Introduction to Dynamic Infrastructure

By Alan G. Labouseur

MARIST SCHOOL OF COMPUTER SCIENCE & MATHEMATICS

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IBM

MODULE SIX

ENERGY EFFICIENCY

Introduction to Dynamic Infrastructure

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Contents

Remarks

It's week six! Can you see the proverbial light at the end of the equally proverbial tunnel?

- I can. It's flashing. Some sort of . . . code . . . maybe binary . . . something about "subdivisions".

Thank you for dropping your mid-term projects in the (drop) box. I've browsed a few and they look great so far. I will read each and every one of them in detail over the next week and give you personal feedback. (So take my address out of your SPAM filter.)

Look in the Meta forum for new developments about our field trip to IBM's Green Data center.

. . . And now, on to Pillar Four: Energy Efficiency.

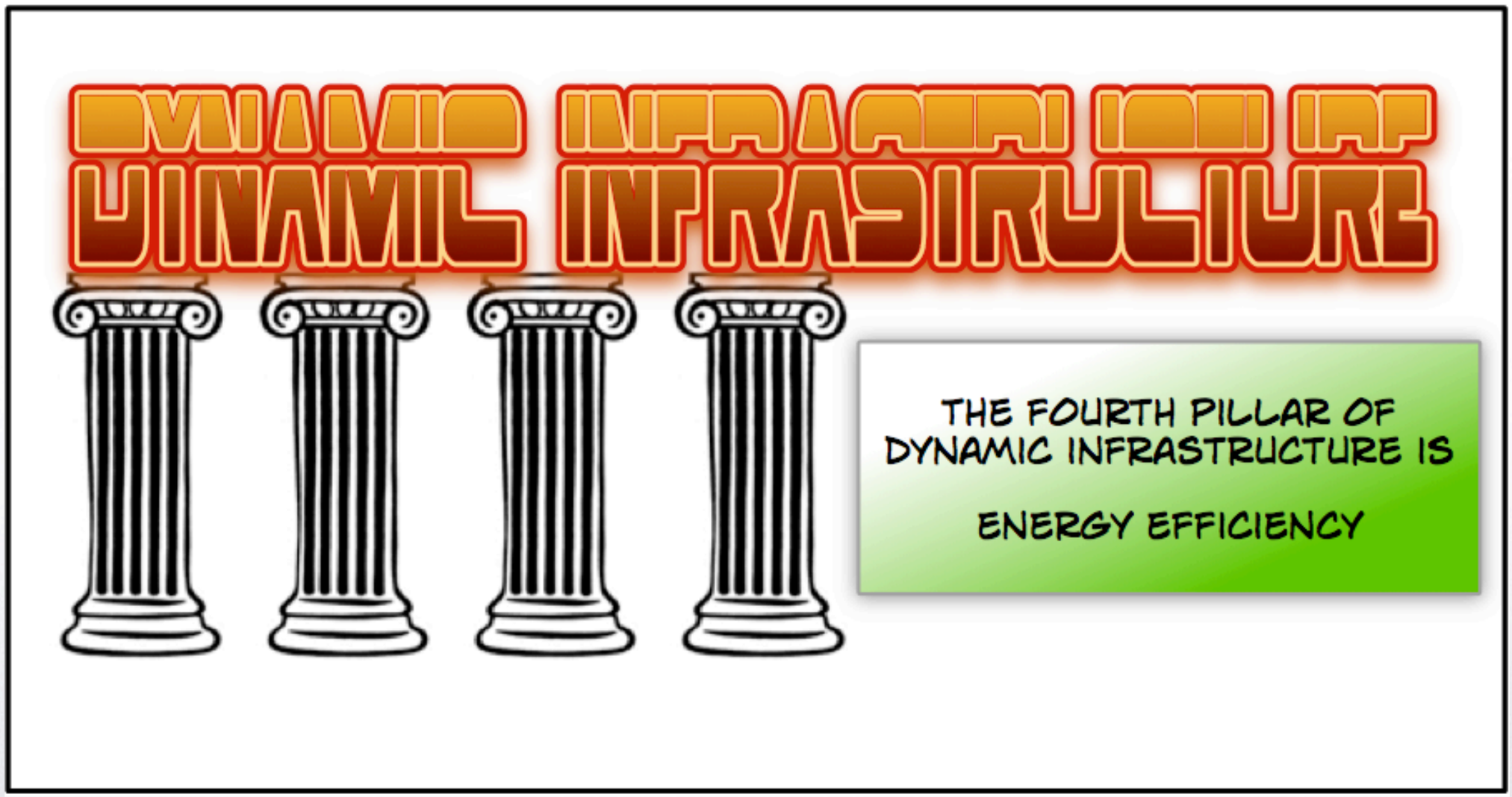
Review

When we last saw our **D**edicated, **I**ntrepid adventurers, they were discovering that . . .

- Service management is managing your customer's experience through technology and processes.
- Service management provides visibility, control, and automation across all business and IT assets for extracting greater value of existing investments, effectively and efficiently deliver higher value services, etc.
- The goal of automation is to leverage service delivery and support automation across the service lifecycle (Jure standards, de facto standards, best practices, open source, certification).
- Asset management is organized and systematic tracking of an organizations physical and virtual assets and can be addressed in three parts: remote control, inventory and software distribution.
- Asset management is optimizing high reliability, low cost, compliance within a framework, with only limited resources.

