# Latest Trends in Data Center Design, Technology and Siting

-IEEE Power & Energy Society and IEEE Industry Applications Society, Santa Clara

**KC Mares** | January 2013

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# What We'll Discuss

- Efficient Data Center Designs
  - Changing Needs by Data Center Operators have Changed What's Important in Design
- Some New Technologies
- New Approaches that Change the Principals of what Makes for a Great Data Center Location

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# My Data Center Experiences

- 15+ Years of Building & operating >$10 Billion of data centers
- Data Center projects in over 20 countries and throughout North America
- Projects with the “Big 7” (Google, Yahoo, Facebook, Apple...) & other Big players in the industry (Equinix, Exodus, Cable & Wireless, DRT, DFT…)
- Work mostly on large data centers (10-100 MWs of IT load per data center) and developer of the Reno Technology Park

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# What do I do?

- Provide data center site selections
- Industry reports and analysis
- Design of ultra-efficient data centers
  - "Mr. Low-PUE": I help design the most-efficient and lowest cost data centers in the world
- Development and review of new data center technologies
- Development of data center energy solutions

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# Some Data Center Design Trends

An Overview

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# Efficient Data Center Designs Are Driven by A Focus on Efficiency—Why is Efficiency the Driver of All Things?

- Power capacity is 80% of the cost to build a data center
- Servers cost more money in energy to run then to buy
- Energy is the #1 driver of a 10-year NPV
- Utility costs Have risen and will likely continue to rise (6%/year but rising far faster in many locations)
- Data Centers have become visible to the average consumer

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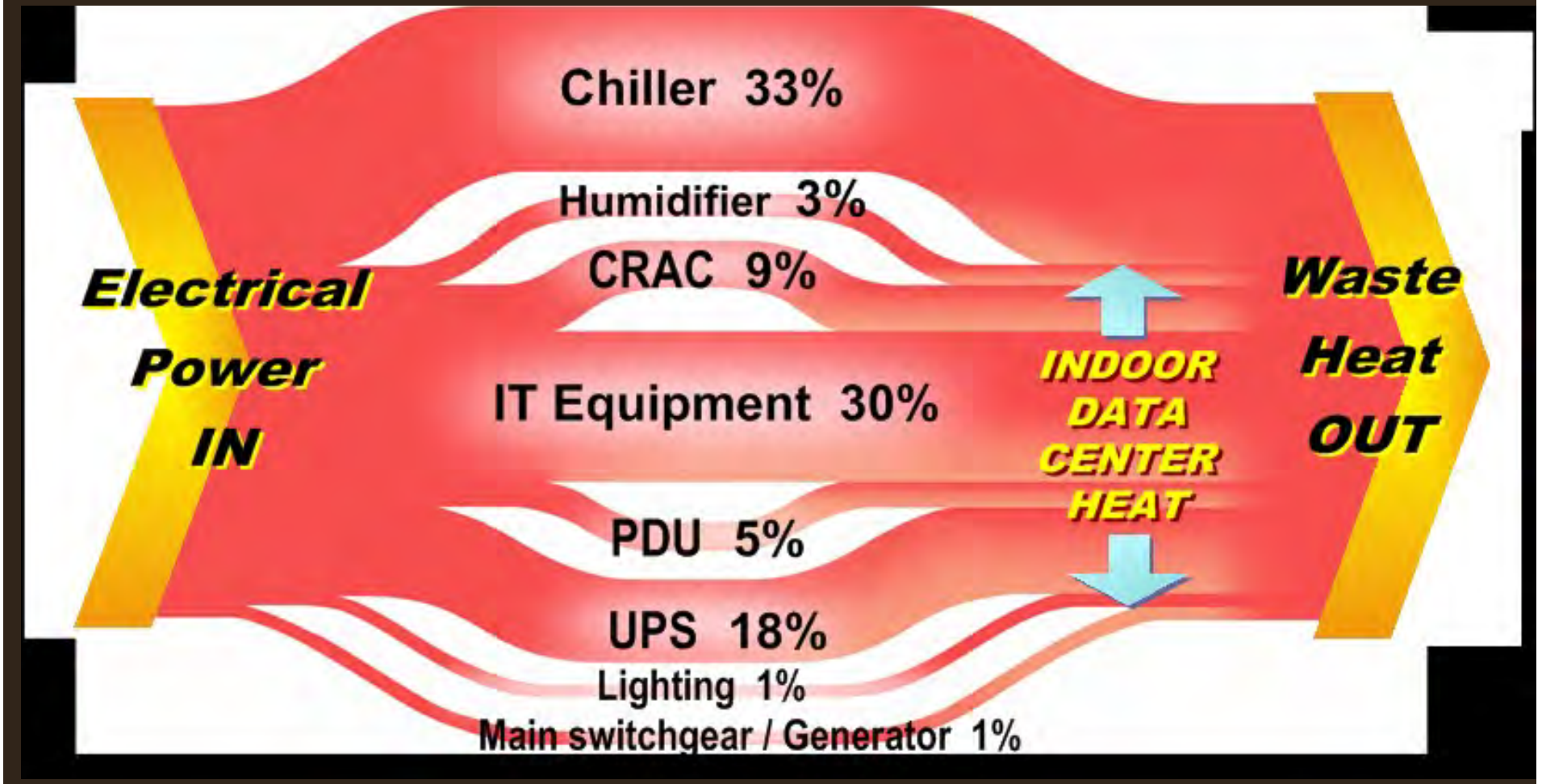


