Body Shop: Building Strategies

Primary Energy Analysis for a Desiccant Based Dehumidification System in a Texas Theater

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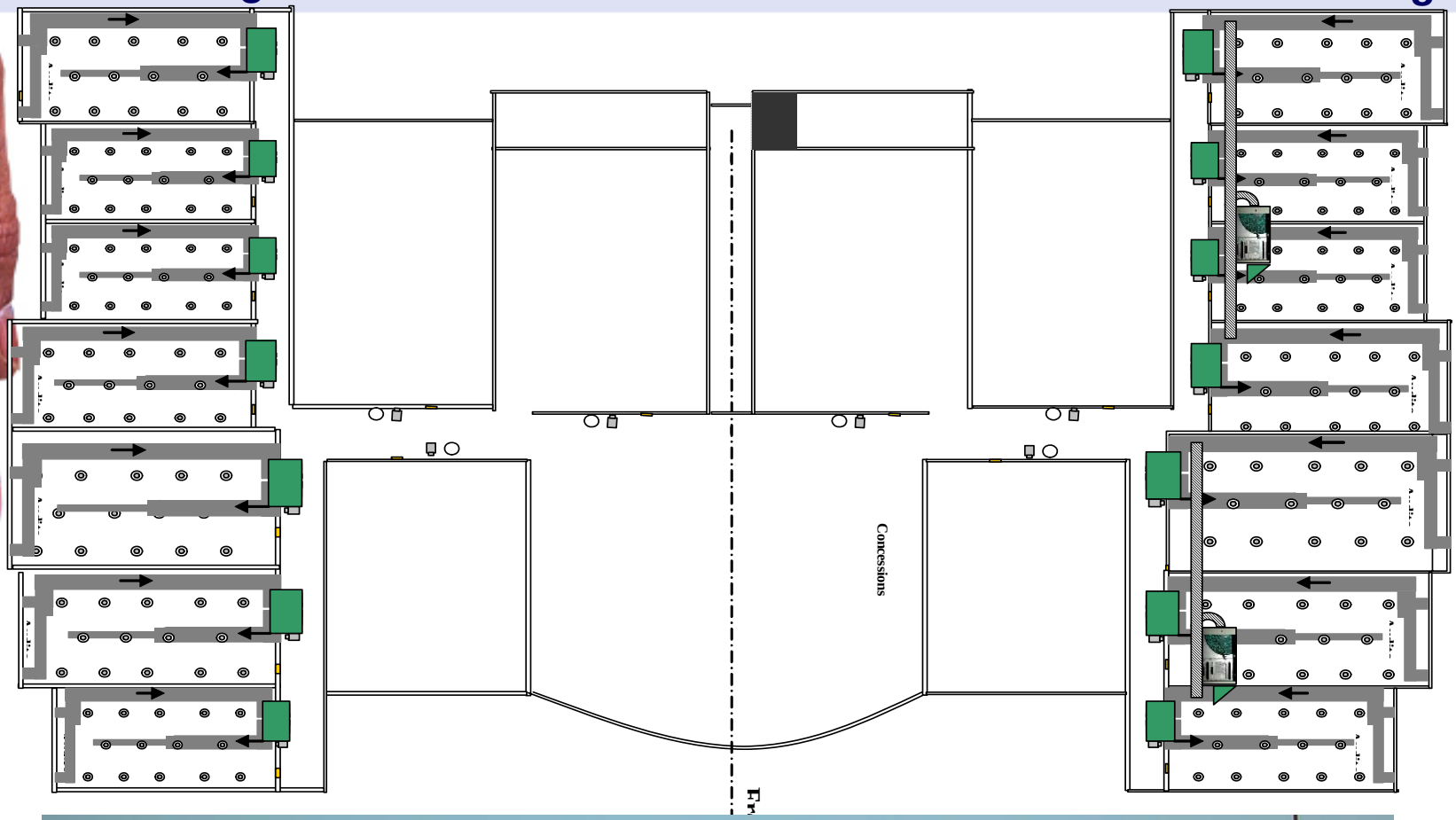
Field Test Objectives

- Comply with building code ventilation requirements and control building pressurization – Increase outdoor air quantities
- Improve space humidity control and viewer comfort
- Optimize energy efficiency
- Evaluate cost effectiveness of enhanced HVAC design
- Evaluate Primary Energy Use Versus Baseline Rooftops and Dedicated Outside Air Units

Theater – Plano Texas

North Wing

South Wing



Integrated Active Desiccant Rooftop (IADR) Test

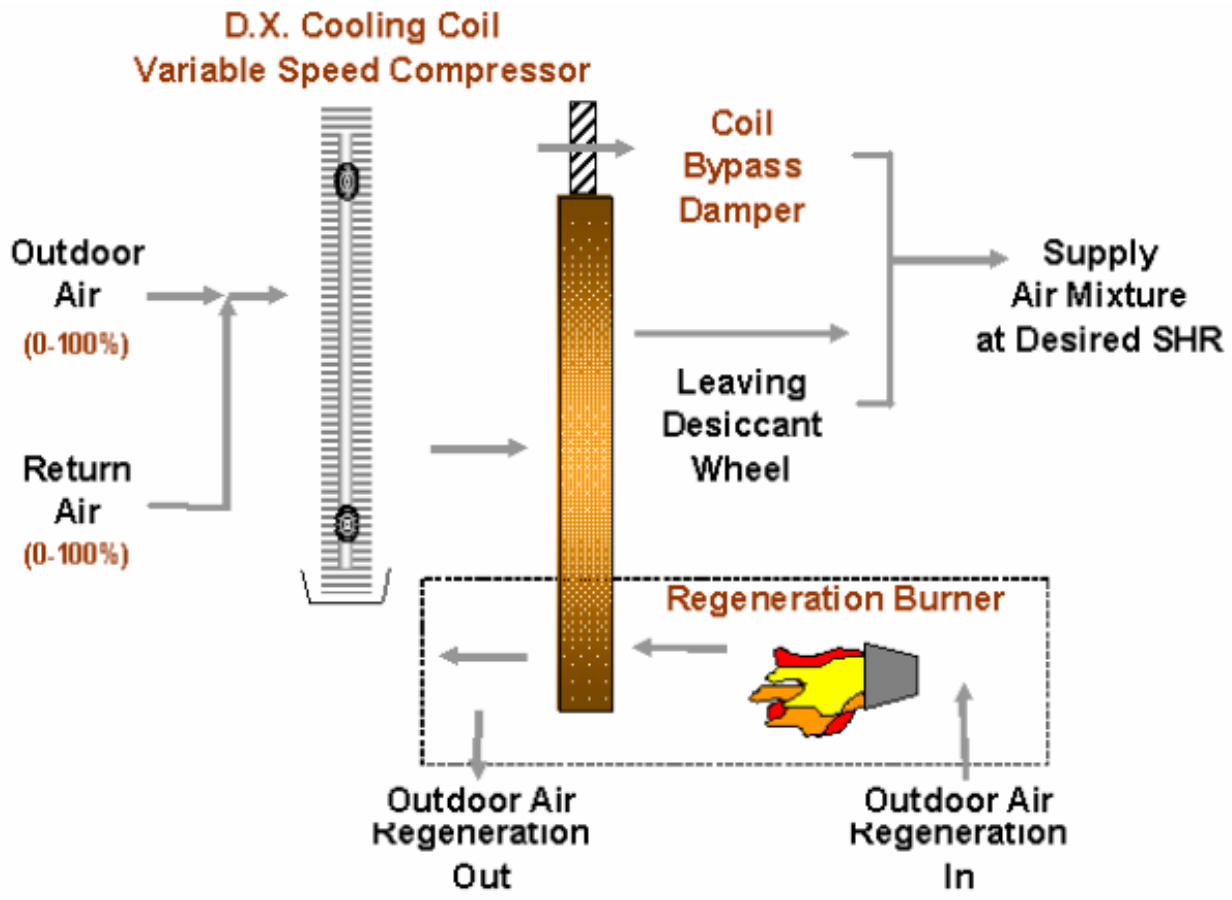
- Two IADR units installed as dedicated outdoor air systems to ventilate and control space humidity in 7 *south wing* theaters
- The *north wing* is a mirror image served by existing conventional rooftops and served as an effective basis for comparison
- Both wings fully instrumented to monitor space conditions, system performance functions and detailed energy utilization
- System operation began November of 2003

