Applying Desiccant Based Systems to Satisfy ASHRAE Standard 62 and 90.1 Requirements

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Presentation Overview

- Why worry about Indoor Air Quality ?
- ASHRAE guidance: Standards 62 and 90.1
- Background on Desiccant Technologies
- DOE Investigation of IAQ in School Facilities Incorporating Desiccant Systems
- DOE Restaurant Pilot Site of New Active Desiccant System

Why IAQ is Important

- Health of Occupants
- Perception – Comfort, Satisfaction with the Indoor Environment
- Worker Productivity
- Sound Economics !

Health Effects Associated with Building IAQ

Health Effect	Affected Annually (U.S.)
Environmental Tobacco Smoke Deaths	45,000
Cancer Deaths Due to Radon	13,000
Communicable Respiratory Infections	260 million
Allergies	50 million
Asthma	16 Million
Sick Building Symptoms (23% of all office workers and teachers)	16 million

Source: Lawrence Berkeley National Laboratory Investigation

Economic Impact of Common Respiratory Illnesses in the U.S.

- 180 million lost work days including 120 million additional days of restricted activity
- Health care costs estimated at $36 billion annually ($140/person)
- Total cost estimate $70 billion

Source: Lawrence Berkeley National Laboratory Investigation

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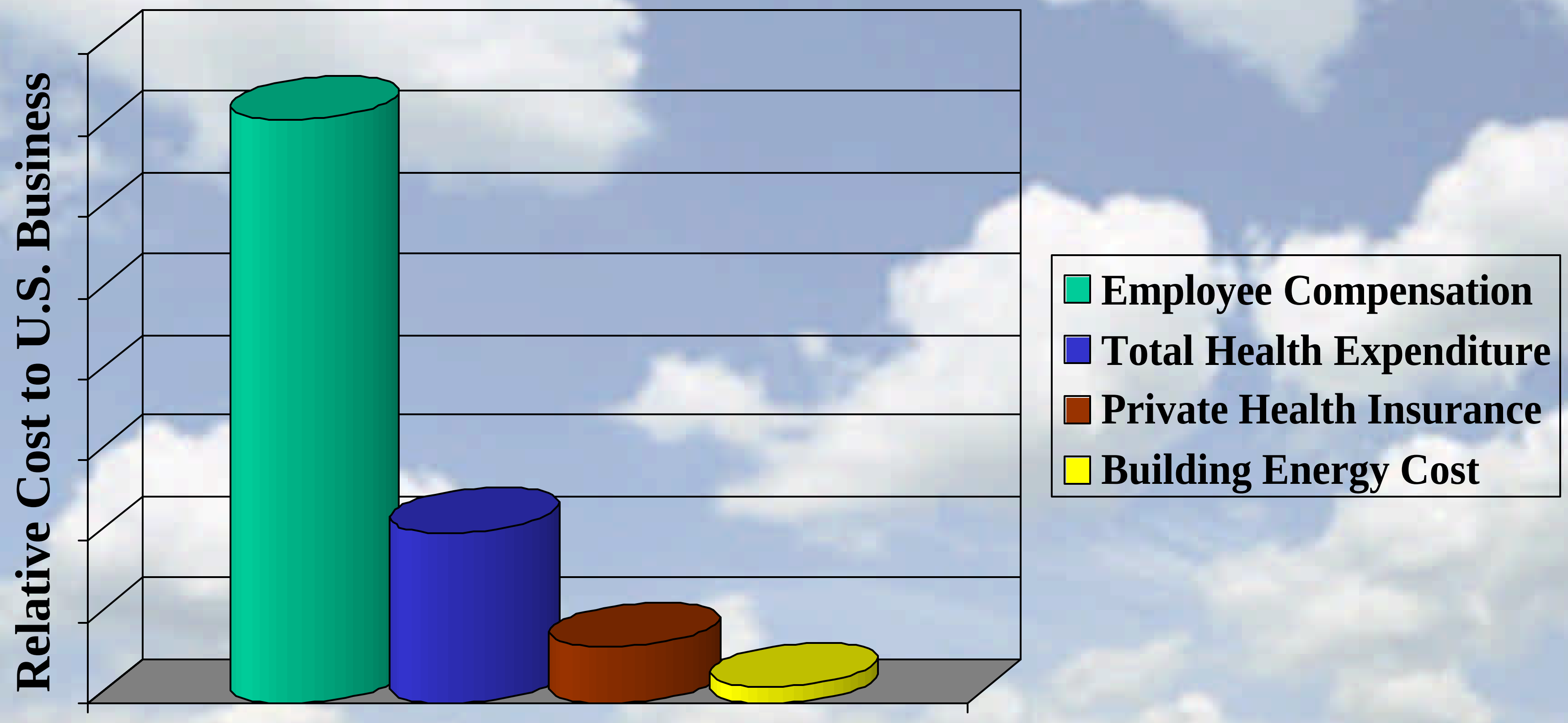
Ventilation Rate vs. Productivity

- Solving addition problems, typing and proof reading were all evaluated as a function of ventilation rate
- Ventilation rates of 7.5, 20 and 60 cfm/person were evaluated for each task
- Productivity increased an average of 5% going from 7.5 to 20, and 7.5% from 7.5 to 60 cfm/person for the three tasks investigated

Source: Wargocki et.al., ASHRAE Indoor Air 2002

The Clear Economic Justification for Providing Good IAQ



Source: Lawrence Berkeley National Laboratory Investigation

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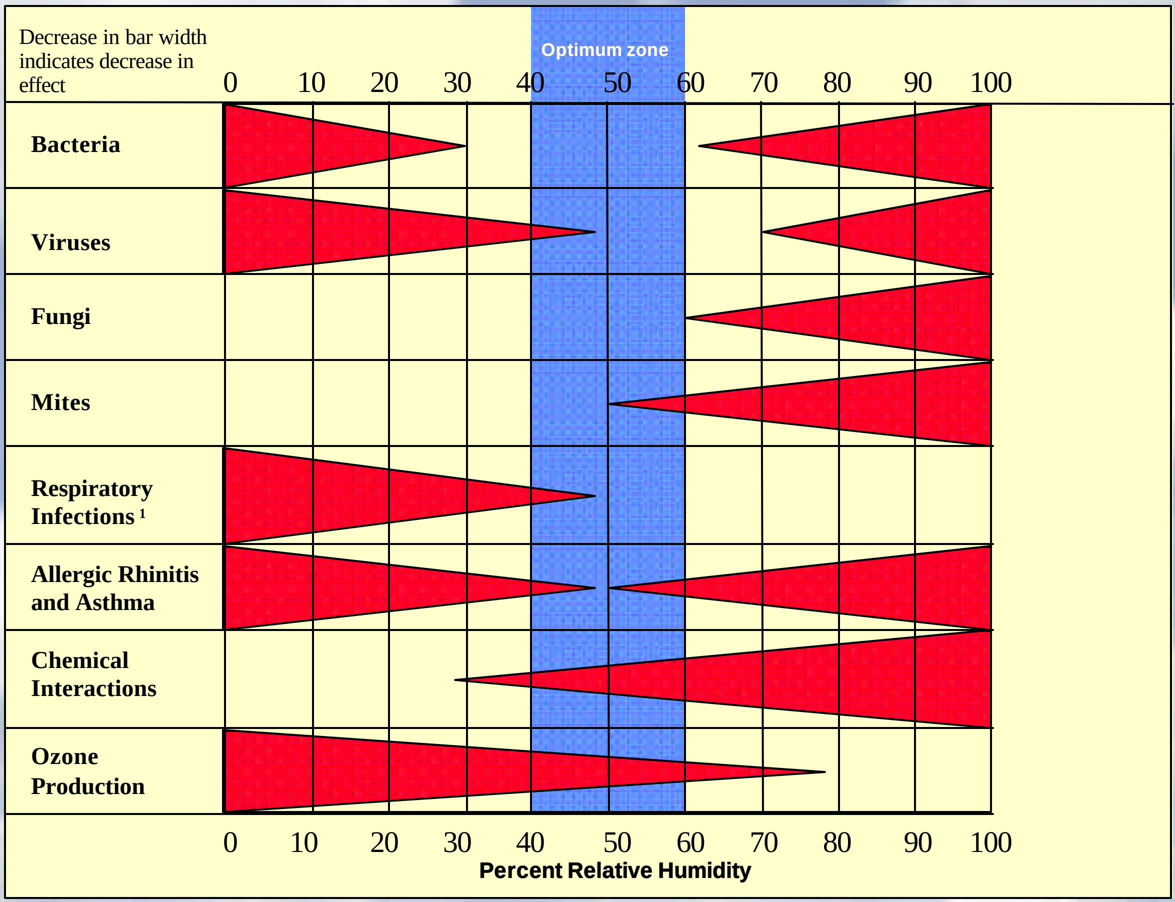
ASHRAE Guidance: Standard 62

- Promotes acceptable IAQ through recommended ventilation rates, space humidity levels and filtration
- VAV systems require multiple space equation “Z factor” to ensure adequate ventilation to all spaces
- Packaged equipment challenged by outdoor air percentages greater than 15% and the need to provide ventilation air continuously

Optimum Relative Humidity Ranges For Minimizing Adverse Health Effects



SOURCE: Theodor D. Sterling and Associates, Ltd., Vancouver, B.C.