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The New York Times

Business Day
Technology





THE CLOUD FACTORIES

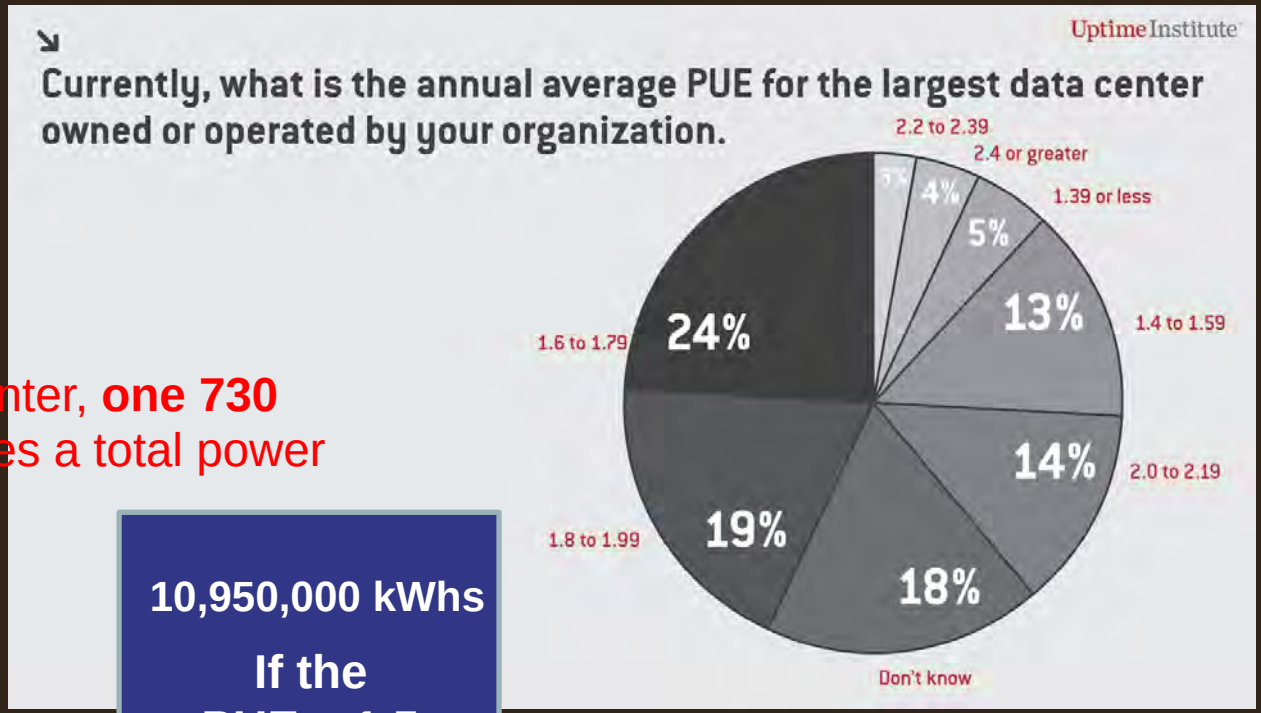
# Power, Pollution and the Internet

Ethan Pines for The New York Times

Data centers are filled with servers, which are like bulked-up desktop computers, minus screens and keyboards, that contain chips to process data.

By JAMES GLANZ
Published: September 22, 2012 | 305 Comments

# Low PUE means more than Bragging Rights




For a 10 MW data center, **one 730 hour month** generates a total power consumption of:

**8,030,000 kWhs**

**If the PUE =1.1**

**10,950,000 kWhs**

**If the PUE = 1.5**

This is real money…A savings of ~$500,000/year per One MW of IT load from a 1.5 PUE to a 1.1 PUE Data Center

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# Adaptability of Density and Design to meet the new ~~computing~~ *Storage* NEED

- Data growth of 60-90% or doubling every 6-18 months (depending upon stats)
- "Every two days now we create as much information as we did from the dawn of civilization up until 2003." "That's something like five exabytes of data."
  - Google former CEO Eric Schmidt, Aug 2010
- "[In 2009], the Digital Universe grew by 62% to nearly 800,000 petabytes… [in 2010], it will grow to 1.2 million petabytes, or 1.2 zeta bytes."
  - IDC/EMC Digital Universe report, May 2010 (35 ZBs by 2020)

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# General Industry Trends

- From highest availability to high availability
- From “NFL” cities to any where
- From one data center to many data centers
- From low to high density racks
- From high-certainty to high-efficiency UPS
- From 30 minutes to .05-5 minutes ride thru time
- From generators to no generator
- From tight to broad environmental controls
- Focus on up-time to total cost
- From reactive to proactive planning
- From 120 VAC to 120-480 VAC at the rack

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# Adaptability

- Modularity: Aligning Capacity with Demand
  - Modular, scalable architecture, including the hardware, the software and the infrastructure
    - Growing capacity with the demand
  - Adaptability and SPEED!
    - Build a greenfield data center in 3 months?!....*YES!*
- Power Density
    - Modularity with density
      - Current designs are 8-15 kW per rack
      - Can adapt to higher or lower densities
      - Higher voltage distribution

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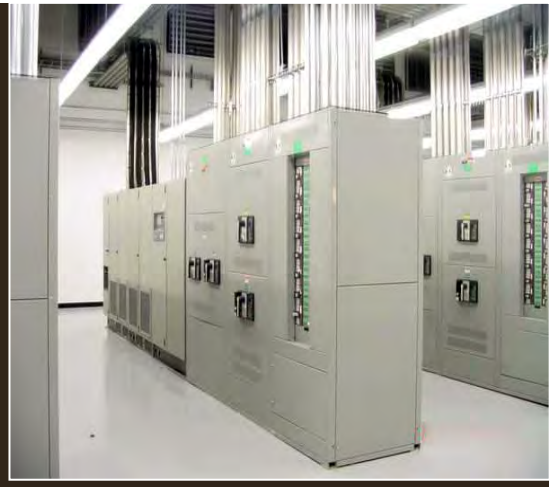
# Changes in Electrical Systems



- No Generators – really!?
- UPS systems – getting simpler
  - Going to off-line from Dual conversion
  - Battery run time reducing to 5 mins or less
- Transformers, PDUs
  - PDUs going away/Higher voltage to racks (230-277) = reducing transformers
  - What if no UPS & transformer? The future will be chipset power distribution
- Overhead Distribution
- Metering & Monitoring
  - Information/data collection/monitoring/DCIM

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# Rethinking Reliability

- Reliability Sanity
  - Designing to actual NEED, and for each application
  - "Redundancy of data centers not redundancy within a data center" – many are building in multiple locations
    - Geographic application redundancy
  - Most big end-user data centers are Tier II
  - And not every computer is connected to UPS
    - When it is, it's often N or N+1 instead of 2N
  - Keeping it Simple – equipment fails but people make mistakes – good process wins the day

    >90% of outages caused by people

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# Essentials to good design

- Fan power reductions
  - VFDs
  - Fanless hardware
  - Fanless data centers
- Close-coupled cooling
  - Racks and coils
- Hot & cold aisle separation
- Economization, air & water

# Expanding the Environmentals

- Intel and Microsoft run at 90+F supply air
- Internal Environmentals
  - Humidity: 0% to 60+%
  - Supply Air Temperature: 50F to 90F
  - Filtration: only major particulates
- Separating hot and cold airstreams
- Separate areas with differing density and environmentals to match their needs