Does this look familiar? It's like Déjà vu all over again.

Energy Efficiency

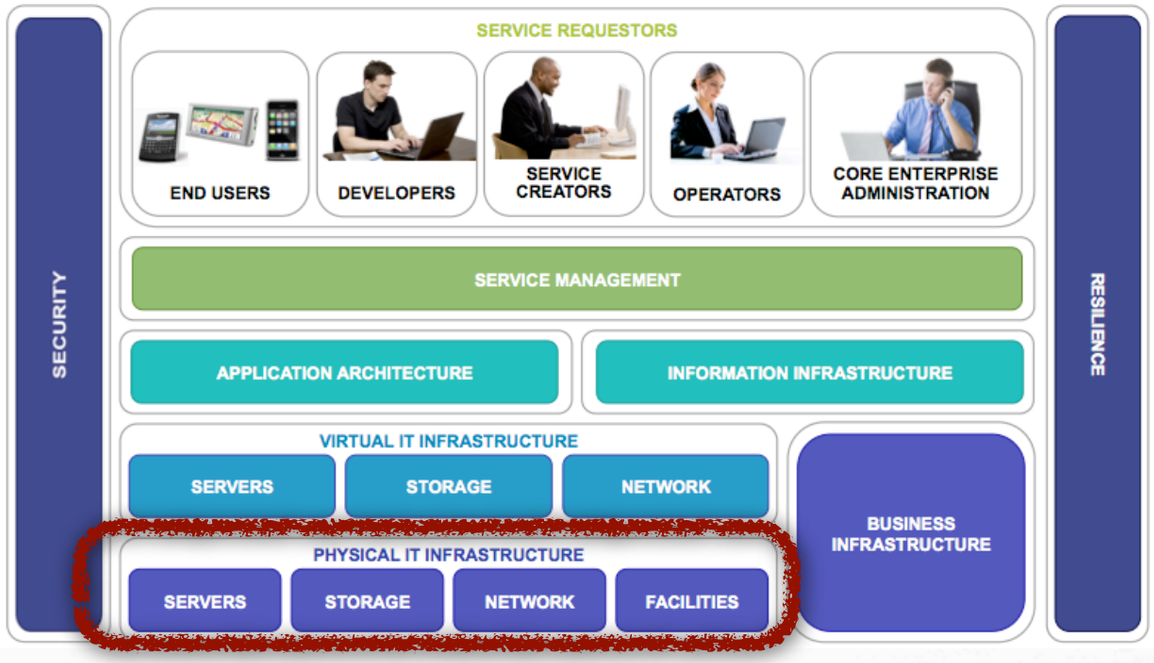


Energy Efficiency

Address energy, environment, and sustainability challenges and opportunities across your business and IT infrastructure.

Optimizing the energy efficiency of the business and IT infrastructure can demonstrate the value in "green."

To meet the needs of the business, a holistic approach is required that encompasses energy management, virtualization, IT and data center facility services, and server and storage products that are designed to be green.



Energy Efficiency > Preparation Questions

Do you know how much you spent on energy over the last three years? Is it growing?

Can you break down the energy costs to IT equipment, IT Support equipment (CRACs,PDUs, Chillers), and other equipment?