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Packaged Equipment and Continuous Outdoor Air

- Moisture condenses on cooling coil surfaces
- When coil (or compressor) is deactivated wet surfaces are exposed to the air stream
- Moisture evaporates back into air stream as the fan continues to run
- Net effect: less moisture removal & higher space humidity levels

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ASHRAE Standard 90.1-1999 Compliance

- Air systems handling more than 5,000 cfm and with an outdoor air percentage greater than 70% must incorporate total energy recovery with an efficiency level of at least 50% (section 6.3.6.1)
- Reheating for humidity control is prohibited unless at least 75% of the reheat energy is provided from a site recovered energy source (section 6.3.2.3)

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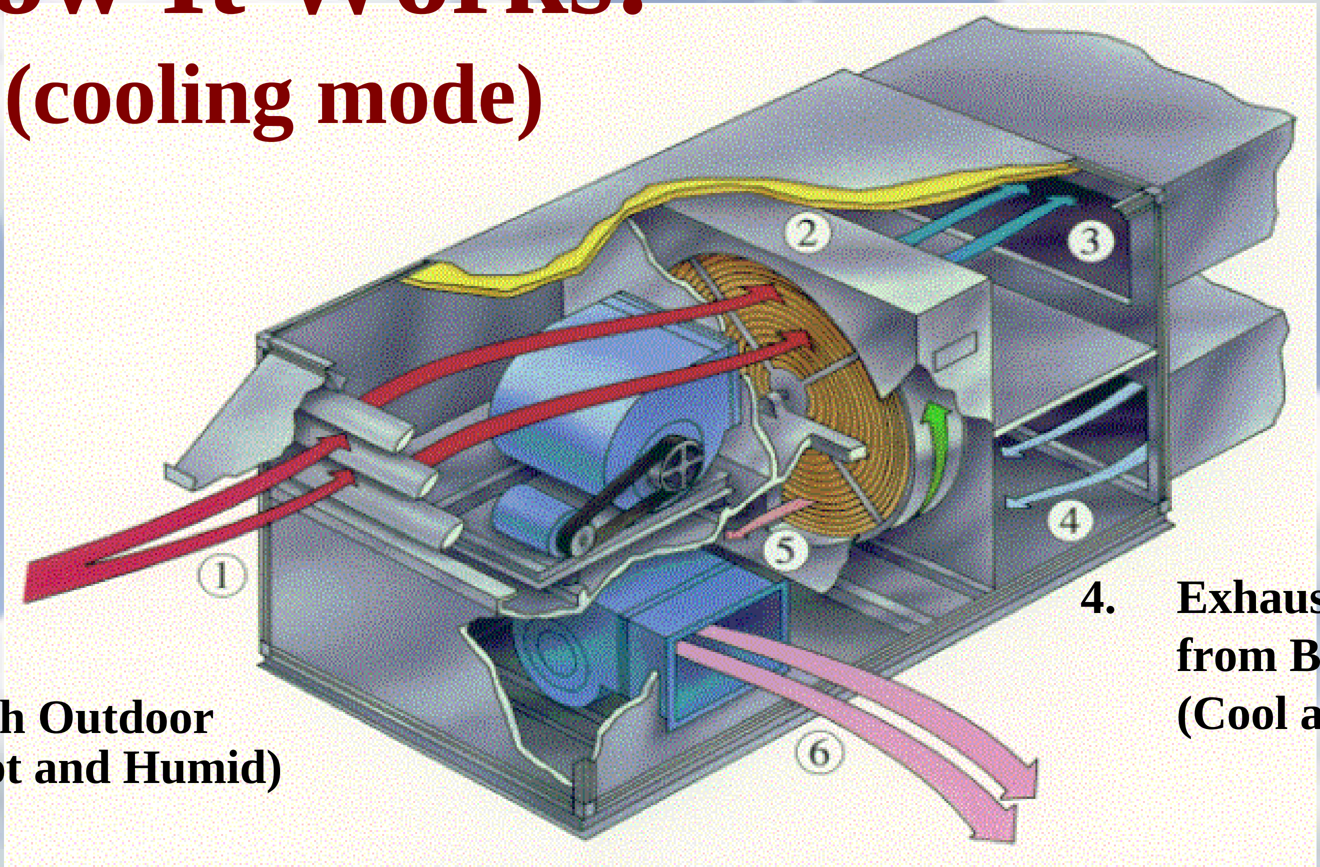
How It Works:
(cooling mode)

3. Outdoor Air to Building (Cooled and Dehumidified)



1. Fresh Outdoor Air (Hot and Humid)

4. Exhaust Air from Building (Cool and Dry)

6. Exhaust Air to Outdoors (Heated and Humidified)

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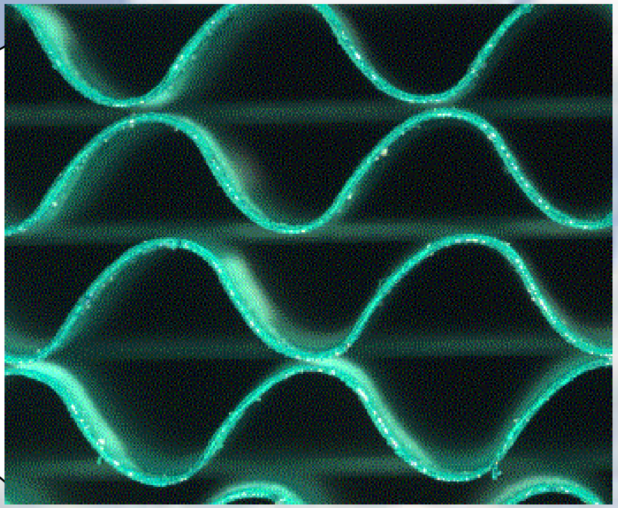
Total Energy Recovery Wheel

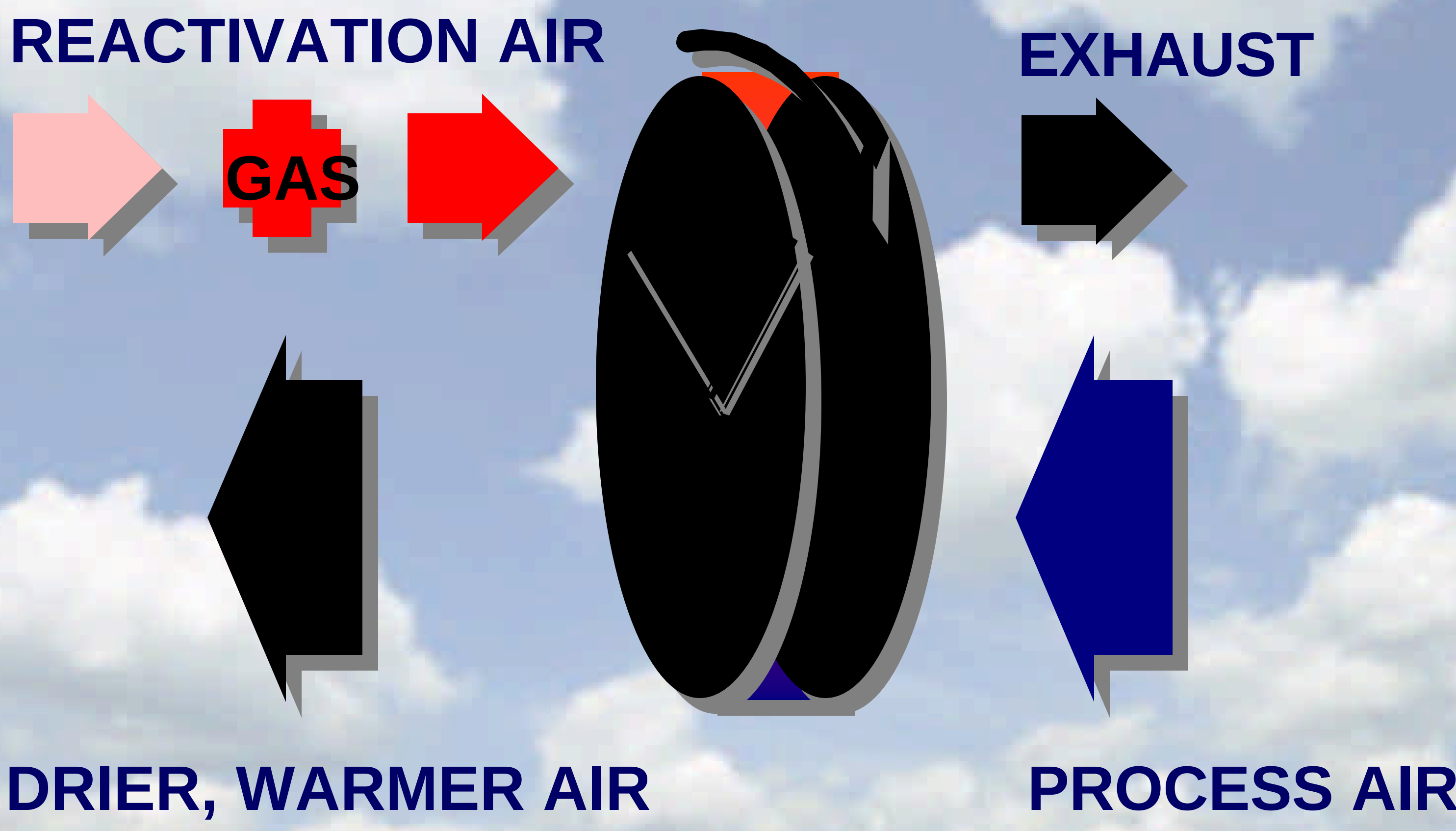
- The SEMCO total energy recovers sensible (temperature) and latent (moisture) energy by up to 85%.