Integrated Active Desiccant Rooftop (IADR)

IADR on RTUs 13-16

IADR on RTUs 17-19

IADR Schematic



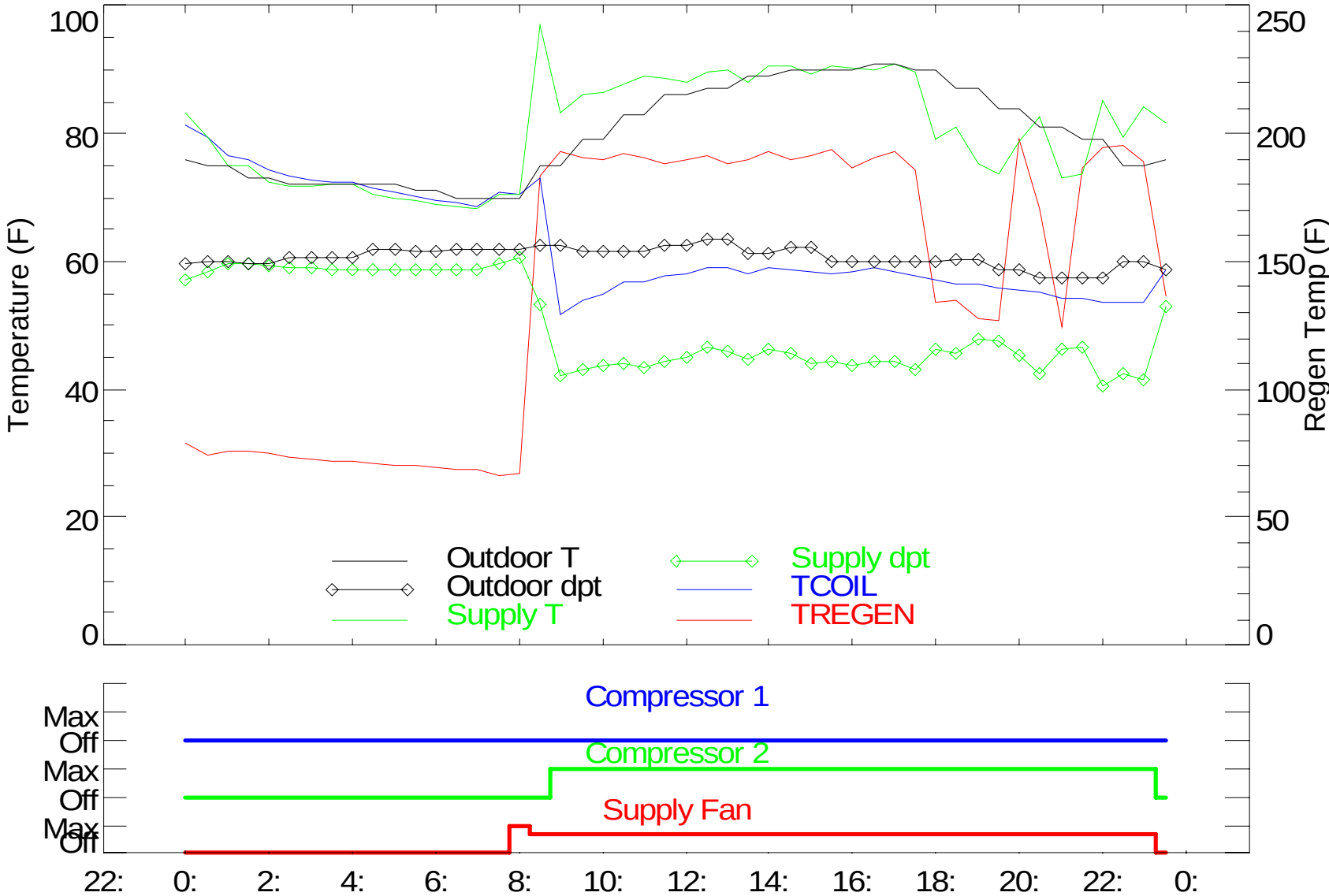
Comparison of North and South Wings

- Initially all of the rooftop outdoor air dampers were closed in an attempt to improve humidity control within the theaters
- The south theaters served by the IADR systems were provided the amount of outdoor air required to comply with ASHRAE 62 based upon the 7.5 cfm/person interpretation – a total of 9,471 cfm
- The north theaters were set up to provide 7,906 cfm of outdoor air, 20% less air than provided to the south theater. This was done to temper the impact on the resulting space humidity levels
- All systems were cycled off between the hours of about 12:30 am and 8:30 am
- Electrical and gas energy consumption was continually measured for all rooftops and the two IADR systems

