Designing Cabling Systems and Data Centers for Green Building Compliance

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Objective

This seminar will introduce the Green Building concept and will propose cabling strategies as well as data center design methods that may contribute for overall building LEED certification according to the USGBC LEED ratings.

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Agenda

- **PART I**
  - Green Building Concept and USGBC Rating Systems
- **PART II**
  - Cabling Strategies for Green Building Compliance
- **PART III**
  - Green Data Center Design Methodologies
- **Final Comments & Conclusions**

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PART I

Green Building Concept and the USGBC Rating Systems

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A Brief History of GBs

- Sustainable design development: 10 yr-old
- It harkens back almost 200 years
- Nineteenth Century: Galleria Vittorio Emanuele II
- One century later: NY Skyscrapers

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A Brief History of GBs (continued)

- In the 1930's: Glass-box style buildings
- Deployment of air conditioning systems
- Reflective glass, fluorescent lighting
- Structural steel
- Energy Task formed in 1970's due to the energy crisis in the U.S.
- Mid-1980's: Creation of the USGBC

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A Brief History of GBs (continued)

- In 1997, the Navy developed the “Whole Building Design Guide”
- Other greening initiatives:
  - E.O. 13101 (September, 1998)
  - E.O. 12123 (June, 1999)
  - E.O. 13148 (April, 2000)
  - Energy Policy Act, Section 914 of 2005
  - Energy Independence and Security Act of 2007

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The Green Building Concept

- The Office of Federal Environmental Executive defines green building as

  "The practice of:

  1) Increasing the efficiency with which buildings and their sites use energy, water, and materials, and

  2) Reducing building impacts on human health and the environment, through better site location, design, construction, operation, maintenance, and removal – the complete building life cycle."

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The Green Building Goals

- Increased building efficiency
  - Energy, Water & Materials
- Reduce building impact on health & environment through;
  - Better site location
  - Design & Construction
  - Operation & Maintenance
  - Removal along its life cycle

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The Basics of Green Buildings

- Third-party environmental certifications:
  - USGBC LEED Rating Systems
  - Green Guide for Health Care (GGHC)
  - Collaborative for High Performance Schools (CHPS)

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Benefits of Sustainable Ratings

- Increase building efficiency
  - save energy, water & other resources
- Indoor spaces quality & productivity
- Educate building occupants
  - energy use & conservation
- Provide reduced environment impact
- Provide important economic performance

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The USGBC LEED Ratings

- United States Green Building Council
  - Leadership in Energy and Environmental Design
  - 1998 created the LEED rating systems
  - define and measure green buildings

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LEED Processes

IN PROCESS

- New construction (NC)
- Multiple buildings or campuses
- Existing buildings (EB)
- Commercial interiors
- Core & shell

UNDER DEVELOPMENT

- Schools
- Healthcare
- Laboratories
- Retail
- Homes
- Neighborhood development

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LEED Processes (continued)

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LEED Goals

- Whole-building approach to sustainability
- Key-areas of human and environmental health:
  - Site sustainability
  - Water savings
  - Energy efficiency
  - Materials selection
  - Indoor environmental quality

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How LEED Works - NC

- It is a credit-based rating system
- Credits represent different approaches within the building rating categories, as follows:
  - Sustainable sites (SS)
  - Water efficiency (WE)
  - Energy and atmosphere (EA)
  - Materials and resources (MR)
  - Indoor environmental quality (EQ)
  - Innovation in design (ID [LEED NC, V2.2])

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Category: Sustainable Sites

- Features:
  - Reduce pollution due to construction activities
  - Reduce impact on the environment due to the building location
  - Protect greenfields, habitats and resources
  - Reuse existing buildings
  - Reduce impacts from automobiles
  - Conserve existing natural areas
  - Reduce water pollution

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Category: Water Efficiency

- Limit or eliminate use of potable water
- Reduce wastewater generation
- Maximize water efficiency inside buildings
- Reduce the burden on municipal supply

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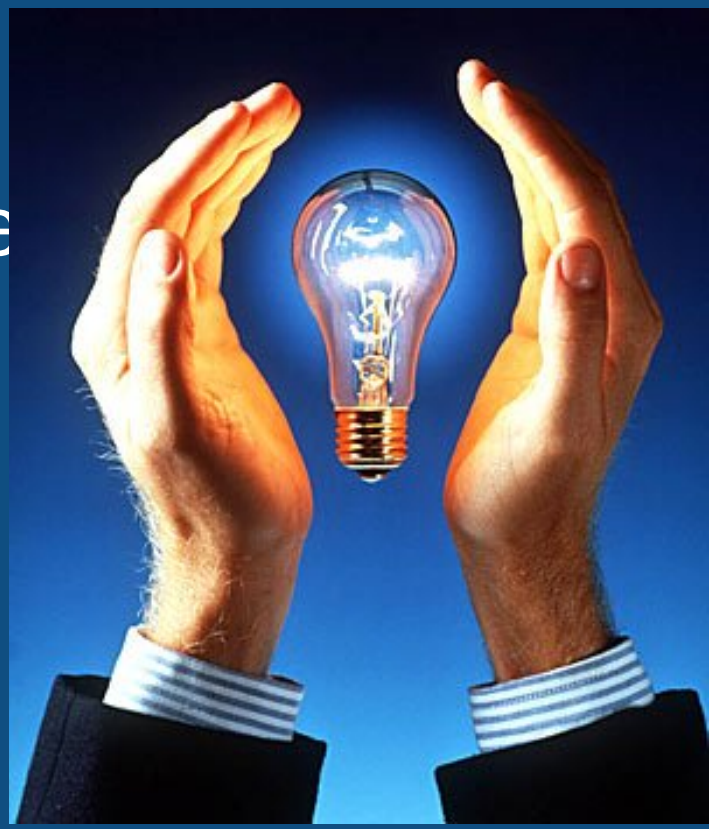
Category: Energy & Atmosphere

- Establish energy efficiency
- Establish system performance
- Establish minimum level of energy efficiency for the building and its systems
- Optimize energy efficiency
- Reduce ozone depletion