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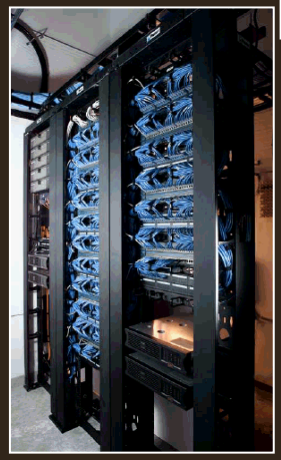
# Other Industry Changes

- Concrete slabs replacing Raised floors
  - Everything is overhead
- LEED & EnergyStar
- Controls
  - Wireless sensors
  - Redwood Systems lighting



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# Electrical Best Practices and Savings

- Rotary or super-efficient UPS

  ➔2%-30% savings

  Consider Off-Line, Delta or “Eco-Mode” UPS

  Reduced ride-thru time – only .05 – 5 minutes needed

- No UPS (Battery on hardware or no UPS at all)

  ➔2%-30% savings

- ~400+ VAC Distribution to the Rack (no PDUs)

  ➔2%-7% savings

- High-efficiency transformers (PowerSmiths)

  ➔2%-5% savings

- LED lighting with motion-sensor control (Redwood Systems)

  ➔1%-5% savings and added functionality

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# Some New Data Center Technologies

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# Software

- Virtualization
- Power management software
- Capacity planning – Lumina ADCAPT
- Active power management – 1E, PowerAssure
- Controls, DCIM
- Document Retention – keep only as long as required/needed
- Data Deduplication

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# Hardware

- ARM processors (Calxeda)
- High-efficiency power supplies and no redundant power supplies
- Solid State storage
- More and faster memory
- Anti-vibration racks for storage

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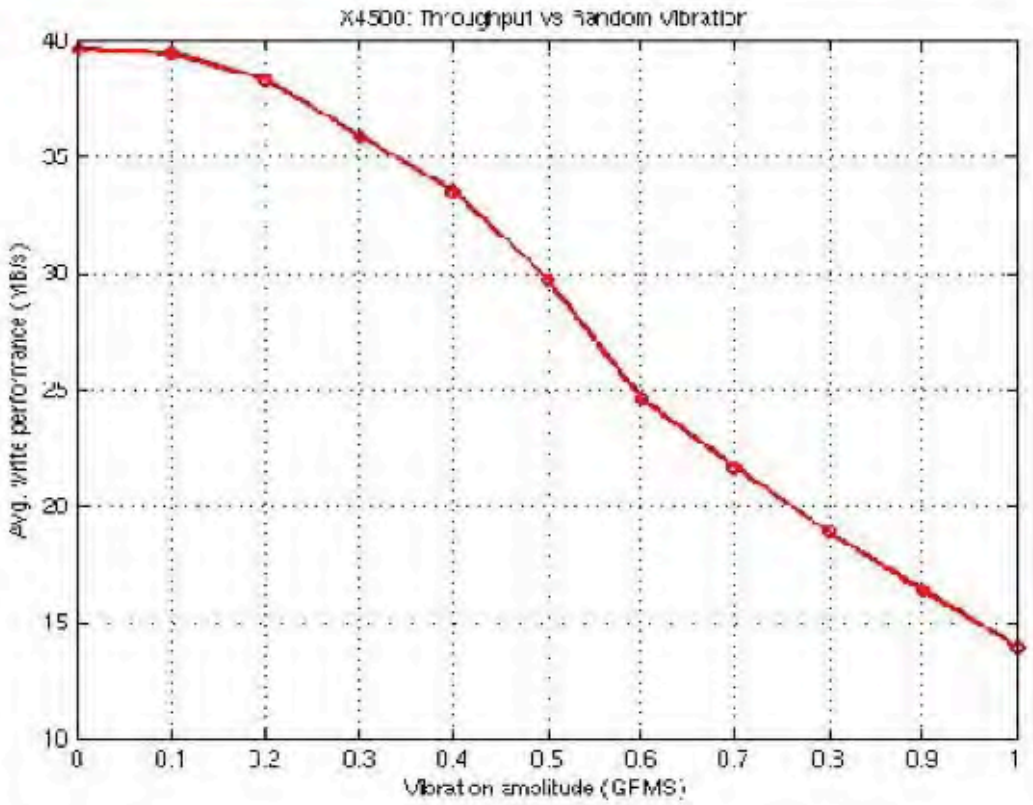
# X4500: Disk Throughput vs Random Vibration

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# What if we Could Remove transformation steps and power conversions?


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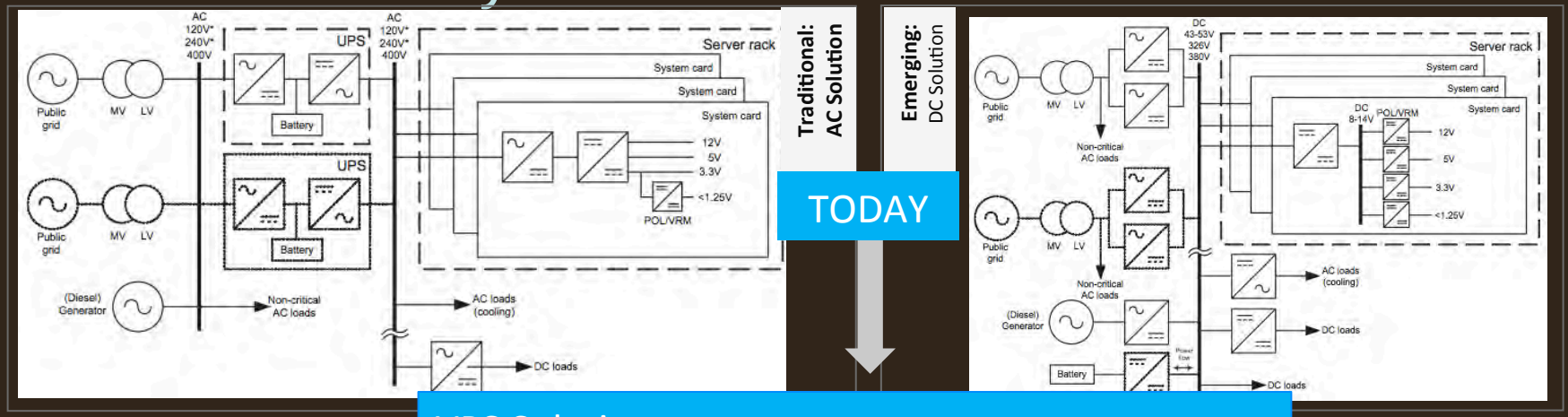
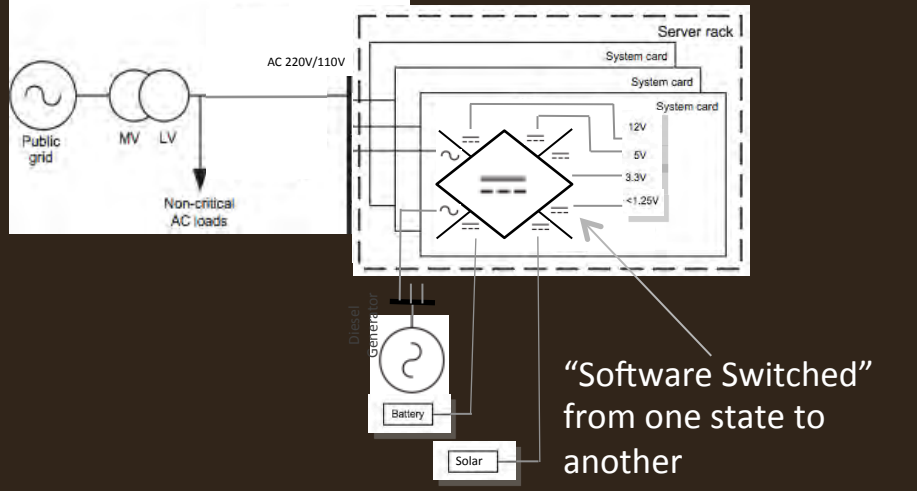
# Virtual Power Systems' Solution




