Most Wanted! Energy Efficiency Without Sacrificing Reliability in Data Centers

2016 Better Buildings Summit

Tuesday, May 10, 11:15AM -12:30PM

Speakers

- Moderator
  - John Clinger – ICF International
- Presenter/Panelists
  - Dave Breland - Intuit
  - John Dumler – Digital Realty
  - Isaac Negusse – Iron Mountain

Data Center Energy Conservation Pathway

intuit
simplify the business of life

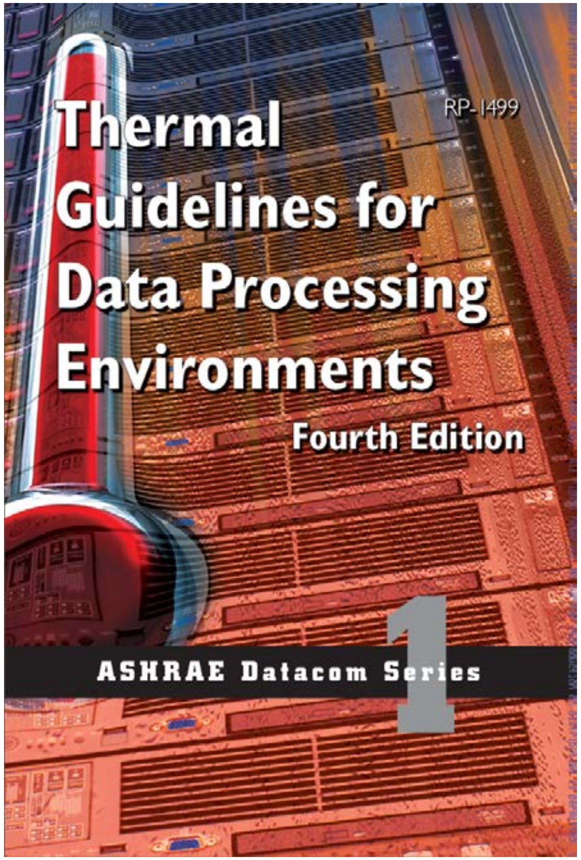
Intuits Enterprise Data Center Quincy WA

- Built 2008 – EYP Mission Critical Engineering/ Corbin Consulting Engineer’s
- 231,280 square feet
- Fault tolerant concurrently maintainable
- Water Side Economizer
- 4’ Raised Access Floor
- CRAH’s in galleries either side of data halls with a 12’ return wall and a 32’ ceiling height.
- Other Quincy Data Centers – Microsoft, Yahoo, Dell, Sabey and Vantage.

Enter ASHRAE TC 9.9

Table A.1 Comparison of 2004, 2008/2011, and 2015 Versions of Recommended Envelopes

	2004 Version	2008/2011 Version	2015 Version
Low-end temperature	20°C (68°F)	18°C (64.4°F)	18°C (64.4°F)
High-end temperature	25°C (77°F)	27°C (80.6°F)	27°C (80.6°F)
Low-end moisture	40% rh	5.5°C (41.9°F) DP	–9°C (15.8°F) DP
High-end moisture	55% rh	60% rh and 15°C (59°F) DP	60% rh and 15°C (59°F) DP



Note: that the Green Grid White Paper #50 speaks to the efficiency and reliability of IT Equipment at the wider operating temperature and humidity ranges. A very good resource.

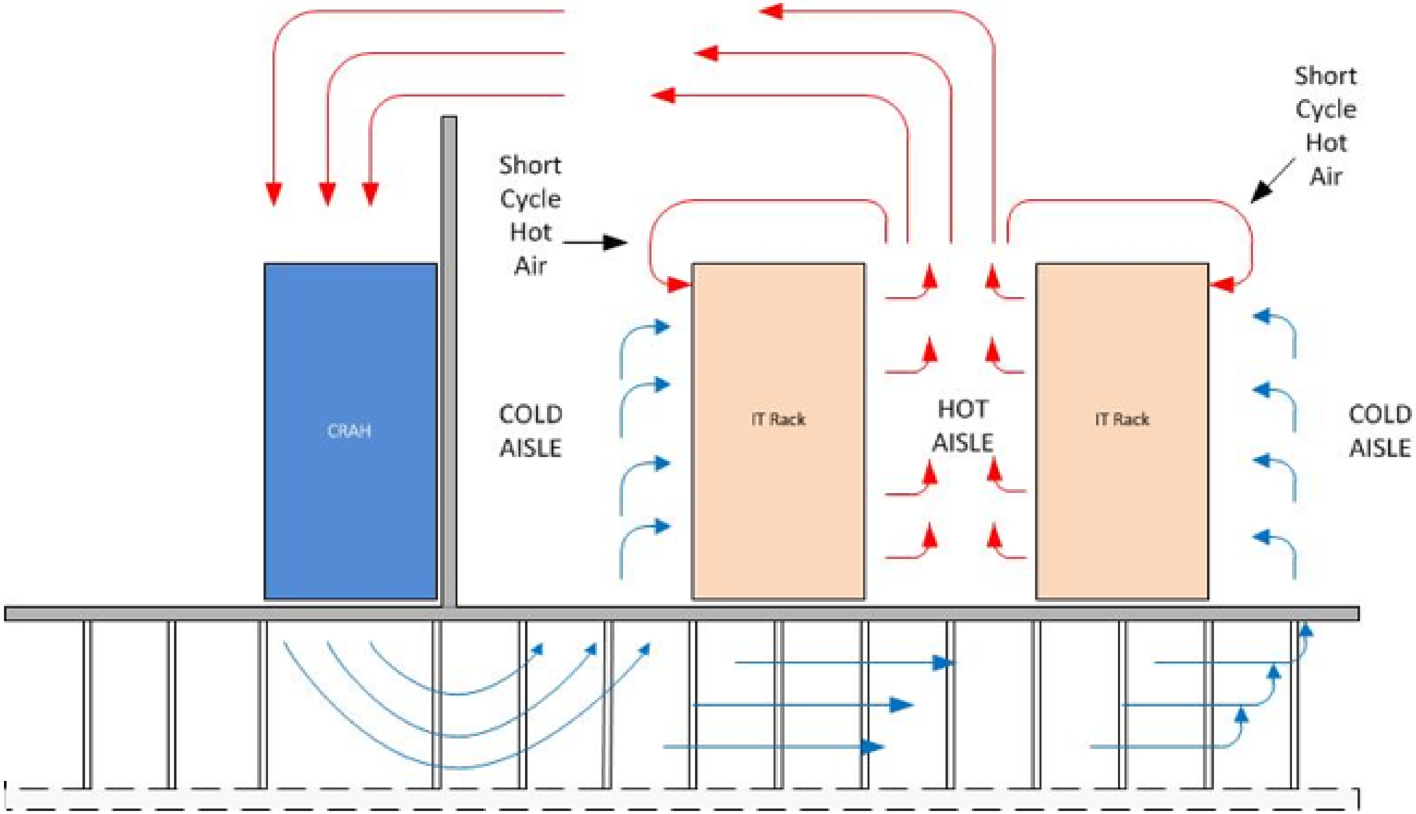
How do I show a value beyond merely uptime? Answer: Reduce Overhead/Energy

