Measured and Simulated Results of Desiccant Systems in Quick Service Restaurants

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Overview

- Objectives
- Describe field-monitored systems and measured results
- Describe computer models used to simulate desiccants and other systems
- Evaluate how desiccant systems compare to other technologies
- Conclusions

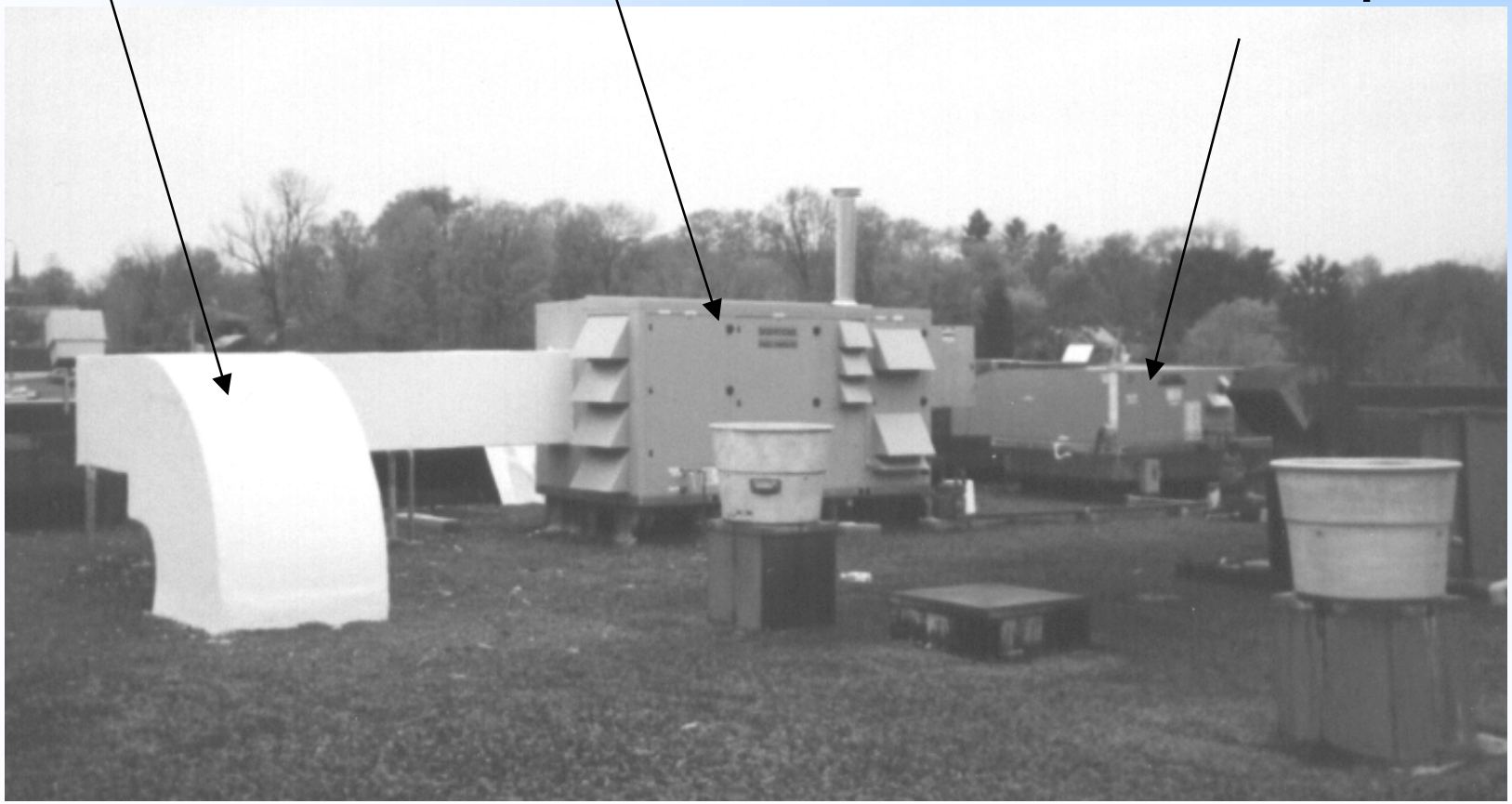
Objectives

- Use field-monitored data from desiccant system installations to show:
  - dehumidification loads, operating hours, and energy use
  - impact on space humidity levels
- Develop building simulation models of restaurant applications to compare desiccants to other systems