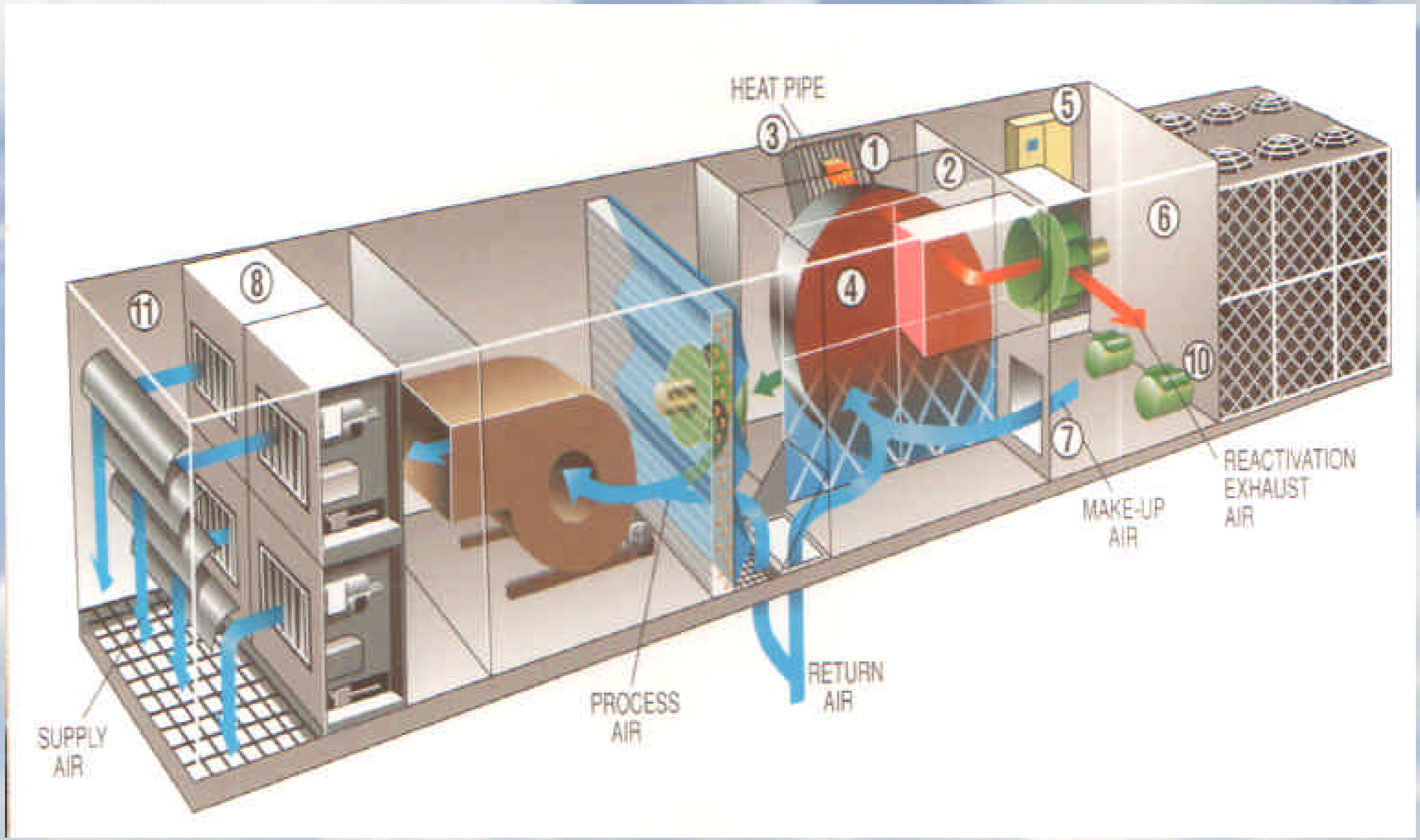
Advantages and Limitations of *Passive* Desiccant Wheels

- Advantages
  - Low-cost add-ons now available for low-cost rooftops
  - Significant reduction in peak load (demand) and energy consumption in both the heating and cooling seasons
  - Can reduce net installed cost of both heating and cooling equipment - big savings
  - ALWAYS the best option if a return air path exists
- Limitations
  - Exhaust must be brought back to ventilation air

Active Desiccant Wheel



Commercial Active Desiccant Systems



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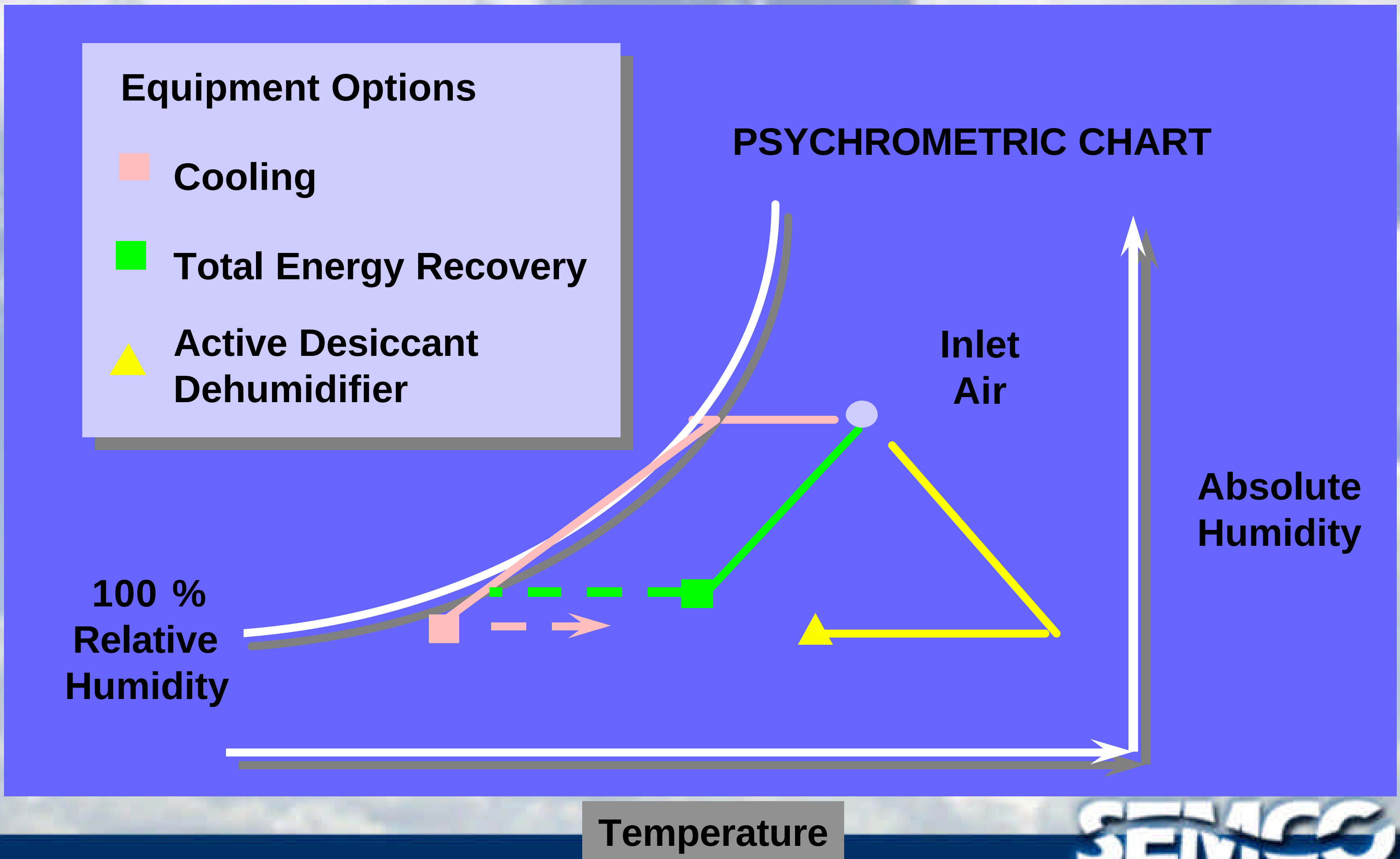
Advantages and Limitations of *Active* Desiccants

- Advantages
  - Tremendous DH capacity - at any dew point
  - Uses low-cost energy - gas or waste heat
  - Does not need exhaust air
- Limitations
  - Relatively high equipment cost/cfm
  - Converts water vapor to heat – significant post cooling required

Psychrometric Processes



Department of Energy Sponsored IAQ/Humidity Control Research Study of School Facilities

- Largest study ever completed
- Two year duration
- Ten Schools Investigated
- Continuous monitoring

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Hypothesis Regarding School IAQ:

"Most IAQ problems in schools result from inadequate ventilation and/or lack of effective humidity control."

- Parallels:
  - NIOSH buildings & Armstrong National Labs studies
  - SEMCO's actual field experience (100+ projects)
  - ASHRAE 62-89 recommendations

Key Findings DOE School Study:

- Outdoor air ventilation key to IAQ, comfort and thereby the learning process (chemical and microbial/bacteriological contaminants)
- Filter maintenance kills IAQ with conventional systems, compromises outdoor air cfm/student. Simplifying filter maintenance is critical.
- Air balancing and classroom over-crowding (common) further compromises OA cfm/student
- Often only 8-10 cfm/student is recognized despite a design for 15 cfm/student

Key Findings (2):

- Many hours with high latent and low sensible loads (part load conditions) creates problems for conventional approaches
- More latent that previously thought based on research (12-20 grain delta on outdoor air volume)
- Humidity spikes in morning and afternoon as students enter and leave the building
- Many teachers set thermostats low (ie. 68-70 degrees) since “students feel & learn better”

Key Findings (3):

- Supplying low dewpoint air (< 50 degrees) is required to maintain space relative humidity at 50%
- Unoccupied mode to control humidity is essential due to high percentage of unoccupied hours
- TERS was found to provide the best IAQ, humidity control and energy efficiency.