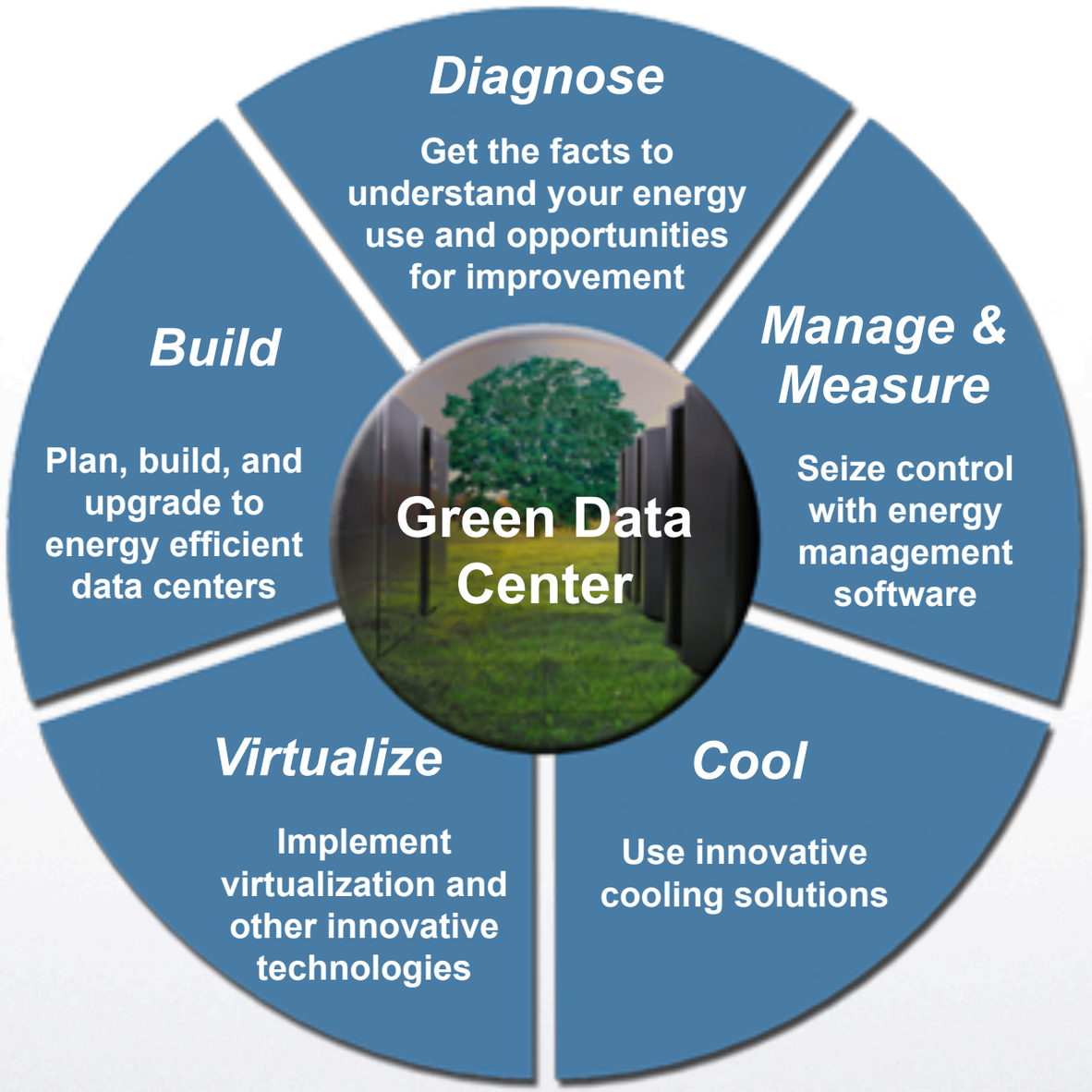
Do you know which IT equipment is consuming the most energy?

Do you have hot spots in your data center?

How dense is your compute environment?

How much more power can you get from your energy supplier?

Energy Efficiency > Plan



Energy Efficiency > Diagnose / Measure / Profile

You cannot change or manage anything you can't measure, so let's get measuring.

Data Center Profiling Tool Objectives

- Estimate the efficiency of the IT equipment (calculations/Watt). Not simple.
  - DCIE = Data Center Infrastructure Efficiency = IT Equipment energy use / total energy use.
  - Energy breakouts can help you decide where to focus efforts.
  - Profiling tools determine only the applicability of various actions, **not** their cost-effectiveness.
- Make an initial estimate of the overall efficiency of the data center support systems (the DCIE metric).
- Create initial, estimated energy use breakouts for the major data center systems.
- Provide a list of applicable energy-saving actions

Energy Efficiency > Profiling

Data Center Profiling Steps

- Describe your energy using systems/hardware
  - Writing a description of the energy-using systems up front helps you focus on which energy streams are needed for a proper profiling exercise.
  - Data Center Loads
    - IT equipment
    - Lights
- Controls for Energy Management
- Electric Distribution
  - Transformers
  - Uninterruptible Power Supplies
  - Power Distribution Units
- Air-side Systems
  - Floor Plenum
  - Ceiling Plenum
  - Ducts, Humidifiers
  - Active Dehumidification via Cooling Coils
  - Dedicated Ventilation Units

Energy Efficiency > Profiling

Data Center Profiling Steps

- Data Center Cooling
  - DX CRACs
    - Air-Cooled Condenser
    - Water-Cooled Condenser, Served by Dry Cooler
    - Water-Cooled Condenser, Served by Cooling Tower
  - DX Package Unit(s)
    - Air-Cooled Condenser
    - Evaporatively-Cooled Condenser
  - Air-Side Economizer
  - Chilled Water Plant
- Hardware Information
- Supplied Electricity
  - The data center is often embedded in a larger building.
  - Just record the electrical streams that feed the datacenter and its support systems.

Energy Efficiency > Profiling

Data Center Profiling Steps

- Supplied Fuel
  - Remember that humidifiers might use fuel other than electricity.
- Supplied Steam
- Supplied Chilled Water
  - In-house or purchased from a third party?
- Energy Use Distribution

Results

- Energy Savings Opportunities in the areas noted above:
  - Data Center Loads, Controls, Electric Distribution, Air Side, Data Center Cooling, and Chilled Water Plant
- Actions, for example:
  - Shut Down UPS Modules When Redundancy Level is High Enough
  - Use High Efficiency MV and LV Transformers
  - Reduce the Number of Transformers Upstream and Downstream of the UPS
  - Locate Transformers Outside the Datacenter
  - Use 480 V instead of 208 V Static Switches (STS)
  - Specify High Efficiency Power Supplies