Monitored Restaurants

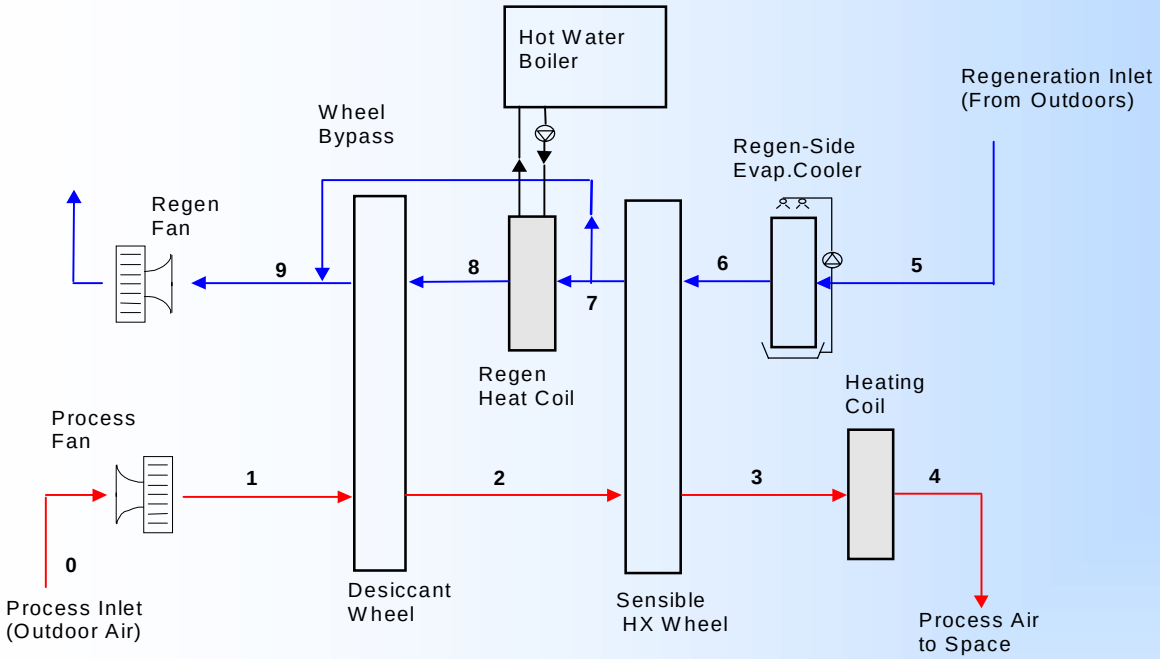
- Gas-fired desiccant system
  - 2 RTUs, 15 tons, near Syracuse, NY
  - 2,000 cfm makeup air unit
  - pre-conditioned air provided directly to space
- All-electric desiccant system
  - 3 RTUs, 22 tons, Tarrytown, NY (near NYC)
  - 2,000 cfm makeup air unit
  - pre-conditioned air provided into RTU return duct