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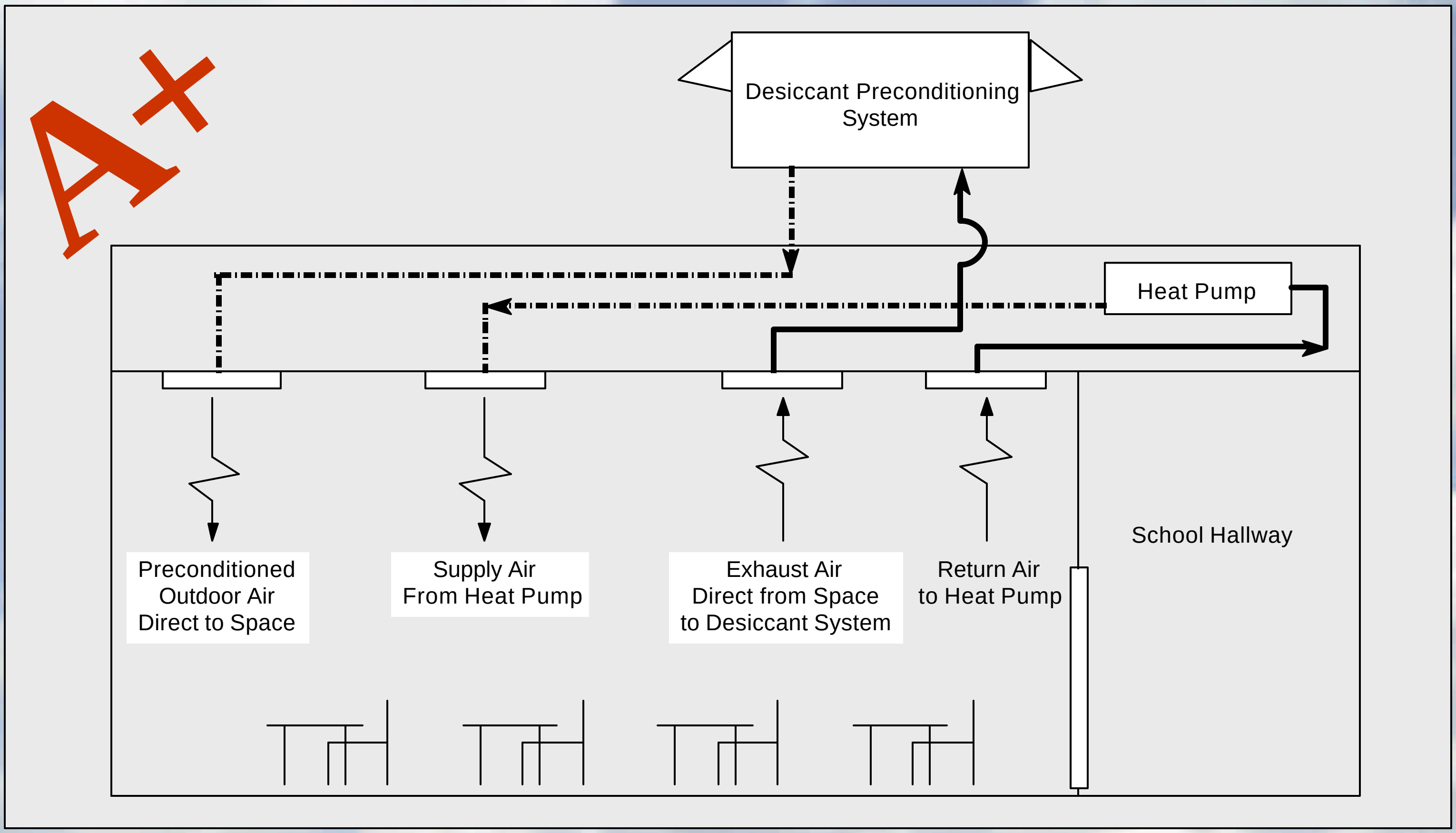
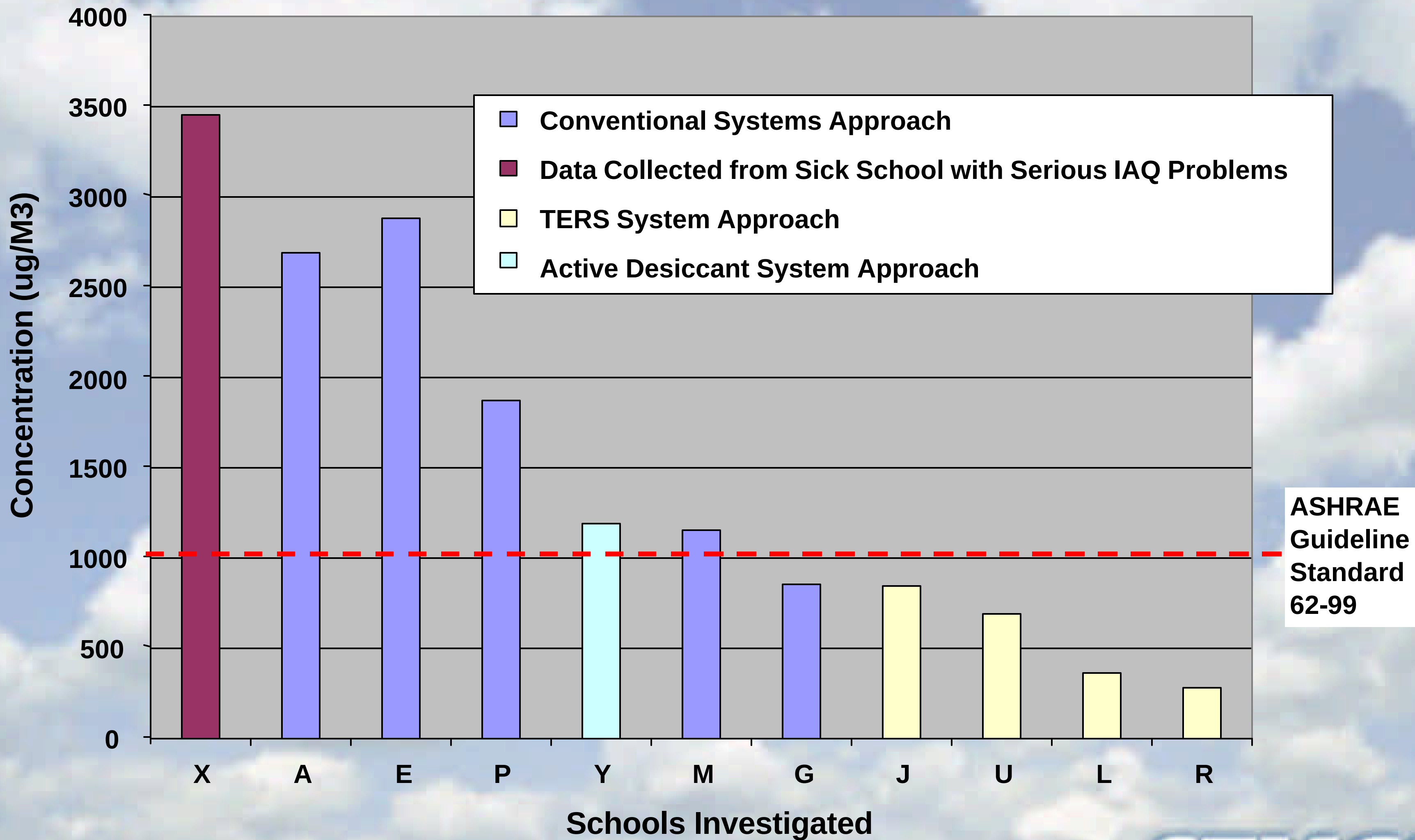
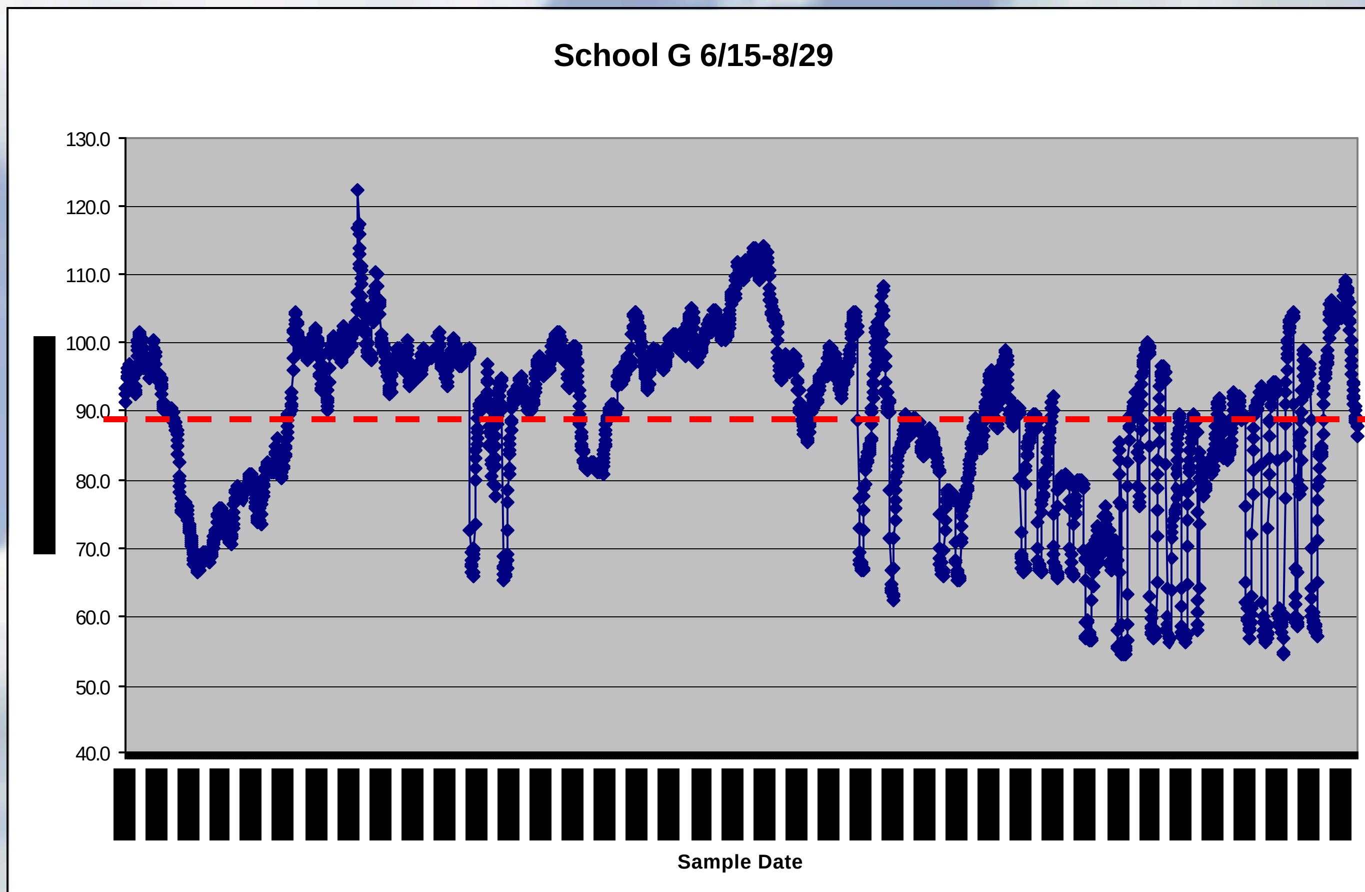
Preconditioned Outdoor Air Ducted Directly to Space