Data Centers are at a Tipping Point

- According to Gartner
  - "By 2008, 50 percent of current data centers will have insufficient power and cooling capacity to meet the demands of high-density equipment."
  - This problem is not going to go away as "The underlying consumption of energy in large data centers to power and cool hardware infrastructure is likely to increase steadily during the next ten years. There are three principal changes that have occurred in the past five years.
- Increased computing demand
  - According to IDC, it is projected between 2000 and 2010 the server installed base over will grow at a rate of 6 times, while storage is expected to grow at a rate of 69 times. Every piece of this equipment drives the need for more energy. This is a lot of incremental capacity installed on the data center floors.
  - If you look at the amount of energy used per square foot, the annual data center energy costs are 10 to 30 times more than those of a typical office building.
  - Data centers are energy hogs because they are filled with technology that uses power. If you look at the use of energy in data centers it has doubled over the past five years.
- Changing cost dynamics
  - Energy use is increasing, but we also know what is happening with energy costs. They are increasing as well. In the US, in the past year commercial electricity rates have increased by 10%.
  - As energy usage and energy costs are increasing, we are seeing the combined effect on our IT operational budgets. Some analysts estimate that the energy costs now make up to 40% of the operational costs of a data center. Whether the CIO is paying for this today or not as it may be buried in a facilities budget. It is a big bill and going up every year.

Data Centers are at a Tipping Point

- Data center lifecycle mismatch
  - The other issue is that we have data centers which where built for 10 – 25 years of life which are trying to support technologies which turn over every 2-4 years. This creates a mismatch. This mismatch can put tremendous stress on the infrastructure, which is called on to support the differences in the capabilities and needs of the data center and the equipment being installed in it.
  - Consider the findings of a recent study by Nemertes Research, which found that that more than 87 percent of data centers were built before 2001.
  - Some consultants indicate that ANY data center more than 5 years old is technically obsolete because it is never designed to support current technology such as Blades.

Put all this together and it's easy to see that the increased demand for energy, increases in the cost of energy and the increasing age of the typical facility really do have data centers at a tipping point.

