Data Center Design Discussion

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Integrated Design Group
ARCHITECTURE | ENGINEERING | PLANNING

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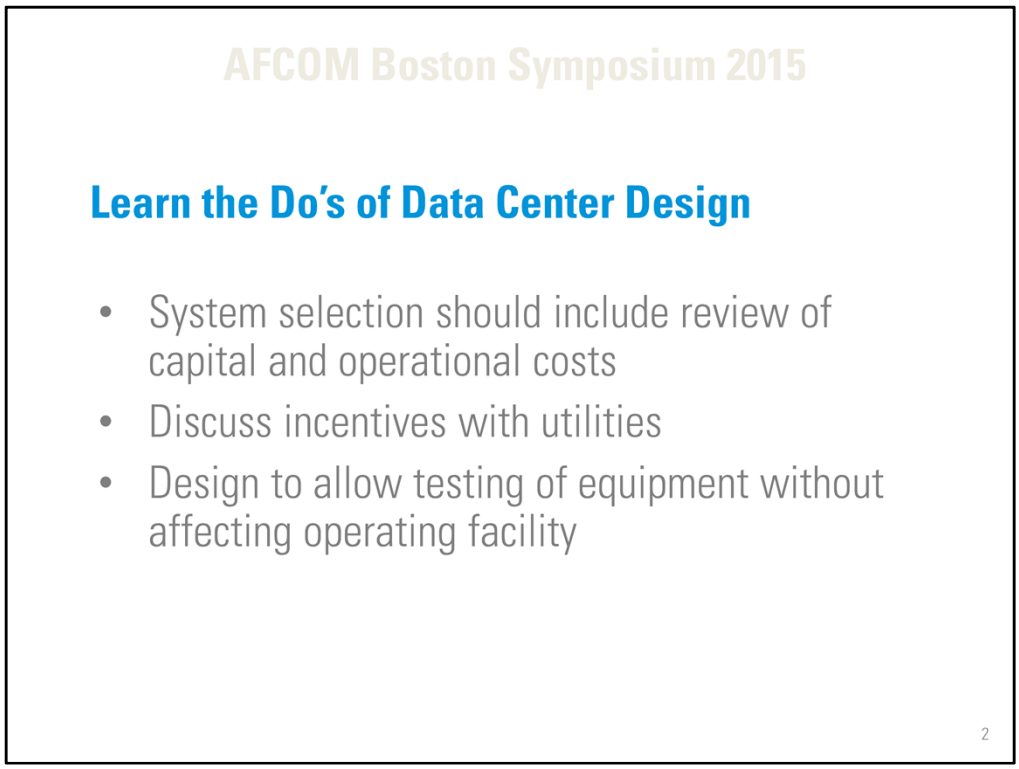
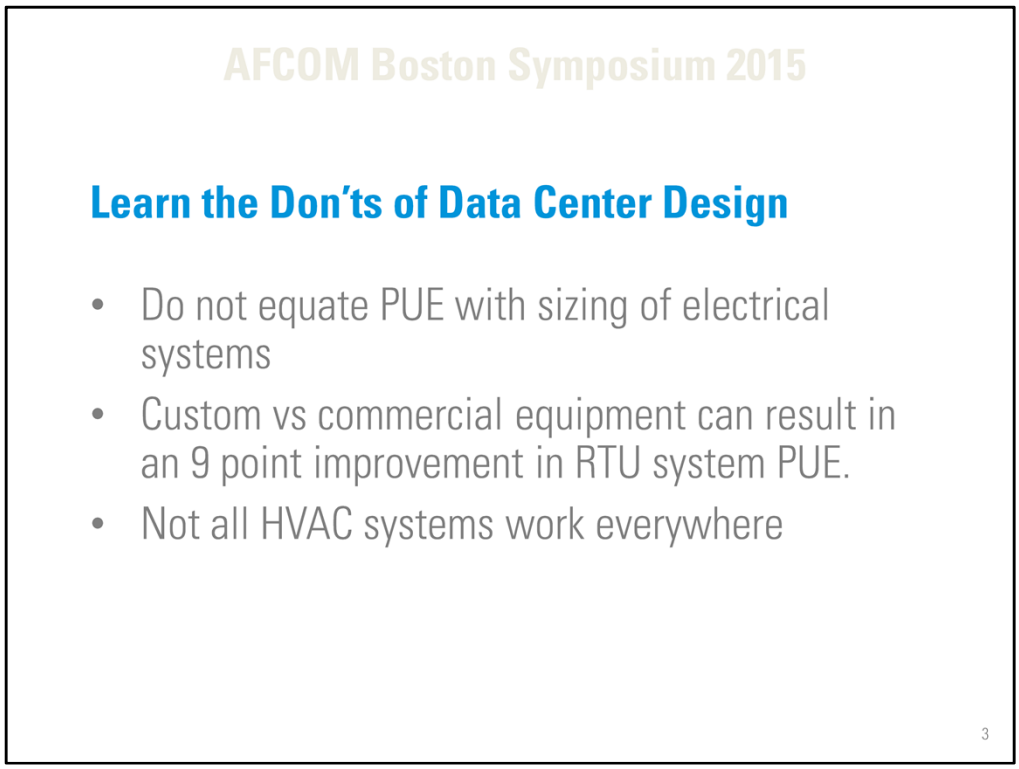


TCO is important.
Capital cost and Operating cost

Spending a lot of additional money to improve efficiency in an area with low utility costs may not be cost effective.

Utility incentives – received $1 million for (2) 1MW data center fit ups
Some utilities provide rebates for:

1. Energy star UPS systems
2. Efficient lighting
3. Efficient HVAC
4. Retrofits of existing systems



Electrical systems must be sized for peak PUE not annual PUE.

