ENERGY SYSTEMS LABORATORY
TEXAS A&M ENGINEERING EXPERIMENT STATION

OPTIMIZATION CONTROL STRATEGY FOR AN AIR HANDLING UNIT WITH DEDICATED ROTARY DESICCANT DEHUMIDIFICATION WHEEL IN HOT & HUMID CLIMATE

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October 8, 2013

Outline

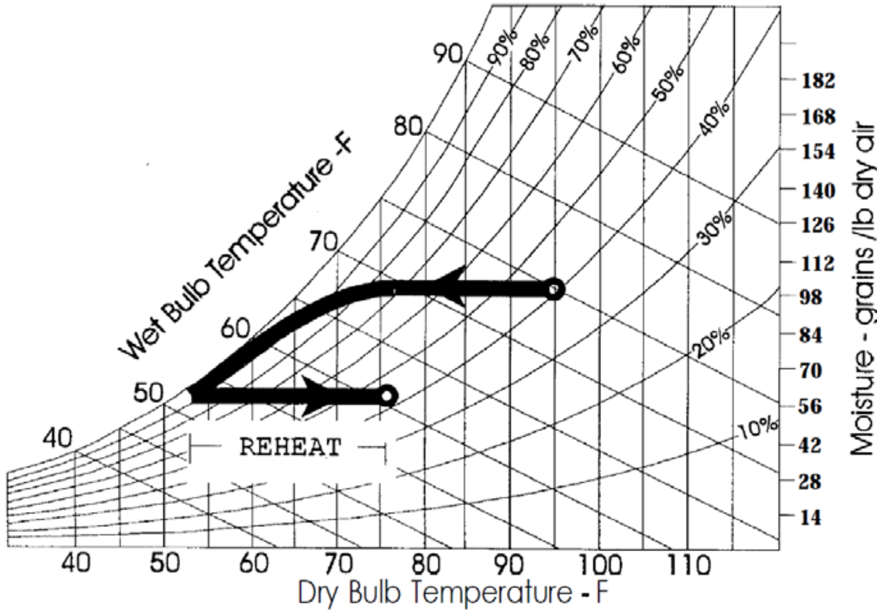
- Background
- Introduction of desiccant dehumidification process
- Mathematical modeling
- Case study systems
- Results and discussion
- Conclusion

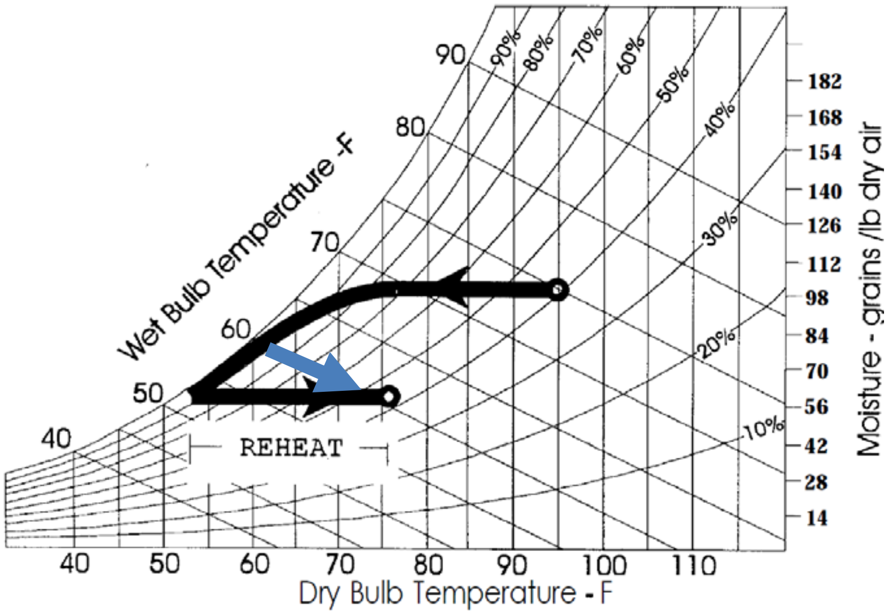
Background

- A new Elementary school was constructed and commissioning during the summer of 2012
- Located in Houston, Texas, USA (hot and humid weather)
- Desiccant dehumidification based Humidity Control Units (HCU), a variable primary flow chilled water system, etc. New technologies are implemented to improve system efficiency.
- However, the actual energy consumption is higher than expectation.
- This paper study the optimization control strategy for HCUs

