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Energy Management Subcommittee

SCTE OPERATIONAL PRACTICE

SCTE 184 2022

SCTE Energy Management Design, Construction and Operational Practices for Cable Facilities

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Document Type

Document Tags:

☐ Test or Measurement	☐ Checklist	☒ Facility
☐ Architecture or Framework	☐ Metric	☐ Access Network
☒ Procedure, Process or Method	☐ Cloud	☐ Customer Premises

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1. Introduction

1.1. Executive Summary

This document provides guidelines for management of critical hub site facilities supporting the cable industry. SCTE 184 focuses on information, methods, and references furthering SCTE Energy 20/20 Standards and Operational Practices to help balance operational energy efficiency and management with essential business availability requirements.

1.2. Scope

SCTE 184 serves as a broad reference document and a guide to other SCTE Energy 20/20 documents that help address overall energy efficiency for cable operator critical space.

This operational practice does not purport to address all safety issues or applicable regulatory requirements associated with its use. It is the responsibility of the user of this operational practice to review any existing codes and other regulations recognized by the national, regional, local and/or other recognized authorities having jurisdiction (AHJ) in conjunction with the facility location. Where differences occur, those items listed within the codes or regulations of the AHJ supersede any requirement or recommendation of this operational practice.

1.3. Benefits

1.3.1. Immediate and long-term benefits of adopting SCTE 184

- Improve efficiency and availability through optimization of site
- Reduce total cost of ownership (TCO) and life cycle cost through low annual operating costs by energy optimization
- Fully evaluate savings and return on investment (ROI) in sustainable facility projects by including such factors as ongoing operational costs, disposal costs or recycling benefits, grants and incentives

1.3.2. Achieve maximum benefit from implementing SCTE 184

- Adopt appropriate critical facility classification as per [SCTE 226].
- Identify gaps where critical facilities are not aligned to practices in SCTE 184 or associated documents.
- Budget for applicable changes based on cable operator strategic needs founded on SCTE 184 recommendations and associated documents.

1.4. Intended Audience

The intended audience includes facility architects, facility design engineers, facility managers and operators.

1.5. Areas for Further Investigation or to be Added in Future Versions

None

2. Normative References

The following documents contain provisions which, through reference in this text, constitute provisions of this document. The editions indicated were valid at the time of subcommittee approval. All documents are subject to revision and, while parties to any agreement based on this document are encouraged to investigate the possibility of applying the most recent editions of the documents listed below, they are reminded that newer editions of those documents might not be compatible with the referenced version.

2.1. SCTE References

No normative references are applicable.

2.2. Standards from Other Organizations

No normative references are applicable.

2.3. Other Published Materials

No normative references are applicable.

3. Informative References

The following documents might provide valuable information to the reader but are not required when complying with this document.

3.1. SCTE References

[SCTE 186]	ANSI/SCTE 186 2021, Product Physical, Environmental, Electrical, Sustainability, and Quality Requirements for Cable Telecommunications
[SCTE 208]	SCTE 208 2021, Cable Operator Carbon Data Collection Recommended Practices
[SCTE 218]	SCTE 218 2021, Alternative Energy & Microgrids for Cable Broadband Providers: Use Cases, Value Proposition, Taxes, Incentives, and Policy Reference Document
[SCTE 219]	SCTE 219 2021, Technical Facility Climate Optimization Methodology
[SCTE 226]	ANSI/SCTE 226 2015, Cable Facility Classification Definitions and Requirements
[SCTE 227]	SCTE 227 2022, Cable Operator Location Risk Assessment Operational Practice
[SCTE 229]	SCTE 229 2022, Operational Practice for Cable Facility Design Process
[SCTE 253]	SCTE 253 2019, Cable Technical Facility Climate Optimization, Operational Practice: Understanding Set Point Values, Part 1

[SCTE 261]	SCTE 261 2020, Cable Operator Considerations for EMP Readiness and Mitigation
[SCTE 274]	SCTE 274 2021, Cable Operator Critical Facility Air Containment Operational Practice
[SCTE 275]	SCTE 275 2021, Electrical Grounding and Bonding for Cable Broadband Network Critical Facilities