Data centers are at a tipping point and energy use and cost is the driver

Increased Computing Demand

Changing Cost Dynamics

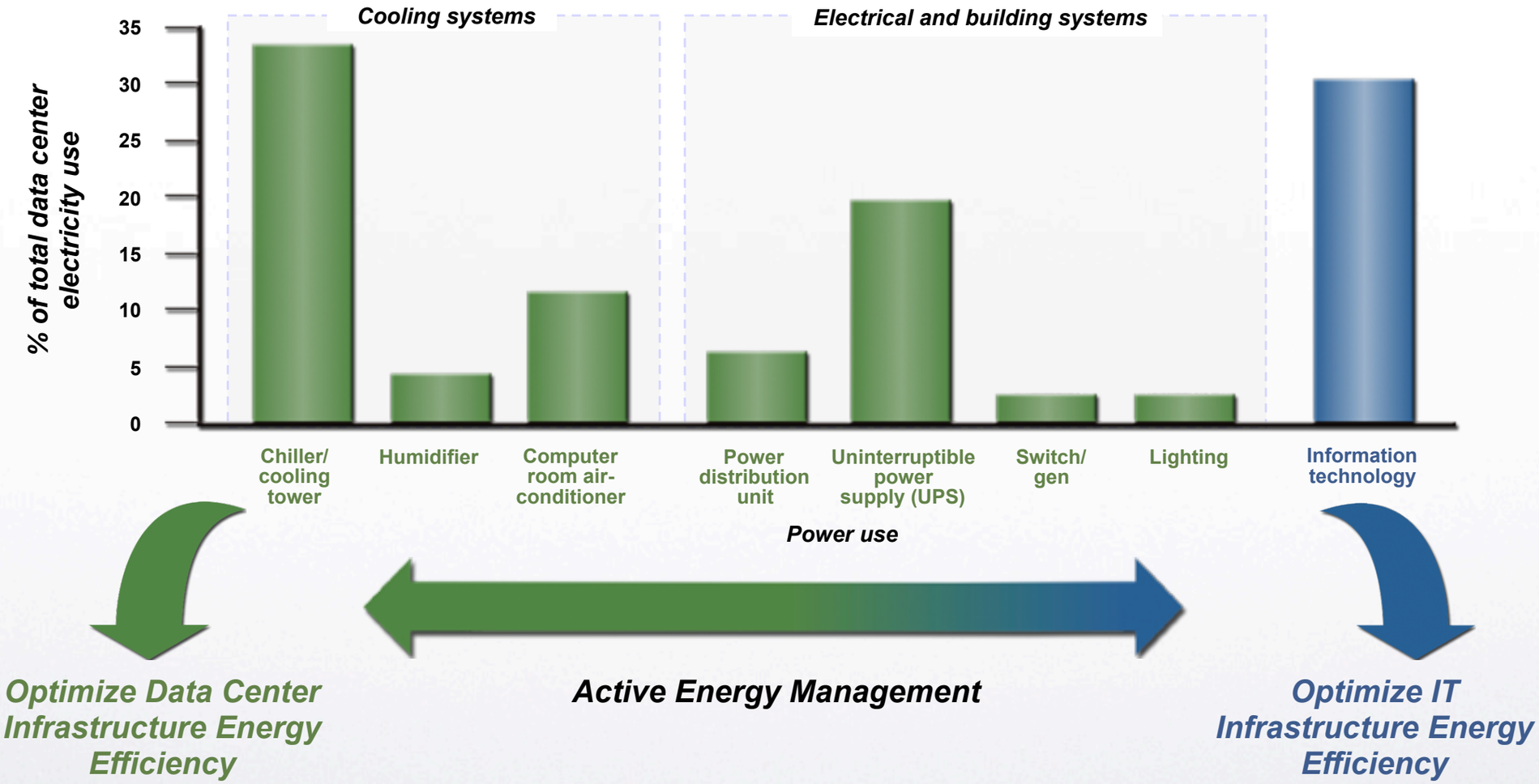
Data Center Lifecycle Mismatch

- **Between 2000 and 2010 sever installations will grow by 6x and storage by 69x. Wintel and Unix server utilization low – 3 to 30% –** *IBM / Consultant studies*
- **Per square foot, annual data center energy costs are 10 to 30 times more than those of a typical office building.** [2] *- William Tschudi, March 2006*
- **Data centers have doubled their energy use in the past five years.**[3] *- Koomey, February 2007*
- **US commercial electrical costs increased by 10% from 2005-06.**[4] **-** *EPA Monthly Forecast, 2007*
- **"Eighty-seven percent of data centers were built before 2001"**[5]
- **"Twenty-nine percent of clients identified" data center capability affected server purchases** *"- Ziff Davis*

1. Gartner, *Data Center Power and Cooling Scenario Through 2015*, Rakesh Kumar, March 2007.
2. William Tschudi, March 2006.
3. Koomey, February 2007.
4. *EPA Monthly Forecast*, 2007.
5. Nemertes Research, Architecting and Managing the 21st Century Data Center, Johna Til Johnson, 2006.

Energy Efficiency > Going Green

Where does the energy go?

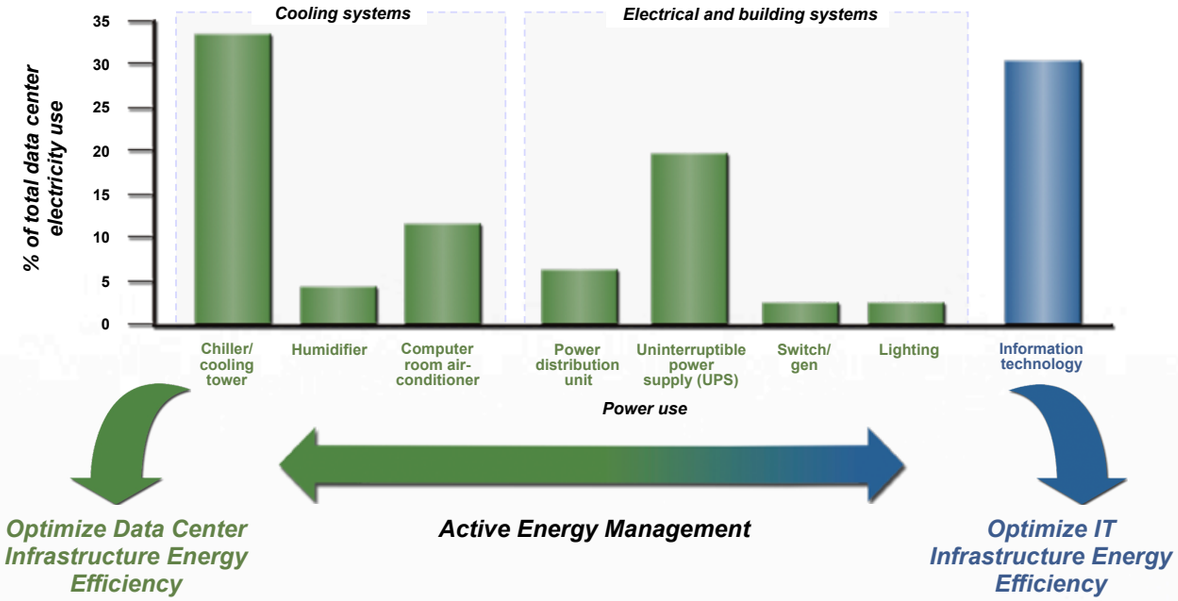


- See? To solve energy related issues you can't just focus on one element in a data center. The data center energy challenge affects both the physical data center and the IT infrastructure components.

Energy Efficiency > Going Green

Where does the energy go?

- One of the surprising elements for clients is to look at the blue bar in the center. This represents IT—server, storage and telecommunication equipment and the power they use. But all this equipment accounts for only 30 to 40 percent of the total energy that the data center uses.
- The other 60-70 percent of the energy used in a data center are the seven other bars shown in green—and they represent the power used by all the non-IT equipment.
  - They're everything from cooling to lighting.
  - They include IT support equipment like uninterruptible power supplies.
- So it's obvious that to solve the challenge of energy use in the data center, you can't just focus on the chips or the servers or the storage. You need to focus on the entire physical data center. You need to fix the technology problems of the IT equipment and the rest of the data center to make them as energy efficient as possible.
- You need a framework that encompasses end-to-end capabilities for power, technology and the data center building. To help you do this, you need to get the facts on your energy usage to understand where to focus your efforts.