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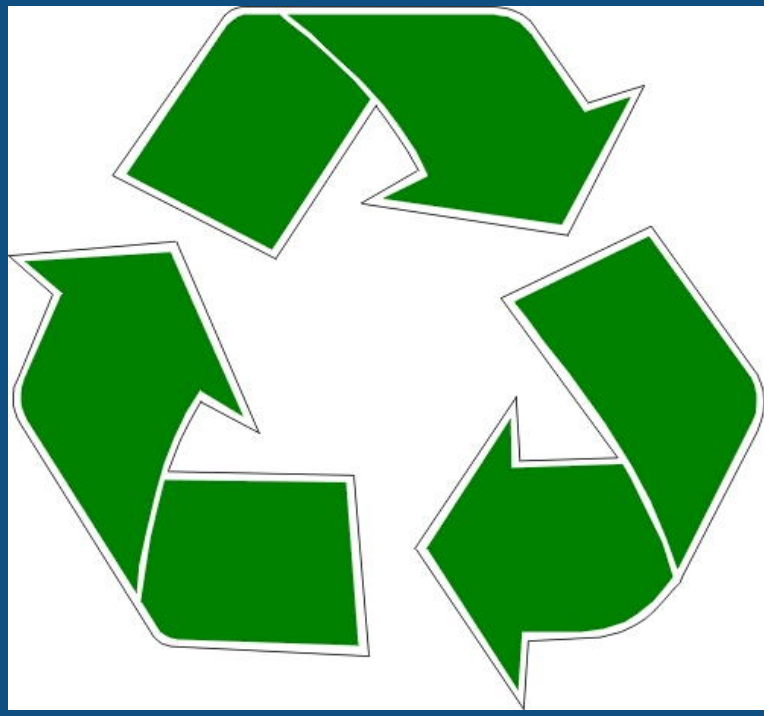
Category: Materials & Resources

- Reduce materials needed in the construction phase
- Reduce waste generated by building occupants
- Use of material with less environmental impact
- Use of rapid renewable materials
- Use of products with recycled content materials



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Category: Environmental Quality

- Indoor air quality performance
- Reduce & eliminate indoor pollutants
- Ventilation system capacity to maintain occupants comfort
- Assure thermal comfort and system controls

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Category: Innovation in Design

- Recognize innovative performance in any achieved LEED NC credit
- innovation in categories not directly covered by LEED NC
- Credit granted for projects in which at least one principal team member has the LEED AP credential

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How LEED Works - NC (continued)

- LEED rating systems have prerequisites that must be met for LEED certification
- LEED rating systems have 69 points (potential)

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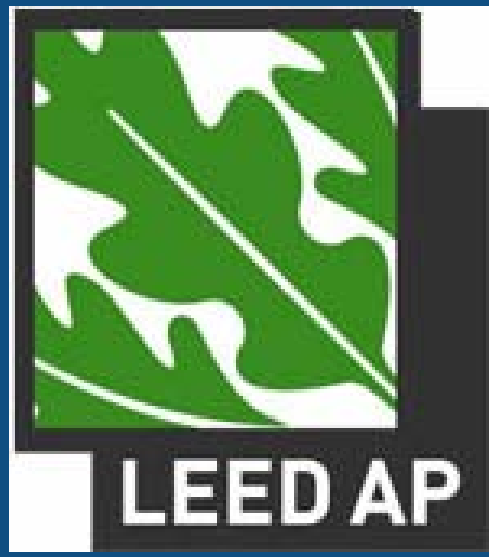
LEED Rating Points - NC

Category	Credits	Points
SS	8	14
WE	3	5
EA	6	17
MR	7	13
EQ	8	15
ID	5	5
LEED AP		1



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LEED Credits - SS

- SS-1p: Construction activity pollution prevention
- SS-1c: Site selection
- SS-2c: Development density & community connectivity
- SS-3c: Brownfield redevelopment
- SS-4.1c: Alternative transportation, public transportation access
- SS-4.2c: Alternative transportation, bicycle storage and changing rooms
- SS-4.3c: Alternative transportation, low-emitting & fuel-efficient vehicles
- SS-4.4c: Alternative transportation, parking capacity

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LEED Credits - SS (cont'd)

- SS-5.1c: Site development, protect or restore habitat
- SS-5.2c: Site development, maximize open space
- SS-6.1c: Stormwater management, quality control
- SS-6.2c: Stormwater design
- SSc-7.1c: Heat island effect, non-roof
- SS-7.2c: Heat island effect, roof
- SS-8c: Light pollution reduction

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LEED Credits – WE

- WE-1.1c: Water efficient landscaping: reduce by 50%
- WE-1.2c: Water efficient landscaping: no potable water use or no irrigation
- WE-2c: Innovative wastewater technologies
- WE-3.1c: Innovative use reduction: 20%
- WE-3.2c: Water use reduction: 30%

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LEED Credits – EA

- EA-1p: Fundamental commissioning of building energy systems
- EA-2p: Minimum energy performance
- EA-3p: Fundamental refrigerant management
- EA-1c: Optimize energy performance
- EA-2c: On-site renewable energy
- EA-3c: Enhanced commissioning
- EA-4c: Enhanced refrigerant management
- EA-5c: Measurement & verification
- EA-6c: Green power

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LEED Credits – MR

- MR-1p: Storage & collection of recyclables
- MR-1.1c: Building reuse, 75% of walls, floors, roof
- MR-1.2c: Building reuse, 95% of walls, floors, roof
- MR-1.3c: Building reuse, maintain 50% of interior and non-structural elements
- MR-2.1c: Construction waste management, divert 50% from disposal
- MR-2.2c: Construction waste management, divert 50% from disposal

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LEED Credits – MR (cont'd)

- MR-3.1c: Materials reuse, 5%
- MR-3.2c: Materials reuse, 10%
- MR-4.1c: Recycled content, 10%
- MR-4.2c: Recycled content, 20%
- MR-5.1c: Regional materials, 10% extracted, processed and manufactured regionally
- MR-5.2c: Regional materials, 20% extracted, processed and manufactured regionally
- MR-6: Rapid renewable materials
- MR-7: Certified wood

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LEED Credits – EQ

- EQ-1p: Minimum IAQ performance
- EQ-2p: Environmental tobacco smoke control
- EQ-1c: Outdoor air delivery monitoring
- EQ-2c: Increased ventilation
- EQ-3.1c: Construction IAQ management plan, during construction
- EQ-3.2c: Construction IAQ management plan, before occupancy

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LEED Credits – EQ (cont'd)

- EQ-4c: Low-emitting materials
  - Four credits (4.1 to 4.4)
- EQ-5c: Indoor chemical
- EQ-6c: Controllability of Systems
  - 6.1: Lighting
  - 6.2: Thermal comfort
- EQ-7c: Thermal comfort
  - 7.1: Design
  - 7.2: Verification

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LEED Credits – EQ (cont'd)

- EQ-8c: Daylighting & views
  - 8.1: 75% of spaces
  - 8.2: 90% of spaces

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LEED Credits – ID

- ID-1c: Innovation in design
  - Credits 1.1 to 1.4
  - Innovative performance in green building categories not covered by the rating systems
- ID-2c: LEED Accredited Professional
  - One principal member of the project team shall be a LEED A.P.

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LEED Certification Process

- Project registration
  - LEED on-line
  - LEED templates
  - Check list
- Technical Review and Support
  - Reference package
  - Credit inquires
- Building Certification Awarded
  - Upon documentation submitted and USGBC review

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LEED Certifications

- There are four levels of LEED recognition for new construction

LEED certification	Points needed
Certified	26 to 32
Silver	33 to 38
Gold	39 to 51
Platinum	52 to 69

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What does a LEED credit mean?