What have we done?	Why	Result
Increased top of rack set points from 72° – 77° f.	Servers begin using more power for cooling at 77° f. yet still remain within manufacturers guidelines	An approximate 10% load reduction on chiller plant. For us that meant approx. 54KW
Working with CRAH manufacturer and design ME reduced fan speeds to best point on fan curve.	To insure as much heat transfer as possible at the CRAH.	Reduced CRAH power by 18%, however began to see hot air migration from hot to cold aisles. 5KW reduction per unit
In touring other facilities we noted that several facilities were using solid back cabinets with chimneys connected to return plenums. We purchased several and put them in production.	The thinking was that the although I have no return plenum, we have a 12' return wall, so if we can get the hot exhaust up to 12', it would be an easier path back to the CRAH than the front of the rack.	No more temperature alarms due to hot air migration and we were able to raise the CRAH discharge temp's as we were no longer fighting hot air migration.

What have we done?	Why	Result
Decided to try making the same principle work on existing rows by have a four foot wall erected above the hot aisle and added doors at either end. This work done by a mechanical contractor.	No one wants to go buy new cabinets, yet we wanted the same result.	With blanking plates and good sealing technologies we found we had attained the same result. Only issue was this was not a flexible option for changes in future.
Cabinet Manufacturer (CPI) introduced us to their containment option that was almost an erector set. Cost of around $15K for a contained 30' pair of rows self installed.	This system allowed my own technicians to self install and is very easily modified to whatever rack or device is deployed.	The CPI system gave the same result yet as it was clear with fire rated Lexan it made for better lighting in the hot aisle. Further doors were favored by the IT team. We will complete the Data Center this quarter.
We have raised our secondary chilled water temperature from 47° to 61° f.	We noted that our CRAH valves were barely opening to maintain temp, especially as we have 2N redundancy	This put the CRAH's back in their sweet spot for control, but best of all increased our hours of economization by almost 20% (annual climate impacts)

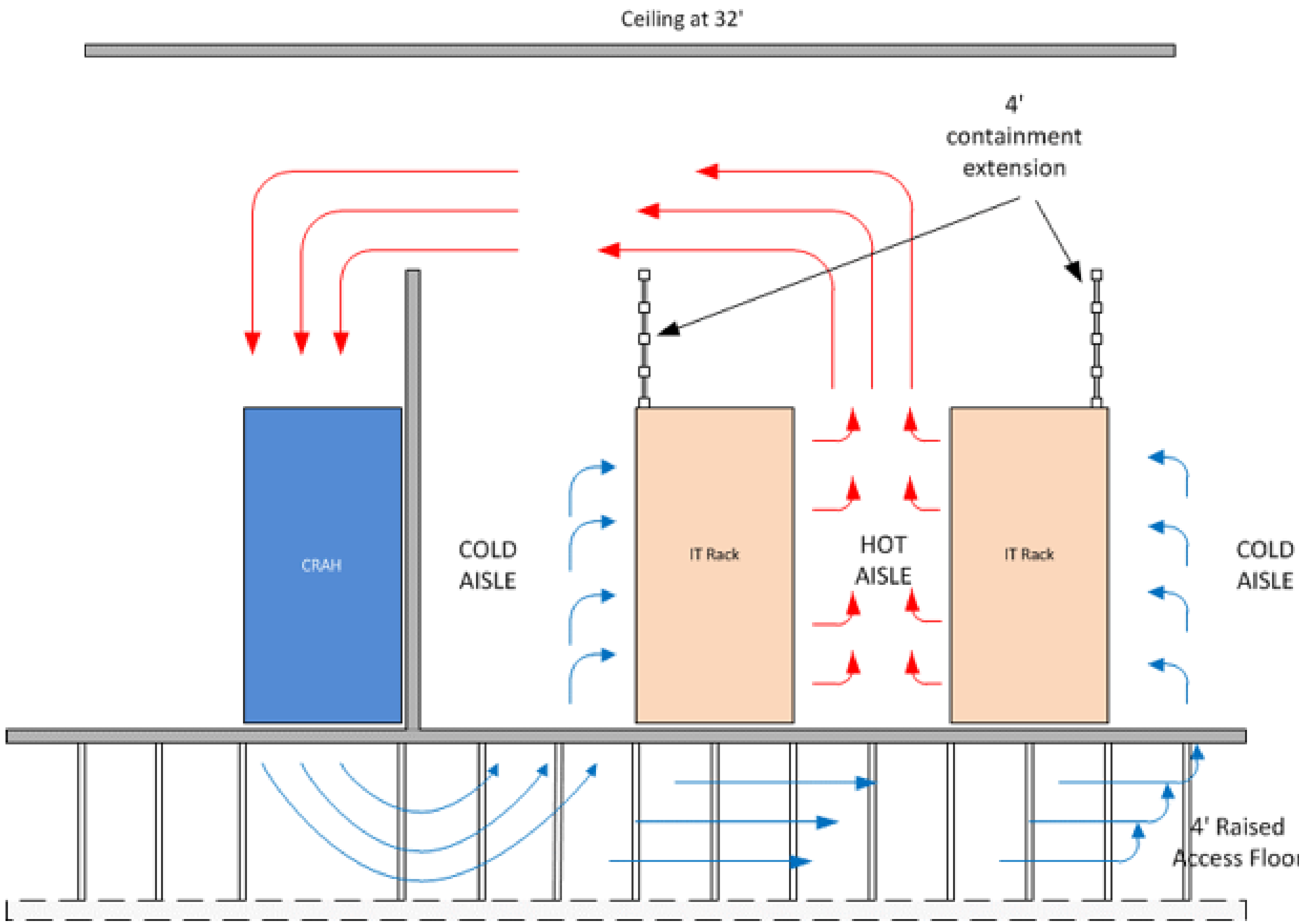
What have we done?	Why	Result
Reduced emergency lighting in data center by 50% and still easily maintain safe egress lighting. Further added motion/occupancy detectors for primary lighting.	The darkest point in the room you could easily sit and read a book. Obviously way too bright.	Annual savings the first year of 173, 295 KWH. Continue review of LED options, especially in exterior lighting applications.
Using our Purkay temp/humidity sensors we have mapped three points on every rack and will be using this data with TileFlow to use their CFD modeling software and further refine temp and humidity in the data hall.	This will let us see the best way to insure cooling is happening only where it needs to and no overheating. I found these tools at 7 X 24 and the Critical Facilities Summits.	Coming Soon!