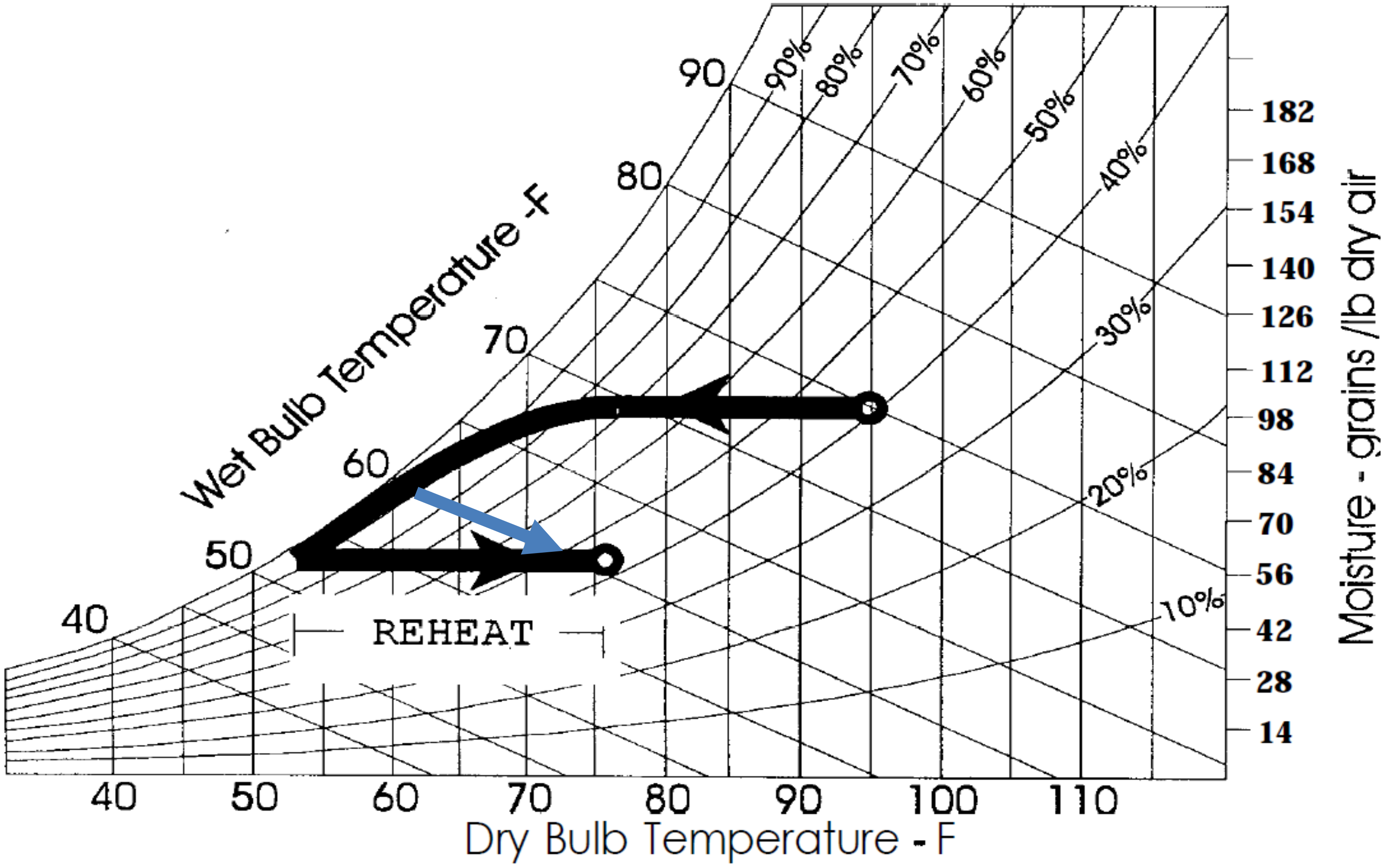
Introduction of two type dehumidification process