Improved custom equipment vs standard commercial grade can improve PUE by 9 percentage points. Change RTU with air economizer from 1.36 to 1.25 annual PUE

Design and control for dew point not relative humidity

AFCOM Boston Symposium 2015

No One Cooling System Is Best In All Locations

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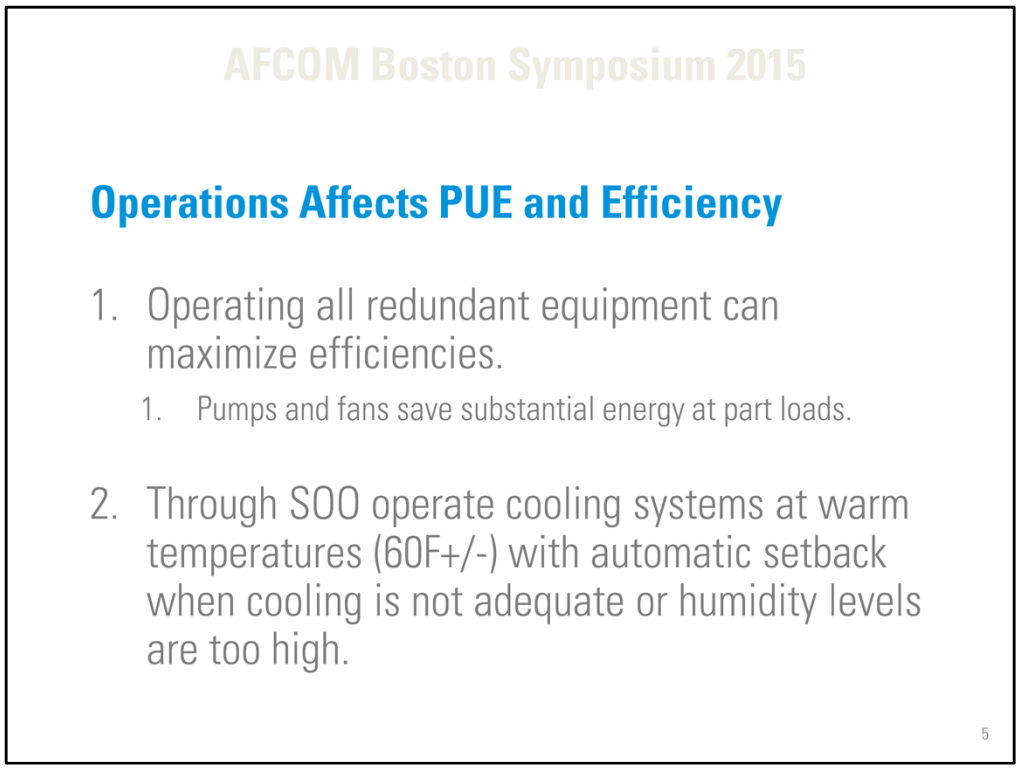
TRADITIONAL –
78F Return air,
35%-55% RH
45F Chilled water temperature

HYBRID –
ASHRAE recommended Class A1 input temperature of 80.6F supply air
ASHRAE allowable Class A1 humidity of 20%-80% RH.
Assumes 105F Return (25F delta T) air
60F Chilled water with temperature reset.



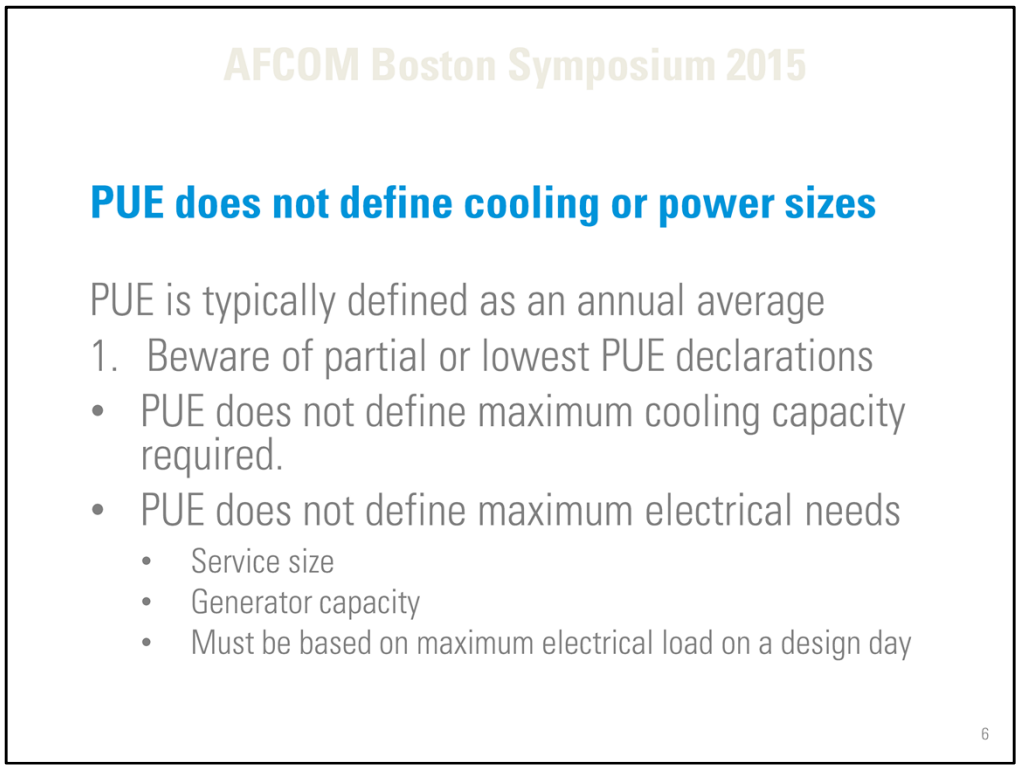
Sequence of Operations (SOO) and interior conditions have the greatest effect on PUE.

Fan Laws:
1. Horsepower (HP) varies with the cube of the speed (RPM)
2. Air volume in cubic feet per minute (CFM) varies directly with RPM.

Pump Affinity Laws:
1. Brake Horsepower (BHP) varies with the cube of the speed (RPM)
2. Flow varies directly with RPM.

Example (for illustration):

A 10HP fan is required to provide the air volume required.
If two 10HP fans are operating then each does the work of ??HP?? Possibly 5HP?
ACTUALLY
Each fan provides only 1/2 of the air volume therefore by the cube law above:
$HP1/HP2 = (RPM1/RPM2)^3$
For a typical 1800 RPM motor: $10/HP2 = (1800/900)^3 = 8$
HP2 = 10/8 = 1.25HP of power required vs 10HP.



