

**Data Center Cooling
Using Wet-Bulb Economizers**
C. Mike Scofield, Thomas S. Weaver
ASHRAE Journal – August 2008

Presented By: Kyle Kron
April 29, 2009

Background Information

- Data processing centers consume approximately 1.5% of the total electricity in the US
- Require 40 to 50 times more power than comparably sized office space
- Only 30% to 40% of power is used to operate computers, servers, and other electronics
- Rest goes to cooling and humidifying the hardware
- Electrical energy usage estimated to double for these facilities from 2006 to 2011 to more than 100 billion kWh

Monitored Data Centers

Investigated effect of air-side economizers on:

- Particle Concentrations
 - Annual average concentrations under ASHRAE Requirements
 - Filtration effectiveness increased from 40% to 85%
- Humidity Control
 - Within ASHRAE Levels
 - Humidification required to reach dew point if air delivery temperature results in relative humidity < 40%
- Energy Savings
 - 30% mechanical cooling power reduction
 - Estimated at 60 MWh to 80 MWh per year

Calculations:

Humidity Ratio: $W = 0.62198 \frac{p_w}{p - p_w}$

Relative Humidity: $RH = \phi = \frac{p_w}{p_{ws} @ t_a}$

Dew Point Temperature:

$$t_d = 100.45 + 33.193(\ln p_w) + 2.319(\ln p_w)^2 + 0.17074(\ln p_w)^3 + 1.2063(p_w)^{0.1984}$$