Gas-Fired Desiccant System



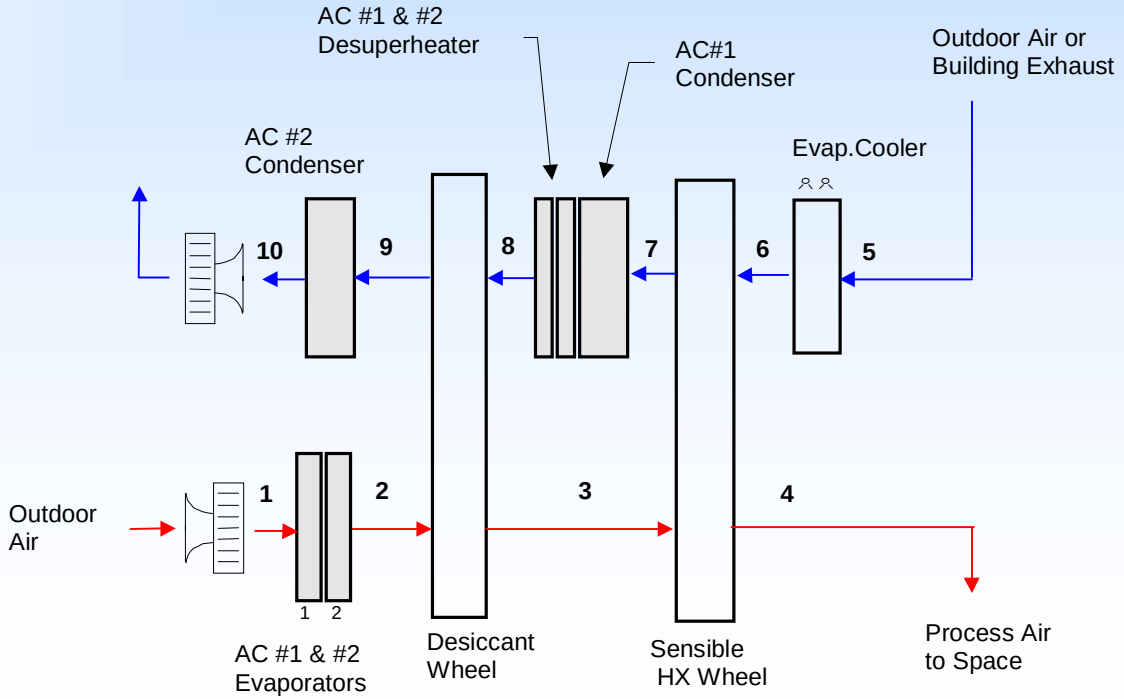
All-Electric Desiccant System

Fresh air ducted into dining area rooftop



Gas-Fired System

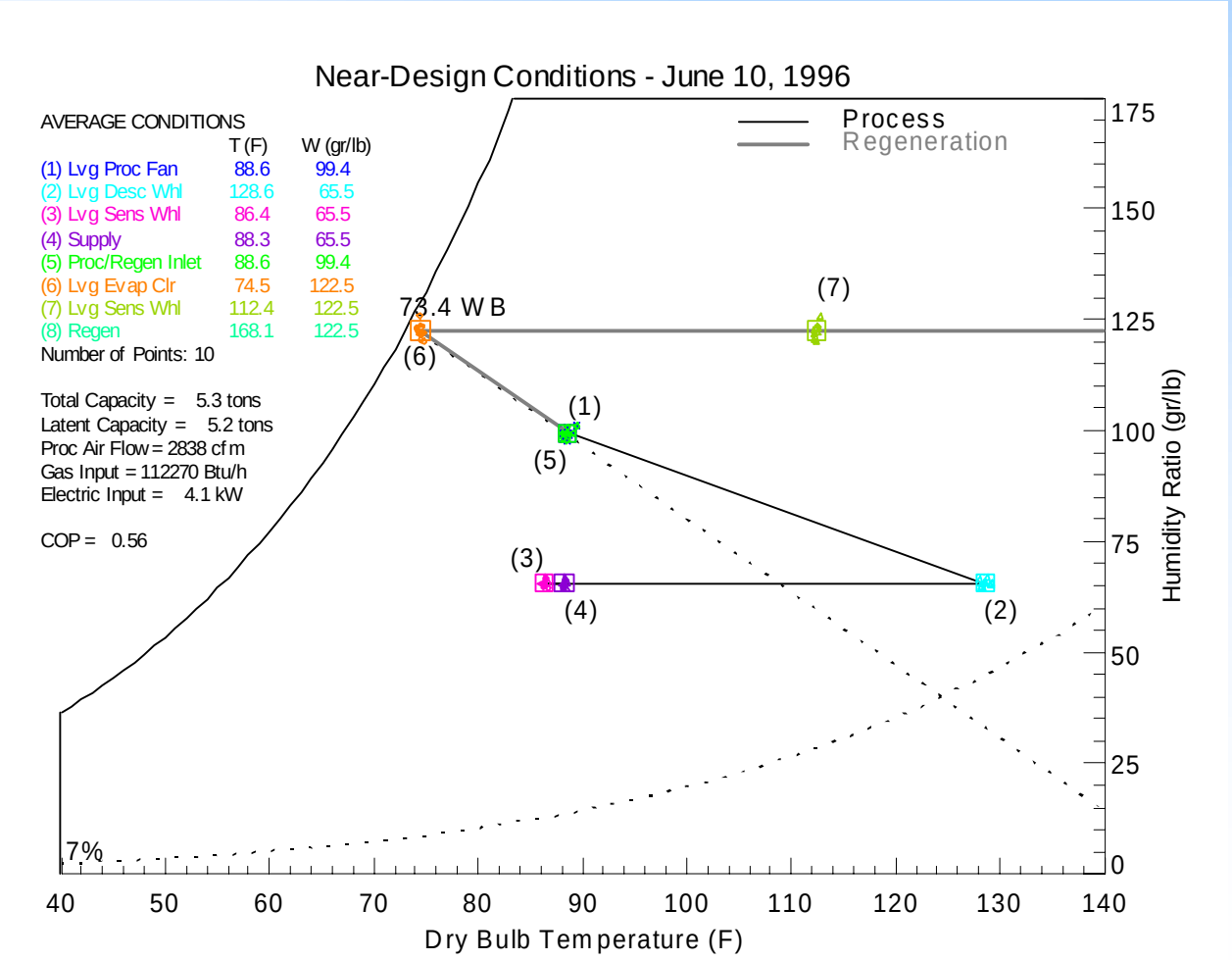
All-Electric System



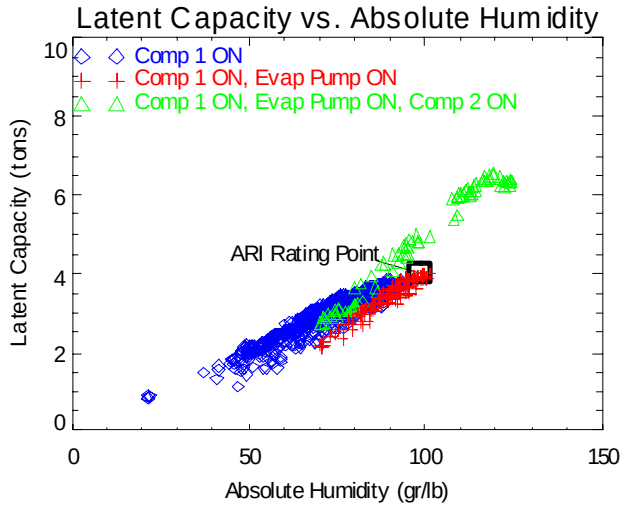
Detailed Field Monitoring

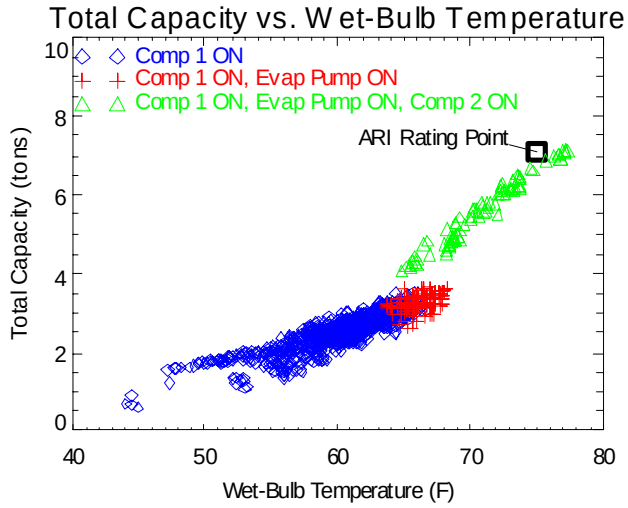
Designed Instrumentation to Quantify:

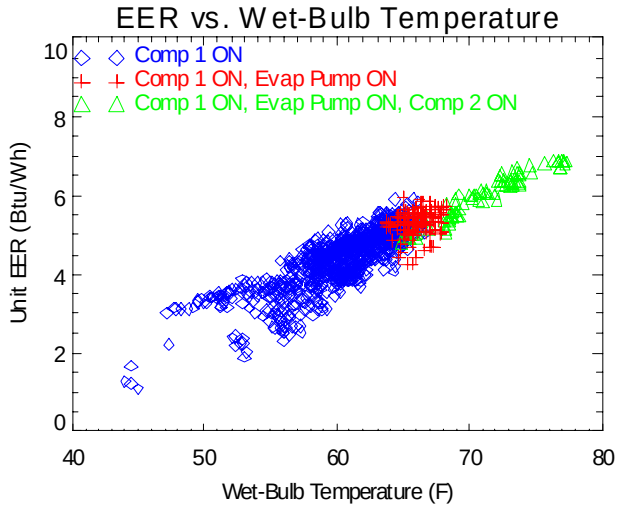
- desiccant unit performance
- operating hours, energy use, and space conditions