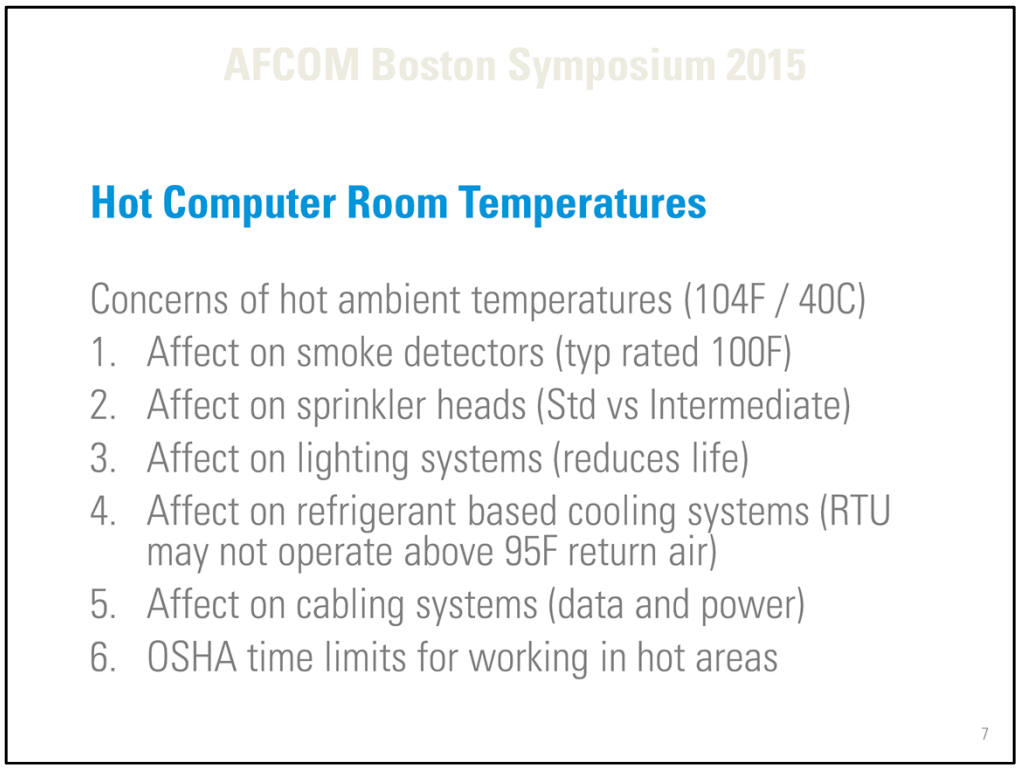
PUE does not equal electric service size or generator capacity. Power Usage Effectiveness (PUE) is a measure of the ratio of total data center power divided by the total IT power. PUE that is measured instantaneously is not valid to determine the total electrical power required unless it is measured at the precise peak power usage of the facility. A correctly calculated PUE uses annual averages to account for seasonal variations. It is possible for the PUE to vary from a monthly high of 1.9 to a monthly low of 1.3 (RTU system in the Northeast) with an annual average of 1.4. If the electrical service was designed based on the 1.4 PUE the service and the engine-generator system would be undersized.

Example: Assuming a 1000kW IT load:

At an average PUE of 1.4 the electrical service and generator system would be sized for 1400kW.

At the peak PUE of 1.9 the electrical service and generator system would be sized for 1900kW.

The system would be short 500kW at peak load, undersized by approximately 35%.



ASHRAE recommended cold aisle temperatures of 80F and a 25F temperature rise (delta T) across the equipment will result in a hot aisle temperature of 105F.

Typical smoke and heat detectors and sprinkler heads are rated for use in 100F ambient maximum. Higher ambient temperatures may result in false activation.

Higher ambient rated detectors will provide more headroom when there is a cooling failure in the Computer room.

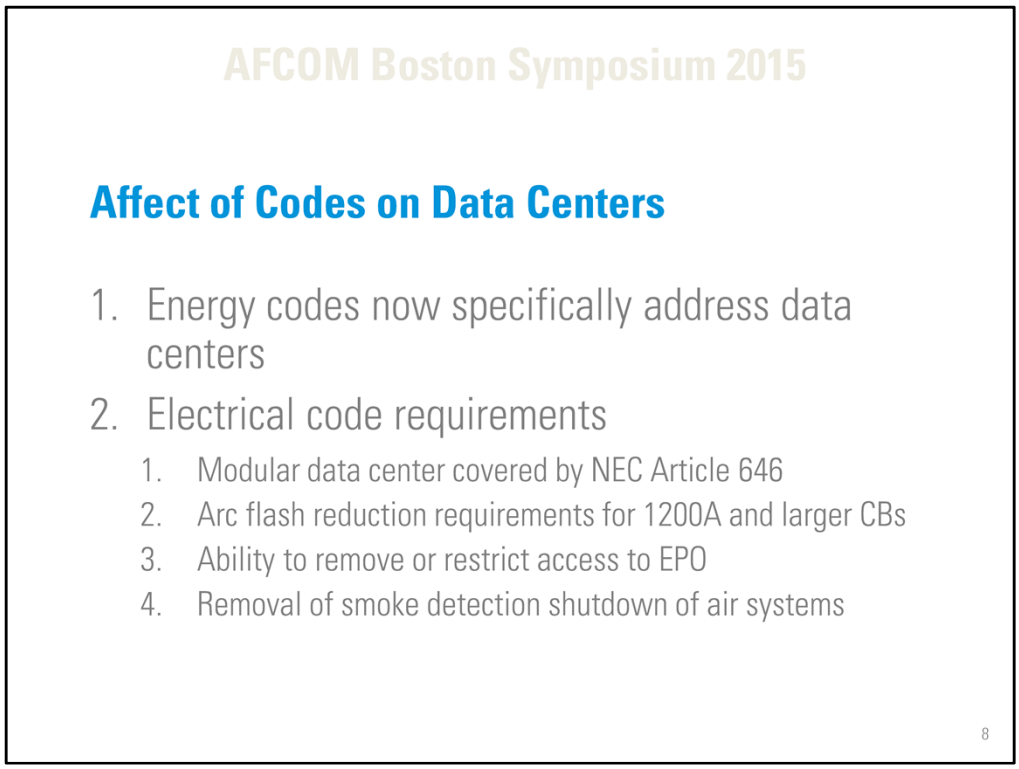
Typical sprinkler head rating is 135F (std) for use in a maximum 100F ambient. A minimum of 175F rated head for ambients over 100F.

