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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:

$Q = M*C_{p*}(T_o - T_i)$

$=k*CFM*(T_o - T_i)$

T_i = Server inlet temp, ~55F

T_0 = Server outlet temp, ~100 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

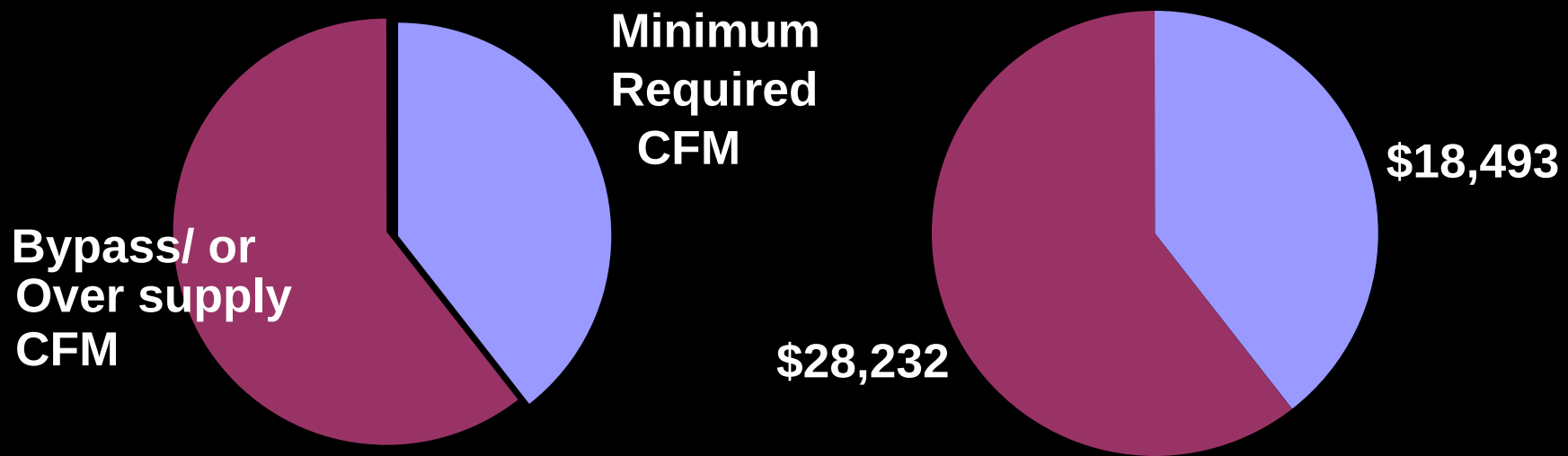
CRAC Units Airflow: 171,100 CFM

…300 tons CRAC units

…based on 72 F return and 53 F supply

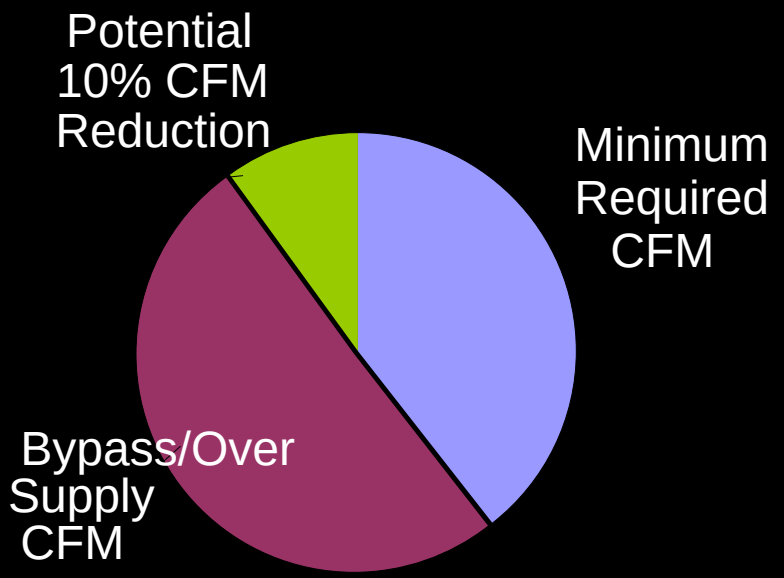
Airflow, min. required vs. actual

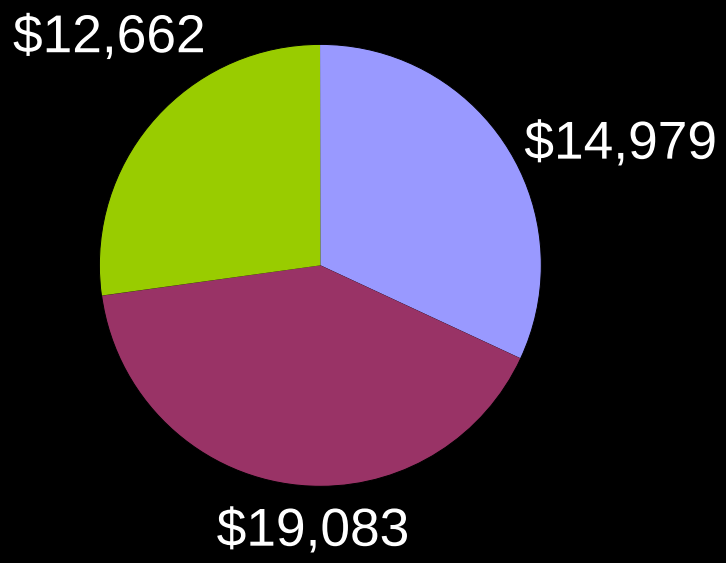
…for 1000 kW server load
…cost based on $.055/kWh



