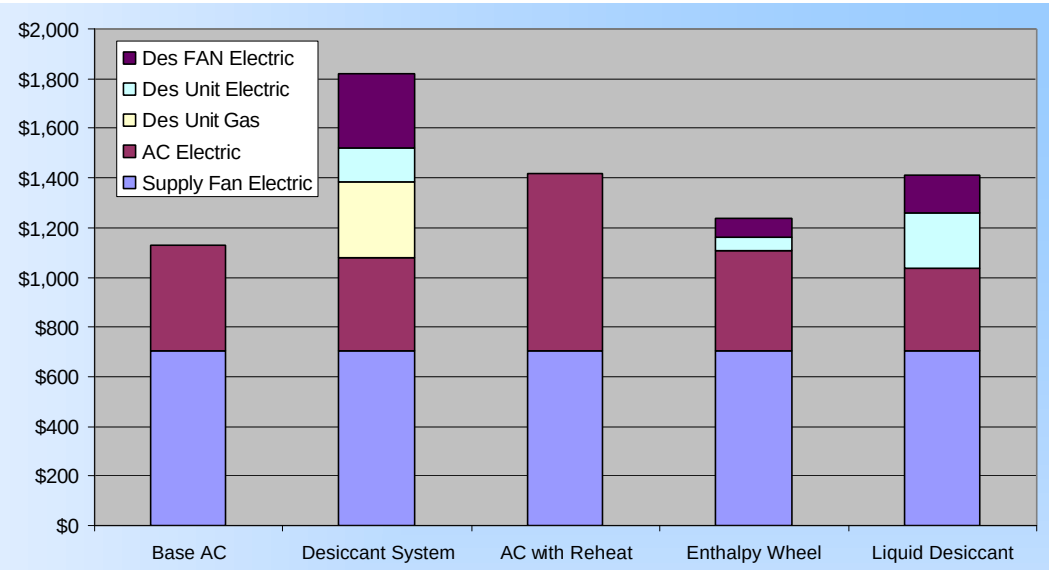
Desiccant Component Options "Inside the Box"

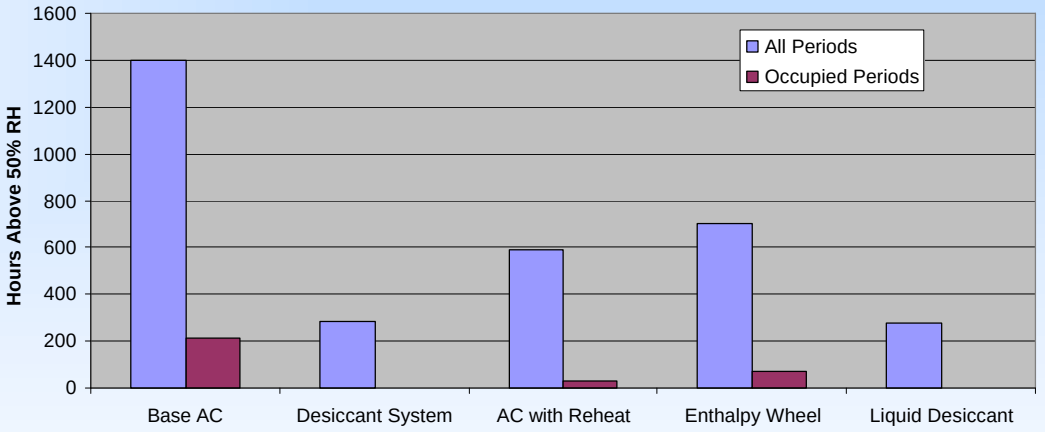
	Description	AC Electric (kWh)	Desiccant Unit			Des Fan Electric (kWh)	Annual Cost ($)
			Runtime (hrs)	Gas Use (therms) [m^3]	Electric (kWh)		
A	Desiccant & SH Whl (w/ SH Whl, Evap Clr & Post Cool)	4,941	273.8	436 [15,400]	1,898	4,342	$1,767
B	Desiccant & SH Whl - NO Evap Cooler (w/ SH Whl & Post Cool)	5,114	272.0	428 [15,110]	1,929	4,342	$1,776
C	Desiccant & Heat Pipe ***[same as System #2]*** (w/ HP, Evap Clr & Post Cool)	5,384	257.2	474 [16,740]	1,879	4,342	$1,822
D	Desiccant & Heat Pipe - NO Evap Cooler (w/ HP & Post Cool)	5,504	257.6	464 [16,400]	1,908	4,342	$1,826
E	Desiccant - Post Cooling ONLY (Run #4)	6,655	263.2	658 [23,240]	1,551	4,342	$2,007

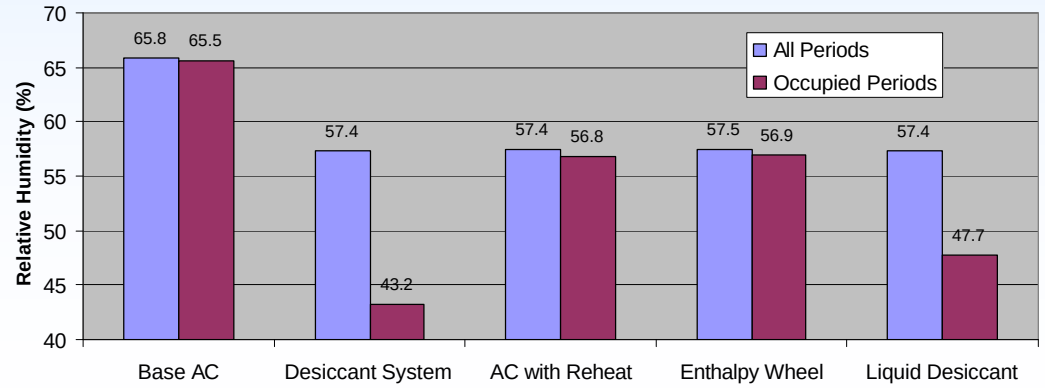
Notes:
SH Whl: Sensible Heat Wheel is 80% effective with leakage rate of 8% (heat and moisture).
HP: Heat Pipe is 60% effective with no leakage.
Evap Clr: Evaporative cooler with 92% saturation effectiveness
Post Cool: cooling DX coil is 5 tons [17 kW] with nominal EER of 10.5 Btu/Wh [3.1 W/W] and SHR of 0.80.
Costs based on $0.07/kWh and $0.65/therm. Costs do not include heating costs
Desiccant Wheel: DesiCalc algorithm for wheel with 75%/25% process/regen spilt

Comparing Alternative Systems

- AC with “free” reheat has lower costs
- Enthalpy wheel costs are lowest but with modest humidity control
- Compressor-based liquid desiccant provides better control at lower cost







Summary

- Developed a model in TRNSYS/TRNSED with simple user interface aimed at limited audience
- Used model to confirm impact of desiccants at field test site in Olathe, KS
  - Desiccant unit as installed had 61% operating cost premium over base AC
  - Some desiccant system components shown to have marginal benefits
  - Installing desiccant unit in recirculation mode had lower operating costs (less efficient → more gas use, but less fan power)
- Model is flexible; can consider new, emerging desiccant systems