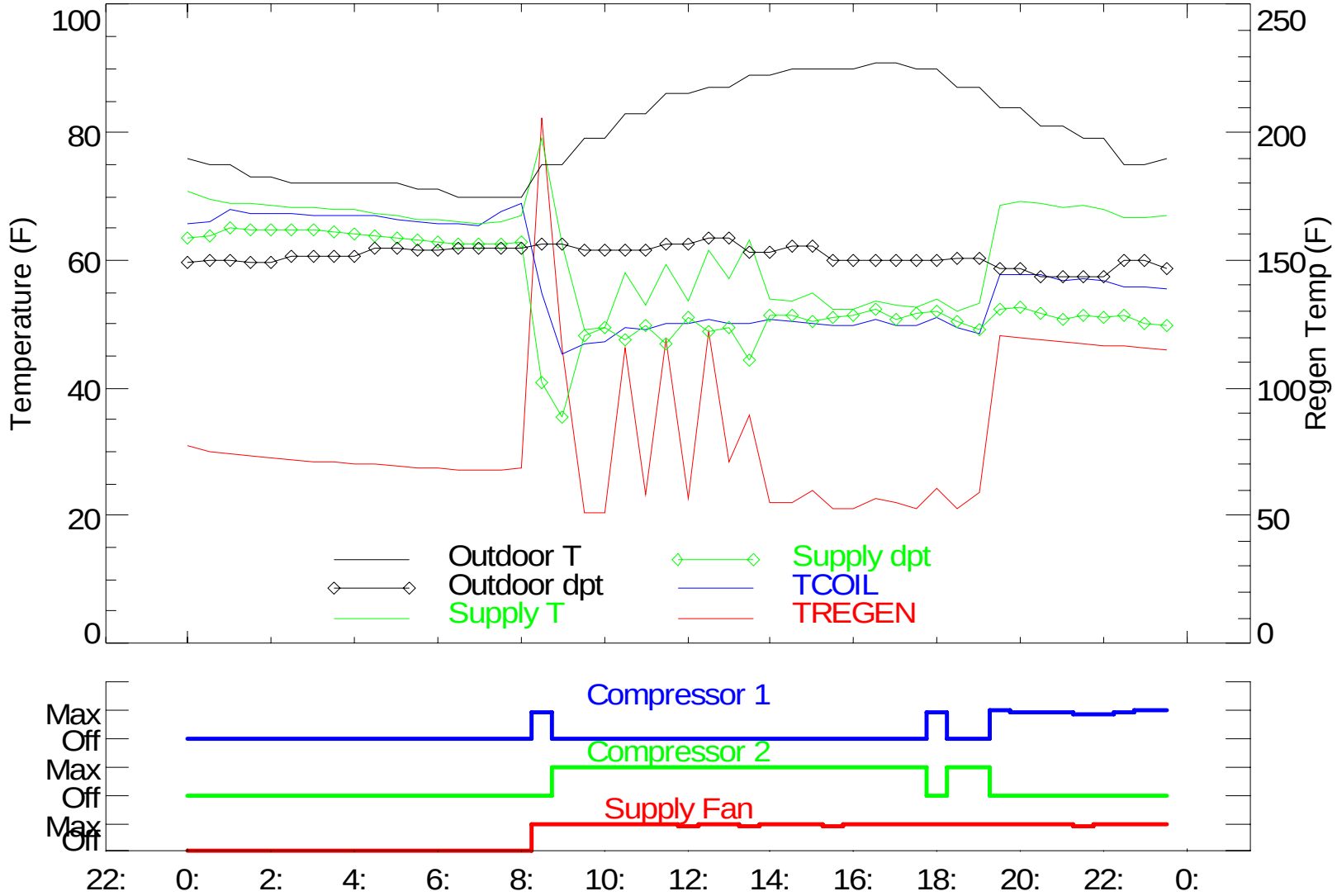
Research Findings

- Extreme space humidity conditions (greater than 80%) were routinely observed in the north wing theaters served by the conventional systems while the south theaters were controlled between 50% and 60%. This occurred at both peak and part load conditions.
- Very dry outdoor air (40 to 45 degree dew point) was needed to maintain the space humidity as desired – moisture capacitance
- A qualitative comfort evaluation confirmed that the south theaters held at 75 degrees and 55% RH were more comfortable than the north theaters at 70 degrees and 80% RH
- Dropping the space temperature in an attempt to reach comfort significantly increases the cost of operating the rooftop units
- The additional energy cost required to reach comfort in the South Wing is modest and the IADR system is an effective way to do so