Cost Impact of 10% Airflow Reduction

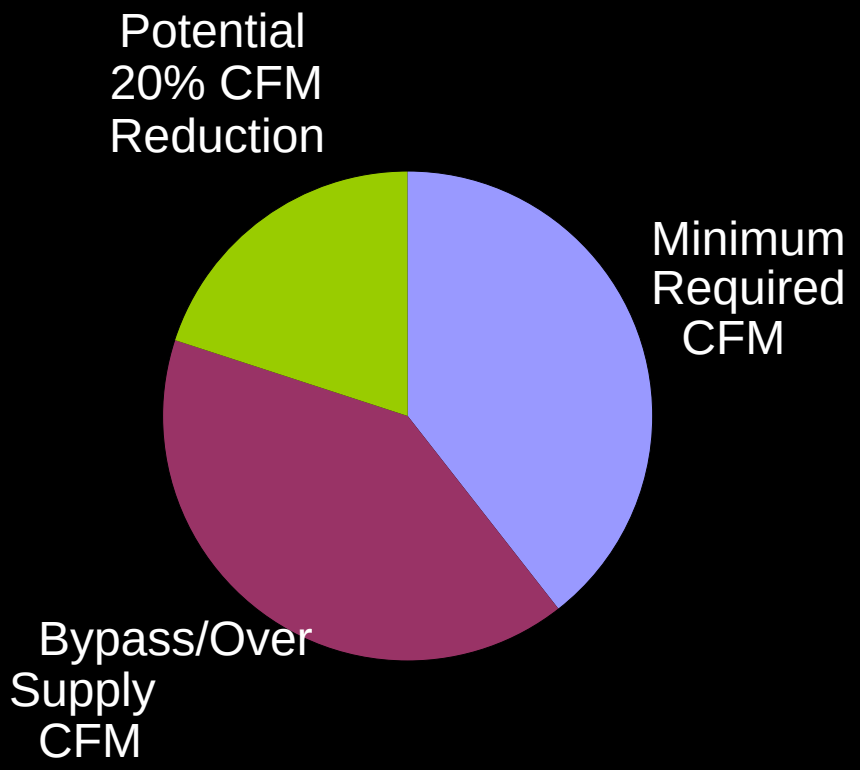
…for 1000 kW server load

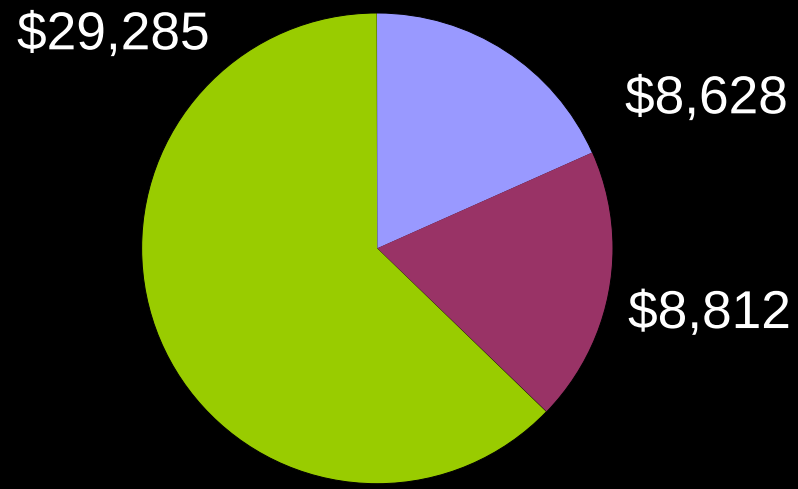




Cost Impact of 20% Airflow Reduction