Peak VOC Level vs. System Approach



Humidity Control Conventional School: Most Hours Over Dewpoint Limit



Source: DOE Schools Investigation

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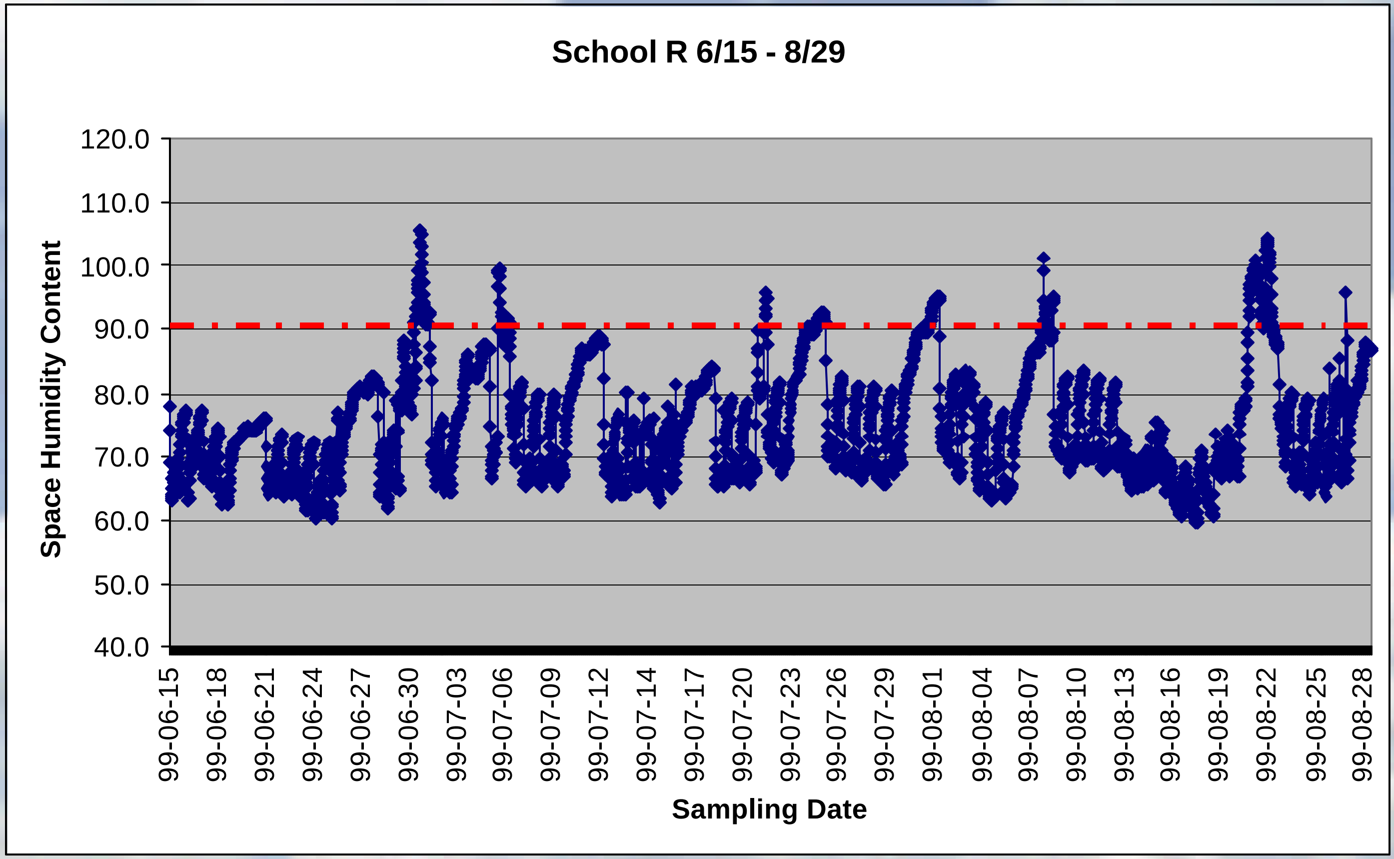
Humidity Control TERS System: Very Few Hours Over Dewpoint Limit

(only when cycled off)



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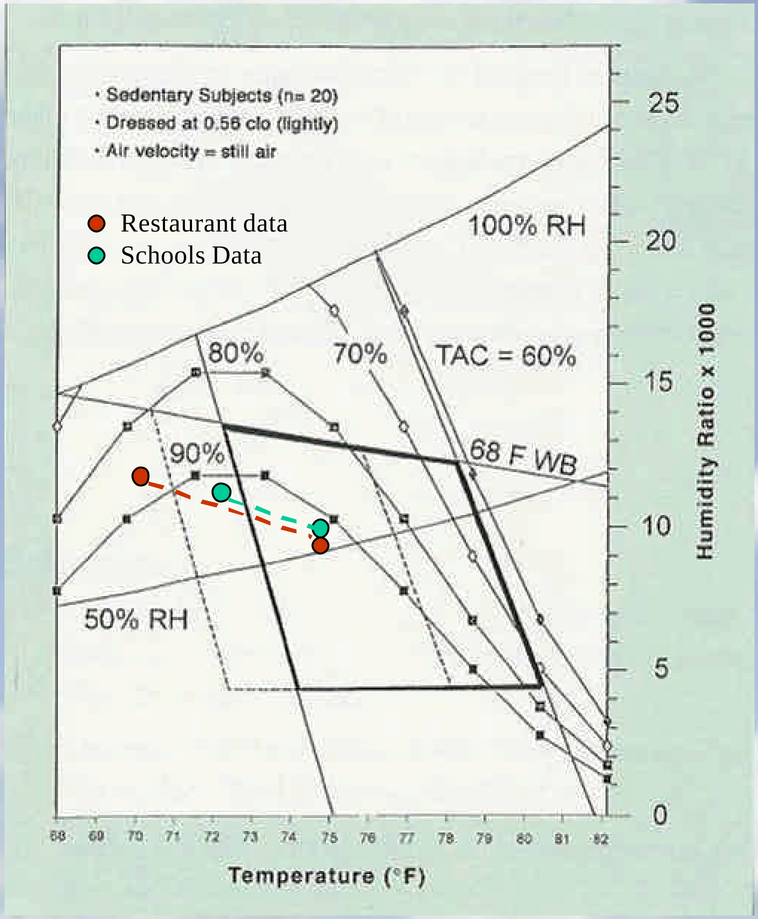
DOE Field Data Supports Comfort Research



- Comfort influenced by temperature and vapor pressure (dewpoint)
- Two year school investigation findings: 72.5^{o}/64% vs. 75^{o}/53%
- Restaurant investigation findings: 70^{o}/75% vs 75^{o}/50%
- Trend shows to achieve comfort, the supply temperature will be dropped .65o/Degree dewpoint or .2 degrees/% RH
- Trend agrees well with ASHRAE Humidity Handbook

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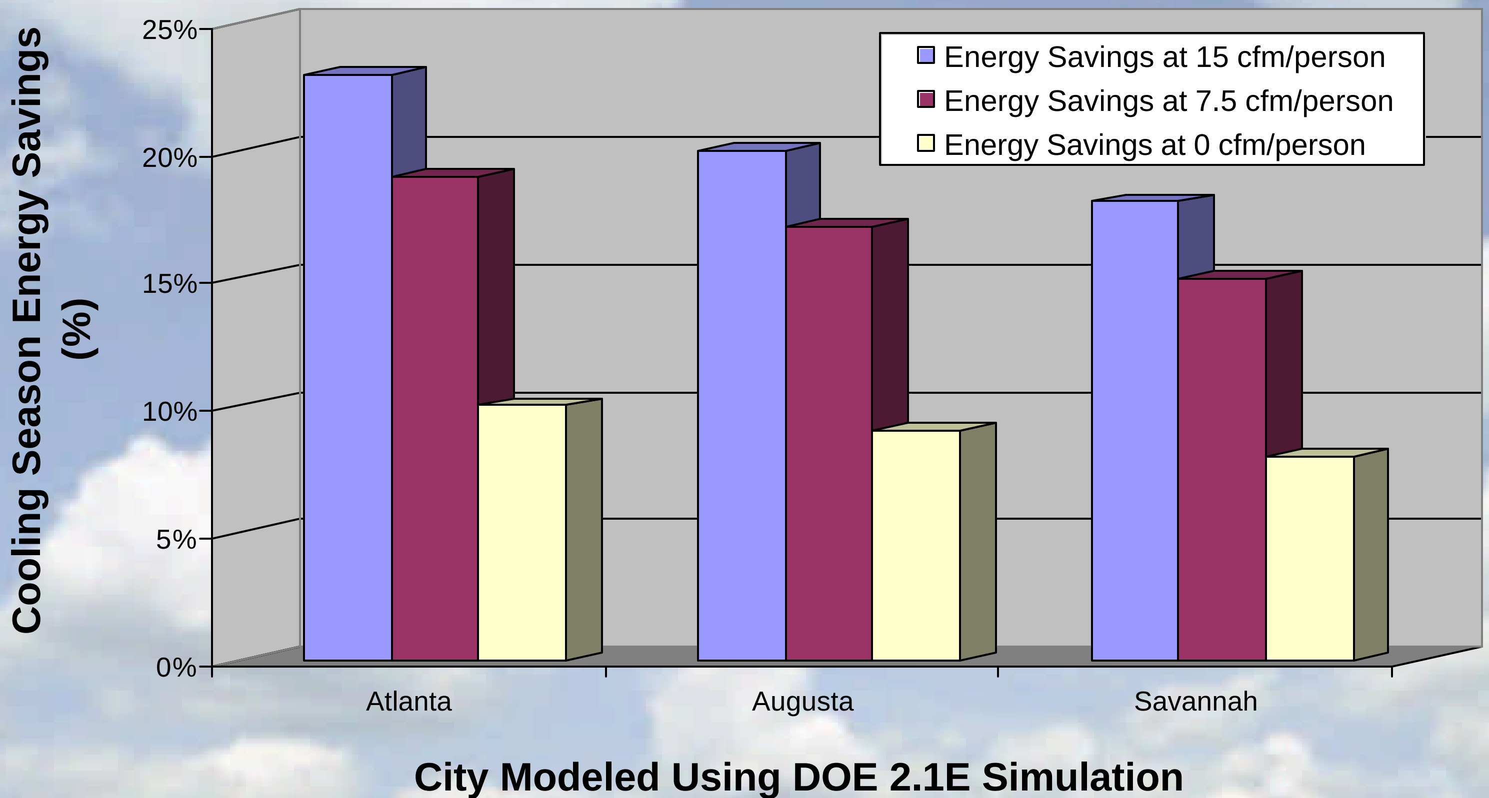
Energy Savings with 2º Rise in Space Setpoint Temperature



DOE Restaurant Pilot Site
Active Desiccant Module (ADM)

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Current Restaurant HVAC Designs Typically Provide Too Much Sensible and Too Little Latent Capacity