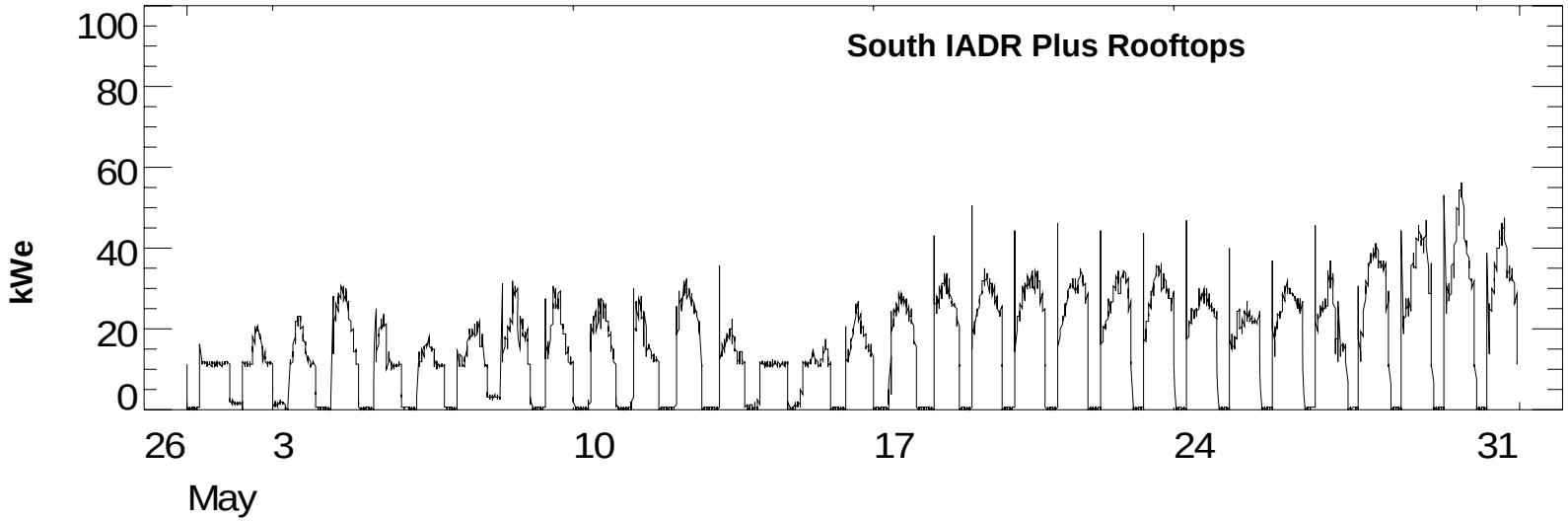
IADR #1 Performance 9/11/04

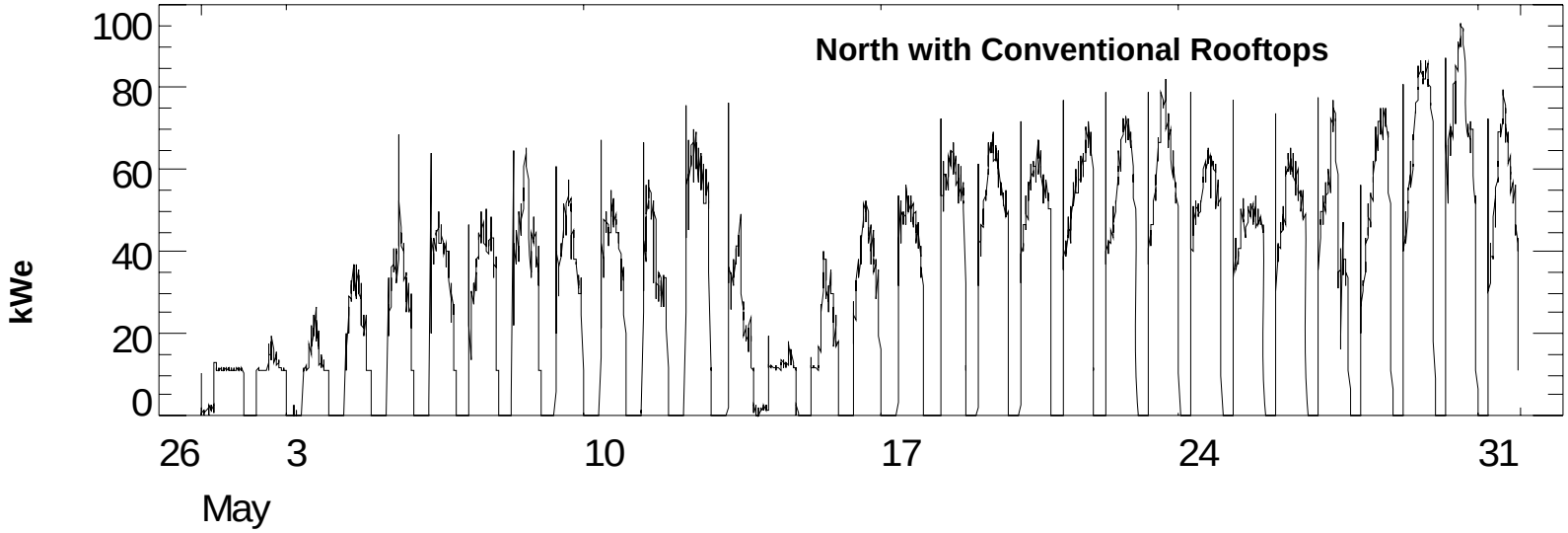


IADR #2 Performance 9/11/04

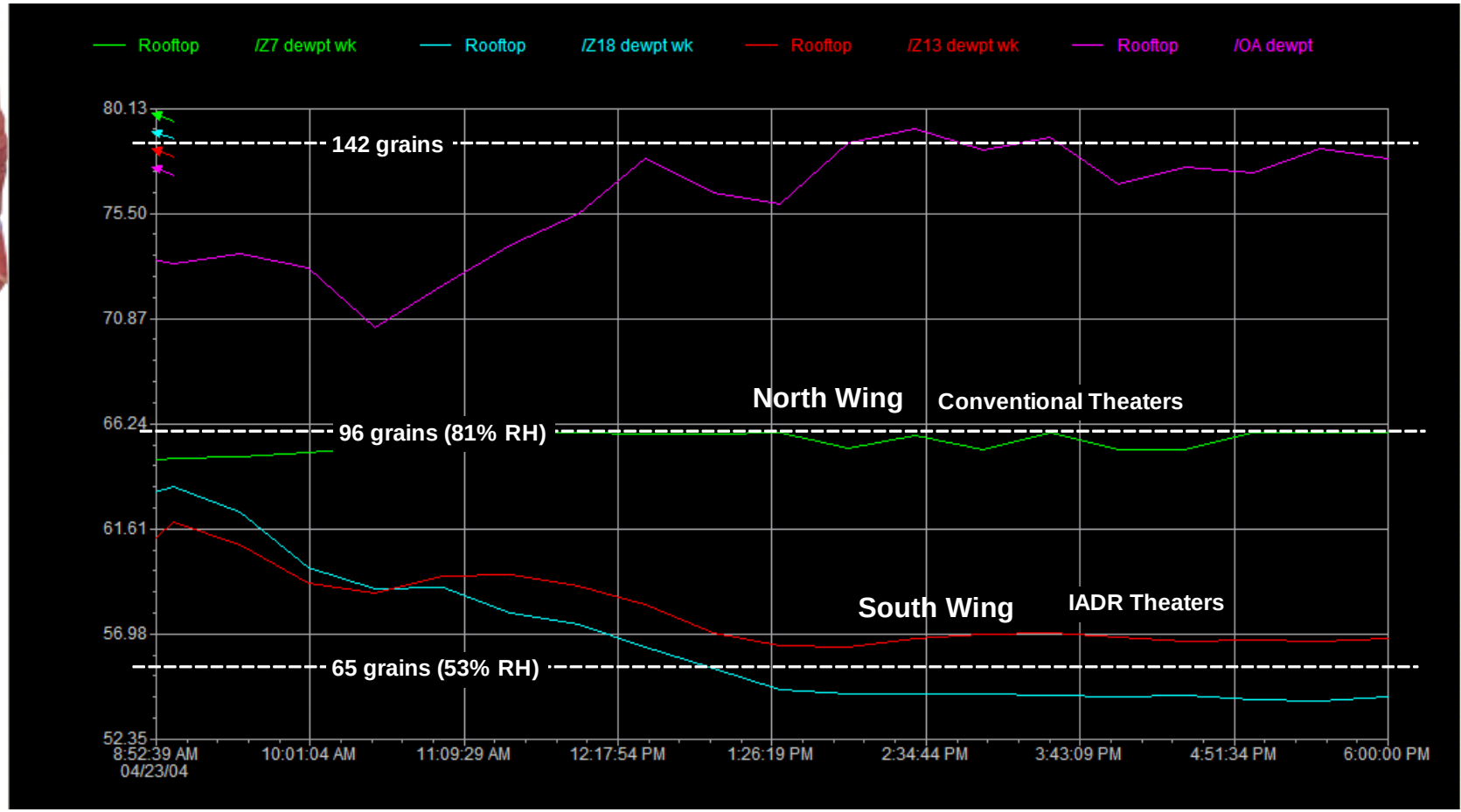


Measuring Energy Use

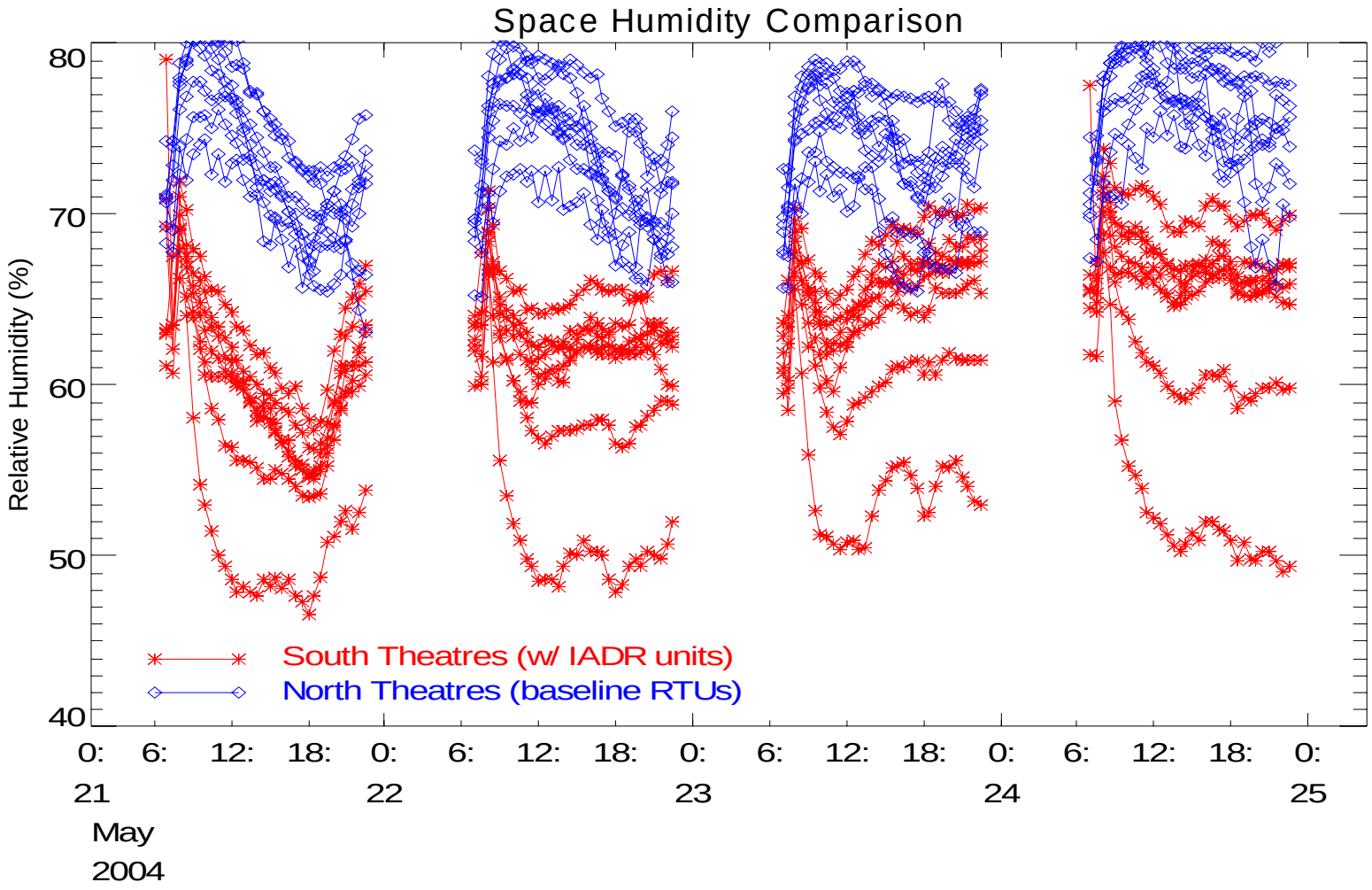




Field Data: Humidity in the North vs. South Theaters