…for 1000 kW server load





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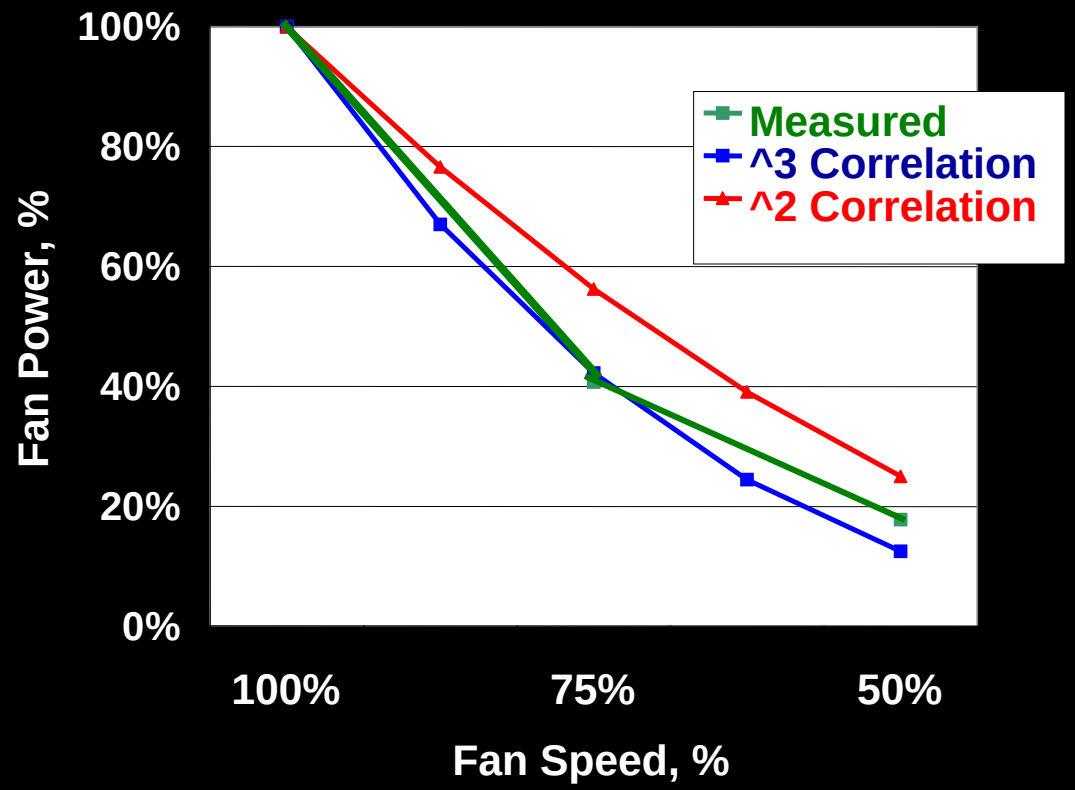
Measured Fan Power Vs. Speed