Airflow Dynamics Prior to Containment



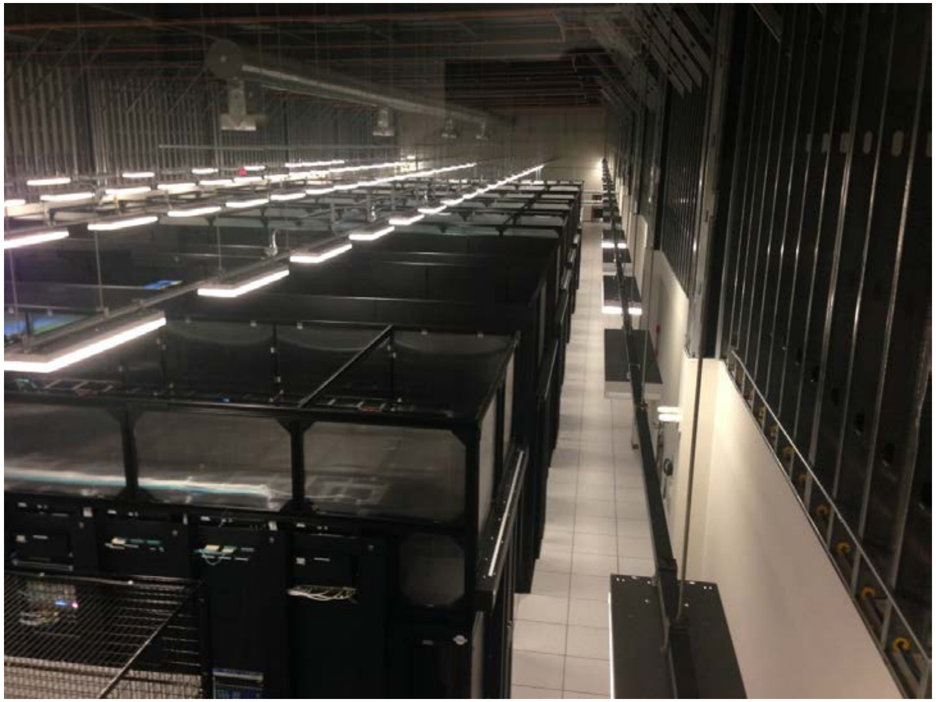
This diagram shows in a very simple way the air flow that was causing heat problems due to short cycling of the hot air. Previous to adopting the ASHRAE TC9.9 standards the cold aisle was more than cold enough to keep cold air rising to the top of rack. With a warmer inlet air, server fans ramp up and change the air flow dynamics.

Final Airflow Patterns After Containment



By inserting a containment chimney of four feet above each of the eight foot racks, the return air then matches the height of the gallery wall, and makes the path back to the CRAH the easier path. I only show one CRAH for simplicity, however there are CRAH's on both sides.

Actual View of Chimneys



Primary tool used for temp/humidity monitoring and data logging beyond JCI

Most Wanted!

Energy Efficiency Without Sacrificing Reliability in Data Centers

DIGITAL REALTY
Data Center Solutions

May 10, 2016

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Digital Realty Overview (NYSE: DLR)

World's Largest Data Center REIT

- One of the 20 largest publicly-traded U.S. REITs[(1)]
- Equity market capitalization of approximately $12.6 billion[(2)]
- Diversified portfolio of properties and tenants, located in over 33 markets throughout North America, Europe, Asia and Australia[(3)]
  - 139 properties
  - 400+ suites (many totally discrete)
  - 25 million+ rentable square feet
- Over a decade of experience providing data center solutions

1) U.S. REITs with RMZ. Source: companies' financials based on latest public filings. Based on equity market capitalization as of February 18, 2015
2) Based on closing common stock price of $85.95 as of April 21, 2016.
3) As of December 31, 2014. Includes investments in fourteen unconsolidated joint ventures.

Who Are Our Target Customers?

Addressing Growing Global Data Center Requirements

SMACC + NETWORK (Social, Mobile, Analytics, Cloud & Content)	IT SERVICES	FINANCIAL SERVICES & OTHER LARGE USERS
facebook, ORACLE, SOFTLAYER an IBM Company, CenturyLink, zayo GROUP	EQUINIX, IBM, at&t	J.P.Morgan, Deutsche Bank, Morgan Stanley

Better Buildings Data Center Challenge

Better Buildings Challenge
Overview

- How is Digital involved?
  - Digital has publically committed to reduce our non-IT energy intensity, within a 20MW sub-portfolio of properties, by 20% over 10 years.
  - Digital is one of (12) Data Center Challenge Partners.
  - ~17% Cumulative Progress (vs. 2013 baseline)
    - Air Management Improvements
    - Controls enhancements
    - CRAH/C EC fan upgrades
    - Operational efficiencies

Energy Efficiency Without Sacrificing Reliability

Efficiency Without Sacrificing Reliability
Overview

Typical Topics/Ideas

- Air management
  - Reducing bypass and recirculation
  - Balance airflow to IT requirements
- Controls enhancements and re-commissioning
- Fan EC/VFD upgrades
- Reduce running redundancy
- Raising set points

Efficiency Without Sacrificing Reliability
Raising Set Points

WHY?

- Improved Efficiency
  - More efficiency equipment operation (increased capacity)
  - Increased Economizer Hours (less compressor usage)
  - Increased deltaT = less fan/pump
- Other?

WHY NOT?

What reasons have you heard?

- We don't pay the bills, but we are responsible for SLA violations.
- It doesn't do anything. A BTU's a BTU
- We haven't touched these set points in years.
- My economizer is more trouble than it's worth.
- Our space has lots of storage and tapes need tighter control bands.[1]
- Raising temps causes dehumidification issues.
- The customer doesn't care about introducing risk and saving $30k/year in energy when they are transacting $1MM/day. Too risky, go away.
- Raising temps too high will cause my server fans to ramp up, increasing energy consumption.
- If the cooling fails, I'll have less thermal ride-through before I get outside the SLA.

1. ASHRAE Thermal Guidelines for Data Processing Environments, 4th Ed

Efficiency Without Sacrificing Reliability
Raising Set Points

THERMAL RIDE-THROUGH

- The time required for an available thermal mass to maintain SLA requirements during a cooling outage. In other words, how long do I have before my temperatures exceed SLA's and potentially damage IT equipment?

- Show of hands – has anyone voluntarily tested thermal ride-through in a live operating environment vs Level 5 Commissioning environment?