1. Cooling the air below its dew point and removing moisture by condensation
2. Sorption by a desiccant material



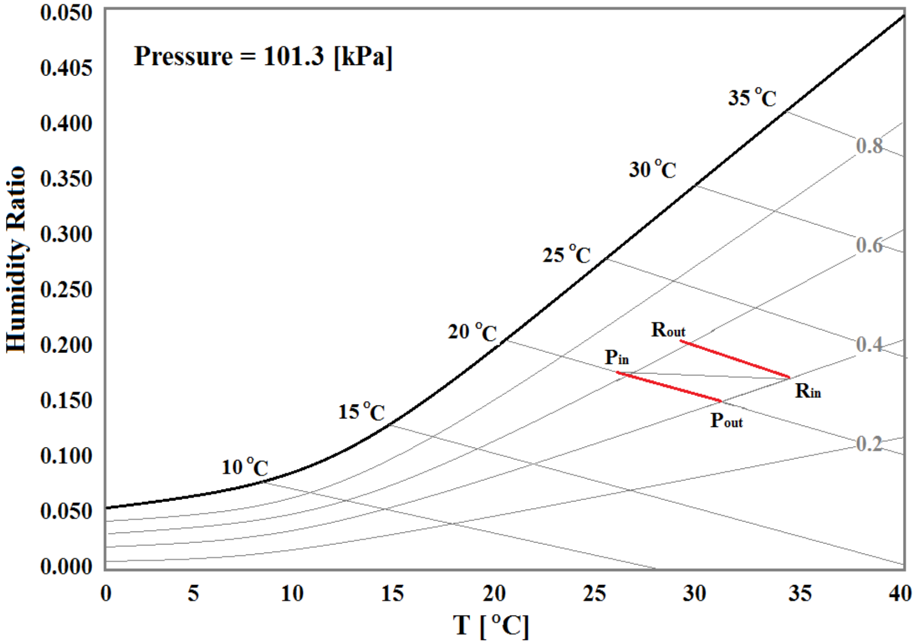


Simplified Example

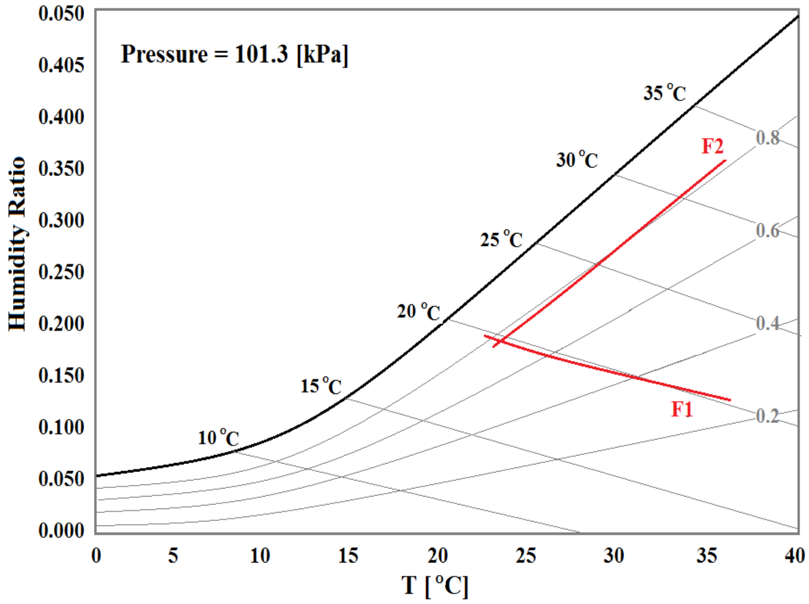


MATHEMATICAL MODELING

Ideal process of absorption



Isopotential lines (F1 and F2)



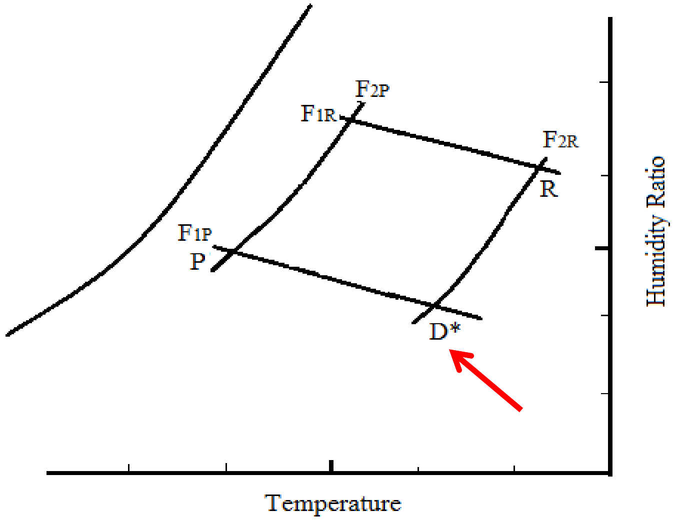
To account for the wave front propagation through the desiccant matrix. Howe [1983] and Jurinak [1982]. Two potential functions (F1, F2)

$$F1 = \frac{-2865}{T^{1.490}} + 4.344\omega^{0.8624}$$

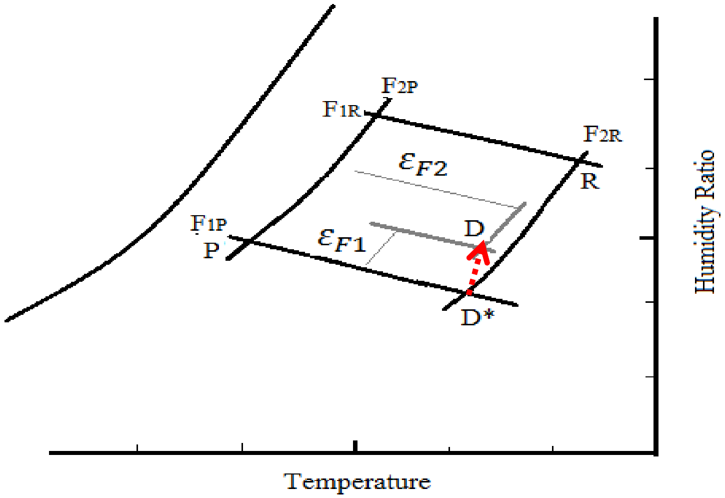
$$F2 = \frac{T^{1.490}}{6360} - 1.127\omega^{0.07969}$$

MATHEMATICAL MODELING

Desiccant dehumidification process (F1,F2)



Actual process of desiccant dehumidification



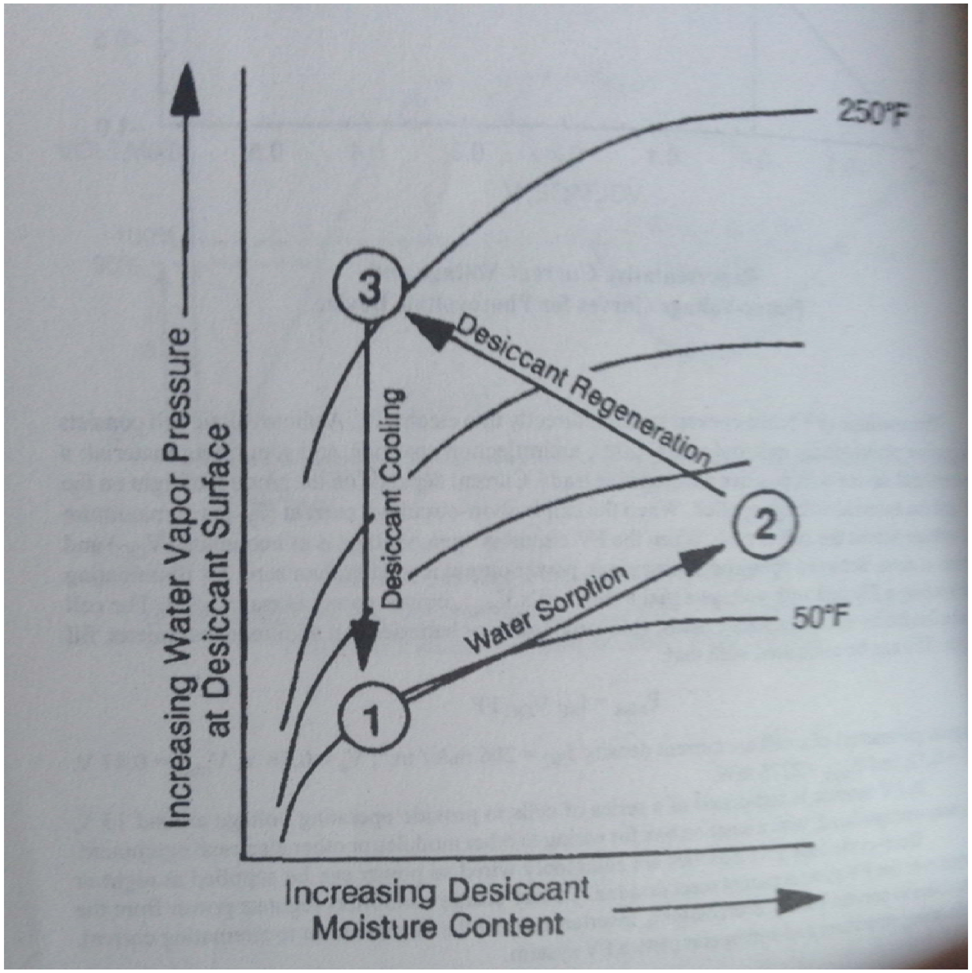
The F1 and F2 isopotential lines are further modified for non-idealities in the system by the use of two effectiveness values ε_{F1} and ε_{F2}