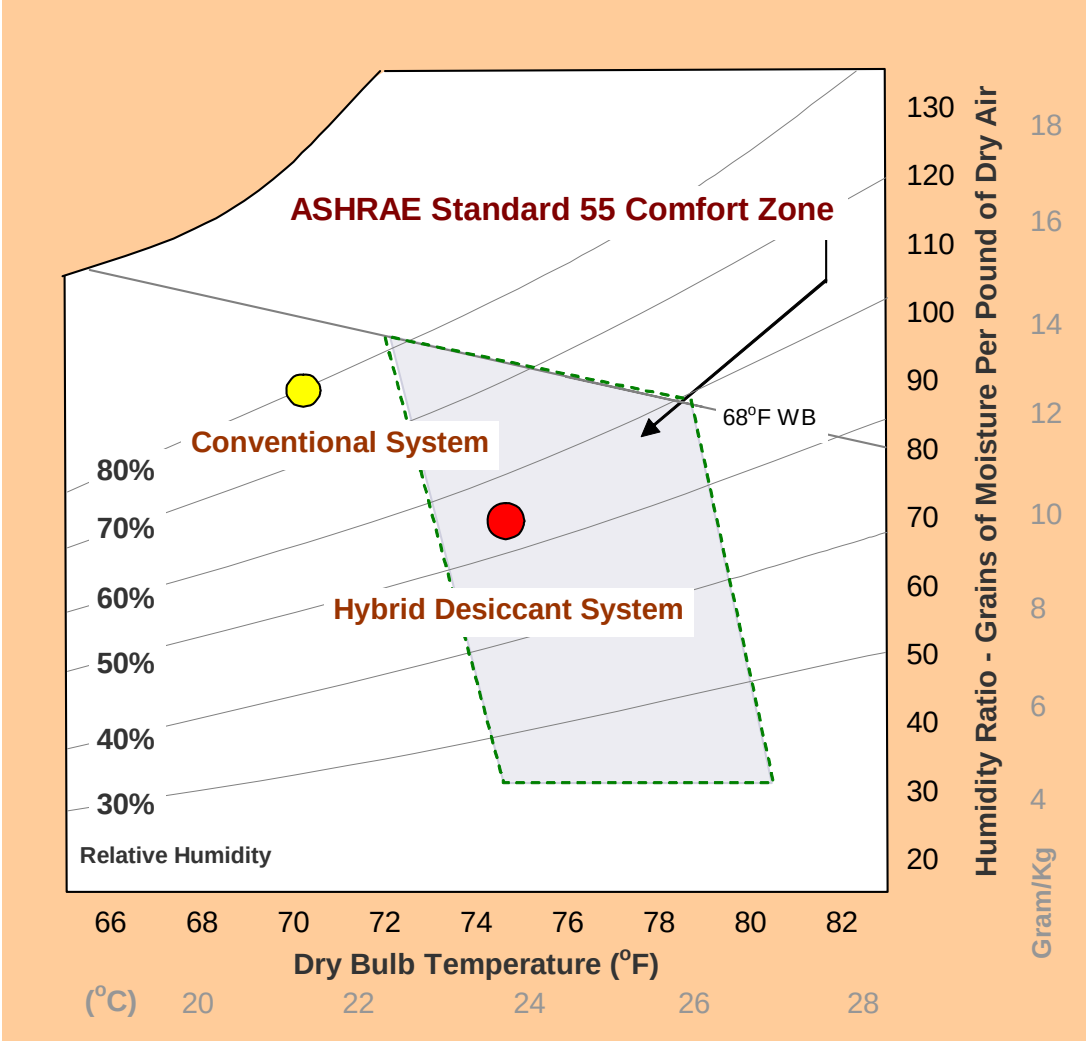


Space Humidity Differences



Note: South Theatres (IADR) Processing 20% More Outside Air

Controlling Humidity Improved Comfort Levels at Higher Thermostat Settings



Source: Field Test Data, ASHRAE Standard 55

How to Make a Fair Energy Comparison?