McDonald's Analysis: Base Design

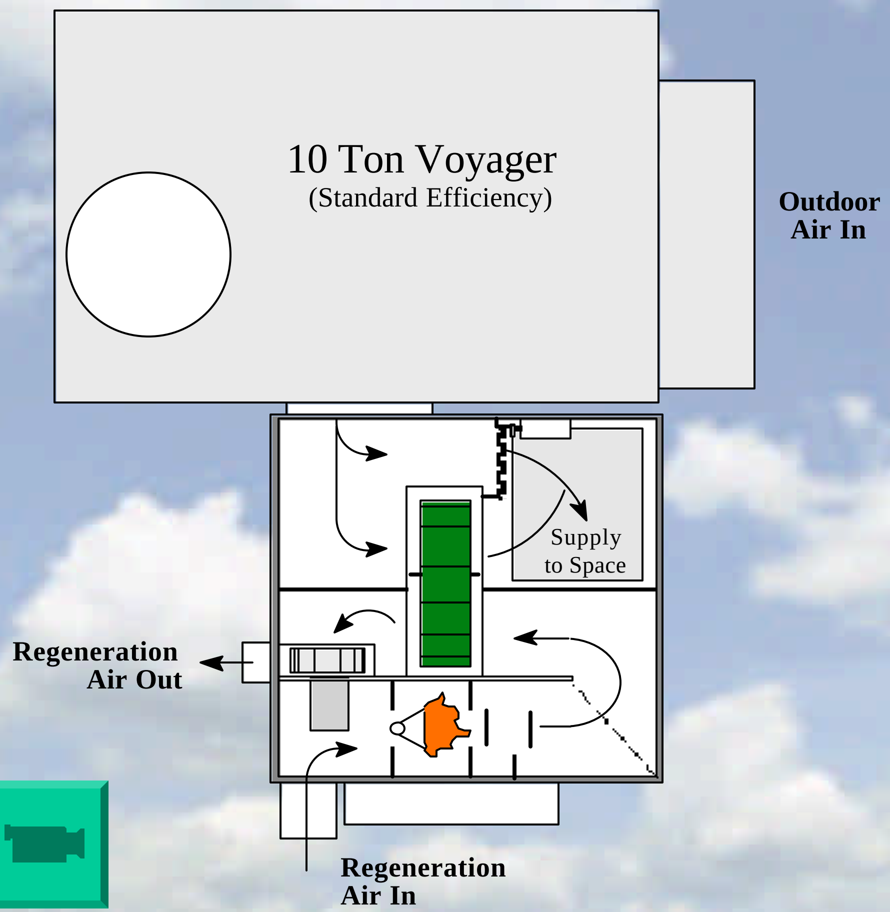
Current Design	AHU-1		AHU-2		AHU-3		AHU-4	
Total Airflow	5,000		5,000		3,000		2,000	
Outdoor Airflow	1,250		900		900		400	
Total Cooling Capacity (tons)	13		13		8		5	
Total cooling capacity delivered	158,000	Delivered	155,000	Delivered	94,000	Delivered	64,000	Delivered
Sensible capacity delivered	130,000	82%	113,000	73%	59,000	63%	44,800	0.7
Latent capacity delivered	28,000	18%	42,000	27%	35,000	37%	19,200	0.3
		Needed		Needed		Needed		Needed
Total sensible needed	83,484	56%	98,646	69%	39,358	45%	18,768	0.5
Total latent needed	66,464	44%	44,810	31%	47,330	55%	19,406	0.5

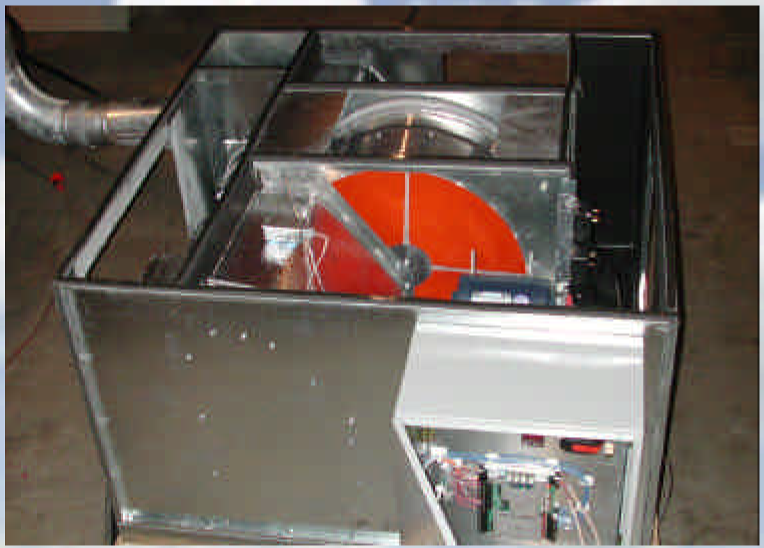
***Conclusion 37.5 tons installed yet still way short on latent capacity**

Results With “Over-sized” Equipment:

- Cold, humid “clammy” space conditions
- Uncomfortable indoor environment, especially at frequent “part load” conditions
- Results from the limitation of conventional packaged equipment to process high outdoor air loads

ADM Approach Places Active Wheel Downstream of the Cooling Coil





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Addition of ADM Matches the Delivered Capacity with Space Requirements

McDonald's Analysis: Alternative 1 with ADM on AHU-1

Alternate Approach 1	AHU-1+ADM		AHU-2		AHU-3		AHU-4	
Total Airflow	4375 CFM		3000 CFM		3000 CFM		1080 CFM	
Outdoor Airflow	2800 CFM		0 CFM		450 CFM		200 CFM	
Total Cooling Capacity (tons)	12.5		7.5		7.5		3	
Total cooling capacity delivered	208690	Delivered	82000	Delivered	92000	Delivered	36800	Delivered
Sensible capacity delivered	70875	34%	75500	92%	65900	72%	24900	68%
Latent capacity delivered	137815	66%	6500	8%	26100	28%	11900	32%
		Needed		Needed		Needed		Needed
Total sensible needed	115848	47%	79854	92%	29962	51%	14592	57%
Total latent needed	130892	53%	7400	8%	28620	49%	11093	43%
Sensible Heat Percentage	0.47		0.92		0.51		0.57	

* Conclusion 30.5 tons installed and latent needs are now met
AHU-1 and 3 work together to manage sensible and latent loads in the dining area

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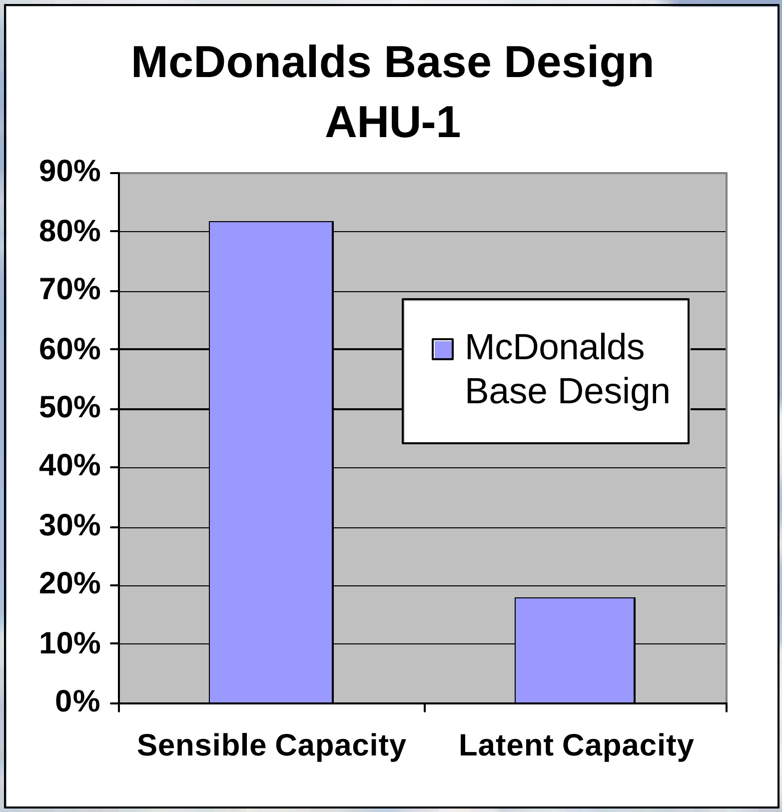
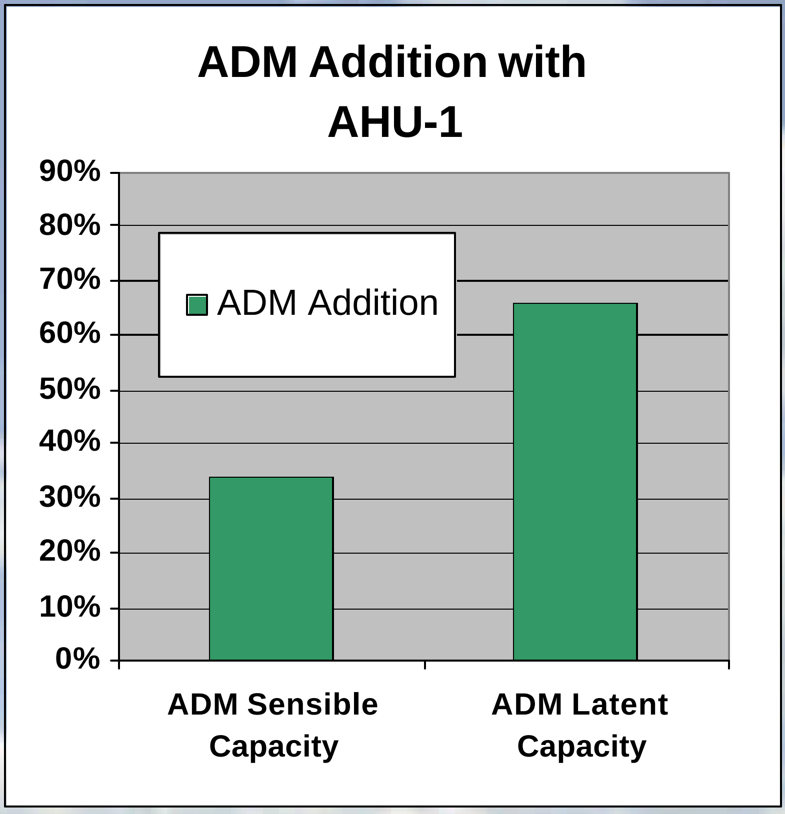
Advantages Offered by ADM

- Reduced cooling tons with increased latent capacity
- Improved humidity control
- Reduced energy consumption – higher thermostat setting at same comfort level
- Lower cost fuel (gas or waste heat) used for dehumidification
- Dehumidification without compressors during part-load conditions