All-Electric Performance Trends







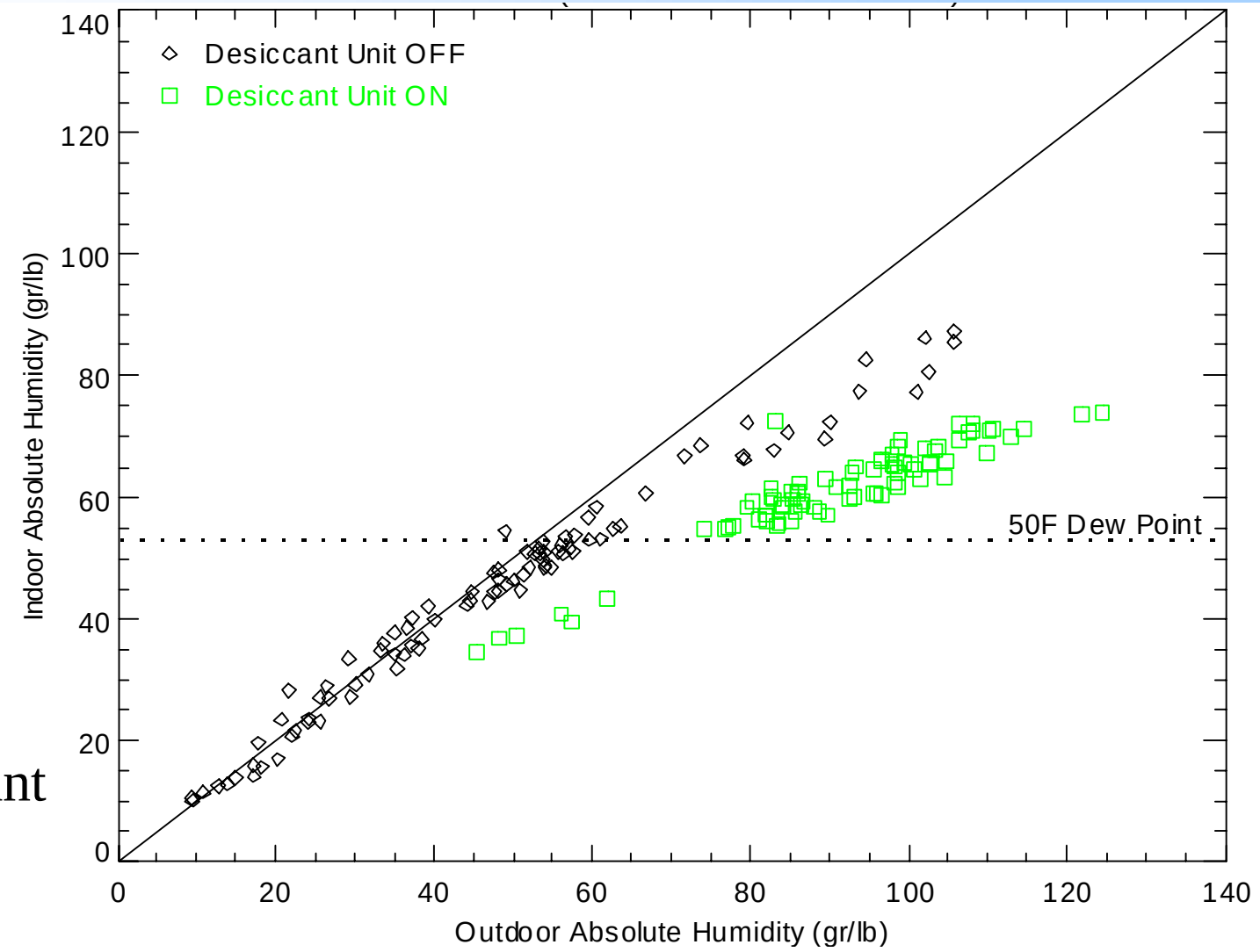
Data used to develop models for simulations

Seasonal Performance Summary

	All-Electric System (New York, NY)	**Gas-Fired System (Syracuse, NY)**
Gas Use (therms)	-	1,372
Electricity Use (kWh)	19,749	6,123
Dehumidification Runtime (hours)	2,253	1,421
Efficiency (total capacity)	4.28 Btu/Wh	0.35 COP

Impact on Indoor Humidity

All-Electric Desiccant System



Comparisons to Other Technologies

- Have field-measured performance of desiccant systems
- But how do they compare to other types of HVAC systems?
- Need to develop a simulation model to compare to other systems
  - use measured data to develop desiccant models and verify building loads
  - use standard models of other equipment

Hourly Simulation Model

- Developed TRNSYS model of all-electric desiccant system & store
  - used nearby TMY weather data (La Guardia)
  - used utility bills to estimate unmeasured cooling loads, lighting loads, etc
  - all-electric desiccant model based on measured data
- Verified building model with measured data