- **If Humidity is <u>higher</u>, space should be colder to maintain equivalent comfort**
- **Starting on May 4, set points changed…**
  - *changed North Theatres from 73°F to 71°F*
  - *changed South Theatres from 73°F to 75°F*
- **Other issues:**
  - *Is supply fan power the same?*
  - *Is Ventilation the same?*

First Level Comparison

- **Basecase (equal dewpoint):**
  - *Poor Indoor Air Quality for Seven Theatres*
  - *71 ℉ setpoint*
  - *June Cost without reheat 36,678 kWh @* ***$2,217***
- **Basecase with Condenser Reheat (equal work)**
  - *Good Indoor Air Quality*
  - *June Model with reheat 63,352 kWh @* ***$3,729***
- **IADRs plus Rooftops (equal work)**
  - *June Cost 32,260 kWh and 767 Therms @* ***$2,833***

Modeling Assumptions

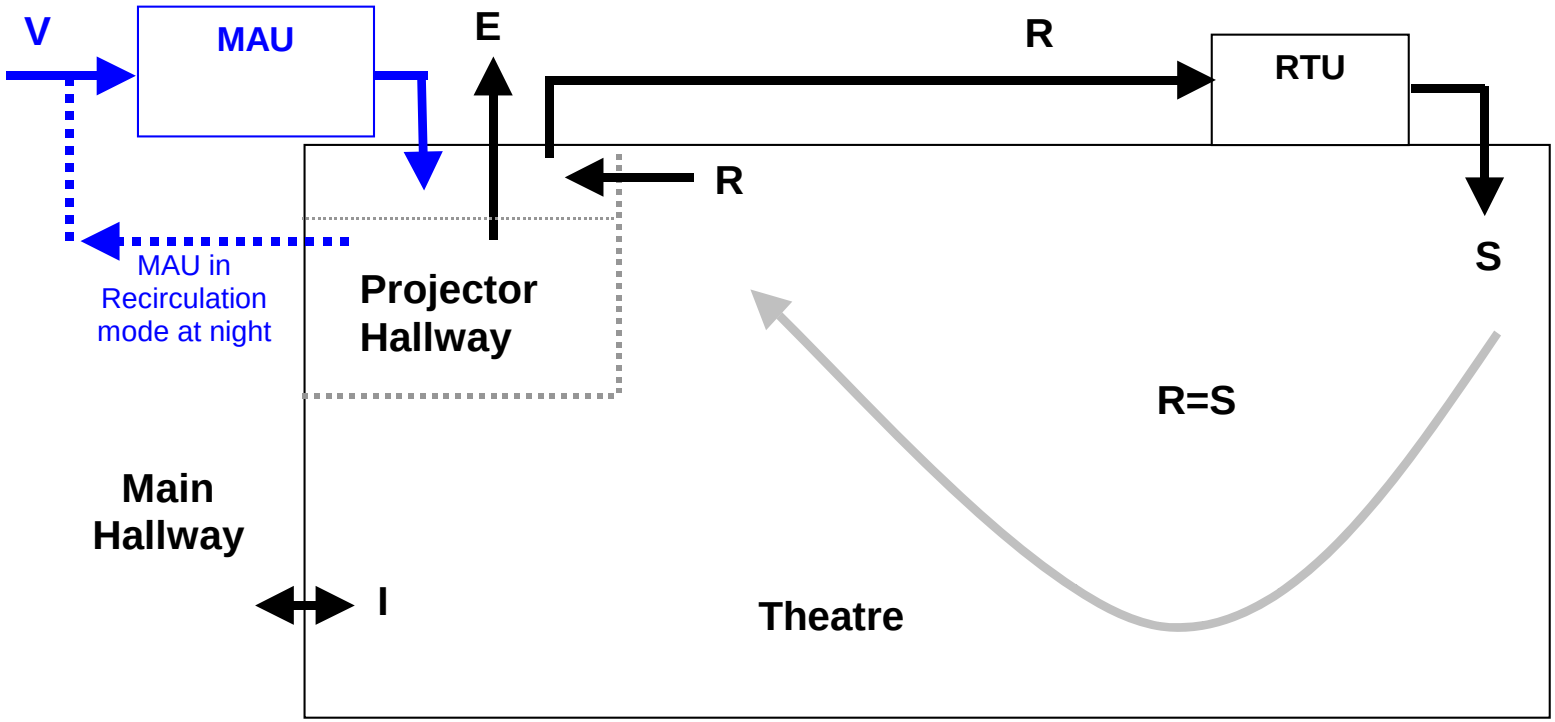
- **TRNSYS model makes the following assumptions:**
- **All the (7) theatres have been lumped together into a single zone; the 7 RTUs are also assumed to be one RTU,**
- **All treated fresh air enters the single large RTU,**
- **The Projector hallway with its exhaust fans are assumed to be integrated into the main zone; the RTUs serving the hallways are ignored; the projector loads in the hall are also ignored since that heat goes up the exhaust.**

Modeling Assumptions

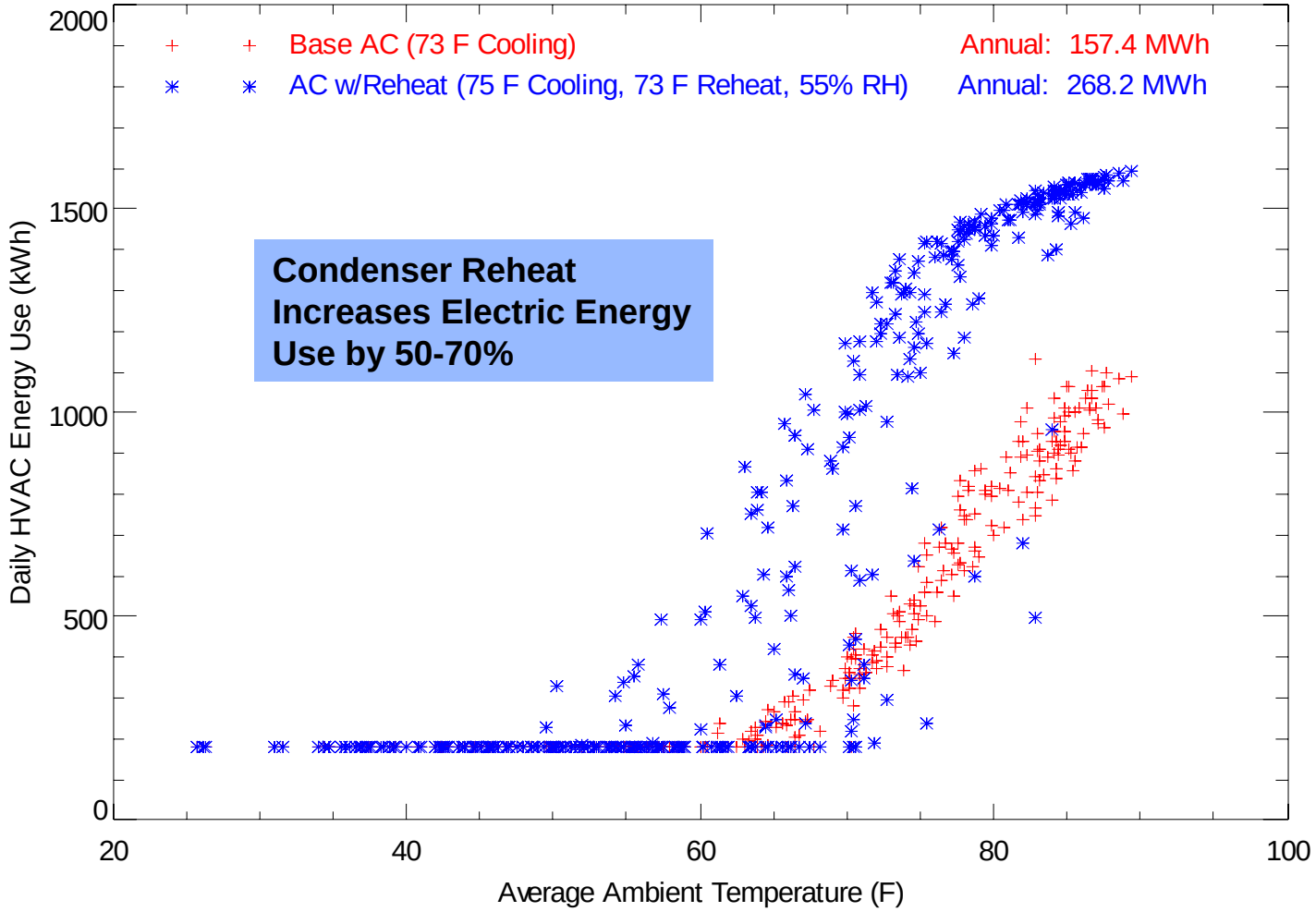
- **The measured data from the site seemed to confirm that there was significant moisture transfer from the main hallways into the theatres.**