Air Management

- Entails all the design and configuration details that go into minimizing or eliminating mixing between the cooling air supplied to equipment and the hot air rejected from the equipment.
- Effective air management implementation minimizes the bypass of cooling air around rack intakes and the recirculation of heat exhaust back into rack intakes.
- When designed correctly, an air management system can
  - reduce operating costs
  - reduce first cost equipment investment
  - increase the data center's power density
  - reduce heat related processing interruptions or failures

Cable Management

- Under-floor and over-head obstructions often interfere with the distribution of cooling air.
- Such interferences can significantly reduce the air handlers' airflow as well as negatively affect the air distribution.
- Cable congestion in raised-floor plenums can sharply reduce the total airflow and degrade the airflow distribution through the perforated floor tiles, both causing hot spots.

Aisle Separation and Containment

- A basic hot aisle/cold aisle configuration is created when the equipment racks and the cooling system's air supply and return are designed to prevent mixing of the hot rack exhaust air and the cool supply air drawn into the racks.
- As the name implies, the data center equipment is laid out in rows of racks with alternating cold (rack air intake side) and hot (rack air heat exhaust side) aisles between them.
- Strict hot aisle/ cold aisle configurations can significantly increase the air-side cooling capacity of a data center's cooling system.

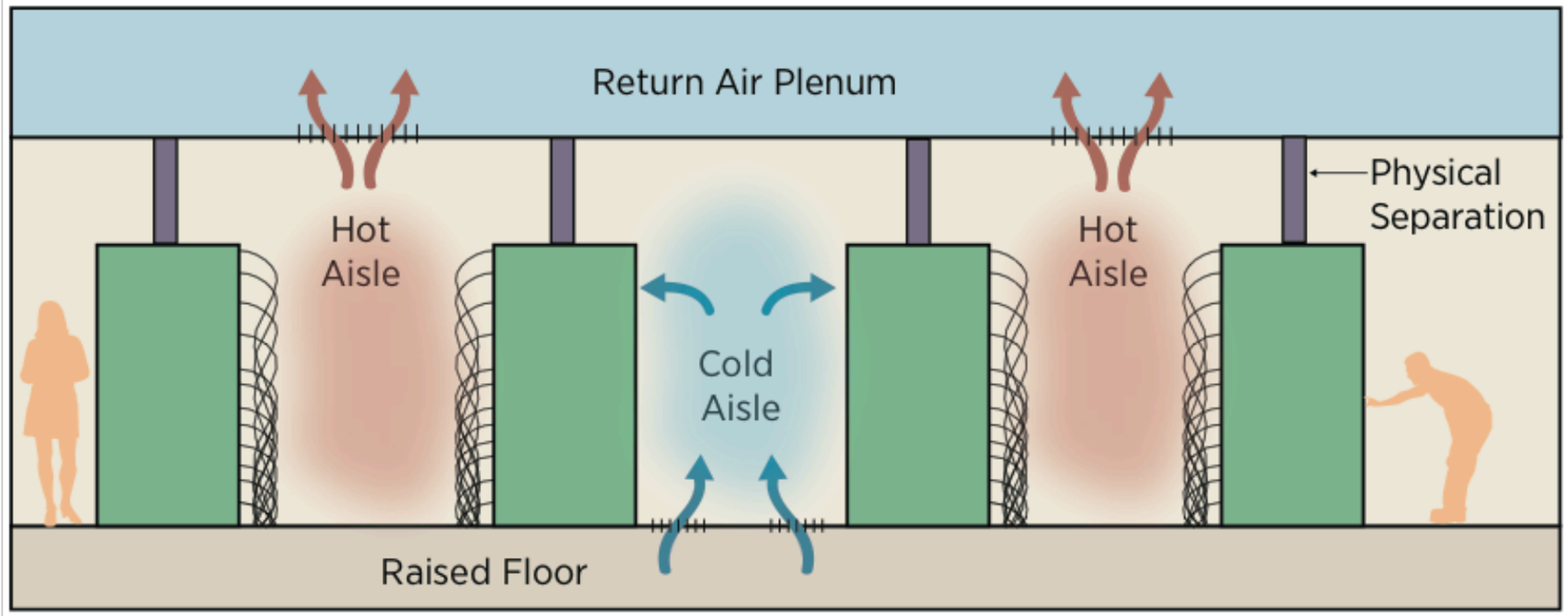


Figure 4. Sealed hot aisle/cold aisle configuration (Source: Rumsey Engineers)

Optimize Supply and Return Air Configuration

- Hot aisle/cold aisle configurations can be served by overhead or under-floor air distribution systems.
- When an overhead system is used, supply outlets that ‘dump’ the air directly down should be used in place of traditional office diffusers that throw air to the sides, which results in undesirable mixing and recirculation with the hot aisles.
- The diffusers should be located directly in front of racks, above the cold aisle.
  - In some cases return grilles or simply open ducts have been used.
- The temperature monitoring to control the air handlers should be located in areas in front of the computer equipment, not on a wall behind the equipment.
- keep in mind that overhead delivery tends to reduce temperature stratification in cold aisles as compared to under-floor air delivery.