Lighting ballasts and lamps affected by elevated temperatures above room temperature. Light output and ballast and LED life is reduced.

Refrigerant based systems may fail on a high head alarm for return air temperatures above 95F.

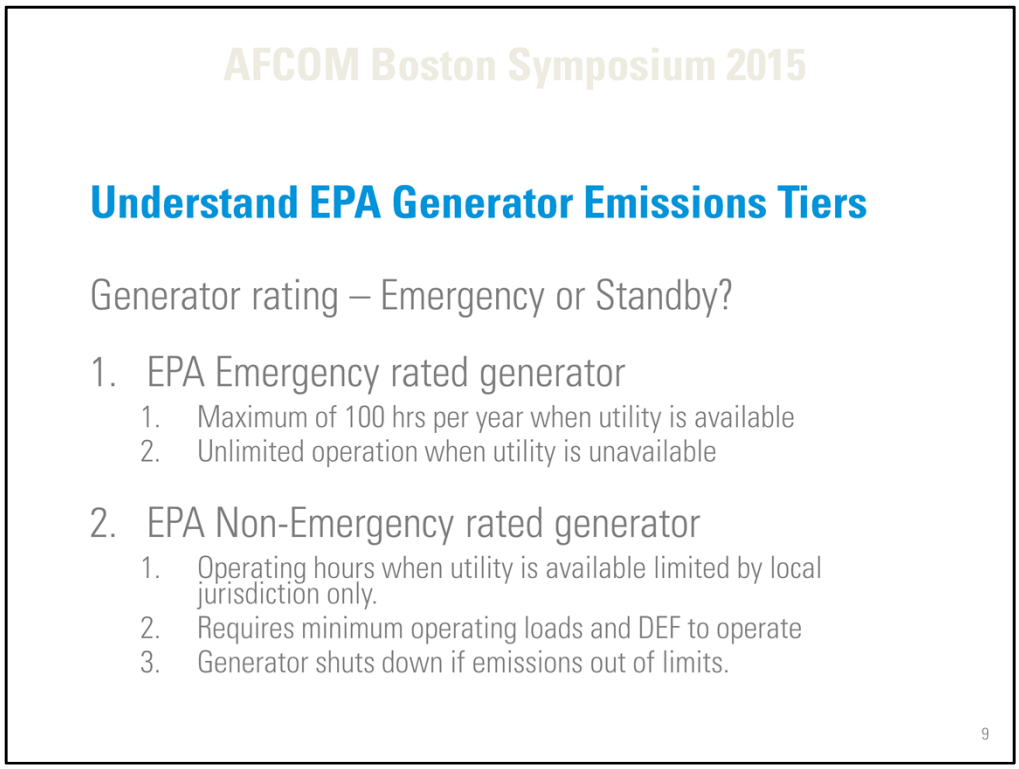
ANSI/TIA 568C.2 standard – Attenuation/insertion loss based on 20C(68F).
At 40C (104F) derate performance almost 10%

National Electrical Code bases conductor ampacity on 86F ambient temperature.
Ampacity must be reduced above this temperature.



ASHRAE 90.1-2010 and 2013 specifically address data centers.

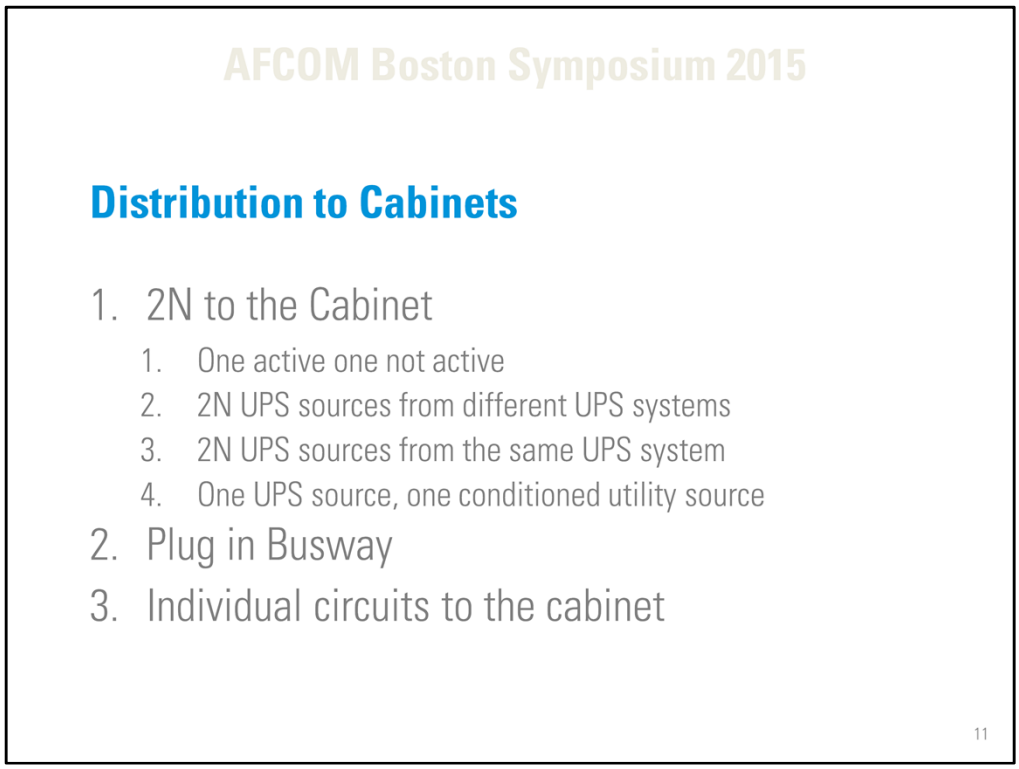
Massachusetts has adopted the 2014 version of the National Electrical Code.