- **In order to add this additional latent load into the theatre we assume equivalent to a effective infiltration flow (I'). Assume air in the main hallway is always 2/3s the way between the theatre and ambient humidity for each hour, or:**
  $W_{hall} = 0.67*W_{ambient} + 0.33*W_{theatre}$

Modeling Assumptions



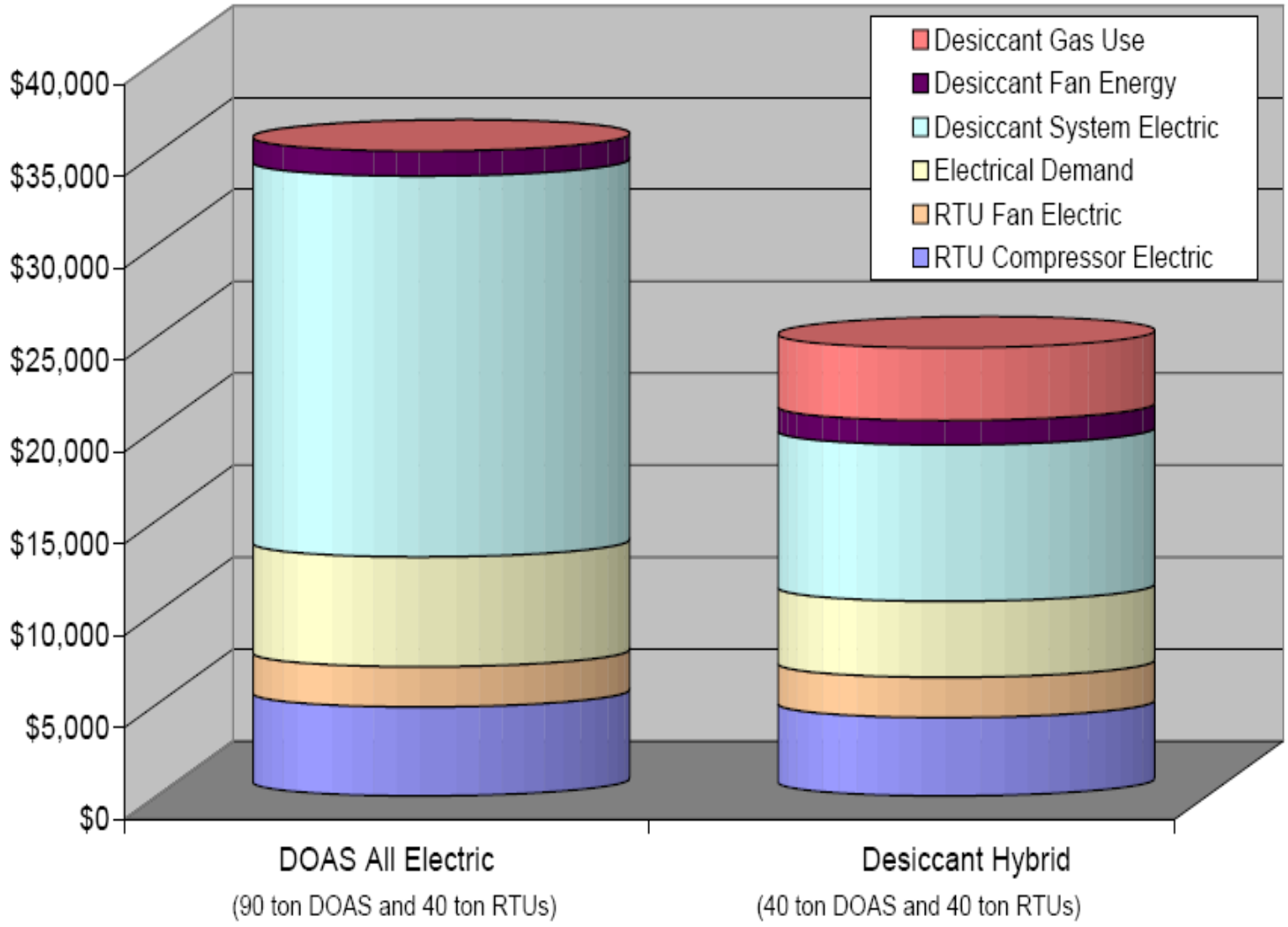
Modeling of Reheat



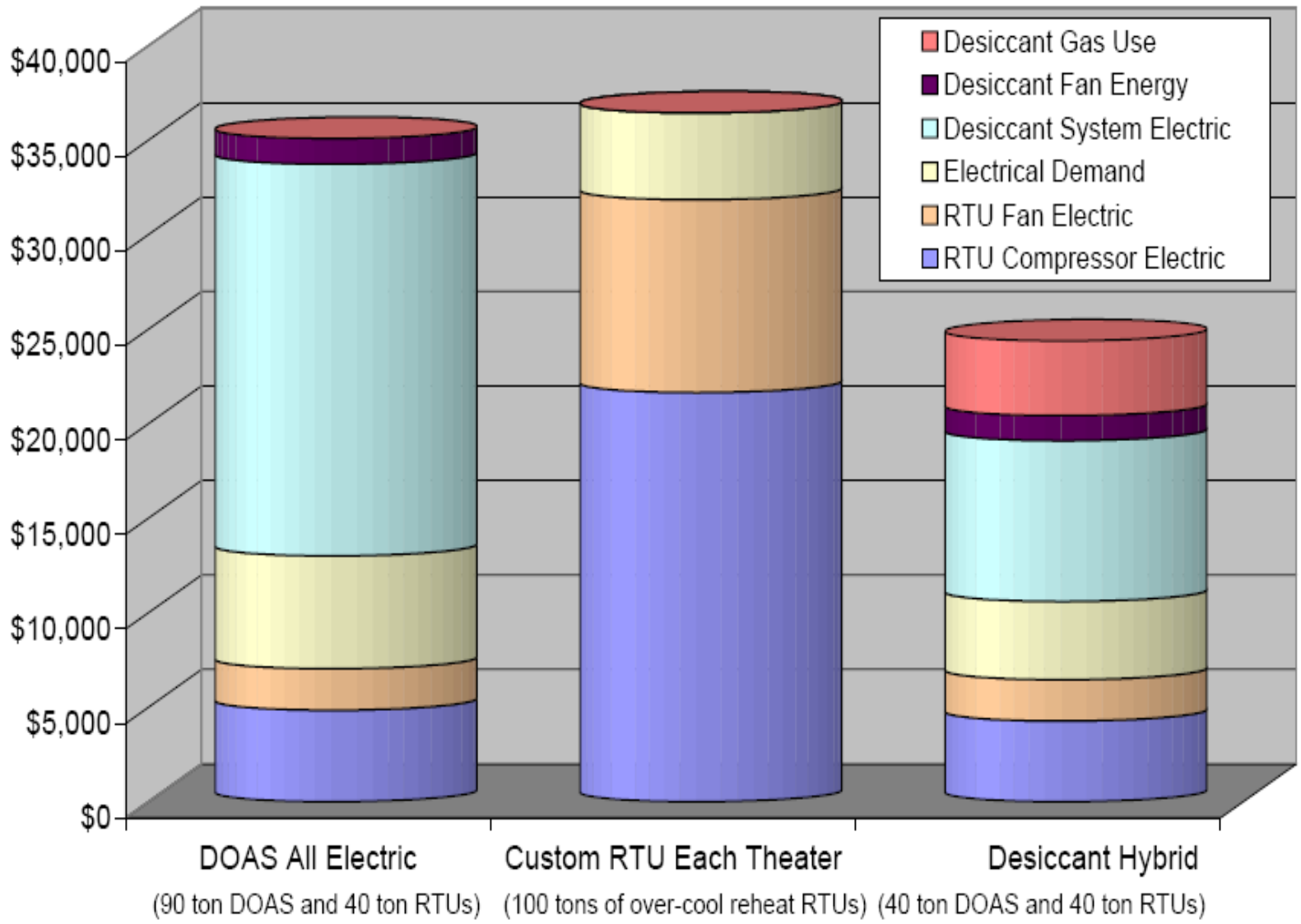
OK – but What About Efficiency?