- Building design, construction and operation meet the highest performance levels in terms of:
  - energy use,
  - environmental conditions for its occupants
  - environmental impact
- Higher the LEED certification level of a building
  - lower its energy consumption
- Building occupants/owners;
  - save money with energy consumption
  - over the building lifecycle

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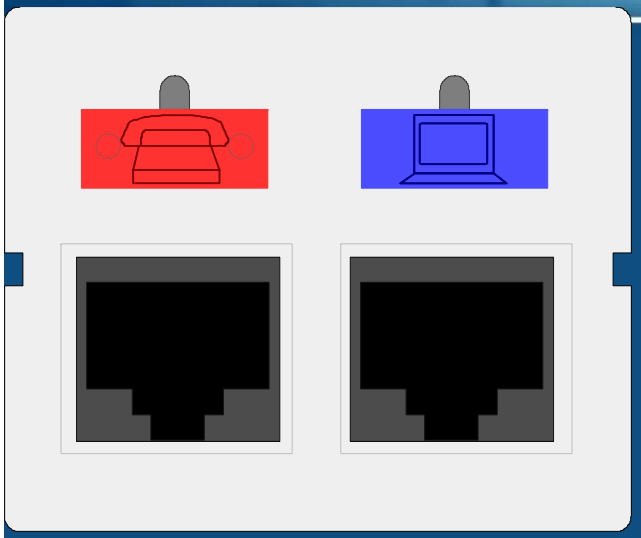

PART II

Cabling Strategies for Green Building Compliance

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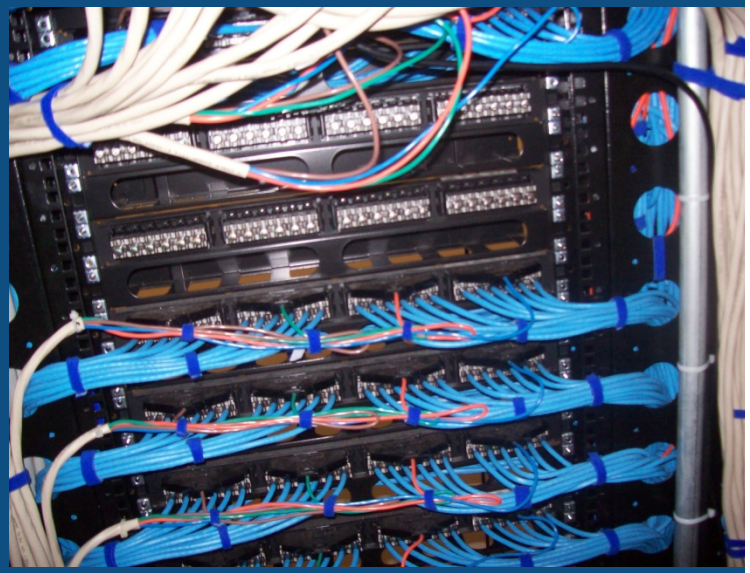
How to Address Cabling?

- Telecommunications cabling is not directly addressed in the USGBC rating systems…



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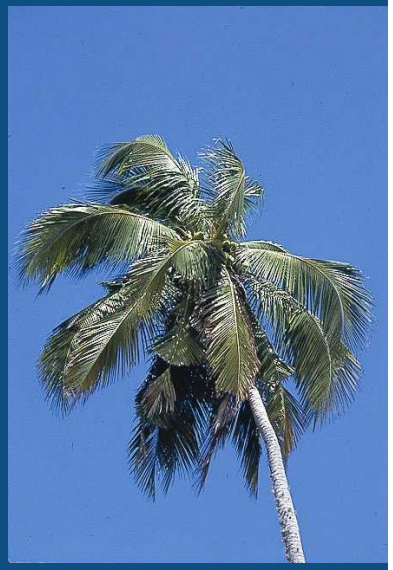
Sustainable Sites

- LEED credits:
  - Construction activity pollution prevention
  - Site selection
  - Development density and community connectivity
  - Alternative transportation
  - Maximize open space, and so on…



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Water Efficiency

- LEED credits:
  - Water efficient landscaping – Reduce by 50%
  - Innovative wastewater technologies
  - Water use reduction – 20%
  - Water use reduction – 30%

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Indoor Environmental Quality

- LEED credits:
  - Environmental tobacco smoke control
  - Outdoor air delivery monitoring
  - Low-emitting materials
    - adhesives and sealants
  - Low-emitting materials
    - carpet systems, and so on…

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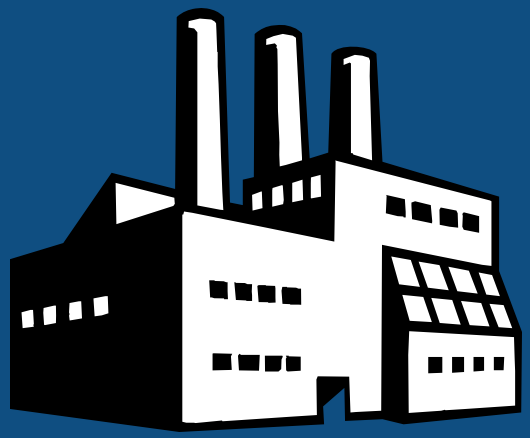
Energy & Atmosphere

- LEED credits:
  - Commissioning of the building energy system
  - Minimum energy performance
  - Fundamental refrigerant management
  - Optimize energy performance
  - On-site renewable energy
  - Enhanced commissioning
  - and so on…



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Materials & Resources

- LEED credits:
  - Construction waste management
  - Materials reuse
  - Regional materials
    - Extracted
    - Processed
    - Manufactured

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Innovation in Design

- NEW to the existing LEED rating systems
  - APPLIES TO new construction
- LEED NC Version 2.2
  - New Construction & Major Renovation
- Credits:
  - Potential technologies & strategies
  - Energy performance
  - Quantifiable environment benefits

CABLING MAY FIT HERE!

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Potential LEED Credits

- Energy and Atmosphere
  - Energy optimization (credit EA 1):
    - Cables of smaller diameters
    - Physical layer management solutions

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Potential LEED Credits (continued)

- Materials and Resources
  - Waste management (credits MR 2.1/2.2)
    - Use of preterminated cabling solutions
    - Use of larger reels of cables
    - Convergence & Cable sharing
    - Physical layer management solutions

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Potential LEED Credits (continued)

- Materials and Resources
  - Materials reuse (credits MR 3.1/3.2)
    - Convergence
    - Cable sharing
    - Modular trunking design (including MPO)
    - Higher-bandwidth solutions

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Potential LEED Credits (continued)

- Innovation in Design
  - Potential technologies & strategies
  - Energy performance
    - (credits 1.1/1.2/1.3/1.4)
  - Physical layer management solutions
  - Cable reduction
  - BAS: Building Automation Systems
  - Higher-bandwidth solutions
  - Wireless network

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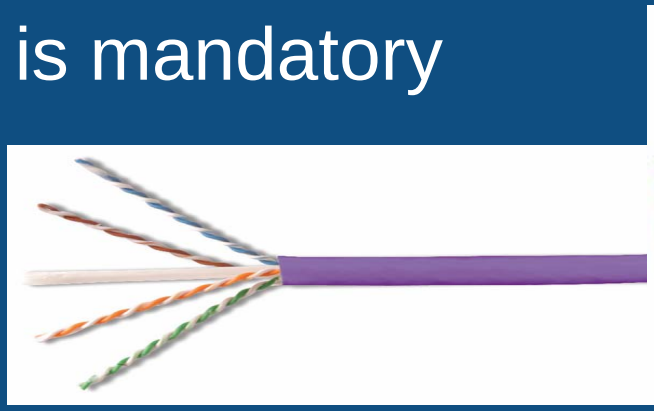
And About Cable Recycling?