Model Verification

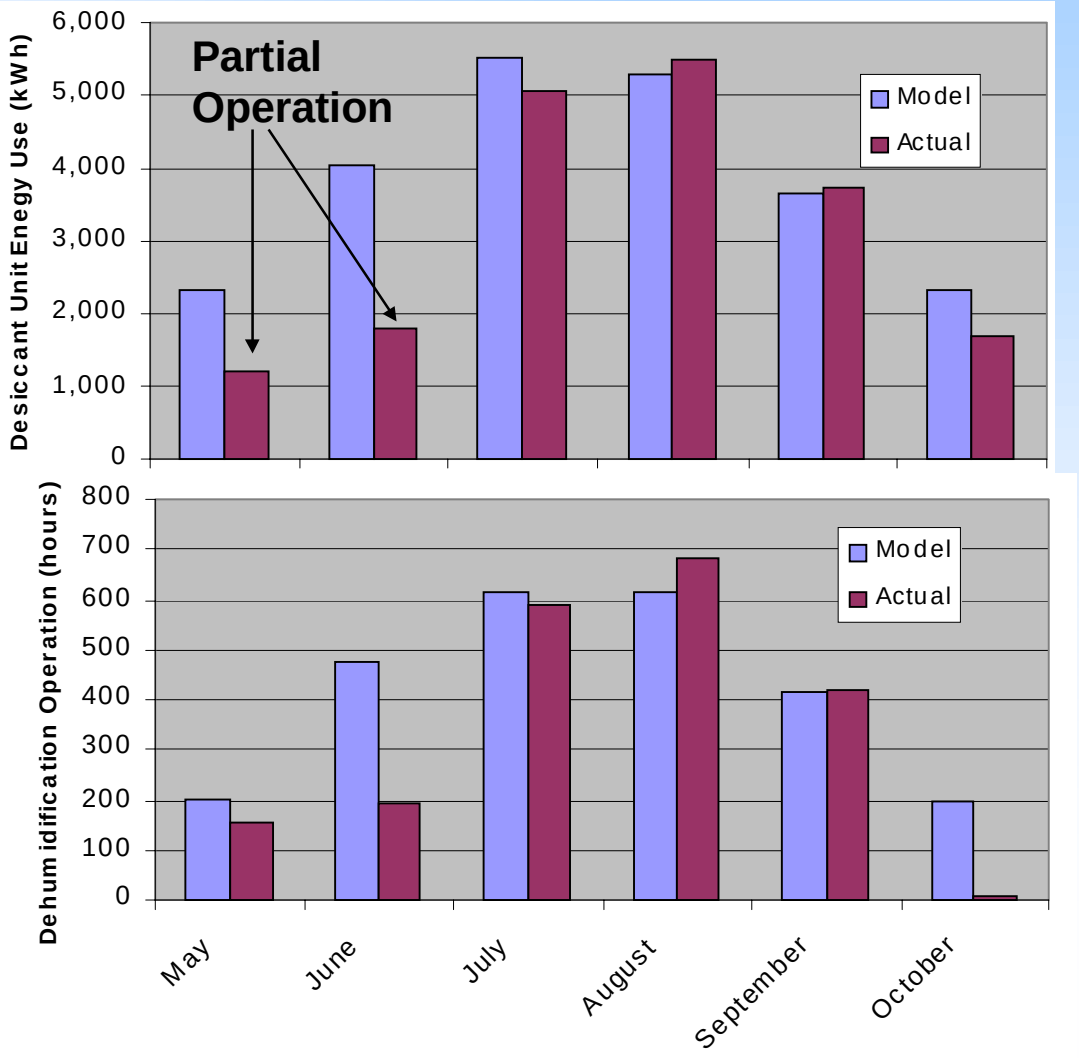
- Different Weather

  Model: *TMY data*

  Actual: *1996 data*

- Desiccant unit did not operate in May and June

- **Good Agreement!**



Other Technologies & Equipment

- ***Conventional AC***. 15 tons, 6,000 cfm. Fresh air enters at rooftop.
- ***Gas-Fired Desiccant***. Same size as all-electric desiccant unit but with process fan at 1.5 kW
- ***AC w/ Reheat***. Condenser reheat coil sized to reject up to 40% of condenser heat. Reheat set point equals 73°F. Static Pressure increased by 0.5 in for reheat coil.
- ***AC w/ Heat Pipes***. Heat pipes are 2 row, 11 fpi. Static Pressure increased by 0.5 inches for heat pipes.
- ***AC w/ Heat Pipes & Reheat***. Static Pressure increased by 1.0 in for both coils.
- ***100% Fresh Air AC***. Pretreats fresh air like desiccant systems. Hot gas bypass holds supply temperature above 50°F. System only runs when ambient is above 65°F.