A. DEF/SCR typically required over 800kW
B. Emissions performance affected by:
    - Properly working equipment
    - Ambient temperature
    - Viable Diesel Exhaust Fluid (DEF, i.e. Urea)
        - Must be kept cool but not freezing to extend life
    - Exhaust temperature
        - Could require load on generator up to 30% or more of nameplate
        - Could be internal load bank in generator exhaust
C. Engine will be shut down and will require factory technician to reset if emissions fall out of tolerance.
D. Designs must account for EPA Tier 4 restrictions on system operation:
    1. Install in warmer air environment (recirculate radiator exhaust to keep room and engine warm).
    2. Provide proper environment for DEF – cool and heat. Be aware of short shelf life of DEF.
    3. Provide quantity of DEF to match fuel capacity.
    4. Need DEF delivery arrangements to match fuel deliveries.
E. EPA Tier 4 Certified vs Compliant
    1. Certified engines must be factory certified and can not be altered in the field
    2. Compliant engines have after market emissions controls added to meet or exceed Tier 4 requirements.
    3. Some areas have stricter requirements than Tier 4 but can not be modified in the field without invalidating the certification.
    4. May be necessary to negotiate with local EPA and Federal EPA.

UPS System Topologies

1. Transformer or transformerless design
2. Distributed or Central Static Switch
3. UPS Systems
    1. 2N
    2. N+1
    3. Distributed redundant
    4. Block redundant
    5. Iso Redundant
    6. Modified Iso Redundant

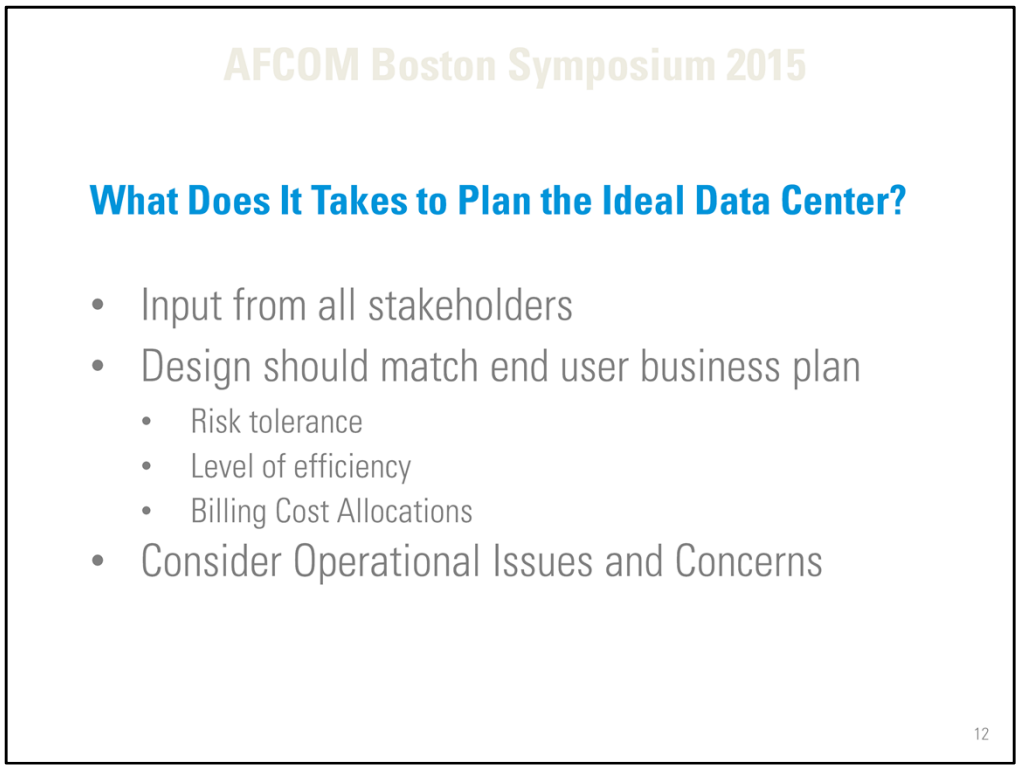


Plug in busway may not the most cost effective in an environment where standard circuit sizes are installed for cabinets.

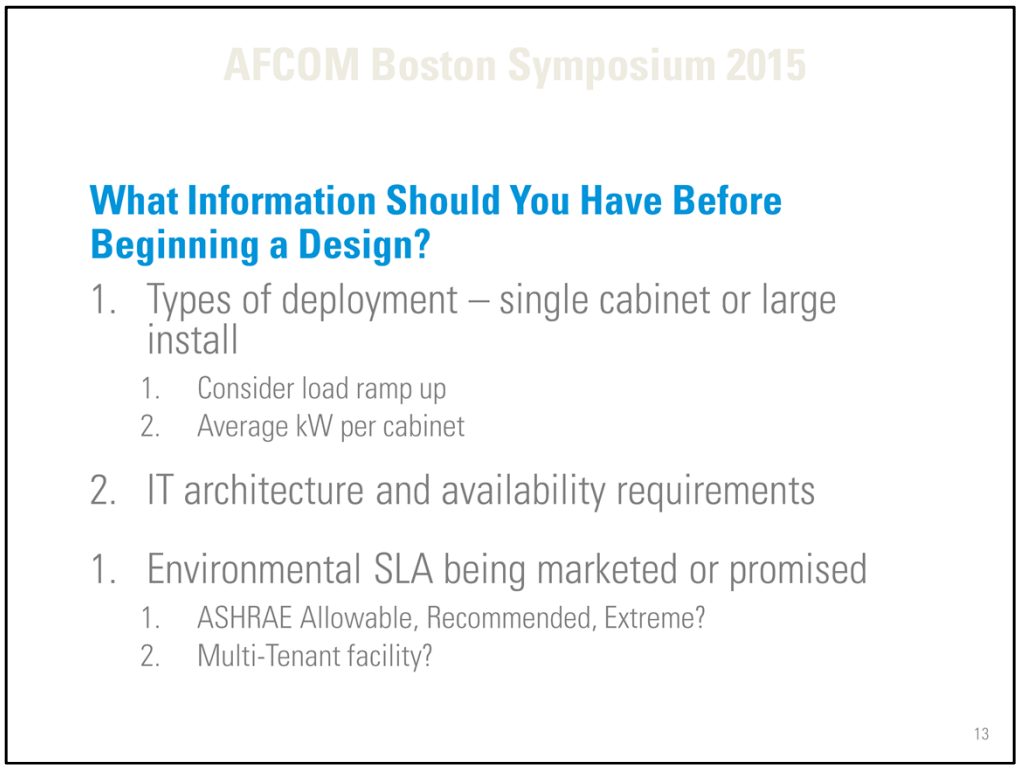
Short circuit rating of busways can be a concern, especially at 400V.