Energy Efficiency > Goals

IT Efficiency

- Reduce energy costs.
- Implement virtualization to Increase IT utilization and efficiency with improved flexibility and resilience.

Data Center Facilities

- Reduce capital and operational costs.
- Implement services to extend the life of a data center and adopt new servers.

Energy Management

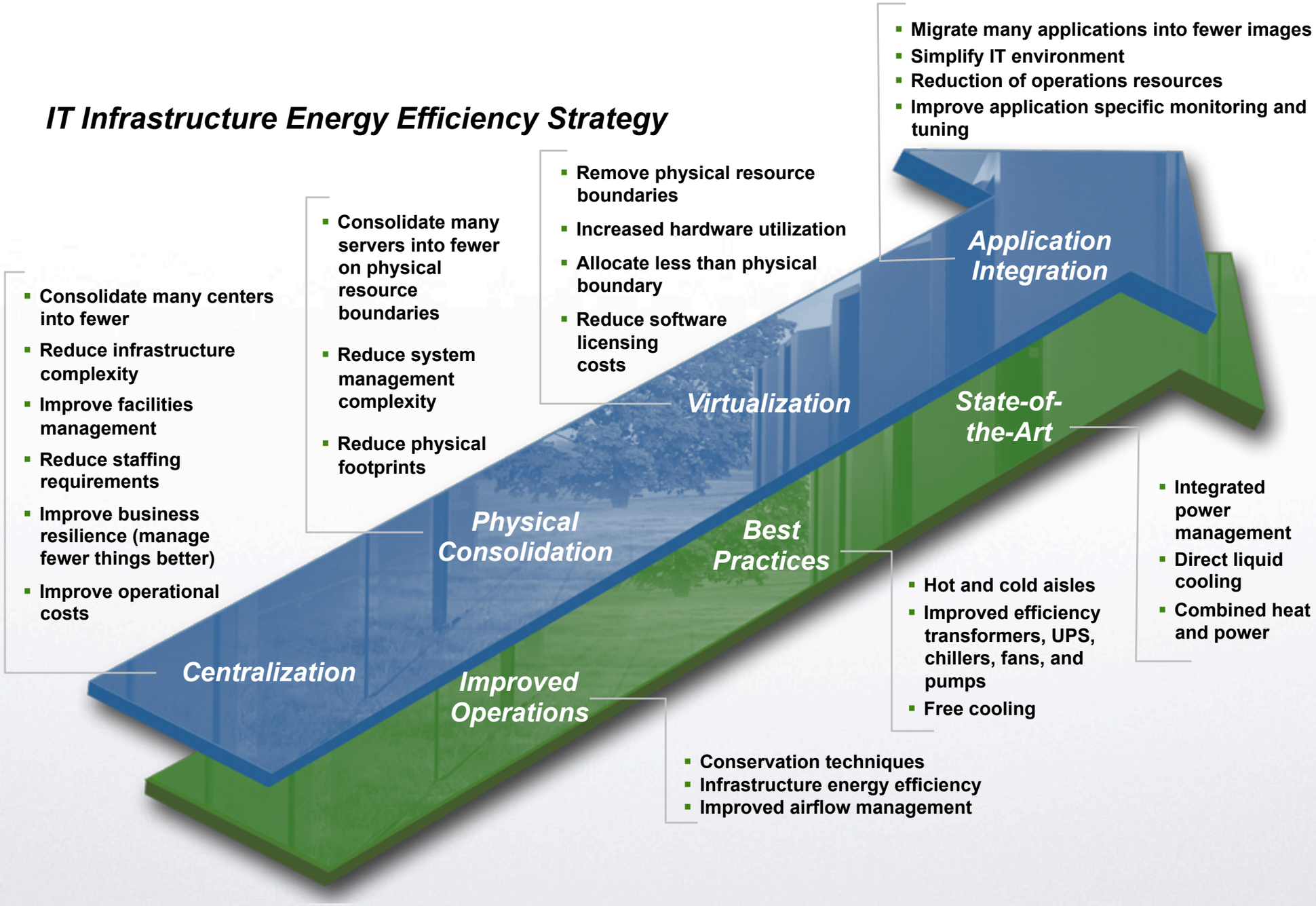
- Measure and control energy usage.
- Implement energy monitoring and reporting.
- Put policies in place to manage and control energy use.
- Integrate energy data into enterprise management applications.

Environmental Leadership

- Establish green strategy.
- Investigate incentive programs to reward IT energy efficiency initiatives.