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

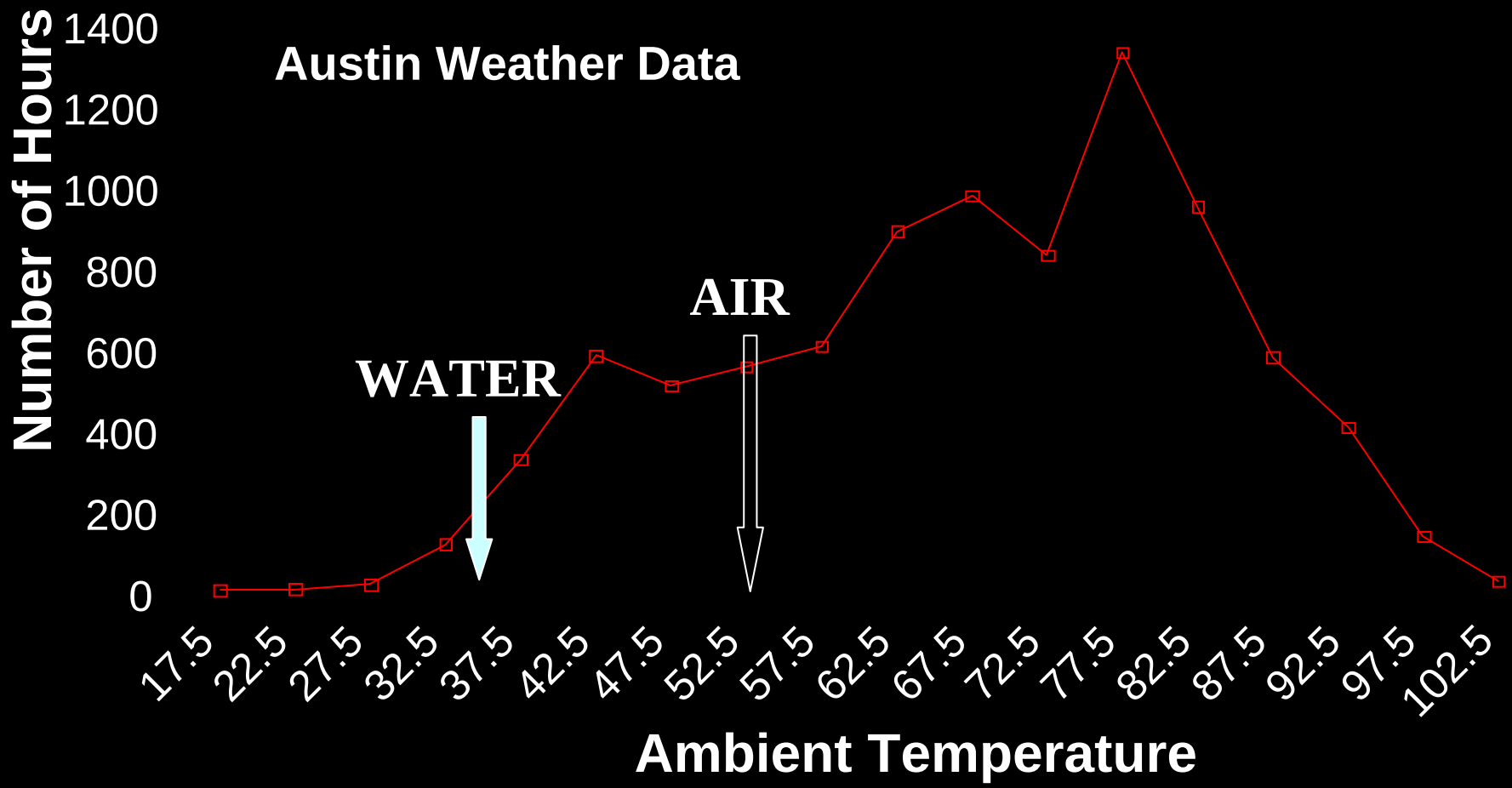
Comparison of CRAC fan energy vs. chiller/central plant