Efficiency Without Sacrificing Reliability
Raising Set Points

<u>CONSIDERATIONS</u>

- Every data center is different.
- Understand existing conditions!
- What’s your risk tolerance?
- What’s your budget?
- What’s your utility cost and true savings opportunity?
- All mechanical systems are different. Failure and restart times are set in design and confirmed in Level 5 Cx
- Is rate of temp change important/relevant?
- How’s your Air Management health?

Efficiency Without Sacrificing Reliability
Raising Set Points

ONE SYSTEMATIC APPROACH – EXISTING (LEGACY) DATA CENTER

- **Assess existing conditions**
  - Air Management (baseline)
    - Balance – bypass/recirculation
    - Tile management
    - DeltaT's
  - Rack inlet temps
  - CRAH/C temps and set points
  - Controls & alarming
  - Utility bills

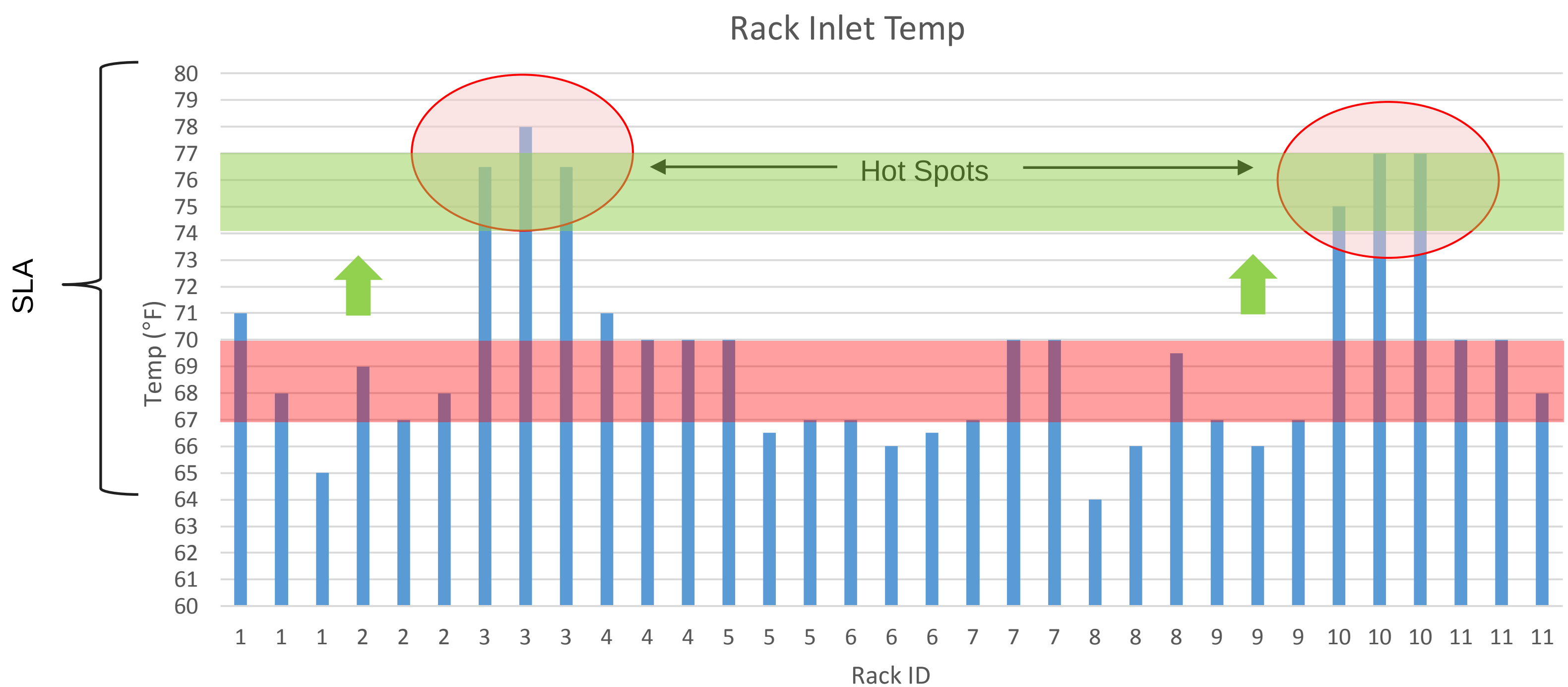
- *Accurate CFD Modeling to help predict outcomes of changes*
  - *Garbage in → Garbage out*

Efficiency Without Sacrificing Reliability
Raising Set Points

ONE SYSTEMATIC APPROACH – EXISTING (LEGACY) DATA CENTER

- Implement
  - Air Management improvements
  - Controls optimizations (may improve existing reliability)
  - Validate improvements
  - Have a plan to react to things when they happen
  - Raise CRAH/C set points slowly and re-assess
    - (1°F/week)
- Continual Improvement Process
  - Maintain optimized Air Management, sensor calibration, etc.

Efficiency Without Sacrificing Reliability
Raising Set Points



- All temps are within SLA's (ASHRAE 2008 TC9.9 recommended ranges)
- Racks 3 & 10 appears to be a "hot spot". Why?
- On average, CRAH/C Return temp set points are between 67°F and 70°F
- On average, CRAH/C Supply temperatures are currently = 55°F
- **Goal: Get all readings closer to the red band, then increase CRAC/H set points**