## VPS Solution




**High Frequency GaN leveraged For**:

- Consolidated Power Conversion in one unit
- Software operated circuit switching and tuning
- Software programmable functions

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# New Data Center Locations and Why Change?

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# Mazlow's Hierarchy of Data Center Needs

Power

Low Taxes

Supporting ecosystem

Natural Surroundings

Business climate

Everything else

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# Data Center Locations

- Locations are moving away from metros
- Fiber is ubiquitous
- Energy Cost
- Energy Generation Mix
- On-site power
- FORWARD cost of energy
- Climate
- Taxes, taxes, taxes
  - Was property tax, then sales tax, NOW INCOME TAX!
    - Income tax on on-line revenue is greater than all else combined!

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THE CLOUD FACTORIES

# Data Barns in a Farm Town, Gobbling Power and Flexing Muscle

Kyle Bair/Bair Aerial

1 2 3 4 5 6 7 8 9 10 11 ➤

Relatively low-cost hydroelectric power has lured technology giants to central Washington State.

By JAMES GLANZ
Published: September 23, 2012 | 187 Comments

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# Beyond “the bill”

Utility portfolio

NERC CIP Compliance

Rate increases

Regulatory

Today’s bill

Future Capacity

PUE

**Today’s power bill is only one of many factors that must be considered in any “apples-to-apples” benchmark analysis of alternative locations based on power costs**

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# NERC CIP Compliance

**Utilities are pretending that malware and cyber threats to the nation's power generation and distribution infrastructure are problems that "we will get to when we get to them…"**

"Rather than becoming integrated with 'smart grids'…data centers in the US would be better off moving to increased independence of the electrical grid…" **"Power: Is the Smart Grid an Intelligent Move," Data Center Dynamics, Feb 2010**

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# Not all utilities are creating equally…..

**Exhibit 7** **Regulated Utilities: Estimated Reduction in Coal-Fired Generation Due to an EPA Mandate to Install SO2 Scrubbers as MACT for Mercury and Acid Gases**

| | | Company Total | | Regulated Coal-Fired Plants | | | |
|---|---|---|---|---|---|---|---|
| | | | | Reduction in Nameplate Capacity | | Reduction in Generation | |
| Holding Company Name | Ticker | Nameplate Capacity MW | Generation GWh | In MW | As % of Total | In GWh | As % of Total |
| CMS Energy Corp | CMS | 6,463 | 12,215 | 1,780 | 28% | 7,393 | 61% |
| Black Hills Corp | BKH | 382 | 1,757 | 125 | 33% | 762 | 43% |
| SCANA Corp | SCG | 5,568 | 26,065 | 1,832 | 33% | 8,501 | 33% |
| Integrys Energy Group Inc | TEG | 2,425 | 9,436 | 492 | 20% | 2,878 | 30% |
| ALLETE Inc | ALE | 1,346 | 7,310 | 359 | 27% | 2,182 | 30% |
| Wisconsin Energy Corp | WEC | 6,114 | 18,513 | 845 | 14% | 4,260 | 23% |
| Southern Co | SO | 42,519 | 182,605 | 8,698 | 20% | 38,735 | 21% |
| DTE Energy Co | DTE | 11,754 | 48,037 | 2,096 | 18% | 9,093 | 19% |
| Great Plains Energy Inc | GXP | 5,760 | 23,740 | 709 | 12% | 3,962 | 17% |
| Empire District Electric Co (The) | EDE | 1,235 | 3,084 | 88 | 7% | 488 | 16% |
| Northeast Utilities | NU | 1,094 | 3,774 | 100 | 9% | 585 | 16% |
| Alliant Energy Corp | LNT | 6,419 | 15,891 | 792 | 12% | 2,309 | 15% |
| American Electric Power Co Inc | AEP | 38,239 | 168,505 | 5,290 | 14% | 19,972 | 12% |
| AES Corp (The) | AES | 11,502 | 40,475 | 879 | 8% | 3,948 | 10% |
| TECO Energy Inc | TE | 4,565 | 18,405 | 326 | 7% | 1,700 | 9% |
| Ameren Corp | AEE | 16,482 | 74,302 | 923 | 6% | 5,305 | 7% |
| Westar Energy Inc | WR | 7,292 | 27,367 | 281 | 4% | 1,809 | 7% |
| Progress Energy Inc | PGN | 21,688 | 90,686 | 1,446 | 7% | 5,121 | 6% |
| Duke Energy Corp | DUK | 34,538 | 132,866 | 2,545 | 7% | 7,250 | 5% |
| Dominion Resources Inc | D | 24,314 | 110,437 | 1,504 | 6% | 5,938 | 5% |
| Xcel Energy Inc | XEL | 16,154 | 68,536 | 667 | 4% | 2,609 | 4% |
| Allegheny Energy Inc | AYE | 9,991 | 31,881 | 601 | 6% | 243 | 1% |
| DPL Inc | DPL | 3,648 | 15,713 | 414 | 11% | 79 | 1% |
| NextEra Energy Inc | NEE | 38,814 | 151,516 | 27 | 0% | 76 | 0% |
| **Total United States** | | **970,280** | **3,722,034** | **51,116** | **5%** | **219,117** | **6%** |