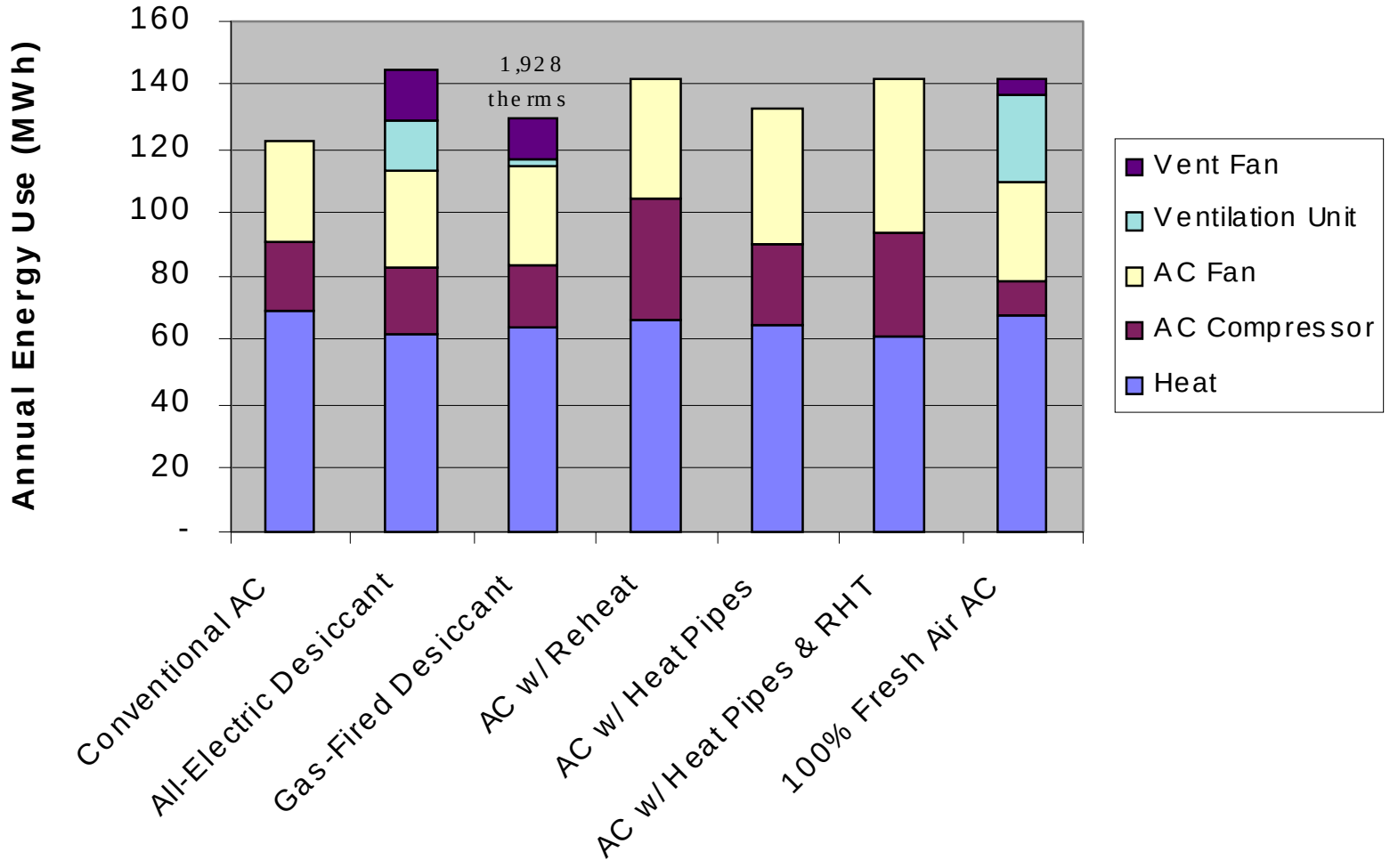
Simulation Results

Systems[2]	Vent Fan Control	Hours Over 50% RH		Annual Energy Use (MWh)							Gas Use (therms)	Total Utility Costs[3]
		All Periods	Occup Periods	L & E	Resist Heat	AC Comp	AC Fan	Vent Unit	Vent Fan	Total Store		
Vent Fan/Damper Operates Continuously, 24 hour Dehumidification												
Conventional AC	ON	2,386	1,750	120.29	69.29	21.83	31.03	-	-	242.44	-	$35,425
All-Electric Desiccant[1]	**ON**	**1**	**-**	**120.29**	**62.45**	**19.81**	**31.03**	**15.61**	**15.51**	**264.70**	**-**	**$37,283**
Gas-Fired Desiccant	ON	2	-	120.29	63.45	20.09	31.03	2.06	13.14	250.06	1,928	$37,105
AC w/ Reheat	ON	467	402	120.29	66.07	37.80	37.89	-	-	262.05	-	$36,300
AC w/ Heat Pipes	ON	878	554	120.29	64.56	25.62	41.59	-	-	252.06	-	$35,596
AC w/ HP & RHT	ON	8	5	120.29	61.50	32.30	48.46	-	-	262.55	-	$36,189
100% Fresh Air AC	ON	258	196	120.29	67.09	11.41	31.03	27.54	5.04	262.40	-	$37,063
Vent Fan/Damper Off During Unoccupied Periods, No Dehumidification at Night												
Conventional AC	Cycling	2,267	1,675	120.29	57.57	21.74	24.21	-	-	223.81	-	$32,596
All-Electric Desiccant	Cycling	5	2	120.29	52.59	19.74	24.65	13.45	11.99	242.71	-	$34,598
Gas-Fired Desiccant	Cycling	3	-	120.29	53.33	19.82	24.27	1.74	9.98	229.43	1,623	$34,223
AC w/ Reheat	Cycling	499	387	120.29	55.14	32.93	30.05	-	-	238.41	-	$33,648
AC w/ Heat Pipes	Cycling	515	372	120.29	53.97	25.14	32.49	-	-	231.89	-	$33,135
AC w/ HP & RHT	Cycling	7	4	120.29	51.61	28.42	38.09	-	-	238.41	-	$33,865
100% Fresh Air AC	Cycling	228	169	120.29	56.00	12.86	24.58	22.68	3.88	240.29	-	$34,264