[Schultz, K.J., 1983]

$$\varepsilon_{F1} = \frac{F1_D - F1_P}{F1_R - F1_P}$$

$$\varepsilon_{F2} = \frac{F2_D - F2_P}{F2_R - F2_P}$$

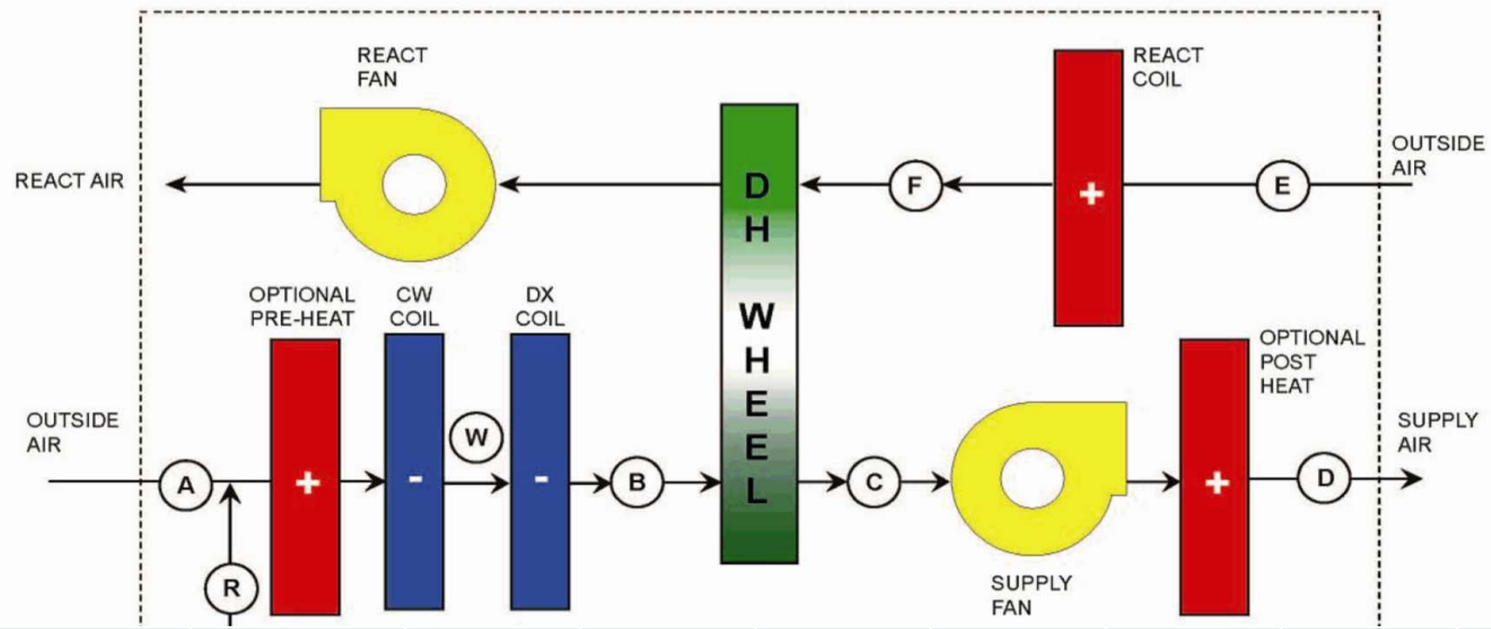
Desiccant Sorption Process



Model calibration

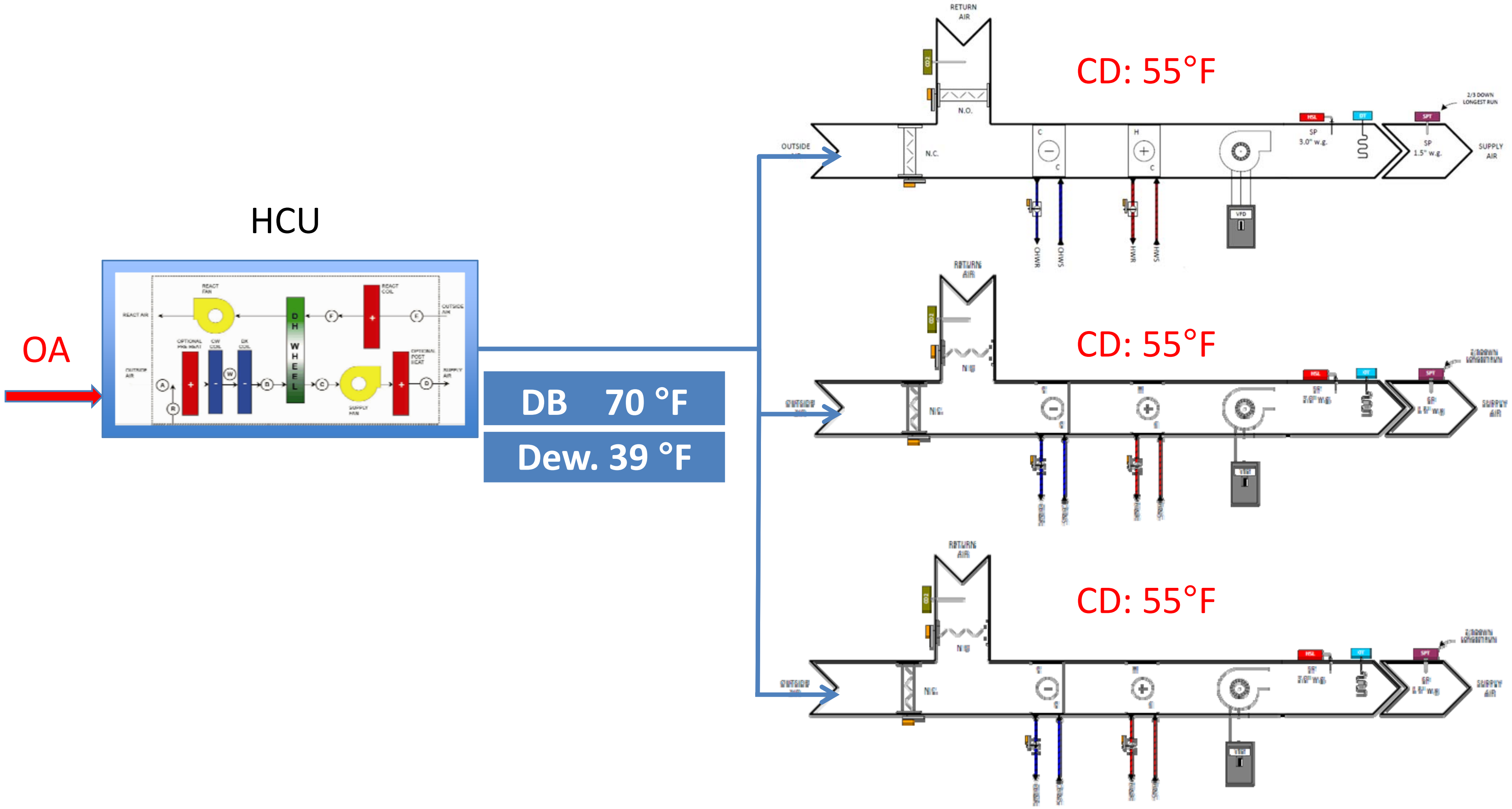
	HCU1		HCU2	
	DB(°F)	WB(°F)	DB(°F)	WB(°F)
Inlet	52	52	50	50
Design outlet	70	54.9	69	53.2
Model outlet	70.7	55.1	69.7	53.5
Error	**0.94%**	**0.42%**	**1.03%**	**0.47%**

DESCRIPTION OF DEDICATED HUMIDITY CONTROL UNITS (HCU)



Run# 1 DESIGN		R	A	W	B	C	D	E
Summer	SCFM	0	8750	8750	8750	8750	8750	8278
	DB (°F)		83	60	50	69	70	83
	WB (°F)		79.3	59.5	50	53.2	53.7	79.3