Source: US Utilities: Coal-fired Generation is Squeezed in the Vice of EPA Regulations, Bernstein Research November 2010

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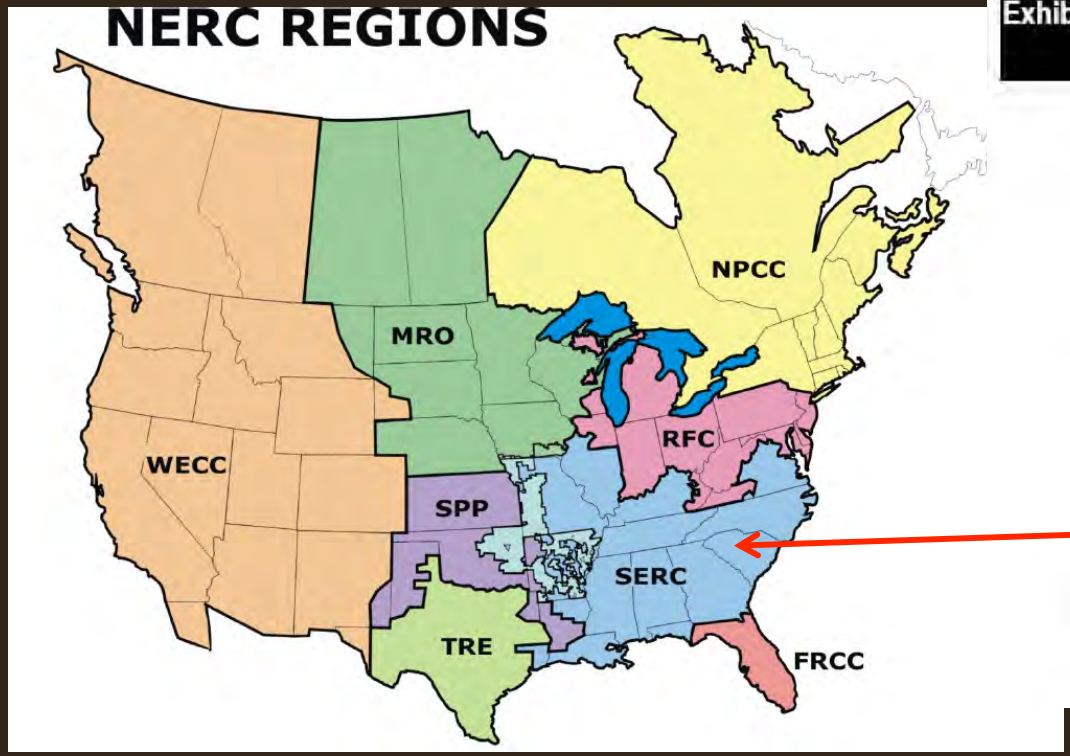
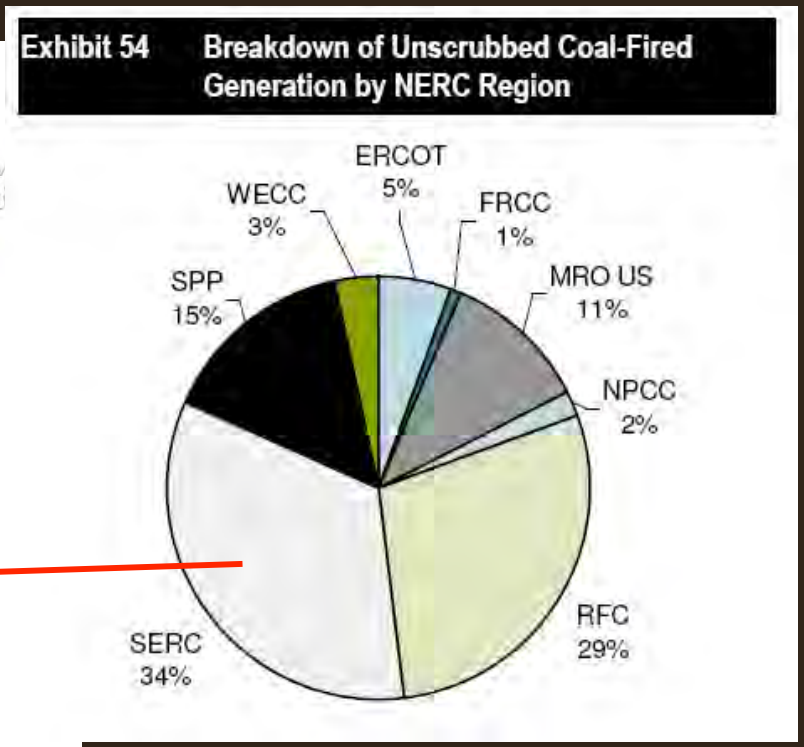
# And some regions will feel the pain more than others…..




According to FBR Capital, the combination of the Transport and MACT rules could ***force the retirement of 30-70 GW of the lowest cost electricity generating capacity***.

Source: US Utilities: Coal-fired Generation is Squeezed in the Vice of EPA Regulations, Bernstein Research November 2010

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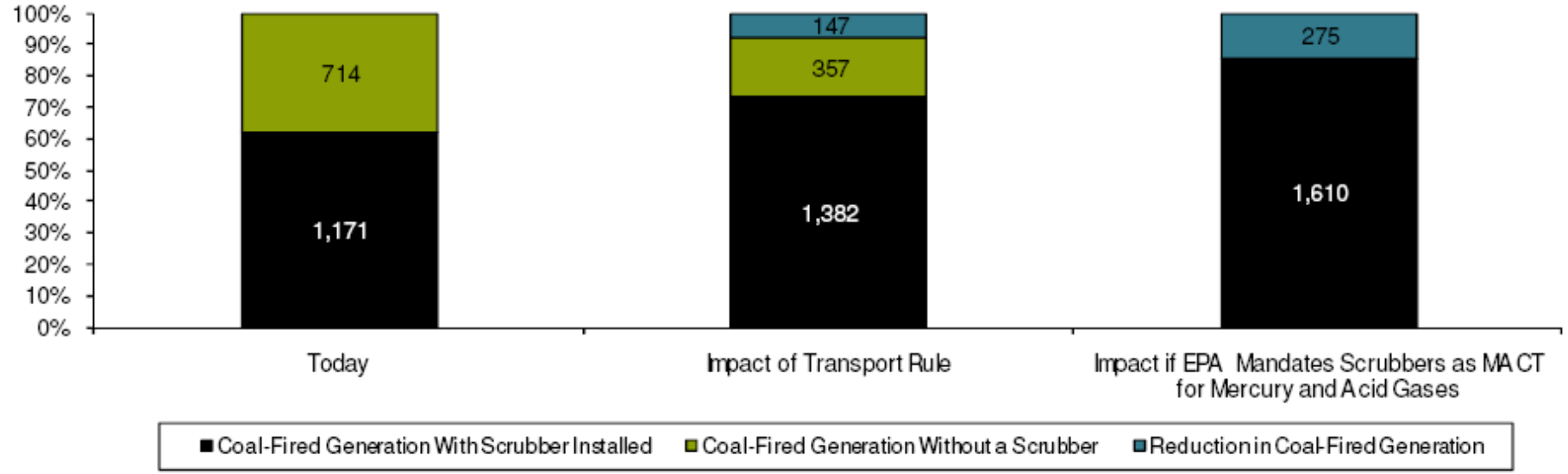
# Regulatory actions (MACT) will impact different segments of the national generation fuel mix