- RECYCLED Telecommunications cables
  - DUE TO the high value of copper SCRAP
- Plastic material (insulator) difficult to reuse
- Burning the plastic causes toxic gas emissions
- Polyvinyl Chloride (PVC) insulator has some lead in its CHEMICAL composition
- Proper disposal is mandatory



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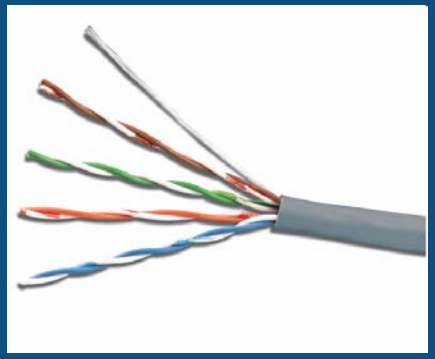
Cable Recycling (continued)

- Burning telecom cables is not allowed in the U.S.
- Recycling facilities exist
- Technology to recycle abandoned cables is improving
- Recycling plastic material is still an issue



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Additional Comments & Conclusions – Part II

- Telecommunications cabling
  - NO direct correlation within LEED systems
- Potential credits:
  - energy optimization,
  - waste management,
  - materials reuse

- MR 5.1/5.2 (Regional Materials)
  - NO direct correlation within LEED systems
  - potential LEED credits MAY BE AVAILABLE

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Additional Comments & Conclusions – Part II (continued)

- Division 27 products (communications products)
  - NOT recognized for LEED credits and points
- USGBC only recognizes CSI
  - Master Format Divisions 2 THROUGH 10
- BICSI & OTHERS are discussing these issues with USGBC
- Expansion of coverage and inclusion of Division 27 is needed to include telecom cables in the LEED punctuation calculations

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Additional Comments & Conclusions – Part II (continued)

- Other recommendations:
  - CONSIDER HIGH PERFORMAMCE, high-density optical networks (ARRAY [MPO & MPT]) for 10GbE (data centers)
  - Consider higher-bandwidth technologies for new constructions
    - Cat 6_A/Class E_A, Cat 7/Class F, Cat 7_A/Class F_A
    - Laser-optimized fiber (OM3, OM4, OS1, OS2)
  - Consider PLM for new constructions
  - Optimize cable use (reuse) for existing installations
  - Consider cable sharing for existing installations

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Potential LEED credits Summary

LEED credits	Component/Technology/Methodology
EA1 **(10 pts max)**	Cables of smaller diameters PLM solutions
MR 2.1/2.2 **(2 pts max)**	Preterminated cabling solutions Larger reels of cables PLM solutions, convergence and cable sharing

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Potential LEED credits Summary

LEED credits	Component/Technology/Methodology
MR 3.1/3.2 **(2 points max)**	Convergence and cable sharing Modular trunk cables and ARRAY solutions Higher-bandwidth solutions
ID 1.1/1.2/ 1.3/1.4 Design phase **(4 points max)**	PLM solutions and cable reduction Wireless network and higher-bandwidth solutions BAS – Building Automation Systems **Note: ID credits apply to new constructions only.**

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PART III

Green Data Center Design Methodologies

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Energy Consumption

- Uptime and redundancy have been the focus of a data center design
- No (or little) concern with energy consumption
- Data center IT equipment and the supporting power and cooling infrastructure are up to 40 times more energy intensive than a typical office building

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Energy Consumption (cont'd)

- Energy consumption of servers in DC has doubled in the past 5 years
- It's expected to almost double again by 2011
- Power consumption estimated to reach 12 GW by 2011
- DC in 2006 consumption: Approx. 1.5% of total U.S. electricity consumption
- Average electrical power fee is approximately US$0.10 per kwh in the U.S.
  - US$ 900 a year for each kW of load
  - US$ 400 a year to power a server
  - US$ 400 a year to cool a server

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EPA Data (2008)

U.S. Environmental Protection Agency - 2007

Projected CO2 Emissions Associated with the Electricity Use of U. S. Servers and Data Centers (MMT -CO2/Year), All Scenarios, 2007 to 2011

Scenario	2007	2008	2009	2010	2011	2007-2011 Total	% of current efficiency trends scenario
Historical Trends	44.4	51.2	59.2	69.2	78.7	302.8	111%
Current Efficiency Trends	42.8	47.9	53.6	60.5	67.9	272.8	100%
Improved Operation	34.8	39	43.5	48.4	53.1	219	80%
Best Practice	30.2	30	29.8	29.7	30.1	149.8	55%
State-of-the-Art	28.1	25.7	23.5	21.4	21.2	119.9	44%