ADM Creates a "Latent Preconditioner" Using a Conventional Rooftop





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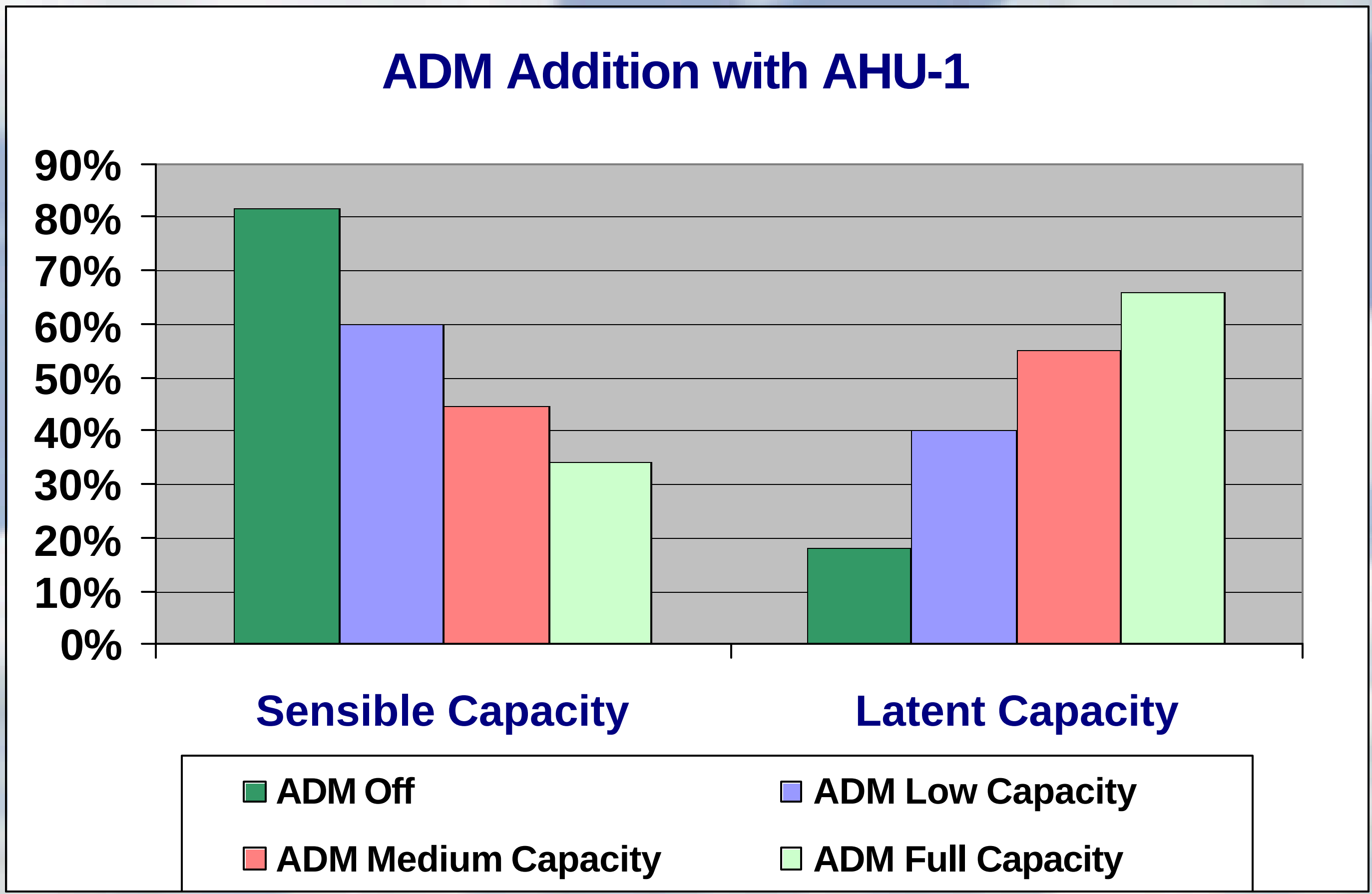
With Modulation the ADM Can Vary the Sensible and Latent Capacity Delivered



ADM Advantage Over Custom Packaged Outdoor Air Systems

	ADM Rooftop Combination	Custom DX Rooftop (over-cool and reheat)
Cooling Capacity Required (Tons)	**5 tons**	**10 tons**
Reheat Energy Required (BTU/Hr)	**0**	**32,400**
Regeneration Energy Rqd. (BTU/Hr)	**33,500**	**N/A**
Supply Dew Point Used for Analysis	**56 degree F**	**56 Degrees F**
Annual Cooling Energy Cost (Note 1)	**$1,360**	**$2,480**
Unit Approximated Size (H x W x L)	**31" x 46" x 46"** (note 2)	**33.5" x 46.5" x 83"**

Hooters of Rome Facility: DOE Pilot Site

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Kitchen Open to the Dining Area

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Fresh, Dry Outdoor Air for Kitchen Exhaust Makeup and ETS

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Summary of Results:

- Maintained goal of 75 degrees at 50% relative humidity under all conditions
- Comfort better than at previous conditions of 69-70 degrees and high humidity
- Simultaneous and independent humidity and temperature control provided
- Fresh air to dining area significantly improved indoor air quality, especially cigarette smoke (ETS)
- Control scheme and remote monitoring worked extremely well

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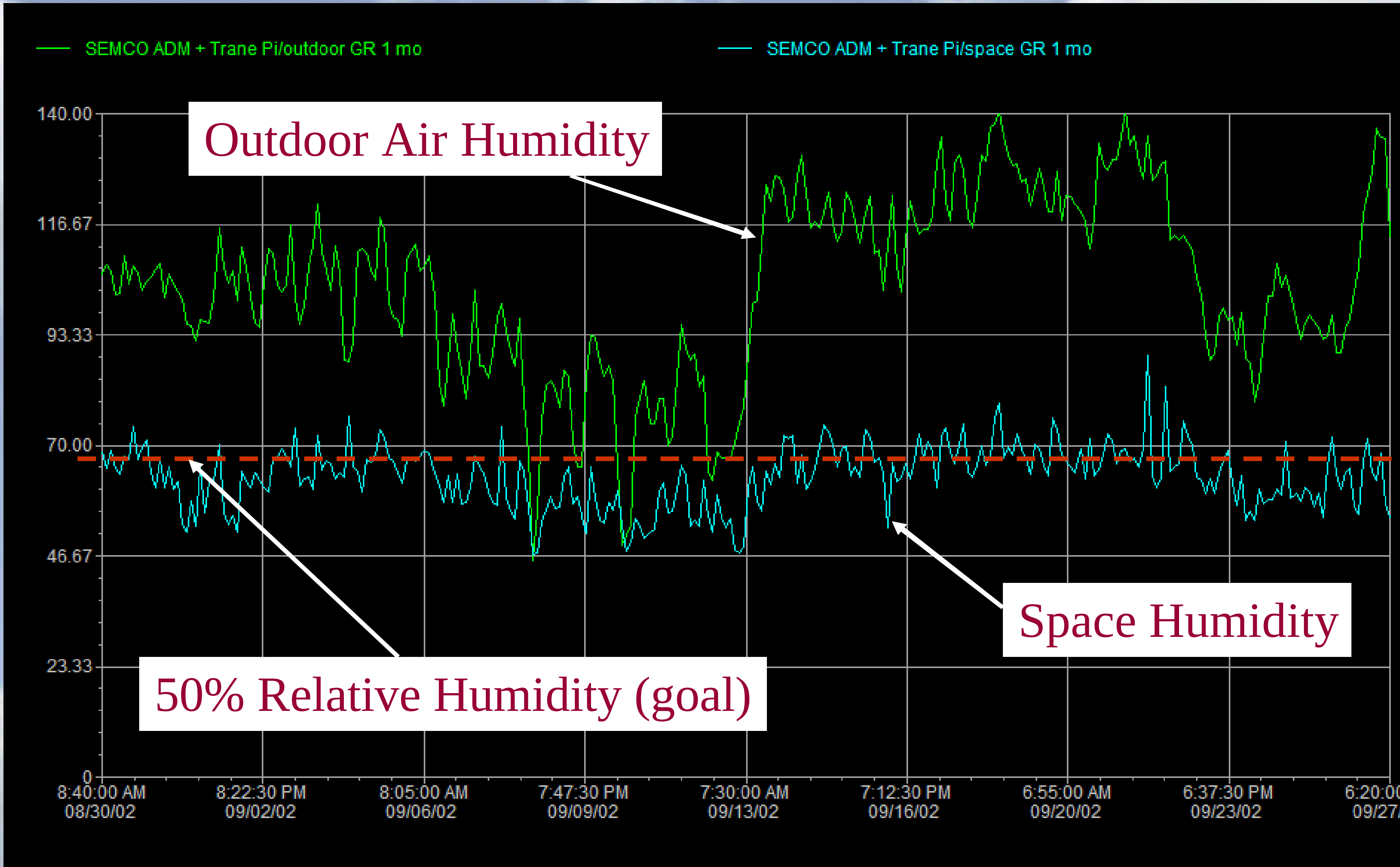