	GR/LB		147	76	54	35	35	147

Diagram of the AHUs system



HCU

OA

DB 70 °F

Dew. 39 °F

CD: 55°F

CD: 55°F

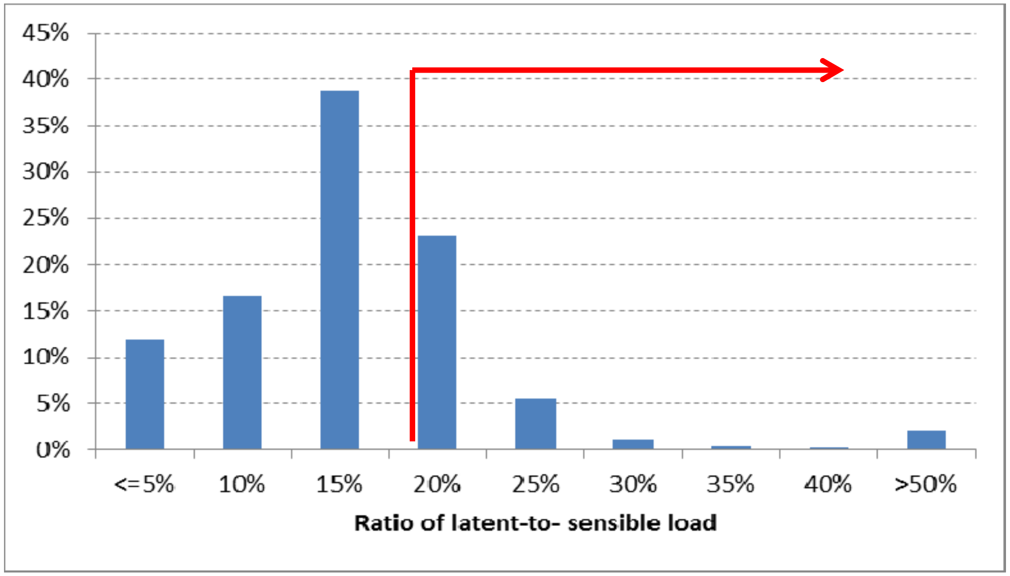
CD: 55°F

SIMULATION MODEL PARAMETERS

Parameters	Value	Unit
The lighting load	0.93	W/ft^2
The internal electrical equipment load	1.4	W/ft^2
Zone floor area per person	110	ft^2/Person
Sensible heat load of people	270	Btu/hr/person
Latent load of people	180	Btu/hr/person
U value for exterior window	0.34	Btu/hr-ft^2
U valve for exterior wall	0.062	Btu/hr-ft^2
Maximum supply air flow rate	1.0	CFM/ft^2
Minimum OA flow rate	0.3	CFM/ft^2
Cooling set point	75	°F
Heating set point	70	°F