Energy Efficiency > Getting to the Green Goals

IT Infrastructure Energy Efficiency Strategy



- Consolidate many centers into fewer
- Reduce infrastructure complexity
- Improve facilities management
- Reduce staffing requirements
- Improve business resilience (manage fewer things better)
- Improve operational costs

- Consolidate many servers into fewer on physical resource boundaries
- Reduce system management complexity
- Reduce physical footprints

- Remove physical resource boundaries
- Increased hardware utilization
- Allocate less than physical boundary
- Reduce software licensing costs

- Migrate many applications into fewer images
- Simplify IT environment
- Reduction of operations resources
- Improve application specific monitoring and tuning

- Conservation techniques
- Infrastructure energy efficiency
- Improved airflow management

- Hot and cold aisles
- Improved efficiency transformers, UPS, chillers, fans, and pumps
- Free cooling

- Integrated power management
- Direct liquid cooling
- Combined heat and power

Required Readings

Websites

- Green Data Center News portal at www.greendatacenternews.org
- IBM Redbooks search: Green Data Centers - here

Papers (some linked from the prior slides)

- Department of Energy Best Practices Guide for Energy-Efficient Data Center Design [*pdf*]
- Journal of Technology Research: How Green can We Perform? [*pdf*]
- Steps for the Journey to Green [*pdf*]
- Microsoft on Green Computing [*pdf*]

Optional Readings

Websites

- IBM Energy Podcast: http://www-01.ibm.com/webcasts/podcasts/channels/gts/gts_channel.shtml#episode24
- Sustainability in Information Technology - http://sustainablestanford.stanford.edu/sustainable_it
- Marist IT going Green (Really?) - http://www.marist.edu/it/green.html
- Mid-size Companies Continue Investing to Reduce Technology's Environmental Impact
  - http://www-03.ibm.com/press/us/en/pressrelease/26823.wss

Papers

- Microsoft Architecture Journal - Green IT [*pdf*]
- IBM Redbook The Green Data Center: Steps for the Journey [*pdf*]
- Going Green: A Strategic Guide to Green IT Management
  - http://www.ca.com/files/whitepapers/ema-green-it-white-paper.pdf
- Going Green with Brocade
  - http://www.brocade.com/downloads/documents/white_papers/GoingGreenWithBrocade_WP_00.pdf
- GITAM: A Model for the Adoption of Green IT
  - http://aisel.aisnet.org/cgi/viewcontent.cgi?article=1074&context=acis2008
- E-Readiness to G-Readiness: Developing a Green Information Technology Readiness Framework
  - http://aisel.aisnet.org/cgi/viewcontent.cgi?article=1031&context=acis2008

Self-test

What needs to be focused on in the challenge of energy use in a data center?

What is air management?

How do cables affect air management?

How does aisle separation work in a data center?

What are some goals of energy efficiency?

Self-test Answers

What needs to be focused on in the challenge of energy use in a data center?

- Technology problems of the IT equipment and the rest of the data center need to be fixed to make them as energy efficient as possible.

What is air management?

- It is managing all of the design and configuration details that go into trying to eliminate the mixing between cooling air and the hot air be ejected from the equipment.

How do cables affect air management?

- Cables can reduce and negatively affect air distribution. Some cable congestion can cause hot spots diminishing airflow distribution.

How does aisle separation work in a data center?

- In a data center there is a concept of a hot aisle/cold aisle. Rows of racks alternate one aisle with air intake side, and other aisles with heat exhaust side.

What are some goals of energy efficiency?

- Reduce capital, operational and energy costs, measure and control energy usage, etc.

Discussions

1. Going Green: How do we tell if it's real or just "green washing"?

- What's "green washing"?
- Why do people do it?
- How can we tell when it's going on?

It looks like I jumped the gun on this topic. So let's reposition it as a discussion for this week (instead of week three) and consider it already complete.

2. Watson won on Jeopardy. How does IBM keep Watson cool?

- Watson is comprised of 90 Power 750 servers, 16 TB of memory and 4 TB of disk storage, all housed in a relatively compact ten racks. The 750 is IBM's elite Power7-based server targeted for high-end enterprise analytics. Watson is maxed out with the 4-socket, 8-core configuration using the top bin 3.55 GHz processors. That's (90 * 4 =) 360 8-core Power7 chips for a total of 2880 cores. Now that's parallel processing! (Which requires concurrent programming. But that's a topic for a different class.)

Remember our discussion expectations and guidelines.

Acknowledgements

Some of the source material and a few of the graphics in this module came from the IBM World Wide Client Technology Centers's very own Frank De Gilio.

More additional material from:

- US Department of Energy and Lawrence Berkeley National Laboratory
  - Data Center Tools Suite / Data Center Energy Profiler ("DC Pro") presentation - 2008
- IBM STG Skills Mastery "Go Green with Global Technology Services" - 2008
- The Microsoft Platform Architecture Team at msdn.microsoft.com/en-us/architecture/bb410935.aspx
- Journal of Technology Research at www.aabri.com/jtr.html
- IBM Redbooks at ibm.com/redbooks

My additional thanks go out to Christina Collesano and Carley Keefe, both Marist students who helped me track down much of the additional material and make this document better than I could have done myself.

Colophon

This work was authored in Keynote by Alan G. Labouseur in August 2010 from his home in Pleasant Valley, NY.

He is . . . Green, just as our data centers strive to be. Or was he just green-washed? (And what is Corbomite?)

Distractions that made writing go slower:

- The Kevin Pollak Chat Show
- More of “Under the Dome” by Stephen King
- VH1 Classics: Live in Concert (Queen, The Rolling Stones, Sting, AC/DC)

Music that made writing go faster:

- iTunes Genius Mixes: Hard Rock, New Wave, AOR Classic Rock
- Specific artists: BB King / Cheap Trick / Van Halen / The Pretenders / Smash Mouth / The Spin Doctors / Queen