	Gas	RTU	Supply Fan	Total Electric	Total Site Electric in MMBTUH	Total Source Electric Use in MMBTUH	Total Source Gas Use in MMBTUH	Total Source Energy in MMBTUH
Baseline		120,299	65,162	185,462	6,330	**19,181**		**19,181**
IADR	5,057	119,604	18,947	229,952	7,848	**23,783**	**5,557**	**29,340**
DOAU 10 EER		228,368	19,359	348,627	11,899	**36,056**		**36,056**
DOAU 8 EER		300,012	19,359	420,219	14,342	**43,461**		**43,461**

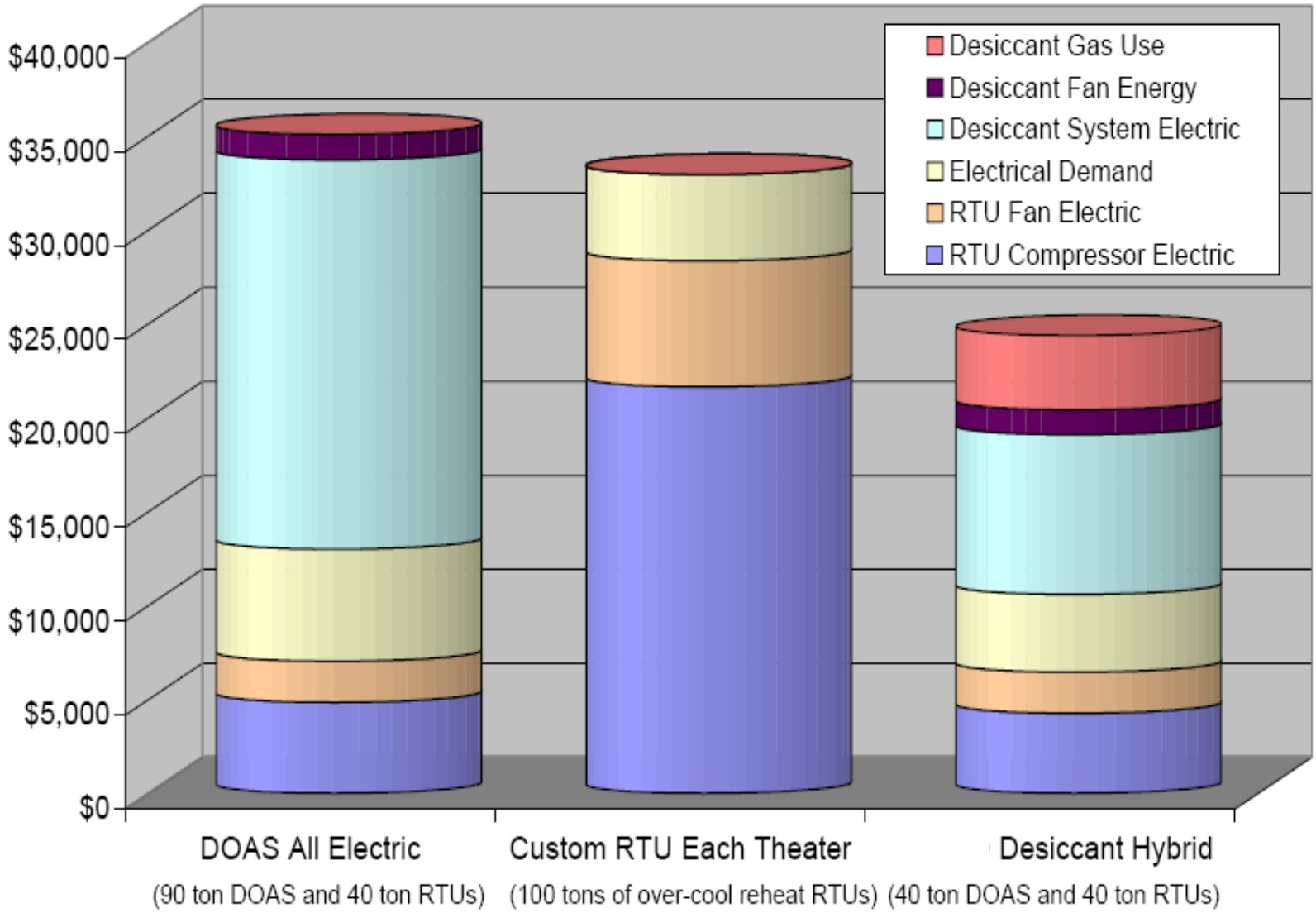
Current Duct Size



Current Duct Size



Increased Duct Size for Custom RTUs



Questions

For more information: www.exergypartners.com