**Exhibit 6** **Scrubbed and Unscrubbed Coal-Fired Generation in 2009 vs. That Expected in 2015 from the Existing Fleet, Given the Transport Rule's SO2 Targets and an EPA Mandate to Install SO2 Scrubbers as MACT for Mercury and Acid Gases**




"We would expect the *net* decline in U.S. coal-fired generation by 2015 to be 165 million MWh, equivalent to 9% of U.S. coal-fired generation in 2009"

US Utilities: Coal-fired Generation is Squeezed in the Vice of EPA Regulations, Bernstein Research November 2010

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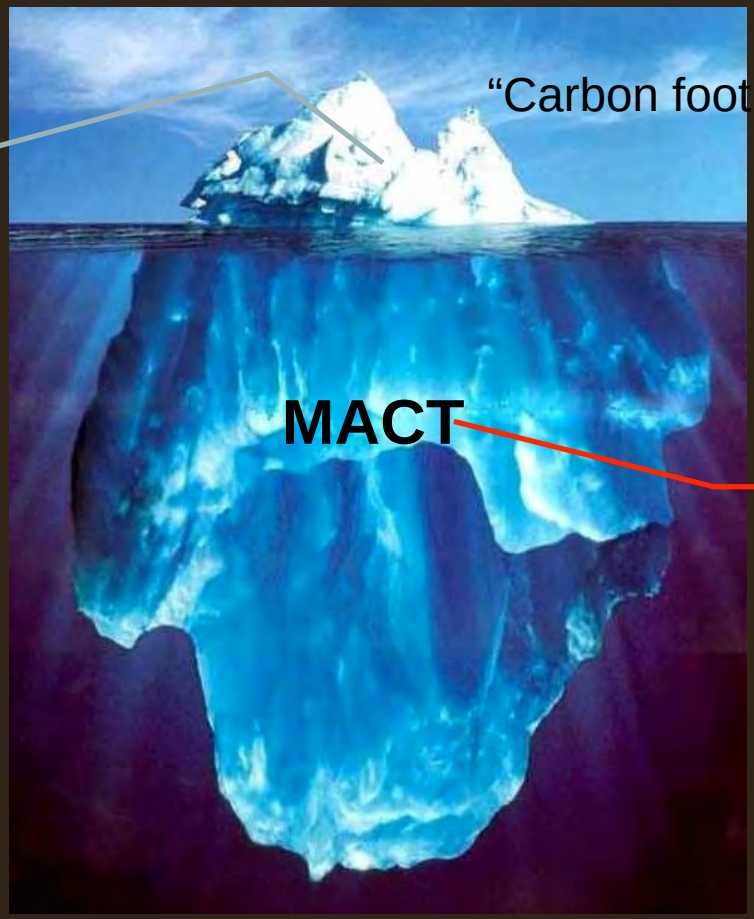
# And there are details…and then *there are details*

There has been a great deal of attention paid to "How green is my data center?" rankings




But the real site selection risk posed by a utility offering low cost coal-based electricity is **MACT**, the EPA regulation recently endorsed by the Federal Appeals Court that will shutter 9% of the nations' power generation capacity in the next 5 years

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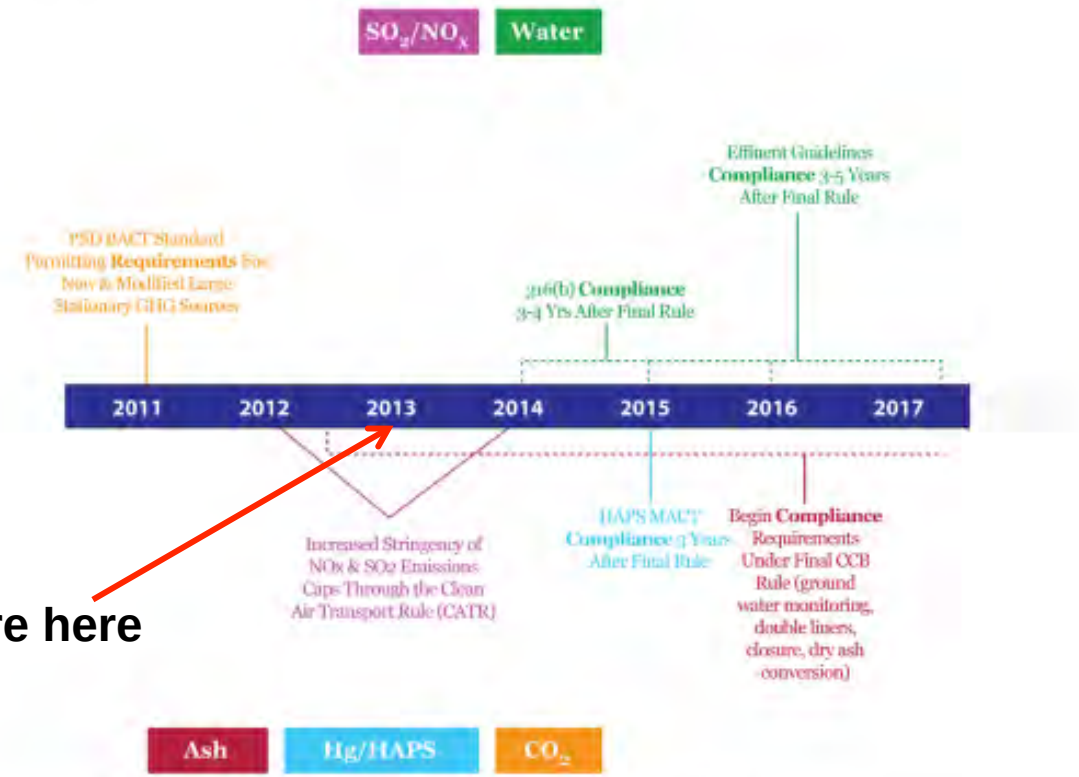
# This is real time…

## Regulatory Compliance Obligations for the Utility Industry




Sources: WRI Analysis based on Edison Electric Institute 2010, Wegman, EPA 2003.