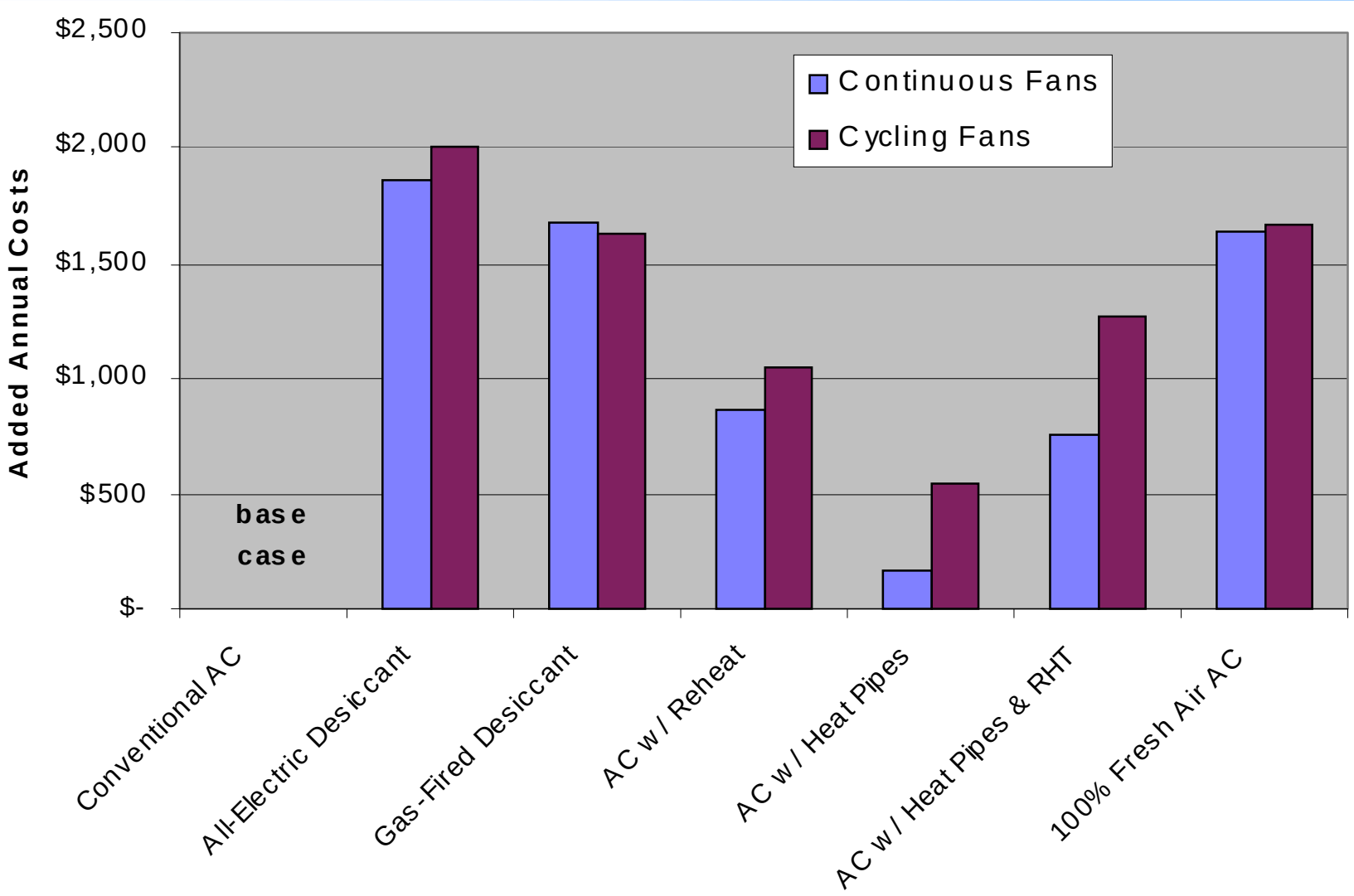
Notes: 1 – This simulation run matches the configuration at the actual all-electric desiccant test restuarant.

2 – Operating costs were calculated using Con Ed's SC-9 rate for electricity and $0.80/therm for gas.