Busway Connection points for full load commissioning.

Busway joint maintenance. Are they maintenance free or require annual infrared scanning and tightning?

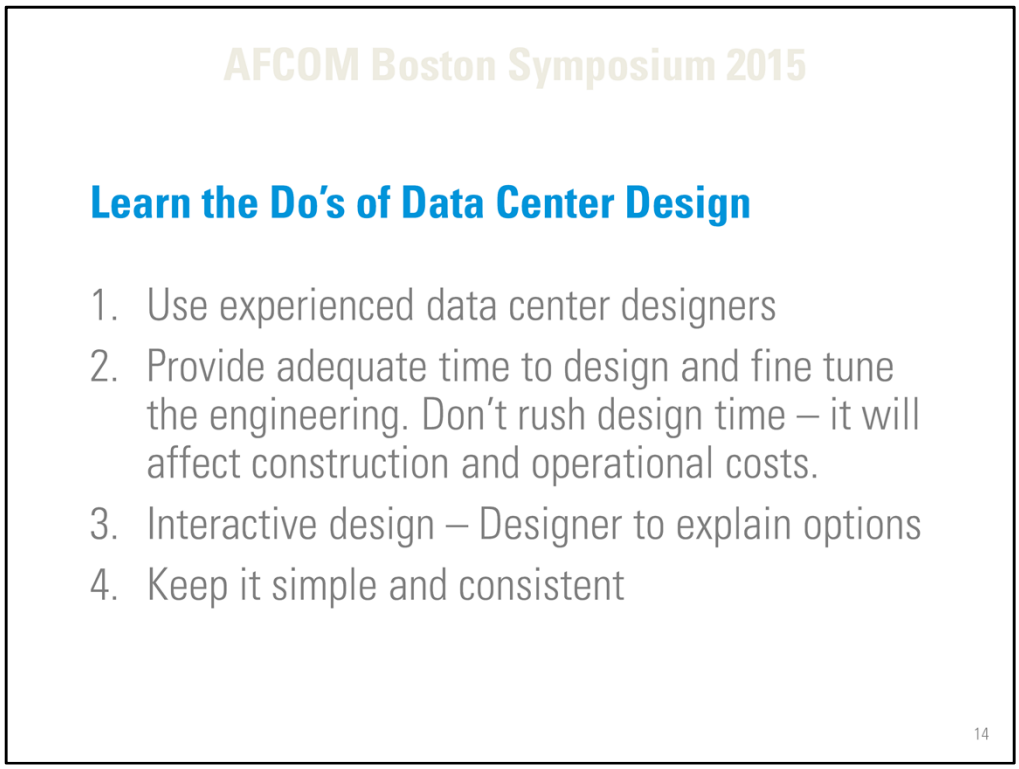


A. Stakeholders:
    1. Real Estate
    2. IT
    3. Corporate
    4. Sales / marketing
    5. Operators
    6. End Users
B. Risk Tolerance
    1. Only mission critical site
    2. Large number of users – concern for reputation or productivity
    3. One of many - systems are software redundant
C. Efficiency
    1. Best in class efficiency
    2. Corporate mandate or goal
    3. Best total cost of ownership (TCO)
D. Operational
    1. Is facility manned 7x24?
    2. How will it be maintained? Internal or outsourced?
    3. How will it be expanded and when?
    4. How will it be tested and commissioned?
    5. Expected growth?



A. Deployment
    1. Single homogeneous user?
    2. Many different system types and requirements?
    3. What will be the minimum load on day 1?
    4. Install all initially or have a scalable modular design?
    5. Average and maximum kW per cabinet.
    6. Will high density cabinets be concentrated or spread out?
    7. One or separate rooms, cages?
    8. Dedicated or shared infrastructure?

B. Availability requirements
    1. Service level agreement (SLA) being marketed?
    2. Single availability level or mixed?
    3. No down time promised?
    4. Temperature and humidity limits?
    5. Redundancy level?
    6. Efficiency/Power usage effectiveness (PUE) goal?



How do you find an experienced mission critical designer?

1. Internet?
2. References from others?
3. What qualifications and experience should they have?
4. Who should lead the project Architect or Engineer or Project Manager?

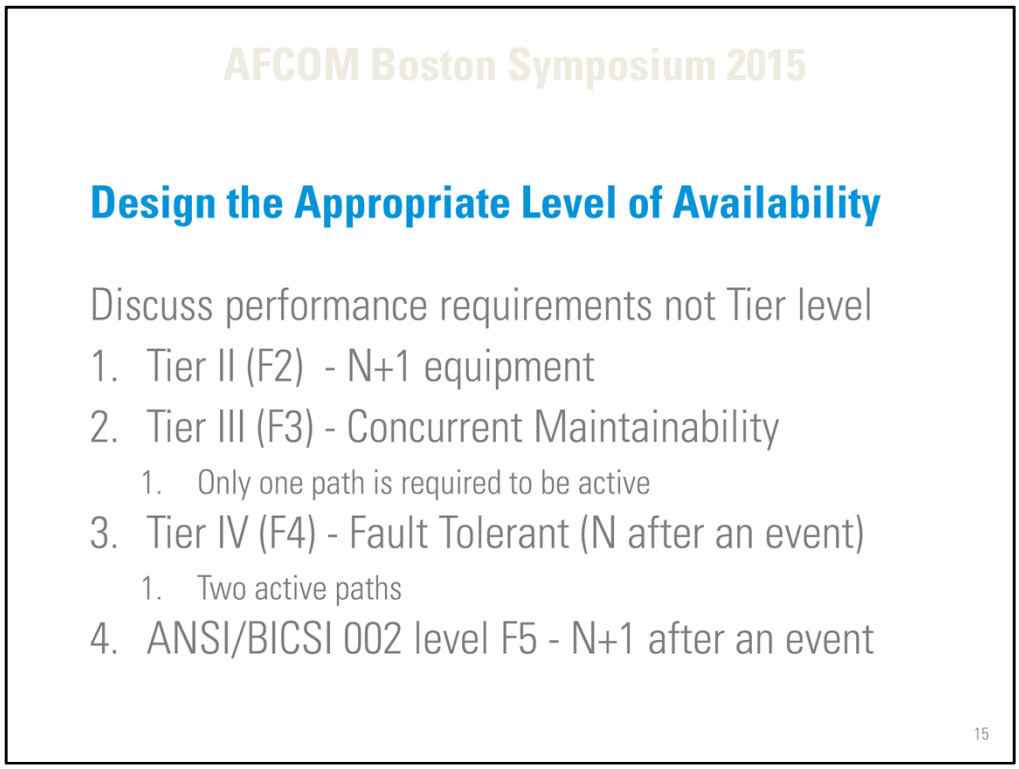
Identical data centers designed by different firms results in in over $350k in difference in electrical costs, $50k in fire alarm costs. Savings of $500-$1000 per kW