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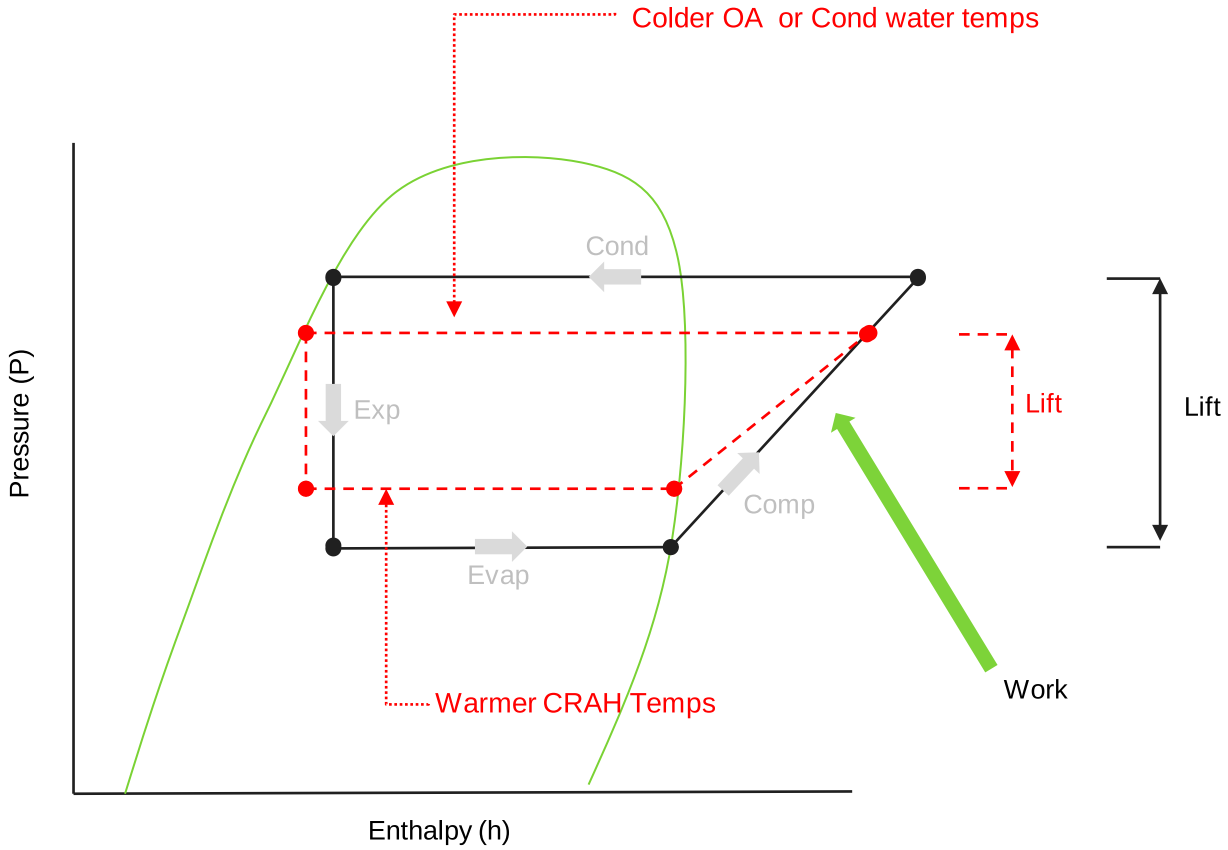
Raising Set Points

REFRIGERATION CYCLE



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Raising Set Points

HOW MUCH DOES IT REALLY SAVE?

- For DX units - approx. 1% efficiency improvement per 1°F temp increase
- For CRAH units – 1% - 2% capacity improvement per 1°F temp increase
- For units with Economizers – It varies depending on economizer type, controls, etc. Many economizers have “benign” operation. i.e. small window of realized benefit.

Efficiency Without Sacrificing Reliability
Raising Set Points

HOW MUCH DOES IT REALLY SAVE? - EXAMPLE

- 600kW IT load
- $0.135/kWh energy cost

		Energy Cost per Year	
RA Temp	%RH	Air Cooled DX	Pumped Refrigerant w/ Economizer
78	41	$343,586.00	$141,221.00
95	18	$289,564.00	$92,139.00
		Savings	
Total Savings		$54,022.00	$49,082.00
Savings/Degree		$3,177.76	$2,887.18
		16%	35%
		~ 1% / degree	~ 2% / degree

- **Can't raise it this much without proper air management and containment

Efficiency Without Sacrificing Reliability
Raising Set Points

EXAMPLE RESULTS

- Digital/Telx UEP Program
  - 11 Data Centers
  - Low hanging fruit approach, including
    - Air management
    - Raising set points
    - Reducing running redundancy
  - ~12% cumulative improvement in PUE
  - ~22% cumulative improvement in PUE-1 (overhead)
    - Total energy increased by ~18%
    - IT energy increased by ~34%
  - **Does not appear have impacted/reduced reliability**

DIGITAL REALTY
Data Center Solutions

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Appendix

Air Management

GLYCOOL DATA

Net Capacity Data BTU/HR (kW) Downflow Models DE = Downflow VE = Upflow	DE/VE72G	DE/VE110G	DE/VE116G	DE/VE192G	DE/VE240G	DE/VE363G
80°F DB, 67°F WB (26.7°C DB, 19.4°C WB) 50% RH						
Total	81,300 (23.8)	116,100 (34.0)	124,100 (36.4)	186,100 (54.5)	231,900 (67.9)	364,400 (106.8)
Sensible	68,600 (20.1)	93,500 (27.4)	108,700 (31.8)	168,800 (49.5)	203,600 (59.7)	307,100 (90.0)
75°F DB, 62.5°F WB (23.9°C DB, 16.9°C WB) 50% RH						
Total	76,100 (22.3)	108,200 (31.7)	115,900 (34.0)	173,800 (50.9)	216,100 (63.3)	340,700 (99.8)
Sensible	66,500 (19.5)	90,600 (26.5)	105,100 (30.8)	163,000 (47.8)	196,700 (57.6)	297,700 (87.2)
75°F DB. 61°F WB (23.9°C DB, 16.1°C WB) 45% RH						
Total	76,800(22.5)	105,500 (30.9)	117,400 (34.4)	176,700 (51.8)	218,400 (64.0)	340,600 (99.8)
Sensible	76,800(22.5)	96,700 (28.3)	117,400 (34.4)	176,700 (51.8)	218,400 (64.0)	340,600 (99.8)
72°F DB, 60°F WB (22.2°C DB, 15.5°C WB) 50% RH						
Total	72,800 (21.3)	103,600 (30.3)	110,900 (32.5)	170,600 (50.0)	207,100 (60.7)	327,000 (95.8)
Sensible	65,100 (19.1)	88,800 (26.0)	102,800 (30.1)	170,600 (50.0)	192,500 (56.4)	291,700 (85.5)
72°F DB, 58.6°F WB (22.2°C DB, 14.8°C WB) 45% RH						
Total	74,100 (21.7)	101,400 (29.7)	113,300 (33.2)	170,600 (50.0)	210,600 (61.7)	328,900 (96.4)
Sensible	74,100 (21.7)	94,700 (27.7)	113,300 (33.2)	170,600 (50.0)	210,600 (61.7)	328,900 (96.4)