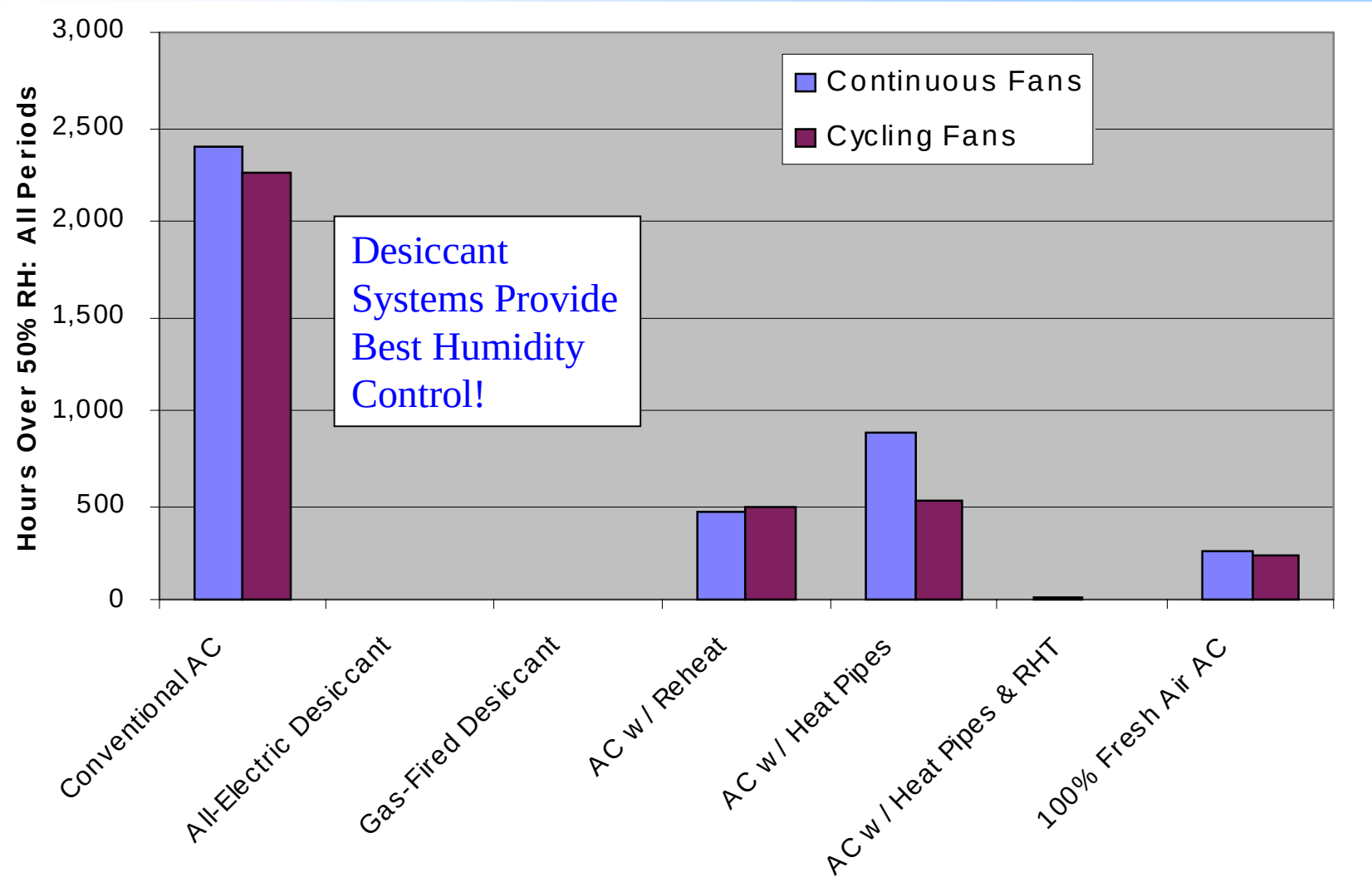
Modeled Energy Breakdown



Operating Cost Comparison



Impact on Space Conditions

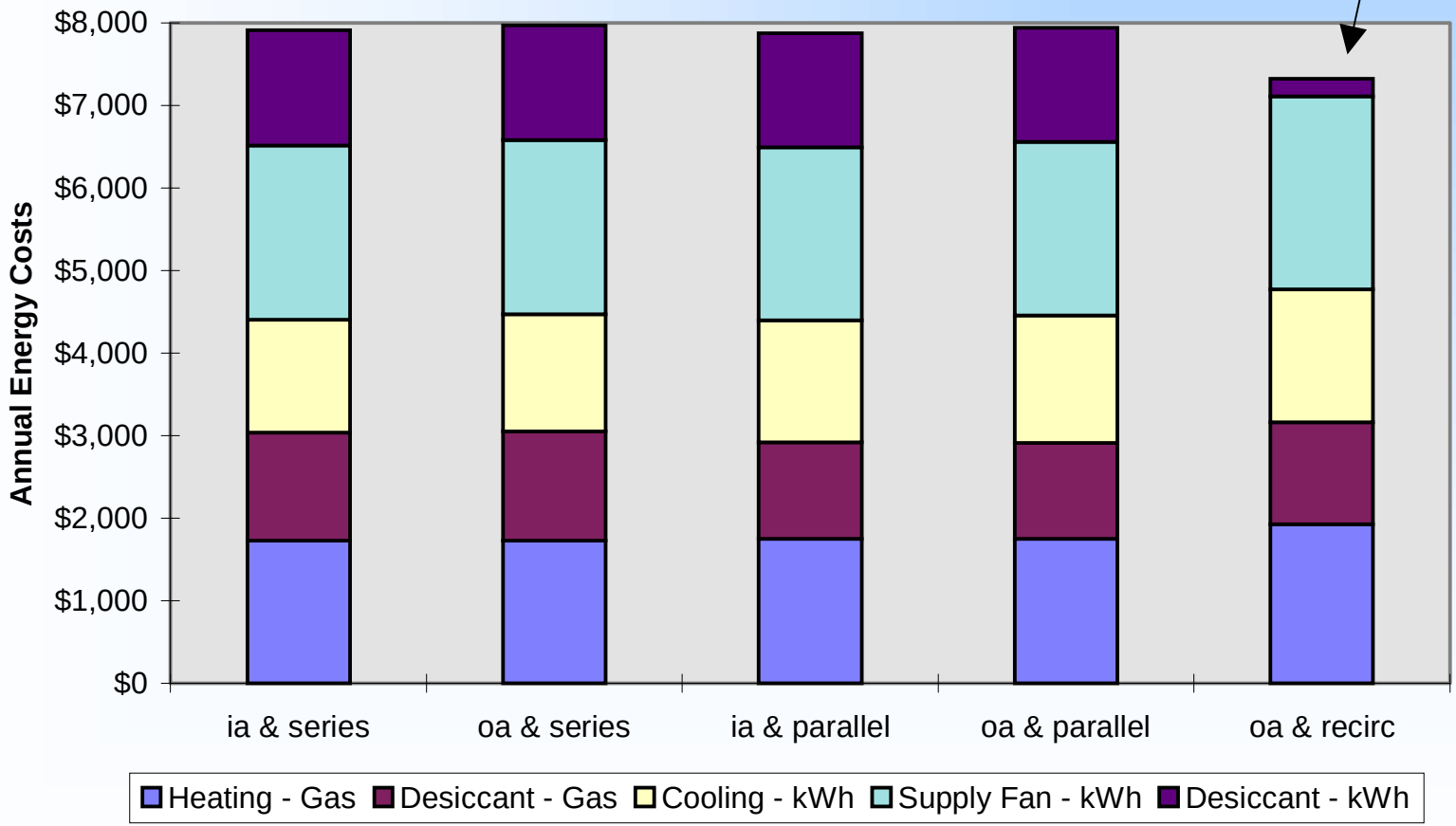


Why the High Operating Costs?

- A large portion of the added costs are due to fan power
- Providing ventilation through the desiccant unit for non-dehumidification hours is a fan power penalty for 6,000 hours per year

The Impact of Fan Power

Recirculation mode has lowest costs!



Lessons

- Fan power is critical issue!
  - Pushing air through the desiccant unit during off-season is expensive
  - annual electric costs equal gas costs
- Even though recirculation mode has 50-60% low COP, annual costs were lower because of less fan operation

Summary

- Both desiccant systems cost more to operate
  - operating costs about $2,000 more than base case
- But provide the best humidity control
  - only desiccant systems can provide “perfect” control
- Minimizing fan power may be the most important issue
  - recirculation mode to limit fan operation?
  - bypass dampers in the desiccant unit?