Review sizing of underground conductors. Discuss load factor. Calculations by engineer not Installer. Reference APC whitepaper: WP43v3-2011 Dynamic Power Variations in Data Centers and Network Rooms

Revit (BIM) does not cure all. Need experienced designers to do coordination. Developing a realistic 3D model requires more time and effort.

Design for arc flash to minimize operational costs. Calculations by engineer not vendor.

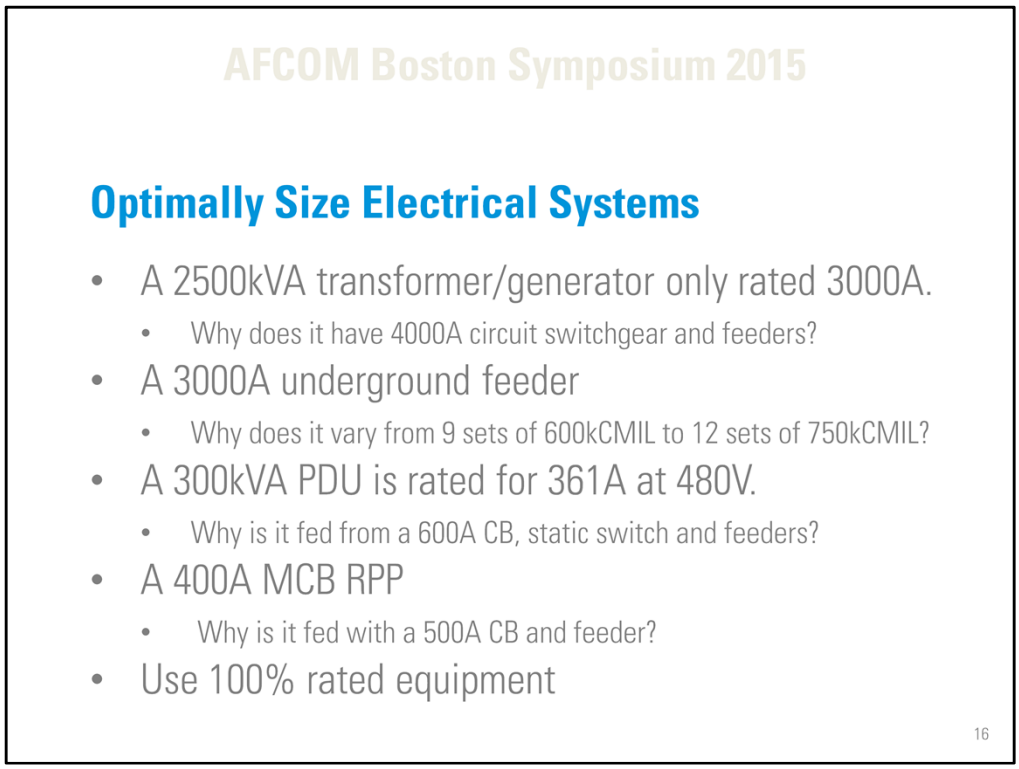
Use modular repeatable designs so look and feel for operations personnel is consistent.



Tier IV fault tolerant does not mean 2N.

Tier III concurrent maintainability does not mean both power paths must be UPS.

Single corded loads in a concurrently maintainable design does not mean both power sources need static transfer switches.



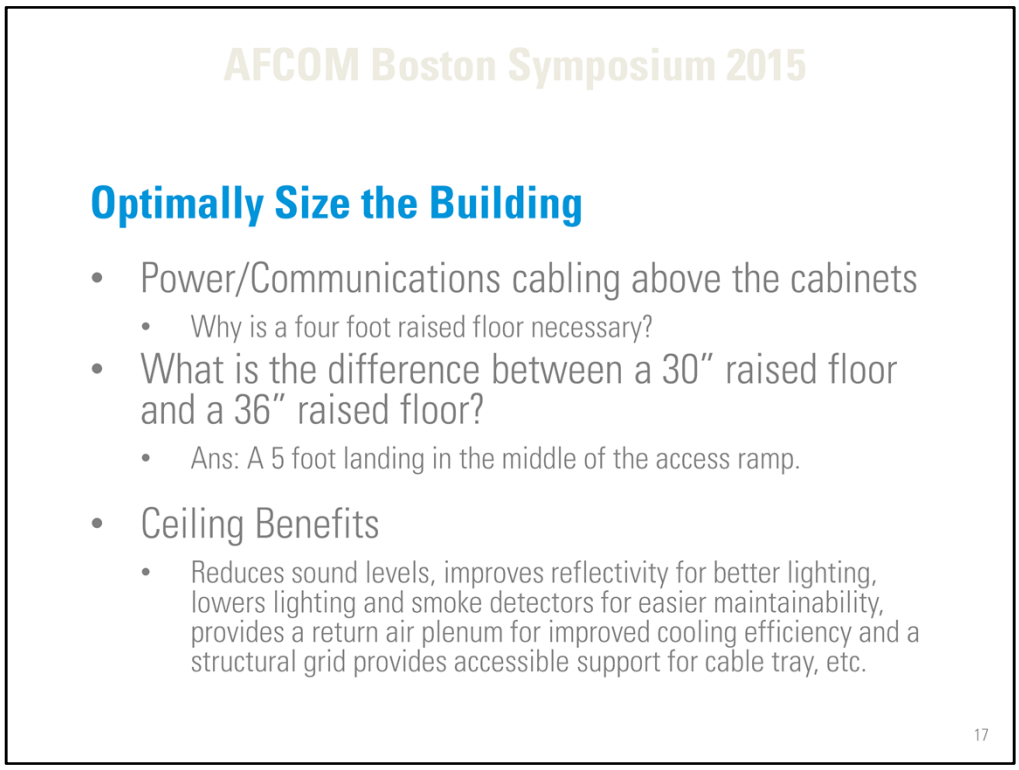
25% - 33% oversized electrical systems.