FH=Downflow UH = Upflow

	FH/UH147C	FH/UH200C	FH/UH248C	FH/UH302C	FH/UH376C	FH/UH422C	FH/UH529C	FH/UH600C (60Hz) FH/UH599C (50Hz)	FH/UH740C (60Hz) FH/UH739C (50Hz)
Capacity Data BTU/Hr (kW) {Based On 45°F (7.2°C) Entering Water. 10°F (5.6°C) Water Rise									
80°F DB, 67°F WB (26.7°C DB, 19.4°C WB) 50% RH									
Total - kBTUH (kW)	136 (40.0)	200 (58.7)	238 (69.8)	277 (81.0)	347 (101.7)	408 (119.6)	497 (145.6)	593 (173.8)	691 (202.5)
Sensible - kBTUH (kW)	104 (30.4)	140 (41.1)	155 (45.5)	202 (59.1)	230 (67.3)	286 (83.8)	324 (94.8)	407 (119.3)	444 (130.1)
Flow Rate - GPM (Vs)	28.3 (1.8)	41.6 (2.6)	49.2 (3.1)	57.9 (3.7)	72.0 (4.6)	85.5 (5.4)	103.3 (6.5)	123.8 (7.8)	143.3 (9.1)
Press. Drop - ft (kPa)	33.8 (100.9)	50.8 (151.4)	31.1 (92.8)	24.3 (72.6)	21.4 (63.9)	28.4 (84.6)	45.7 (136.4)	54.4 (162.4)	80.1 (238.9)
75°F DB, 62.5°F WB (23.9°C DB, 16.9°C WB) 50% RH									
Total - kBTUH (kW)	95 (27.8)	143 (41.8)	175 (51.2)	193 (56.5)	248 (72.8)	281 (82.4)	358 (104.8)	408 (119.5)	496 (145.4)
Sensible - kBTUH (kW)	88 (25.9)	121 (35.3)	134 (39.3)	172 (50.5)	196 (57.5)	242 (70.8)	277 (81.0)	342 (100.3)	378 (110.7)
Flow Rate - GPM (Vs)	20.0 (1.3)	30.1 (1.9)	36.5 (2.3)	41.1 (2.6)	52.3 (3.3)	60.1 (3.8)	75.4 (4.8)	86.7 (5.5)	104.4 (6.6)
Press. Drop - ft (kPa)	17.7 (52.8)	27.4 (81.7)	18.0 (53.6)	12.9 (38.4)	11.9 (35.5)	14.8 (44.3)	25.7 (76.5)	28.2 (84.2)	44.7 (133.5)
75°F DB, 61°F WB (23.9°C DB, 16.1 °C WB) 45°% RH									
Total - kBTUH (kW)	88 (25.7)	138 (40.3)	162 (47.4)	174 (50.8)	233 (68.3)	272 (79.7)	330 (96.6)	384 (112.5)	450 (131.9)
Sensible - kBTUH (kW)	88 (25.7)	129 (37.7)	139 (40.8)	174 (50.8)	206 (60.4)	259 (76.0)	287 (84.1)	362 (106.0)	388 (113.8)
Flow Rate - GPM (Vs)	18.6 (1.2)	29.1 (1.8)	33.9 (2.1)	37.3 (2.4)	49.2 (3.1)	58.2 (3.7)	69.8 (4.4)	81.9 (5.2)	95.2 (6.0)
Press. Drop - ft (kPa)	15.5 (46.1)	25.7 (76.6)	15.7 (46.8)	10.8 (32.1)	10.7 (31.8)	14.0 (41.7)	22.3 (66.5)	25.4 (75.9)	37.8 (112.7)
72°F DB, 60°F WB (22.2°C DB, 15.5°C WB) 50% RH									
Total - kBTUH (kW)	73 (21.4)	121 (35.4)	146 (42.7)	145 (42.6)	207 (60.8)	237 (69.3)	295 (86.4)	335 (98.3)	405 (118.7)
Sensible - kBTUH (kW)	73 (21.4)	111 (32.5)	122 (35.8)	145 (42.6)	179 (52.5)	222 (65.1)	250 (73.4)	311 (91.0)	340 (99.6)
Flow Rate - GPM (Vs)	15.7 (1.0)	25.7 (1.6)	30.7 (1.9)	31.6 (2.0)	44.1 (2.8)	51.2 (3.2)	62.9 (4.0)	72.2 (4.6)	86.1 (5.5)
Press. Drop - ft (kPa)	11.3 (33.7)	20.3 (60.4)	13.1 (39.0)	7.9 (23.6)	8.7 (26.0)	11.1 (33.0)	18.4 (54.9)	20.2 (60.2)	31.4 (93.7)
72°F DB, 58.6°F WB (22.2°C DB, 14.8°C WB) 45% RH									
Total - kBTUH (kW)	73 (21.4)	110 (32.2)	142 (41.7)	145 (42.6)	187 (54.8)	215 (62.9)	266 (78.1)	308 (90.4)	363 (106.3)
Sensible - kBTUH (kW)	73 (21.4)	110 (32.2)	130 (38.2)	145 (42.6)	187 (54.8)	215 (62.9)	266 (78.1)	308 (90.4)	363 (106.3)
Flow Rate - GPM (Vs)	15.7 (1.0)	23.5 (1.5)	30.0 (1.9)	31.6 (2.0)	40.0 (2.5)	46.8 (3.0)	57.1 (3.6)	66.8 (4.2)	76.0 (4.8)
Press. Drop - ft (kPa)	11.3 (33.7)	17.1 (51.0)	12.6 (37.4)	7.9 (23.6)	7.3 (21.8)	9.4 (28.0)	15.4 (46.0)	17.5 (52.2	25.0 (74.6)

DX Cooling

- For every 1°F RA temp setpoint increase, the cooling efficiency improves approx. 1% to 2%
- Increasing RA temp setpoint also increases economizer hours on units with Econocoils.

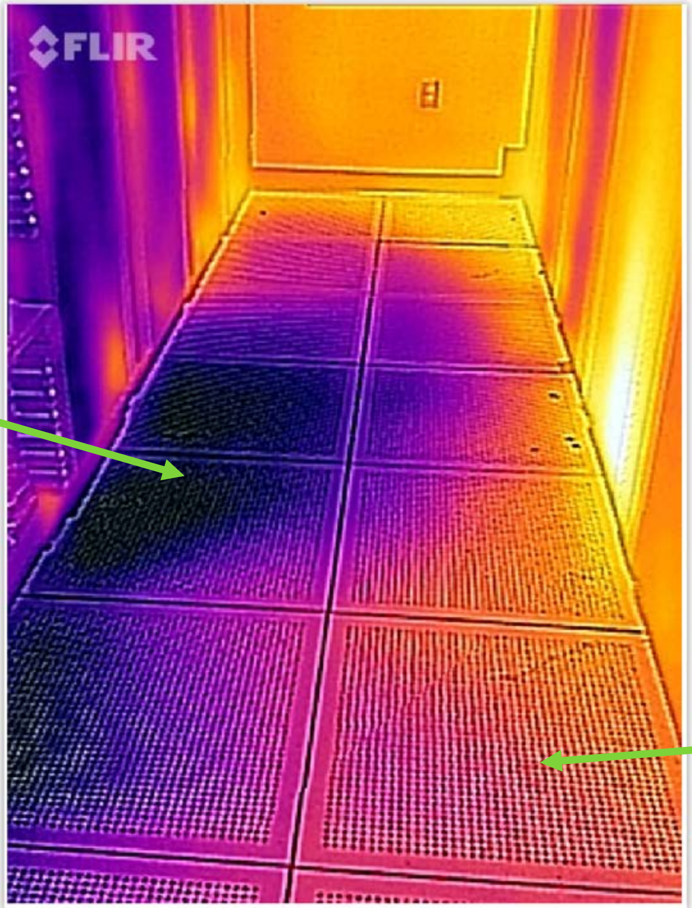
Chilled Water Cooling

- For every 1°F RA temp setpoint increase, the cooling efficiency improves approx. 2%