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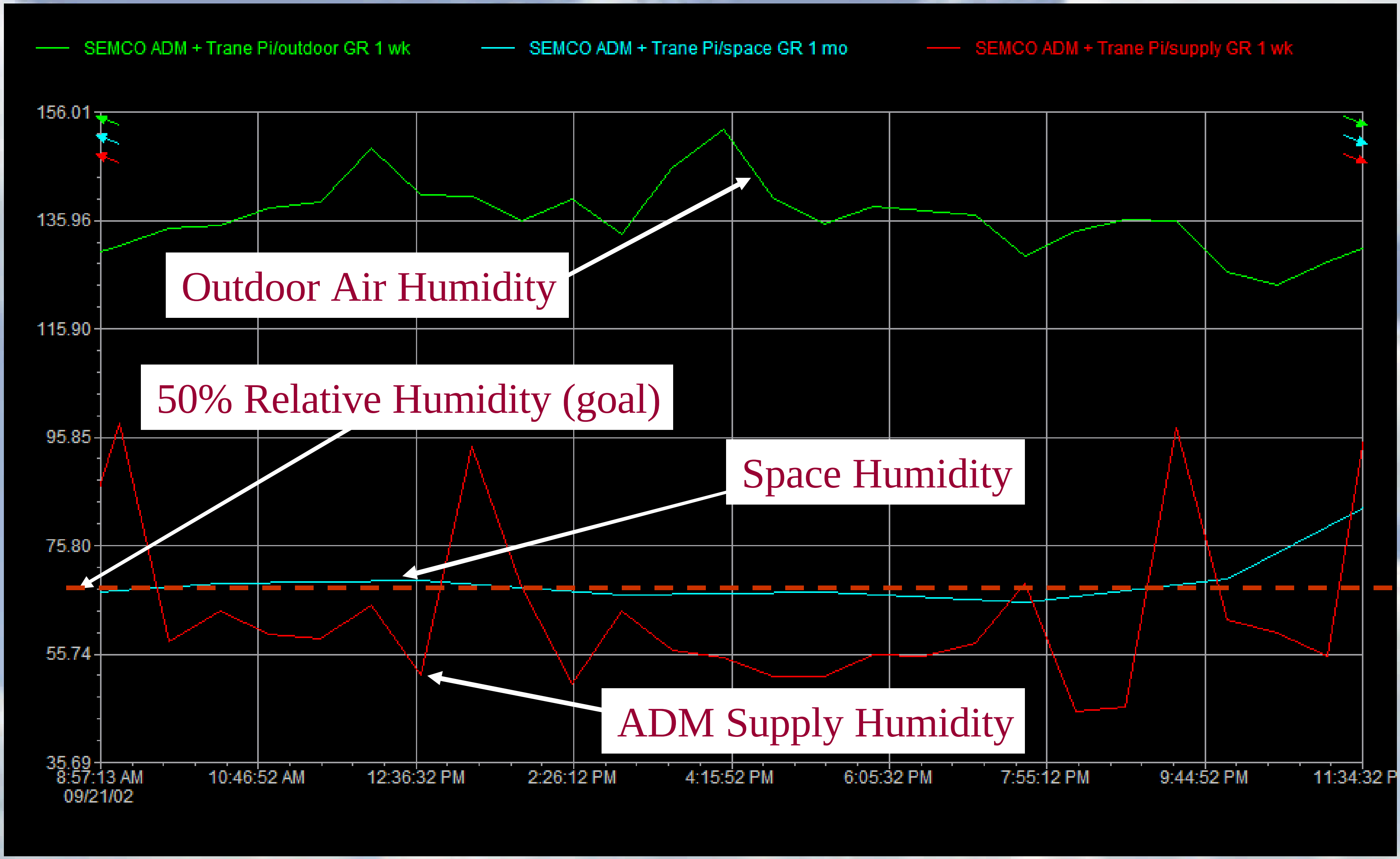
Humidity Control

- Very dry air, not possible with conventional packaged equipment, was provided by the ADM approach
- This “low dewpoint air” is necessary to maintain the desired space humidity level within the occupied space



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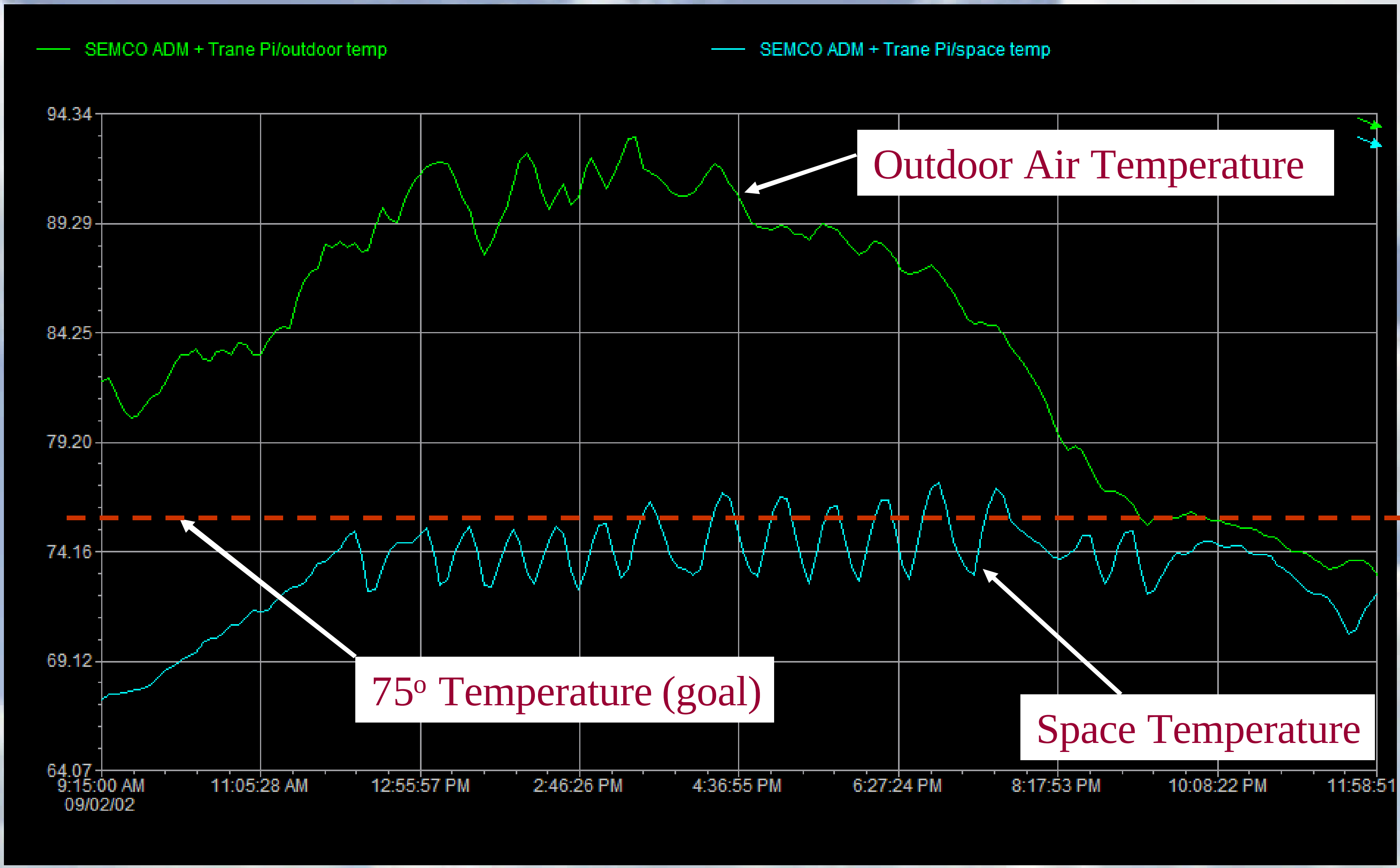
Temperature Control

- The temperature delivered by the ADM is influenced by the number of cooling stages operating and the active dehumidification wheel regeneration temperature.
- The DDC control system optimizes energy efficiency and humidity control while maintaining the desired space temperature



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Pilot Site Confirmed Benefits Associated with Humidity Control

- Space thermostat setting raised from about 70 degrees to 75 degrees while still increasing the comfort of occupants (no longer cold and clammy)
- Raising the thermostat setting has a significant impact on energy consumption
- Unoccupied mode provided by ADM mitigates high humidity buildup, avoids mold and other moisture problems experienced in restaurants

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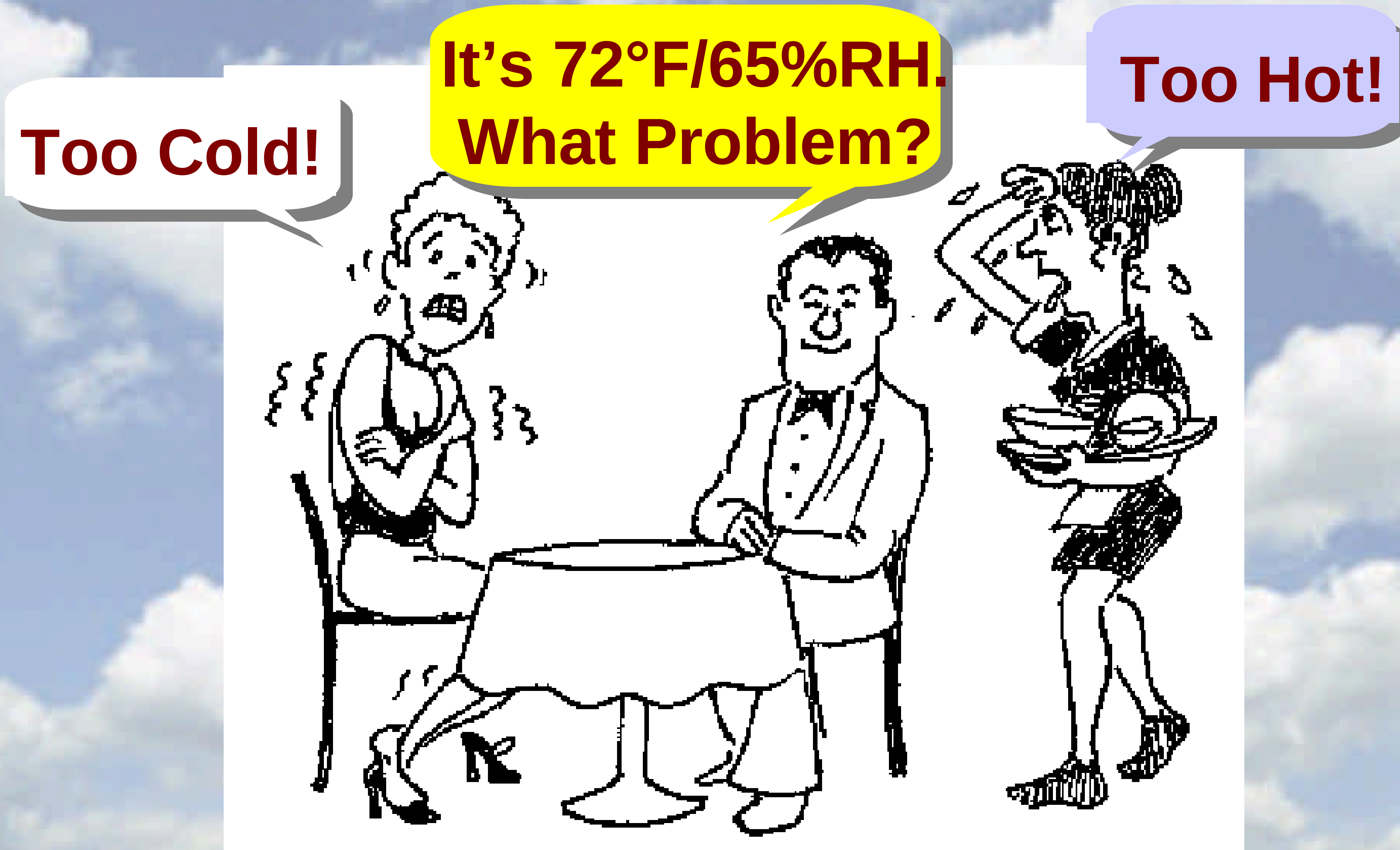

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