RESULTS AND DISCUSSION

Building Load Analysis

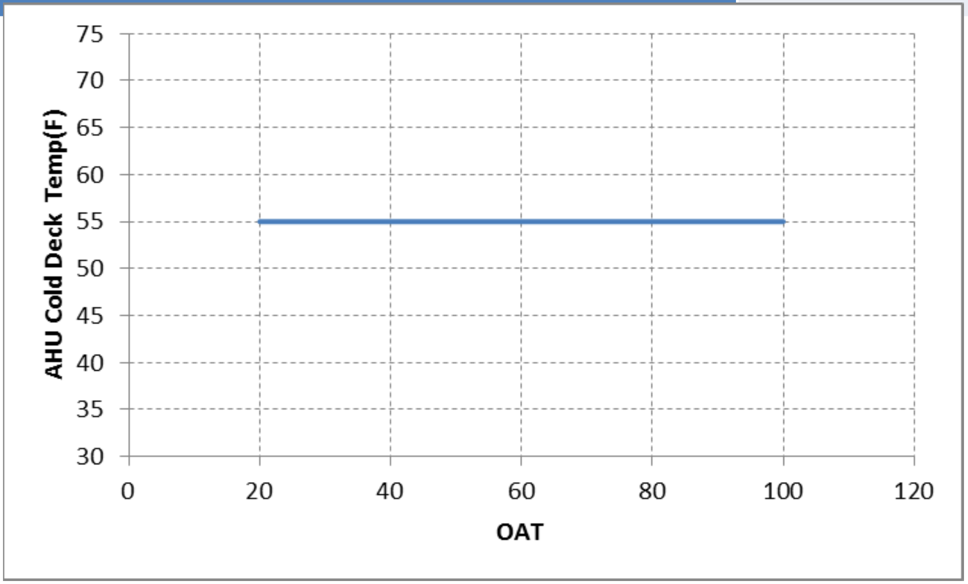


Frequency of latent-to-sensible ratio

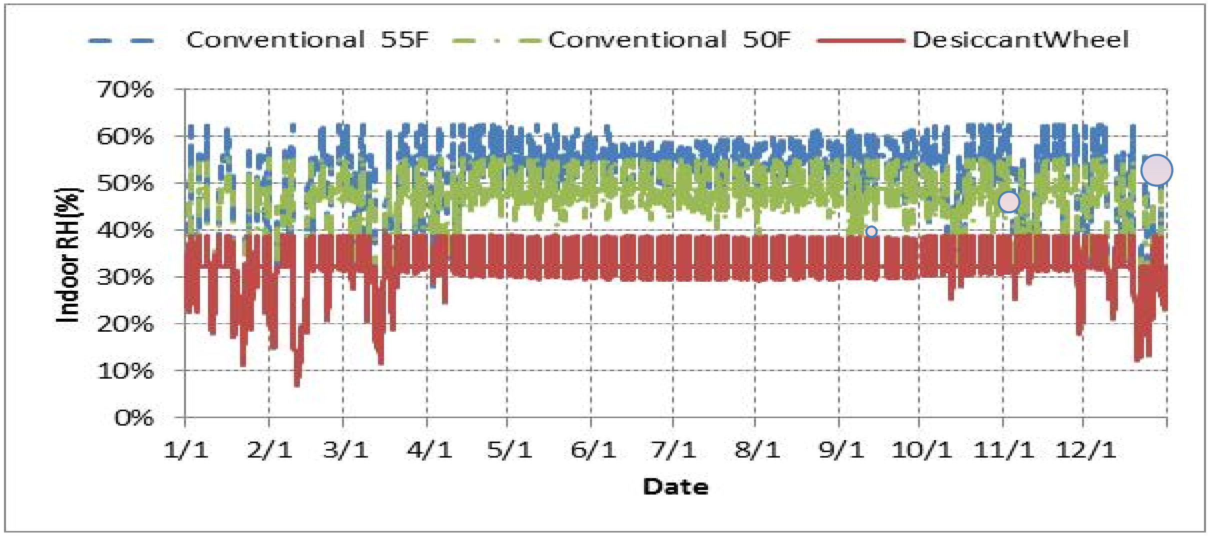
The desiccant dehumidify system will benefit from higher latent load ratio period