Modern data centers operate at high power factor (pf). There is no need to size electrical systems for the typical 0.8 power factor generators are rated for since the limiting design load will be kW.
At 480V:
2000kW = 2410A at 0.8pf 2500kVA = 3012A
2000kW = 2410A at 0.95pf 2105kVA = 2537A
2500kW = 3012A at 0.8pf = 3125kVA = 3765A
2500kW = 3012A at 0.95pf = 2632kVA = 3170A

4000A = 3320kVA at 0.95pf = 3154kW

Busway concerns:
1. Annual joint infrared scanning and tightning
2. Hygroscopic - Tendency to absorb moisture if not energized and warm enough to keep dry. This moisture can lead to failure due to insulation failure.
3. Factory built with specific dimensions. Little field flexibility during installation.

Cablebus an engineered system that uses free air ratings to reduce conductors required.



A. High ceiling and raised floor heights increase building size and construction costs of not just the exterior walls but all the interior walls.
    1. When does a raised floor become an OSHA confined space? 4ft?

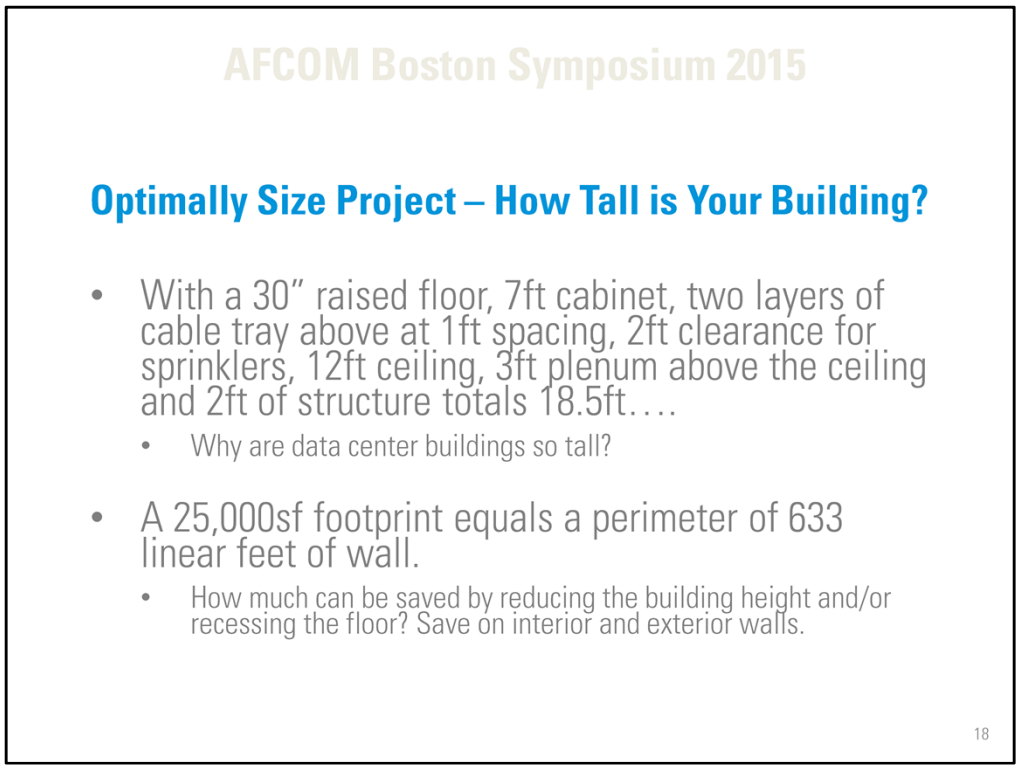
B. CFD analysis can show that reduced volumes for the computer room still adequately cool the cabinets.

C. Sound levels are increasing due to equipment and fan/air noise. May reach levels requiring special fire alarm annunciation and OSHA required hearing protection.
    1. *OSHA 1910.95(d)(1) - When information indicates that any employee's exposure may equal or exceed an 8-hour time-weighted average of 85 decibels, the employer shall develop and implement a monitoring program.*

D. Ceiling plenum improves hot/cold air separation and increases energy efficiency.

E. Excessive ceiling height increases construction costs and operational costs, and since the heat stratifies at the top, the air circulation is at the lower level and it provides little help as a heat sink during cooling failures due to rapid heating.

F. Structural support built into the ceiling allows supporting cable tray, busway, etc without penetrating the ceiling.



Potentially save $65,000 per foot of height.
A seven foot reduction in height could save $500,000 in construction plus reduce operating expenses.

3 Key Things You Have Learned During this Session

1. Design can have a large impact on construction cost vs the design fee and design time saved.
2. Interior operating conditions have the largest impact on PUE.
3. Effects of hot computer room temperatures

Thank you

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Published articles I will forward if requested

1. 2014 Electrical Code Impact On Data Centers
2. 11 Data Center Myths and Design Issues
3. Load-on Demand Delivery Systems and Innovative Design Techniques
4. Design Considerations for Highly Reliable Electrical Systems
5. Impacts on Data Centers from the new ASHRAE 90.1-2010 Energy Standard