- EPA, 2007

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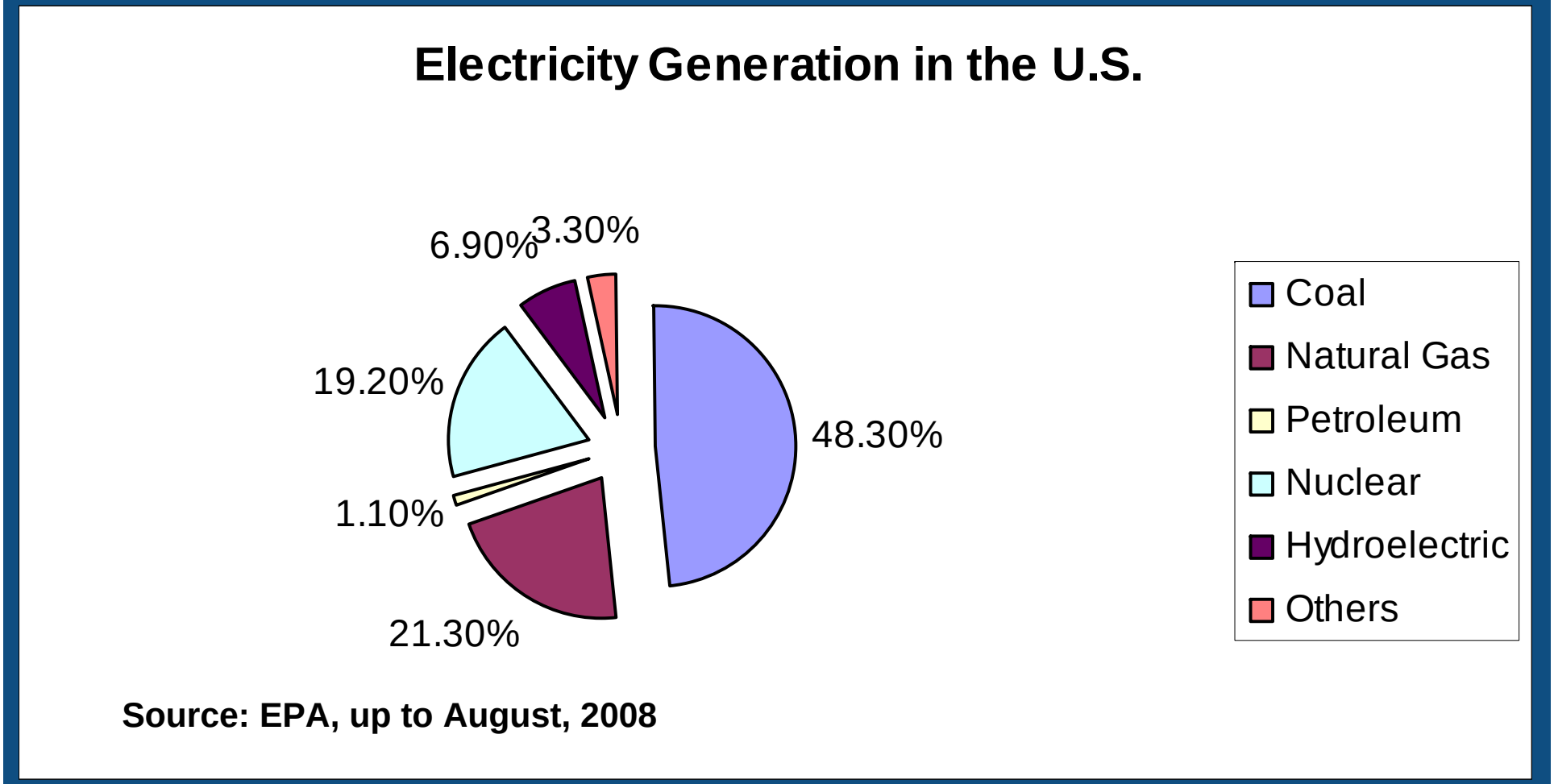
The U.S. Electricity Generation



Source: EPA, up to August, 2008

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The Green Data Center Concept

- Challenge for today's facility and data center managers
  - to reduce operating costs by minimizing energy consumption while maximizing;
    - power reliability
    - IT application performance
    - availability
    - system availability

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How to get Green?

- Data center energy consumption is by design
- Computer loading and IT equipment determine the data center power demand
- Facility engineers: power distribution capacity and reliability
- IT/DC Managers: servers availability and service level agreement (SLA)

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Data Center Metrics

- Green Grid metrics
  - PUE (Power Usage Effectiveness)
  - DCiE (Data Center infrastructure Efficiency)
  - DCE (Data Center Efficiency)
  - DCP (Data Center Productivity)
  - DCPE (Data Center Performance Efficiency)
- CADE metrics
  - Corporate Average Datacenter Efficiency

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Power Usage Effectiveness

$$PUE = \frac{\text{Total Facility Power}}{\text{IT Equipment Power}}$$

- Total Facility Power is defined as the power measured at the utility meter
- The IT Equipment Power is defined as the equipment that is used to manage, process, store, or route data within the data center

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Data Center Infrastructure Efficiency

$$DCiE = \frac{1}{PUE} = \frac{\text{IT Equipment Power}}{\text{Total Facility Power}} \times 100\%$$

- Example
  - IT Equipment load (power) = 216kW
  - Mechanical/Cooling load (power) = 300kW
  - Lighting load (power) = 18kW
  - UPS/Batteries load (power) = 66kW
  - IT Load = 216kW - Total Facility Load = 600kW
  - **DCiE = (216/600)x100% = 36%**

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Data Center Efficiency

$$DCE = \frac{\text{IT Equipment Power}}{\text{Total Facility Power}}$$

Data Center Performance Efficiency

$$DCPE = \frac{\text{Useful Work}}{\text{Total Facility Power}}$$

- DCPE (DCP) is difficulty to determine
- Useful work is related to energy and processing
- Data Center seemed as a black box

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Examples of calculations

- Consider the following scenario
  - IT Equipment Load: 6,500kW
  - Total Facility Pwr: 15,000kW
  - Useful IT Work: 5,500kW

$$DCE = \frac{\text{IT Equipment Load}}{\text{Total Facility Pwr}} = \frac{6{,}500}{15{,}000} = 0.43$$

$$DCPE = \frac{\text{Useful IT Work}}{\text{Total Facility Pwr}} = \frac{5{,}500}{15{,}000} = 0.37$$

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Corporate Average Datacenter Efficiency (CADE)

- CADE has four key components:
  - two related to IT and two related to facilities
- Site energy efficiency: This measure is defined as the nominal IT load divided by total energy consumed in the data center
- Site asset utilization: The actual IT load (including servers, storage devices, networking, and telecom equipment) divided by the site capacity
- IT energy efficiency: This metric is set today at 5% for servers
- IT asset utilization: This is measured by average server CPU utilization