Existing Control Sequence

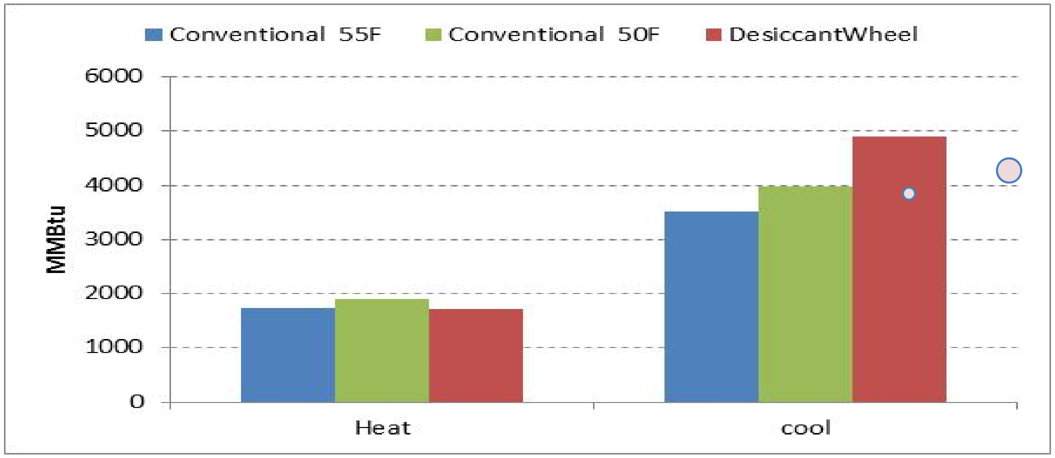
HCU Set Points	Existing
Dx coil set point (°F)	50
Humidity ratio set point (lb/lb)	0.005



Space RH and Energy consumption Under Existing Control Sequence



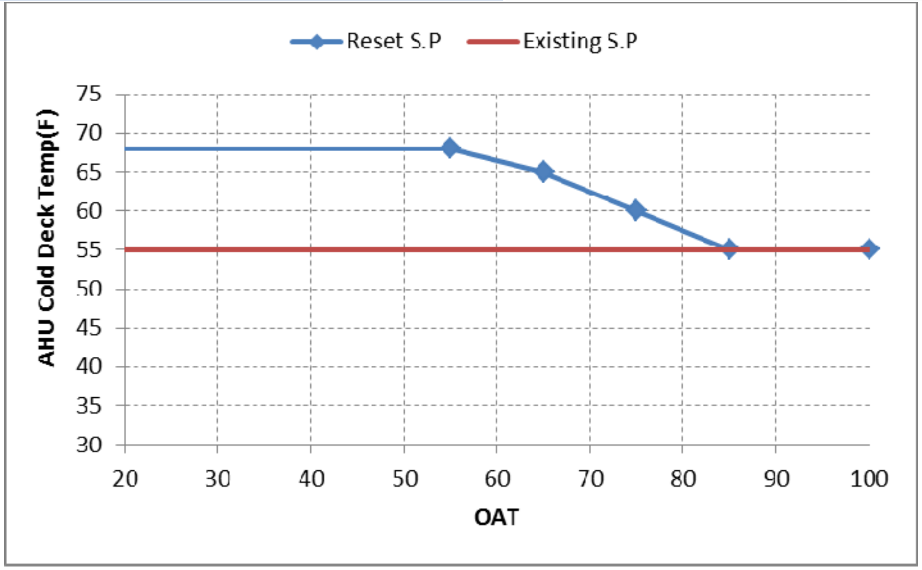
Drier space



However, higher energy consumption

New Control Sequence

HCU Set Points	Existing	New
Dx coil set point (°F)	50	55
Humidity ratio set point (lb/lb)	0.005	0.006