- 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**

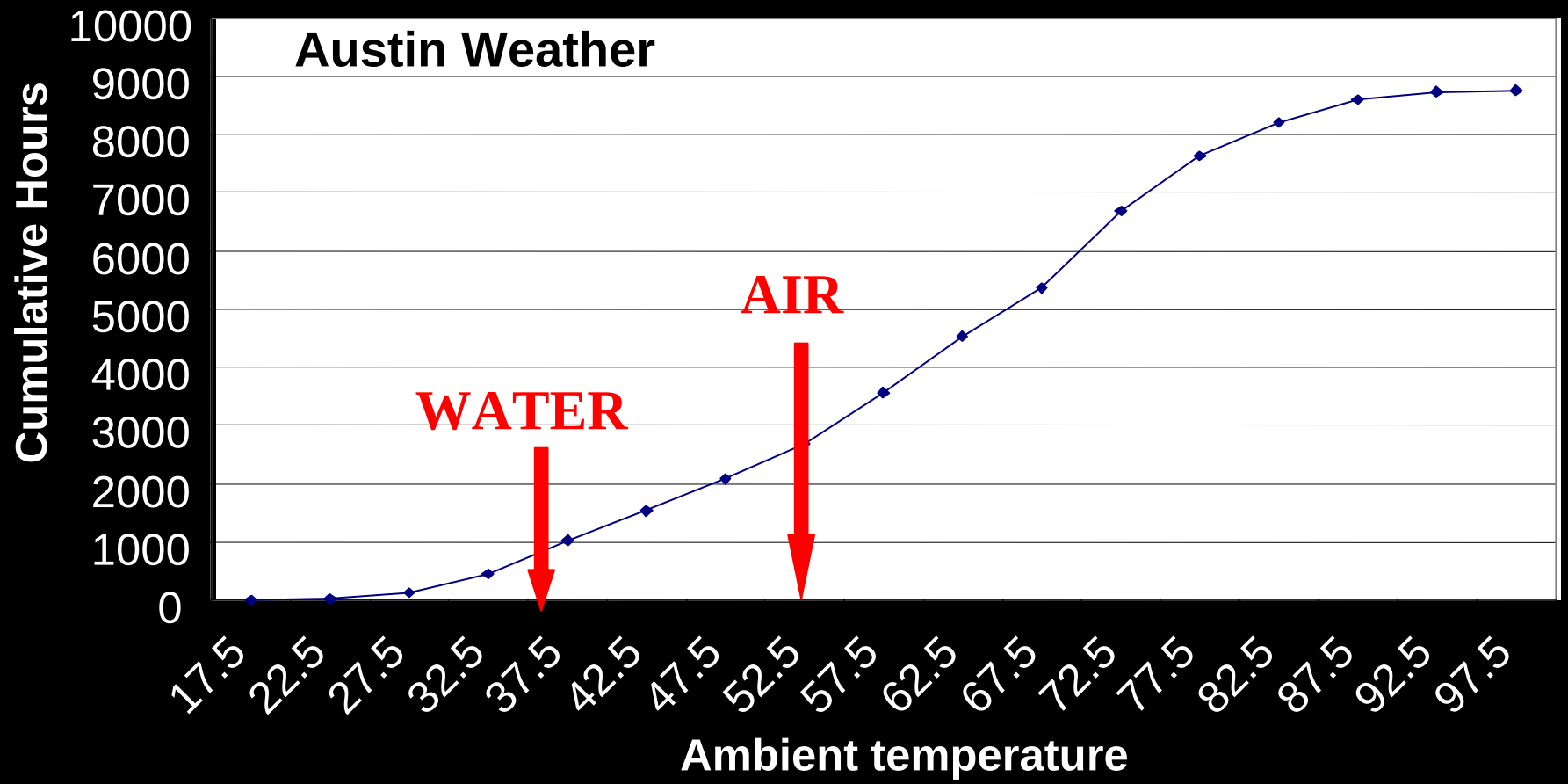
Free cooling

- 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



Free Cooling Potential



Air side economizer

- Large amounts of outdoor air needed
- ~1,710,000 CFM needed at 53 F
- ~3400 ft^2 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


QUESTIONS
ANSWERS
Q&A
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World-Class Austin Data Center

Oracle's 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