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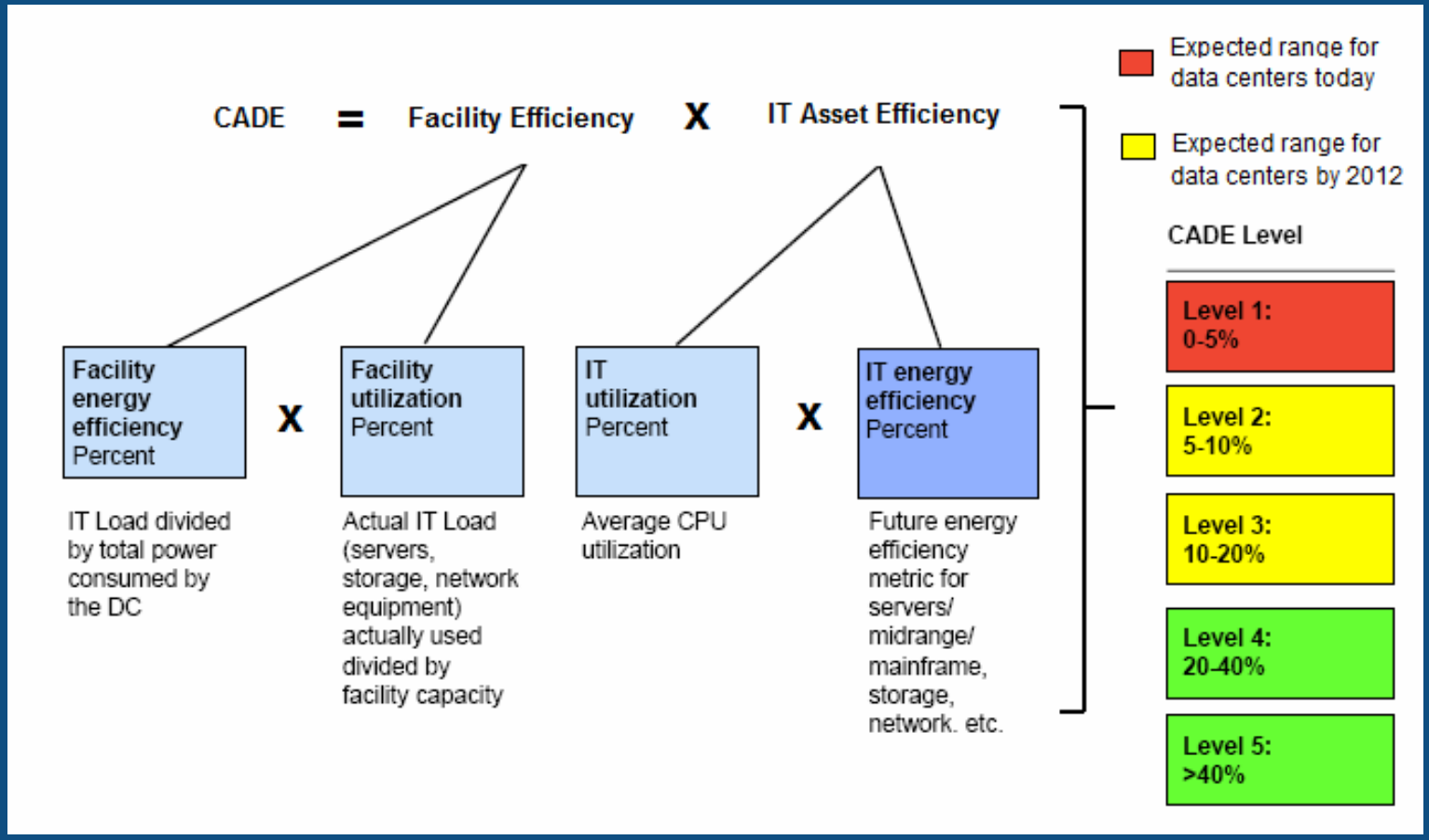
CADE (cont'd)



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CADE - Example

- Data Center Load
  - IT equipment: 1,080kW
  - Lighting: 90kW
  - UPS/Batteries: 330kW
  - Mech./Cooling: 1,500kW

$$\text{Facility energy efficiency} = \frac{\text{IT load}}{\text{Total DC power}} = \frac{1{,}080}{3{,}000} = 36\%$$

$$\text{Facility utilization} = \frac{\text{IT load}}{\text{Facility IT capacity}} = \frac{1{,}080}{1{,}500} = 72\%$$

$$\text{Average CPU utilization} = 5\%$$

$$\text{CADE} = \text{Facility energy efficiency} \times \text{Facility utilization} \times \text{Average CPU utilization} = 1.3\%$$

CADE Level 1 (0-5%)

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How to improve CADE?

- Improvements to reach CADE higher levels:
  - Remove dead servers (CPU utilization target: 10%)
  - Virtualize servers on 4 to 1 ratio, with 50% utilization (further average CPU utilization target: 15%)
  - Adopt industry best practices
  - Optimize use of energy inside facility
  - Adopt efficient energy management methods

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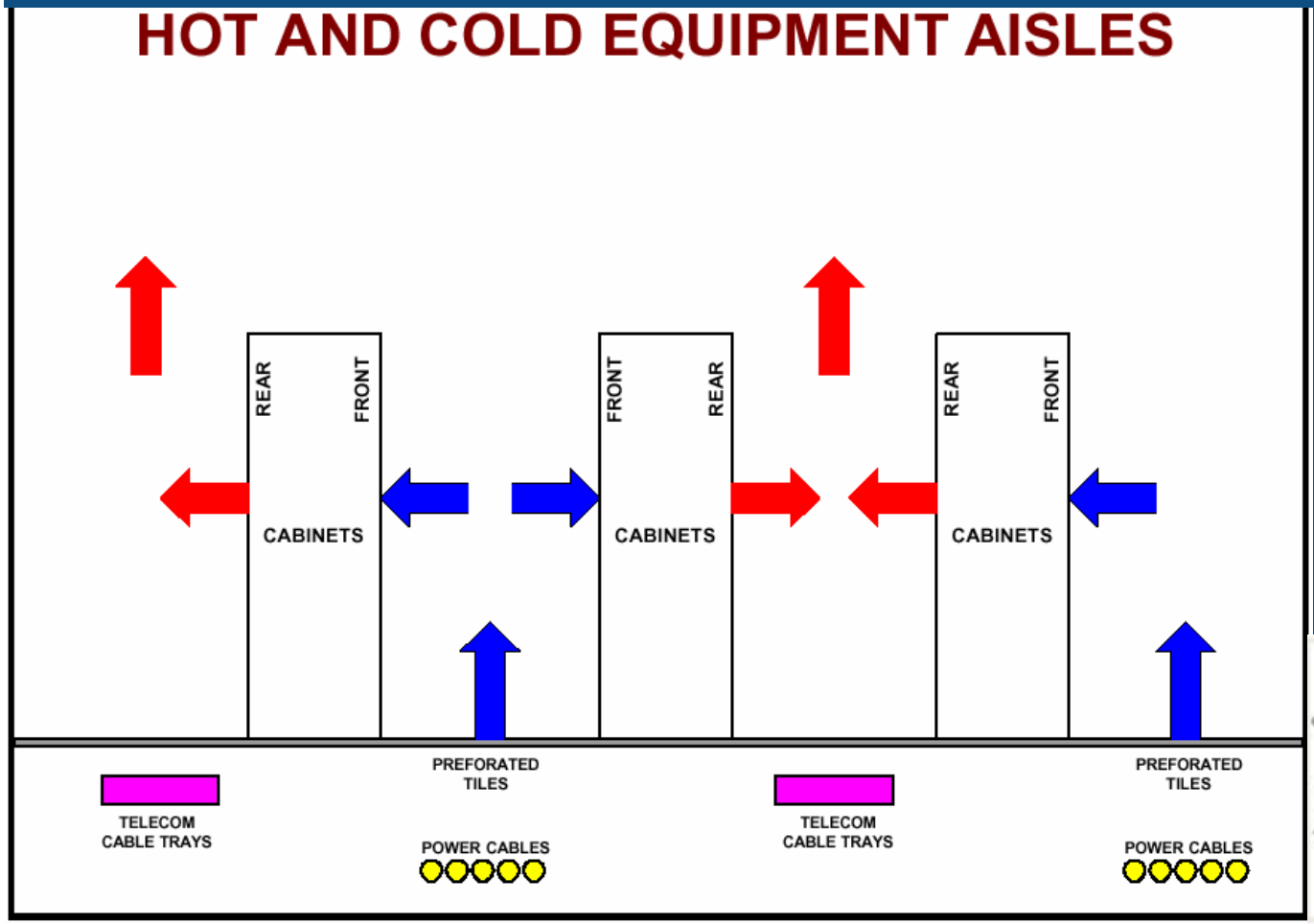
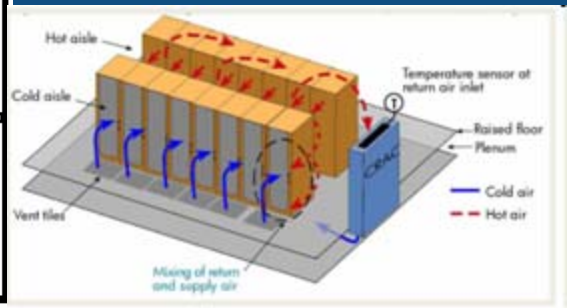
Cooling Efficiency