Raising Set points
Air Management

Seeing Air Management Issue

64°F



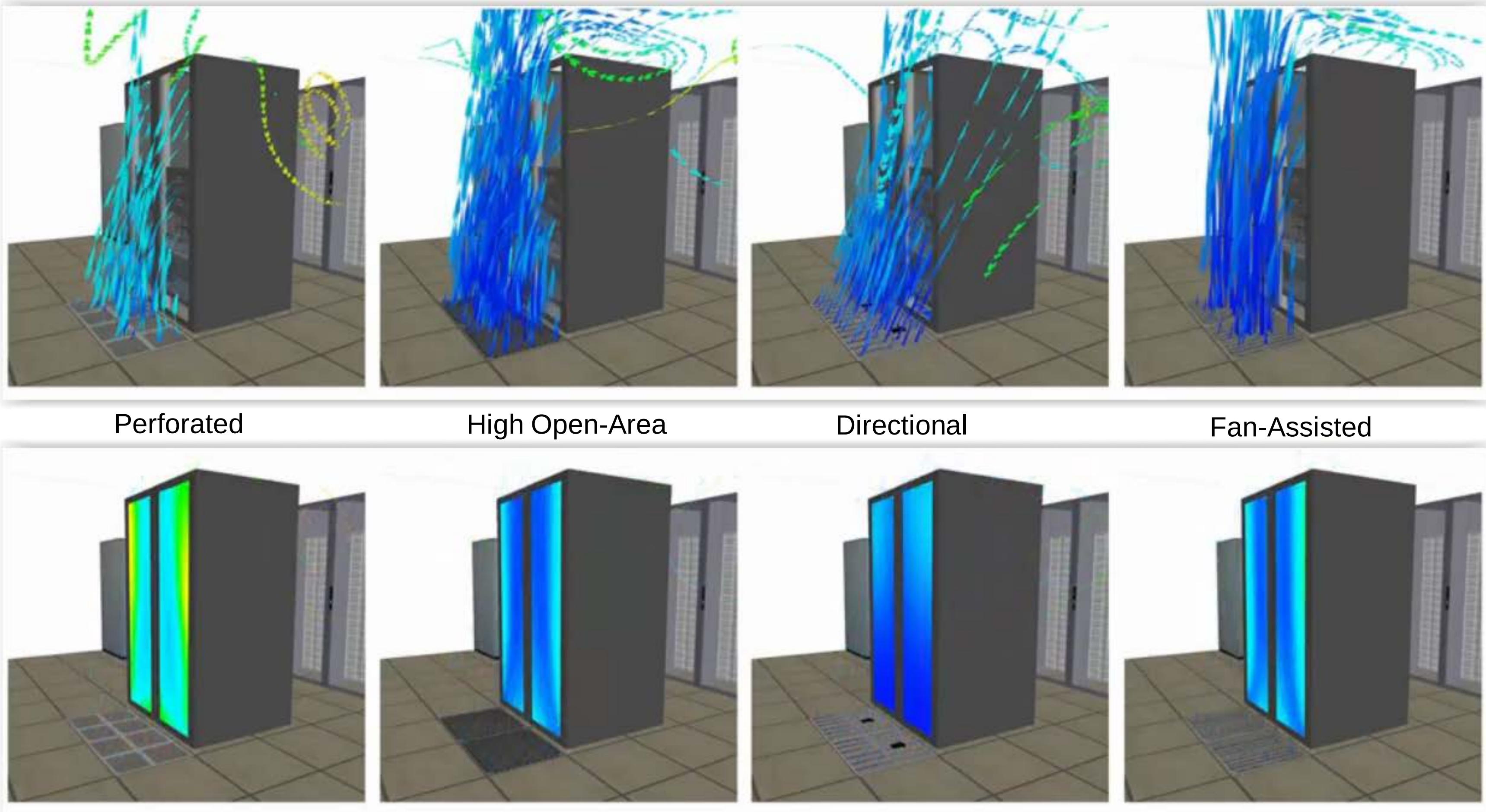
71°F

FLIR ONE - $250

Best Practices: Energy Management

Airflow Management

"SEEING" AIR MANAGEMENT ISSUES



Better Buildings Partner – Iron Mountain

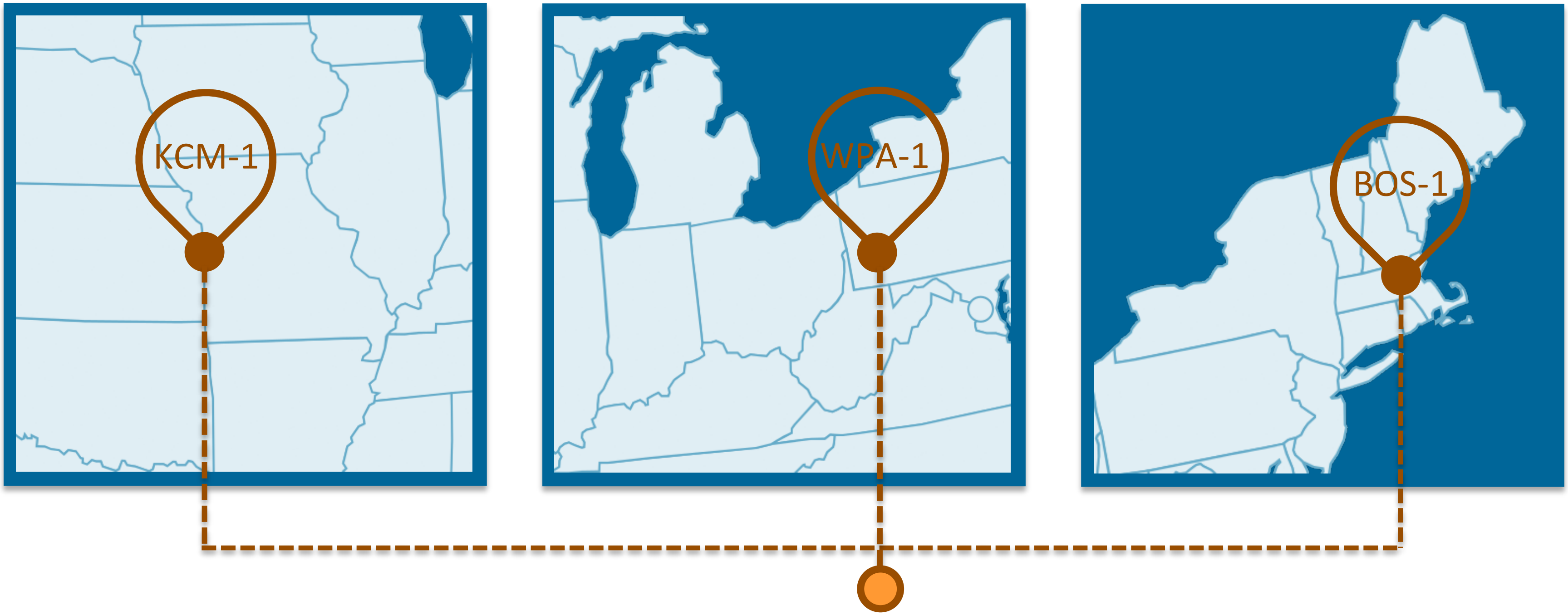
Isaac Negusse | Iron Mountain Federal Data Center Practice Lead