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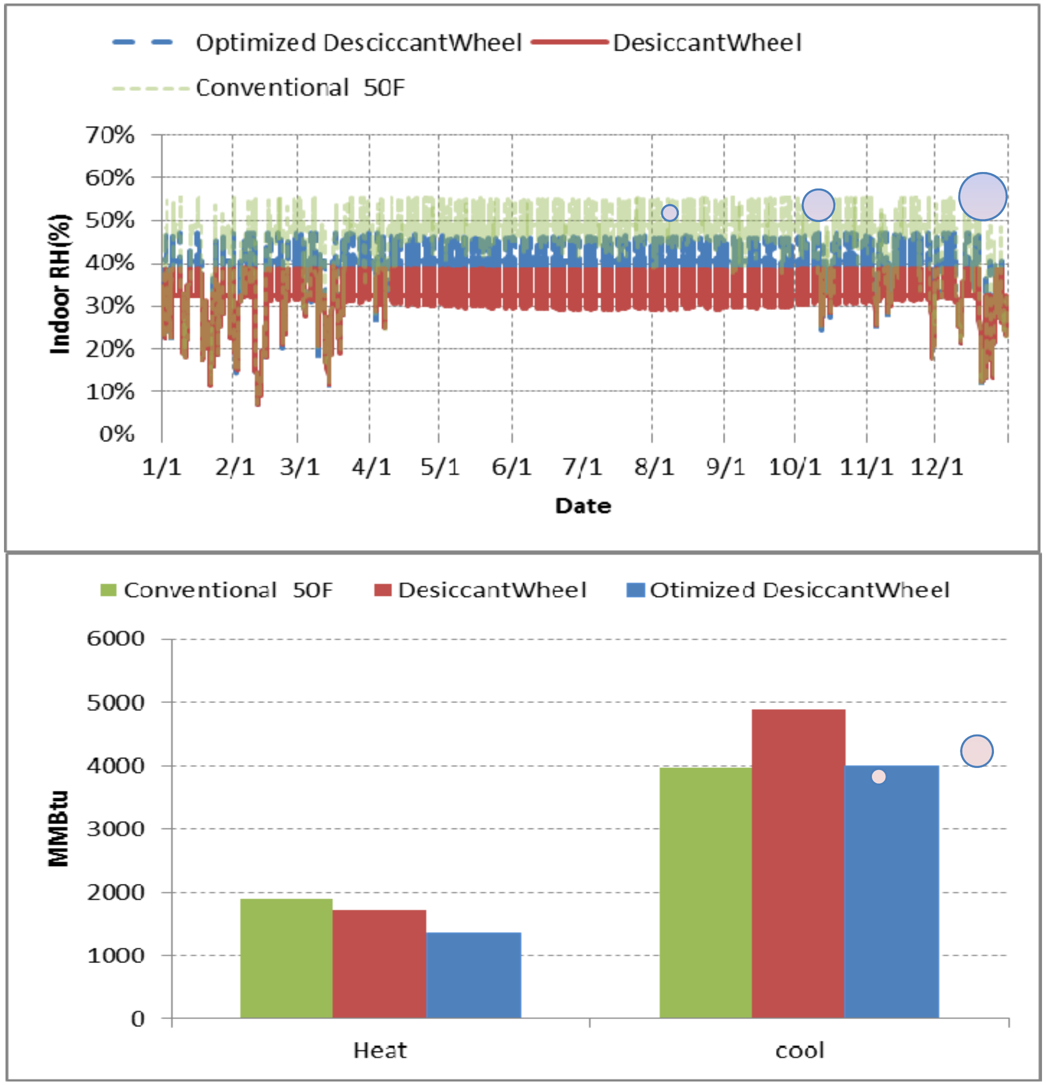
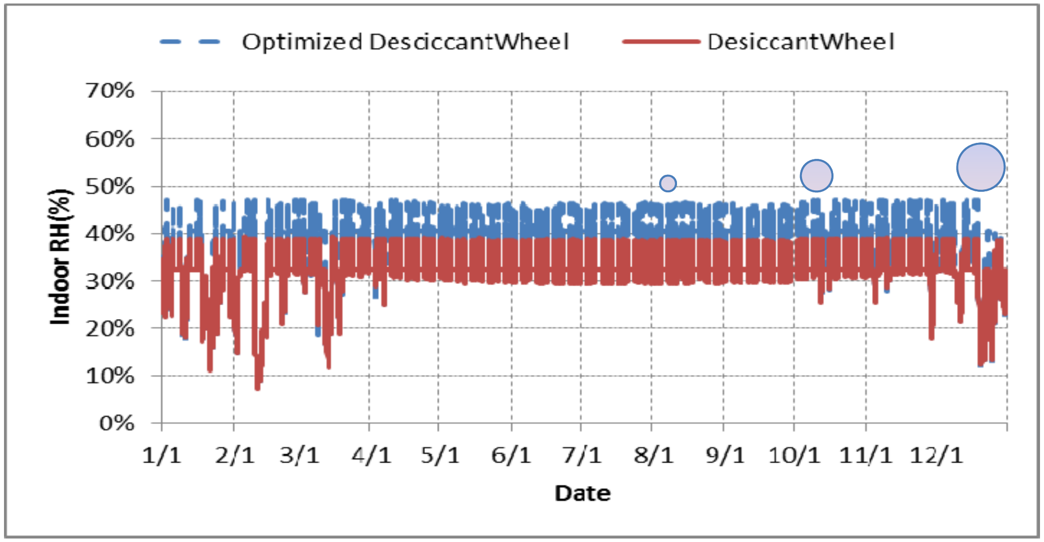
Space RH and Energy consumption Under New Control Sequence



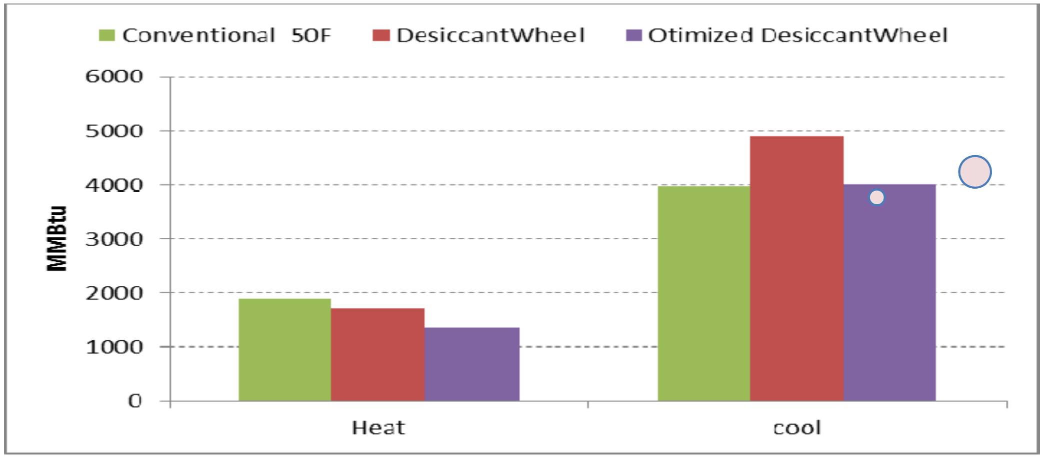
Still maintain in comfortable zone

Less Energy Consumption

Space RH and Energy consumption Under New Control Sequence



Still maintain in comfortable zone



Less Energy Consumption

Conclusion

- The existing AHU control sequence could not take advantage of the low humidity ratio of makeup air.
- The existing control sequence of HCUs and AHUs could provide a drier indoor environment, but the energy consumption is higher than a conventional pretreated outside air unit.

Conclusion

- The new control sequence only slightly increases the space RH from 40% to 45%. However, it can significantly reduce CHW and HHW energy consumption about 18% and 21%, respectively
- The above conclusion is only applied to the simulated building load profile. Once the building load profile is changed, the proposed control sequence needs to be revised to suit for new application.

Thanks