Wet-Bulb Economizer

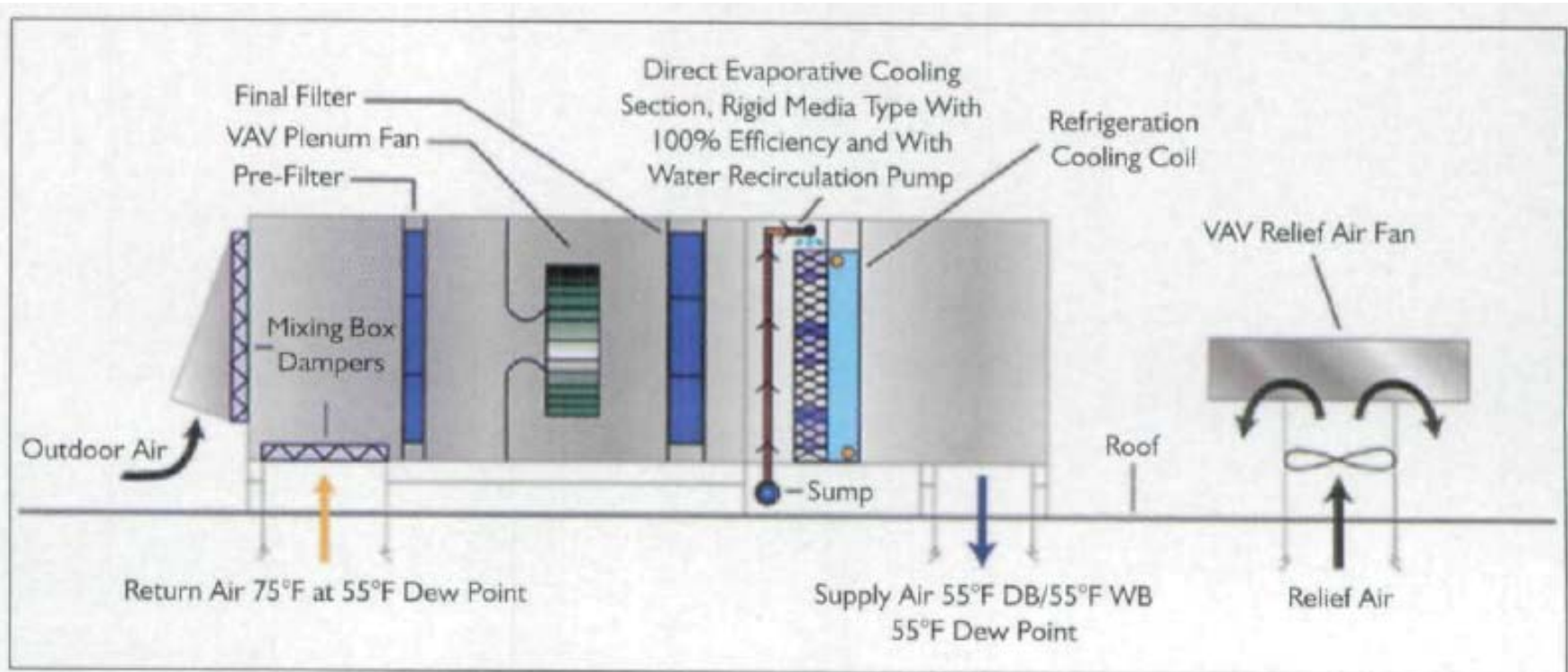


Figure 1: A roof mounted air-handling unit with a wet-bulb economizer blends outdoor air with return air to produce the required supply air dry-bulb temperature to the space. For simplicity, the figure shows performance based on a 100% saturation efficiency for the adiabatic device. Fan heat is not included. Space positive pressure is maintained by the variable air volume relief air fan.

Wet-Bulb Economizer

- Provide stable room humidity control and reduced particulate concentrations
- Air scrubbed by direct evaporative cooling device
- Contains a Direct Evaporative Cooler
 - Extends data center economizer cooling hours and provides humidity control
 - Outdoor air mixes with return air in order to achieve wet-bulb condition
 - fan heat added results in setpoint supply air temp. and dew point
- Uses heat generated by electronics to evaporate water off a wetted rigid media pad

