EPA Conference on Enterprise Servers and Data Centers: Opportunities for Energy Savings

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Case Study: Expanding Existing Data Center

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Energy Efficiency Options for...

Expanding Existing Data Center

- Tier 4; ~45,000 ft$^2$ raised floor; Add ~27,000 ft$^2$
- ~Average 125 W/ft$^2$; Add up to ~400 W/ft$^2$
- ~4 kW/rack; up to ~25 kW/rack
Existing Data Center Expansion

Primary Focus: Cooling System
✓ Electrical hardware procured earlier
✓ Air distribution critical
  ...especially for high density racks
✓ Free cooling opportunities
  • Air side economizer
  • Water side economizer
✓ VFD for new chillers?
HVAC System

• 30 tons CRAC units, under floor air distribution (~1800 tons); Add ~1200 tons
• 4x600 tons chillers, capacity modulation
• 2x600 tons additional chiller
• Primary/Secondary pumping
• 5 Cells cooling tower
Heat Rejection Chain

Several heat transfer loops

...independent, but interacting

• Server fans, from server chips to room air
• CRAC, from room air to cooling coil water
• Secondary pumps, from cooling coil water to primary loop
• Primary pump, from loop to chiller
• Condenser water, from chiller to cooling tower
• CT fans, from condenser water to air
Air Flow

Air flow determined from heat carrying capacity:

\[ Q = M \times C_p \times (T_o - T_i) \]

\[ = k \times \text{CFM} \times (T_o - T_i) \]

\( T_i = \text{Server inlet temp, } \sim 55\text{F} \)

\( T_o = \text{Server outlet temp, } \sim 100\text{F} \)

(acceptable, chip core temp <190 F)
Required airflow...

Minimum server flow: 67,600 CFM
...for removing 1000 kW server load
...based on 53 F server inlet and 100 F discharge temp

**CRAC Units Airflow: 171,100 CFM**

...300 tons CRAC units
...based on 72 F return and 53 F supply
Airflow, min. required vs. actual

...for 1000 kW server load
...cost based on $.055/kWh

Minimum Required CFM

Bypass/ or Over supply CFM

$18,493

$28,232
Cost Impact of 10% Airflow Reduction

...for 1000 kW server load

Potential 10% CFM Reduction

Minimum Required CFM

Bypass/Over Supply CFM

$12,662

$14,979

$19,083

$14,979

$19,083

$12,662
Cost Impact of 20% Airflow Reduction

...for 1000 kW server load

Potential 20% CFM Reduction

Minimum Required CFM

Bypass/Over Supply CFM

$29,285

$8,628

$8,812

$29,285

$8,628

$8,812
Measured Fan Power Vs. Speed

- Measured
- \(^3\) Correlation
- \(^2\) Correlation

Fan Speed, %

Fan Power, %

0% 20% 40% 60% 80% 100%

100% 75% 50%
Reducing flow/ using VFD

**Against**
- Data center load is constant and does not vary
- It is not used in data centers
- Not cost effective?
- How would you control VFD?

**For**
- Data center is designed with ~15-20% redundant CRAC and airflow capacity
- Data center load does vary, not hour to hour, but from day to day as number of servers change
What won approval for VFD?

...Energy savings???

However, for a 1000 kW server area, use of VFD would save 50 kW power at 80% fan speed.

Would IT rather have 50 kW power to put 10 additional 5 kW server racks?
VFD Economics

Estimated payback ~16 months
(assuming avg. 15% speed reduction, ~50% power reduction)

Actual payback ~8 months
(time required to load servers/racks; VFD operated at ~50% speed, >80% power savings)

Recommendations: Oversupply of air; Reduce Airflow; VFD Cost effective
Comparison of CRAC fan energy vs. chiller/central plant

- A 40 ton CRAC has ~15 hp fan, ~11 kW
- Typical 20% redundant/extra capacity, fan power ~13kW
- Fan power load constant 365x24
- Chiller central plant power ~.70 kW/ton
- A 40 ton CRAC will use ~28 kW
- Central plant energy use will change with ambient, average ~20kW for 365x24
- Fan energy ~30-45% of total HVAC energy
Free cooling

- **Air side economizer**
  - Can be used when ambient air below ~55 F

- **Water side economizer**
  - Run cooling tower when ambient outdoor is cold to chill condenser water to ~42 F
  - Use cooling tower water to cool chilled water to 45 F
  - Can be used when ambient outdoor wet bulb temperature is below ~35 F
Free cooling potential

Austin Weather Data

WATER

AIR

Number of Hours

Ambient Temperature

17.5 22.5 27.5 32.5 37.5 42.5 47.5 52.5 57.5 62.5 67.5 72.5 82.5 87.5 92.5 97.5
Free Cooling Potential

Austin Weather

Cumulative Hours

Ambient temperature

WATER

AIR
Air side economizer

- Large amounts of outdoor air needed
- ~1,710,000 CFM needed at 53 F
- ~3400 ft² opening/ filter area needed (at 500 FPM)
- No convenient way to bring outside air to CRAC on raised data floor with down flow design
- Humidity control problems; other contaminants
- Did not find it practical
Water side economizer

- Preferred to air side: Avoids contaminants, humidity problems, large OA opening, delivering OA to CRAC on raised data floor
- However, fewer potential hours <600 annually
- Question about cooling tower operation and performance at freezing ambient conditions; not enough information, data available
- Controls issues with switching between condenser mode to economizer chiller mode
- New VFD chillers very efficient at low ambient
- Heat exchanger requirement between condenser and chilled water; retrofit impractical with existing system
Additional Chillers

- Existing chillers constant speed, vane capacity modulation
- Newer technology (primarily refrigerant) available
- Will chiller VFD...
  - Provide any energy benefits?
  - How will it be sequenced with existing chillers operating in parallel?
- Selected VFD for new chillers
  - More efficient new chillers are lead chillers
  - Still optimizing operational and control sequences
Lights out data center

- Installed motion sensors on fluorescent lights between isles
- Cost effective questions as people would be working most of the time?
- Certainly cost effective to install now than to retrofit later
- Security issue; emergency 7x24 lights sufficient for new security cameras
- Reduced light power load can be spared for use by IT equipment
World-Class Austin Data Center

- 1 Acre of computer room space
- Middle of the US
- Dual power feeds
- Five 2-MegaWatt diesel backup generators
- Three 600 ton chillers
- Dual redundant OC12 Ring to RMDC