-Placement of floor tiles is critical

- If there are too many floor tiles in the facility, cool air pressure will be too low and won't be able to reach the top of the racks



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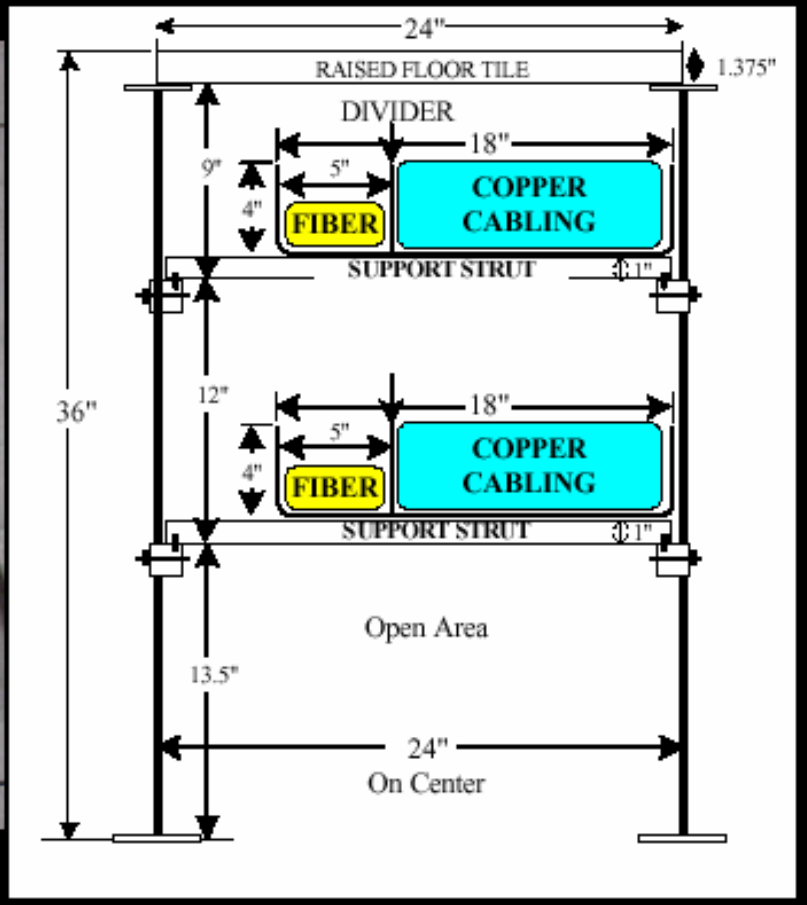
Cooling Efficiency (cont'd)



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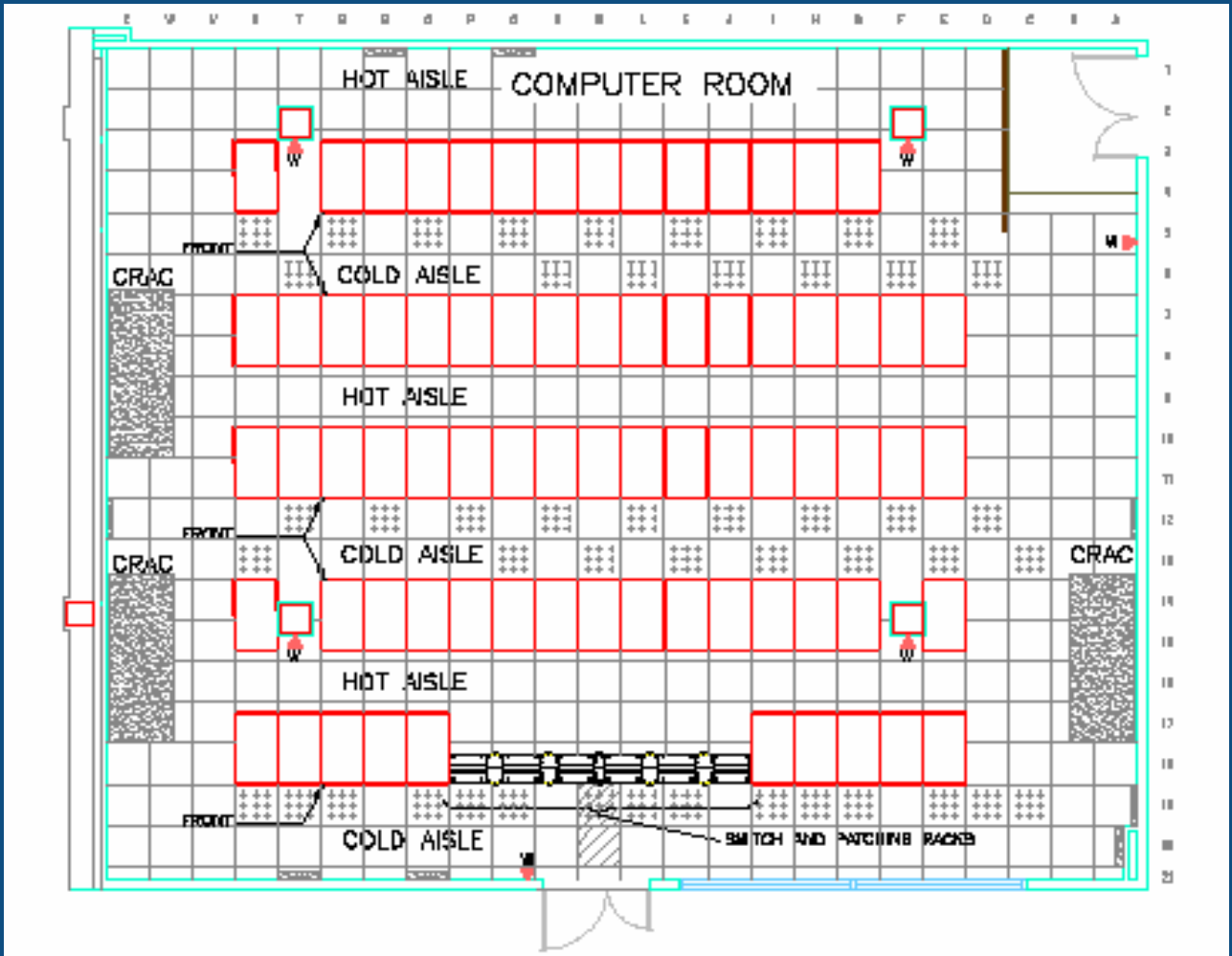
Cooling Efficiency (cont'd)