- 17+ years experience in IT
- Previous: Sprint, AT&T

IRON MOUNTAIN®

- Fortune 1000, publicly traded
- Real estate network: 69+ million square feet, 1,100+ facilities, 37 countries
- 30+ Years of colocation excellence
- US DOE BBI partner since 01/2016

US DoE Better Buildings Initiative: Challenge Partner Commitment Level



8.75 Megawatt Reduction in Energy Intensity Over a 10-Year Period

Importance of US DOE Better Buildings for Iron Mountain Data Centers

Why Challenge Partner Level?

- Iron Mountain serves 92% of Federal agencies and 96% of Fortune 2000
- Federal customers facing EO 13693, DCOI
- Only fully FISMA High MTDC Provider
- Supports corporate commitment to energy efficiency
- Drives good economics

Increasing Efficiency without Impacting Reliability

1 WATER

2 AIR

3 PEOPLE

4 CASE STUDY

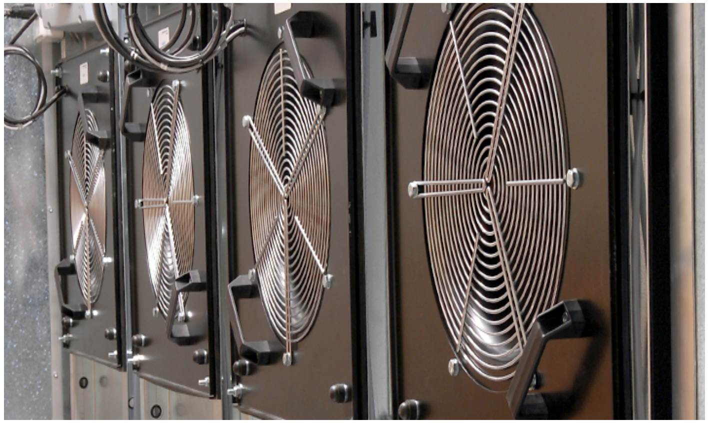
Water

Efficiency Measure: Water

- 26-acre lake exists underground within 145-acre complex
- Geothermal cooling utilizes 54°F lake water to cool closed water loop

Mitigating Reliability Concerns
MSL below data center floor altitude
Lake water loop cools CRAH water loop thru heat exchanges (no water transfer)
Dehumidifiers in use (no humidification)

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy



Efficiency Measure: Air

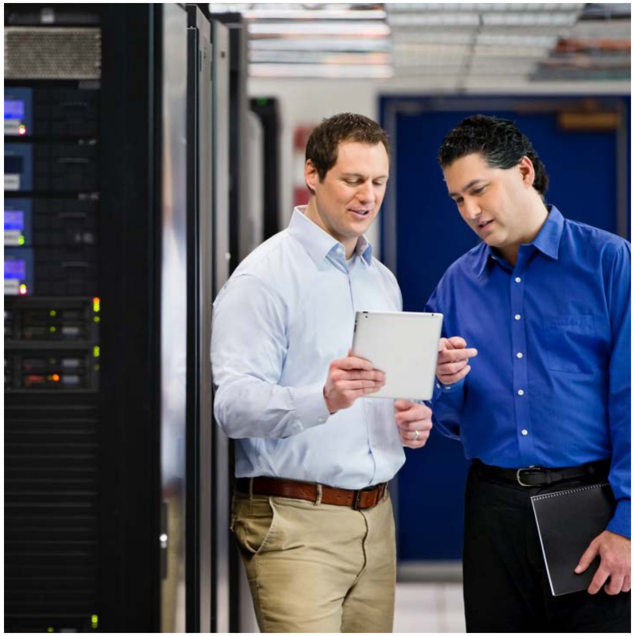
- Utilization of plug fans, TC 9.9, electrically commutated
- No blower shafts, pulleys, belts
- Maximizes use of coil surface area ~10% efficiency on CRAH

Mitigating Reliability Concerns
Retrofit takes CRAH off line utilizing (N+2, component level) redundancy to bring retrofitted unit online without cooling interruption/risk
Additional control system integration – test failure of system; rack level temp sensing (commissioning/alarm process)

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

30+ Years of Colocation Excellence

Experience Has Uniquely Prepared Our Engineers to Deliver Both Outstanding Availability and Energy Efficiency.



Efficiency Measure: People

- Well-trained; strong retention & pride in facility ownership
- Ongoing experimenting with constant load & regular data logging = powerful combination
- Motion-sensor LED lighting keeps personnel off ladders

Case Study: Global Travel Company

Challenge

Upgrade legacy data center for global travel company, increasing efficiency without production infrastructure downtime

Action

Transition to geothermal cooling, closed 2 valves and opened 2 valves, existing taps

Results

- >1 million kilowatt hours saved annually
- 60% reduction in PUE
- No chillers/cooling towers, only moving part: geothermal pumps

BEFORE
8-Year Old Data Center
Chillers & Cooling Tower
PUE in Excess of 2.0
IT Load: 30% of UPS Capacity

AFTER
Retrofit / Upgrades
Aquifer / Geothermal Cooling
Reduced PUE by 60%
Reduced Power Costs

Commitment to Environmental Responsibility

EPA GREEN POWER PARTNER

Long-Term Renewable Energy Plans

15-Year Wind Power Purchase Agreement

- Stabilized energy cost, predictable
- Better for business & the environment
- Pittsburgh data center powered by 100% renewable energy by end of 2016

Participating in EPA's Green Power Partnership

- 30% of total US portfolio renewable energy by 2017
- Top 20 renewable energy users in the Fortune 1000