**You are here**

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# Data Center Site Selection and the Law of Unintended Consequences


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# SECURITY

- Social Media, aka, data centers, helped to change the leadership of three dictator led countries last year!!!
- 2.5 billion people on the net
- 1 billion facebook users
- More smart phones being purchased than PCs
  - 1 trillion devices by 2013
- In the US, each Internet user has about 8 Internet connected devices!
  - Each device is a security risk

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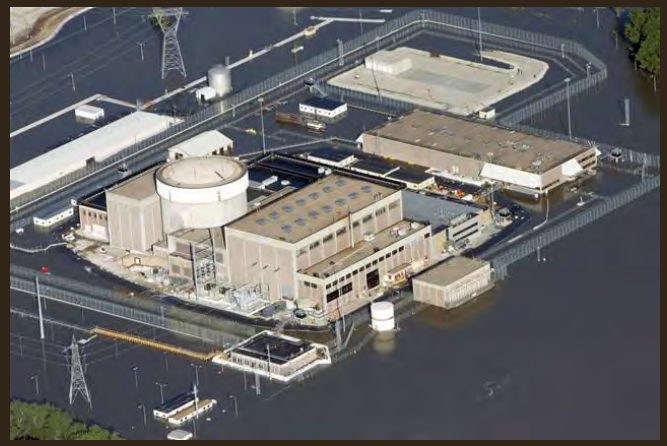
Stuxnet
“Although specifics regarding the source, target and purpose of Stuxnet are mostly speculation, computer security experts generally accept that its existence puts many of our critical infrastructure systems at greater risk than previously believed.” Electric Light & Power Jan/Feb

# Then there is the “Weather Channel” Factor

- Google’s App Engine Datastore services went down in August 2011. The company traced the cause to a thunderstorm that interrupted utility power to a Google data center in the American Midwest. In this case, the automatic-failover mechanism for switching to generator power failed to do its job.



Heavy rains caused the flooding of the Ft. Calhoun nuclear generating station in Nebraska, forcing the utility to keep the station off line and driving them into the spot market to make up power shortfalls. Fairly frequent natural events can have multiple impacts on mission critical facilities in mid western and other locations

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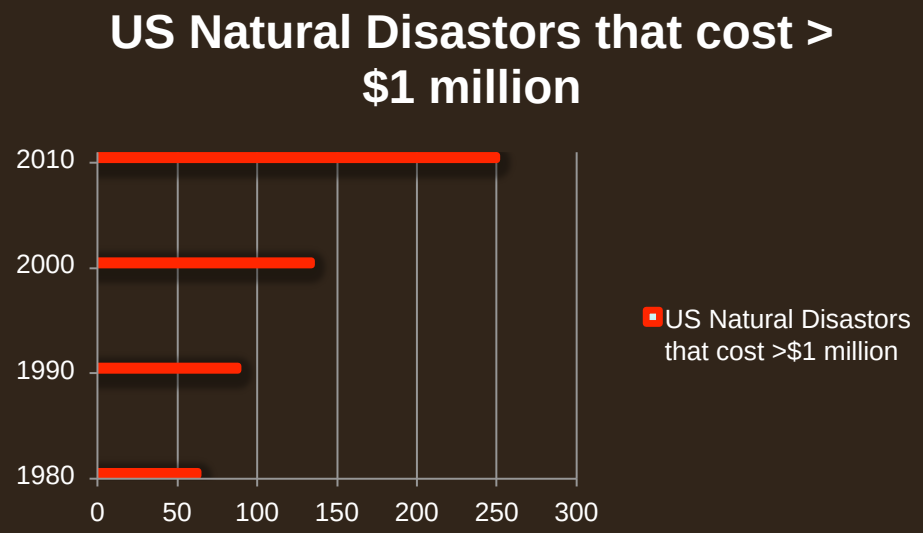
# Weather Disasters Increasing




-- The second costliest year of the study period, 2011, was dominated by strong storms. Insured losses in the U.S. due to thunderstorms alone was the highest on record at an estimated $26 billion, more than double the previous thunderstorm record set in 2010.

-- Insured losses from disasters averaged $9 billion a year in the 1980s. By the 2000s, the average soared to $36 billion per year.

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# Do you worry about a 12 year event?


In 35 years, we've had 3-Mile Island, Chernobyl, Fukushima…and Chernobyl made 100,000 square miles forever uninhabitable due to a 2-minute user error!

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# What Might be the Unknown Risks?