- Correct sizing and placement of floor tiles
- Remove under-floor obstructions

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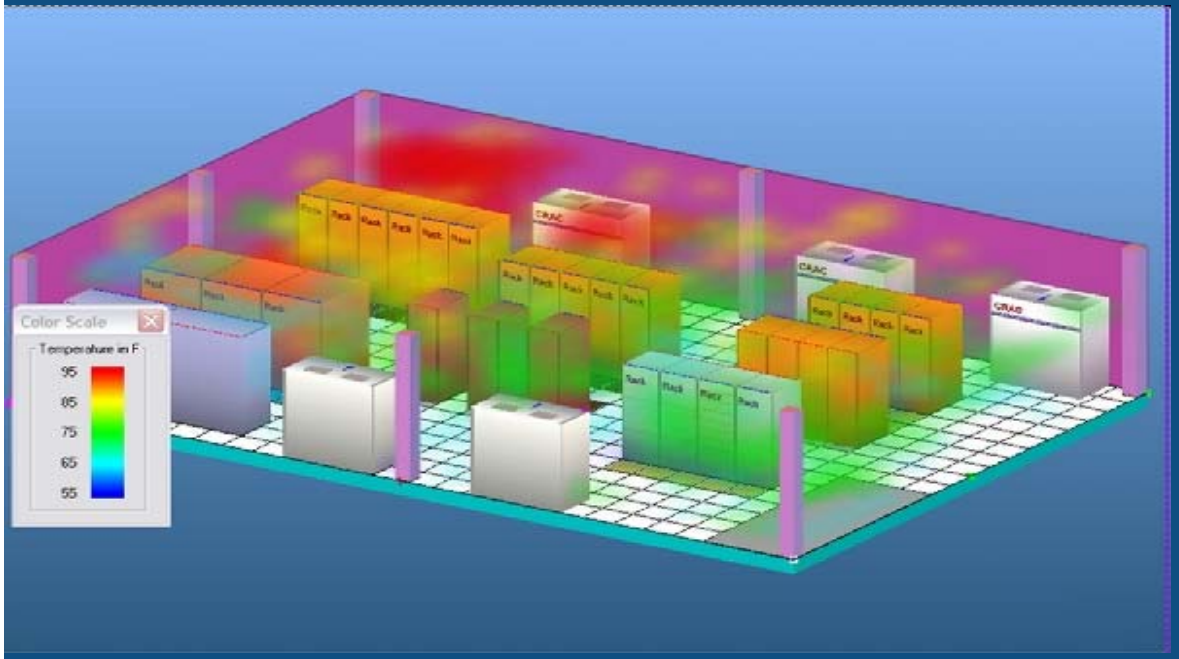
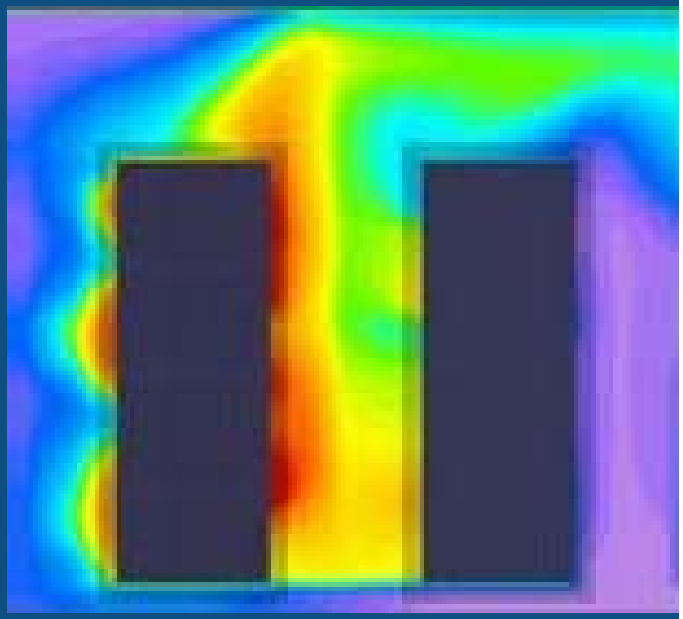
Computational Fluid Dynamics





- CFD in the data center is a powerful tool to help to increase cooling efficiency
- Predict optimum floor tile placement and management
- Cooling optimization using CFD can offer 25% reduction in cooling system power usage

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Power System

- Elements of a power system:
  - Utility Provider
  - Backup Power Supply
  - Generators
  - Switch Gear
  - Uninterruptible Power Supplies (UPS)
  - Power Distribution Units (PDU)
  - Grounding System

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Power Capacity & Efficiency

- A Data Center must meet the following requirements:
  - The site shall have an alternate source of power to the Utility
  - The site shall have an Uninterruptible Power Supply (UPS)
  - The site must have a proper grounding system

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DC Electrical System Categories

- **Tier 1**: The single power supply datacenter

Capacity = N

- **Tier 2**: The single power supply plus redundant components

Capacity = N + 1 (or higher)

- **Tier 3**: The concurrently maintainable and operable data center

Capacity = N + 1

- **Tier 4**: The fault tolerant fully redundant data center

Capacity = 2N (or higher)

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Power Capacity & Efficiency (cont'd)

- Capacity (N): The power (kW) required to supply a load (N)
- Design efficiency or Utilization efficiency: is the ratio of the power (kW) required to supply the load divided by the total installed power (kW) for that system
- Higher levels of availability require higher levels of redundancy
- Higher tier ratings require higher levels of redundancy
- The highest level of availability will not always have the highest utilization efficiency

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Final Comments & Conclusions

- How to reduce lifetime DC power costs:
  - Equipment retirement plan: modern equipment consumption is about 25% lower
  - Remove dead servers: may result 10% CPU utilization
  - Power management: server management software can contribute to power down IT hdwr
  - Virtualization: 4 to 1 ratio, with 50% utilization (further average CPU utilization target: 15%)
  - Efficient lighting: Dark data centers

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Final Comments & Conclusions (cont'd)

- Modular UPS: use of multiple UPS modules to form larger UPS systems
- Three-phase power: eliminate step-down transformers can mitigate power losses
- Better cooling: raise computer room temperature may reduce electricity usage by approximately 20% a year
- Correct sizing, placement of floor tiles, and removal of under-floor obstructions may increase cooling efficiency in the data center

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Other Green Initiatives

- Green Star Program (Australia and NZ)
- Comprehensive Assessment System for Building Environmental Efficiency (ASBEE [JAPAN])
- EEWH (Taiwan)
- Building Resource Establishment Environmental Assessment Methodology (BREEAM [UK])
- Green Building Council Brazil (BRAZIL)

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