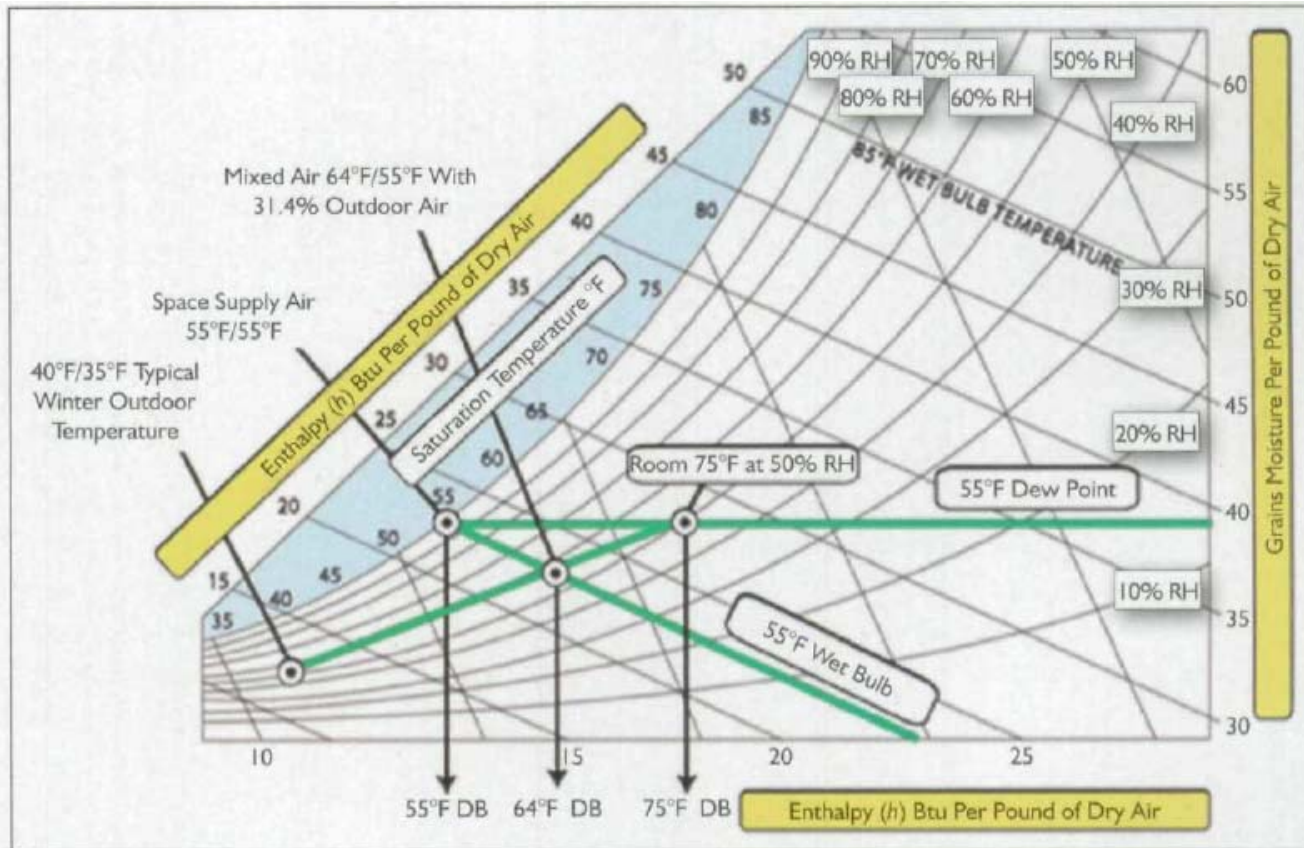


Figure 2: The wet-bulb economizer process is illustrated at a typical 40°F ambient outdoor winter condition. Both room dew-point (humidity) and setpoint supply air temperature are generated with the heat recovered from the data center return air by the rigid media cooler/humidifier. Fan heat is not included.

- Adjusting the proportions of outdoor and return air determine supply air setpoint conditions
- Dry Bulb delivery temp as high as 68°F to 77°F
- Dew point max of 63°F and 70°F sets the upper limit for delivery condition of adiabatic cooler/humidifier system

Cold Climates

- Heat recovery and humidification provided by WBE system
- Outdoor Ambient Temperature Zones
 - **Zone 1:** Heat recovery for free humidification while keeping refrigeration off
 - **Zone 2:** Provides free cooling and humidification and keeps refrigeration off
 - **Zone 3:** Controls the room delivery of DP (humidity) with reduced refrigeration by introducing 100% outside air to adiabatic device
 - **Zone 4:** Air dampers close to minimum position to maintain data center positive pressure control and refrigeration is required

Location	Zone 1 Hours/Year %	Zone 2 Hours/Year %	Zone 3 Hours/Year %	Zone 4 Hours/Year %
Boston	59	8.5	16.5	16
Chicago	56	7	17	20
Atlanta	34	9	21	36
Denver	59	30	11	0
Sunnyvale, Calif.	35	22.5	38.5	4

Table 1: Percentage of annual hours that reside in each zone of Figure 3 for five North American cities based on bin weather data and a 24/7 duty cycle.

Refrigeration Redundancy

- Refrigeration Cooling systems do Fail
- Adiabatic evaporative cooling/humidification system runs with a 90% saturation rate
 - Provides the cold aisle inlet conditions
 - Humidity not within recommended levels
 - Allows for continuous operation during failure and prevents costly shutdown
 - Hot aisle resultant return air should remain Class I-IV operating limits
 - Dew Point does not exceed 63°F
- 100% outside air can be used and data center will still remain within acceptable limits

Filtration Redundancy

- Introducing outside air need filters with MERV rating of 10 to 11
- 12 in. deep wetted media pad acts as an air scrubber
- Direct evaporative cooler/humidifier
 - Not used as primary source for data contamination removal
 - Provide a valuable redundancy to principal filtration system

Conclusions:

- WBE in large air handling units offer advantages:
 - Recapture valuable data center floor space for more hardware
 - Increase computer-center security through elimination of in-room maintenance
 - Simplified dew-point control
 - Filtration redundancy
 - Refrigeration redundancy
- Payback for one of the WBE units is one year for a 24/7 duty cycle of data center operation
- No longer need large pumps, unit coils, cooling towers, etc