Phoenix, Arizona 2011

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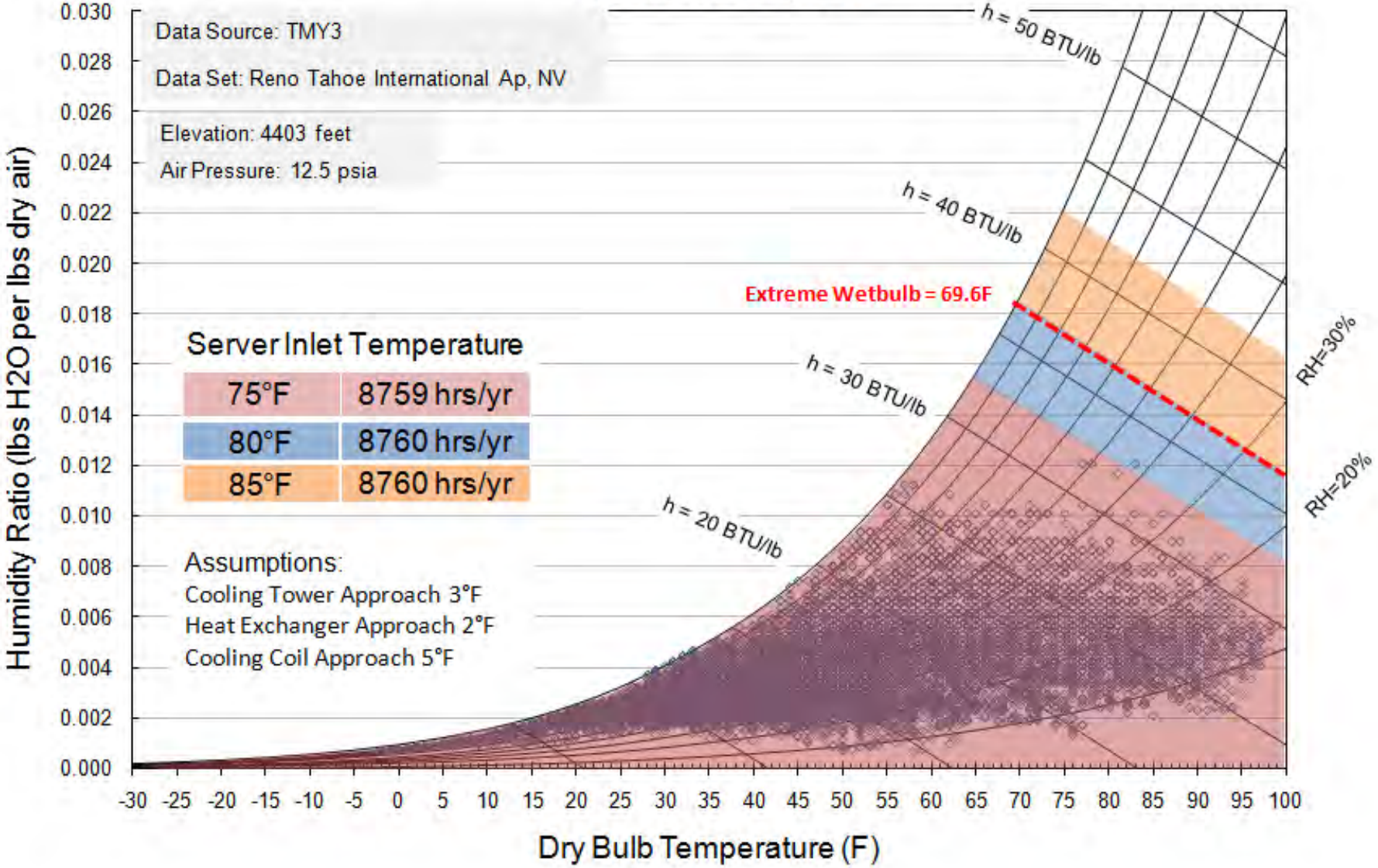
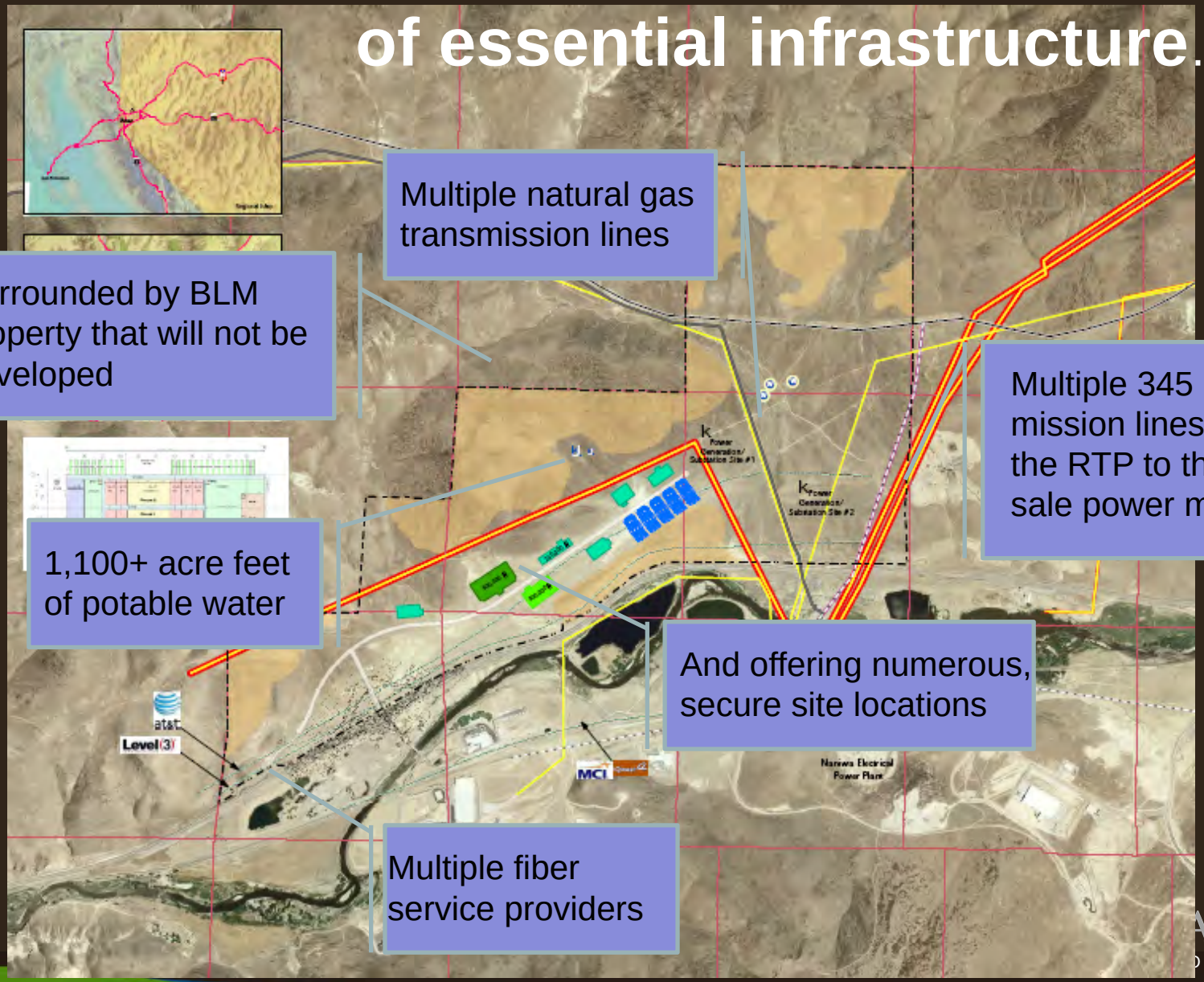
# Psychrometric Chart for Waterside Economizing
## Reno-Tahoe, NV

by The Integral Group



# Featuring an extraordinary concentration of essential infrastructure….

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“The US economy could expand more than 70% through 2030 and use 11% less electricity than in 2008 because of energy efficiency advances associated with semiconductor technologies. By our calculations here, the cumulative net electricity bill savings enabled by semiconductors might exceed $1.3 trillion through 2030.”

**The American Council for an Energy Efficient Economy**

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Thank you.