3.2. Standards from Other Organizations

[ASTM F1712]	ASTM F 1712 Standard Specification for Steel Chain Link Fencing Materials Used for High Security Applications
[ASTM F 2611]	ASTM F 2611 Standard Guide for the Design and Construction of Chain Link Security Fencing
[BICSI 002]	ANSI/BICSI 002-2019, Data Center Design and Implementation Best Practices
[CLFMI]	CLFMI Product Manual CLF-PM0610
[CLFMI]	CLF- TP0211 - Tested and Proven Performance of Security Grade Chain Link Fencing Systems
[ISO 14644]	ISO 14644 - Cleanrooms and associated controlled environments. 2015
[NFPA 70]	NFPA 70 the National Electrical Code
[NFPA 75]	NFPA 75 2020 Standard for the Fire Protection of Information Technology Equipment
[NFPA 110]	NFPA 110 2022 Standard for Emergency and Standby Power Systems
[NFPA 111]	NFPA 111 2022 Standard on Stored Electrical Energy, Emergency, and Standby Power Systems
[TIA 607]	ANSI/TIA-607-B 2019 Commercial Building Grounding and Bonding Requirements for Telecommunications Standard
[TIA 942]	ANSI/TIA-942-A 2005 Telecommunications Infrastructure for Data Centers

3.3. Other Published Materials

[ASHRAE DESIGN]	ASHRAE Design Considerations for Datacom Equipment Centers, 2nd Ed., 2009
[ASHRAE GUIDELINES]	ASHRAE Environmental Guidelines for Datacom Equipment—Expanding the Recommended Environmental Envelope. 2008
[ASHRAE]	ASHRAE - 2011 Gaseous and Particulate Contamination Guidelines for Data Centers, Whitepaper prepared by ASHRAE Technical Committee

	(TC 9.9 Mission Critical Facilities, Technology Spaces and Electronic Equipment, 2011.)
[CANMET]	Canada centers for Minerals and Energy technology
[DC Energy]	Report to Congress on Server and Data Center Energy Effici ency: Public Law 109-431
[Earthquakes]	http://earthquake.usgs.gov/hazards
[EPA]	EPA Report to Congress on Server and Data Center Energy Efficiency
[EU]	EU Code of Conduct on Data Centres – Best Practices
[EU Code]	EU Code of Conduct on Data Centres – Best Practices
[Field Inspection Guide]	LFMI Product Manual CLF-PM0610, CLF- TP0211 - Tested and Proven Performance of Security Grade Chain Link Fencing Systems, and CLF-F0111 Field Inspection Guide
[Fire Code]	Uniform Fire Code, Article 100.7.3 of the 1994
[GR-63]	Telcordia, GR-63-CORE, NEBS Requirements: Physical Protection
[USDOE]	U.S. Department of Energy, Federal Energy Management Program, Best Practices Guide for Energy Efficient Data Center Design, March 2011
[MEPTEC]	MEPTEC Report. The Threat to Miniaturization of the Electronics Industry. Quarter 4, 2004
[SWERA]	SWERA (Solar and Wind Energy Resource Assessment)

4. Compliance Notation

shall	This word or the adjective "***required***" means that the item is an absolute requirement of this document.
shall not	This phrase means that the item is an absolute prohibition of this document.
forbidden	This word means the value specified ***shall*** never be used.
should	This word or the adjective "*recommended*" means that there *may* exist valid reasons in particular circumstances to ignore this item, but the full implications *should* be understood and the case carefully weighed before choosing a different course.
should not	This phrase means that there *may* exist valid reasons in particular circumstances when the listed behavior is acceptable or even useful, but the full implications *should* be understood and the case carefully weighed before implementing any behavior described with this label.
may	This word or the adjective "*optional*" indicate a course of action permissible within the limits of the document.
deprecated	Use is permissible for legacy purposes only. Deprecated features *may* be removed from future versions of this document. Implementations *should* avoid use of deprecated features.

5. Abbreviations and Definitions

5.1. Abbreviations

10G	10Gbps, bi-directional capability of cable broadband network
AC	alternating current
A/C	air conditioning
AHJ	authority having jurisdiction
ANSI	American National Standards Institute
ASHRAE	American Society of Heating, Refrigerating, and Air-Conditioning Engineers
ATS	automatic transfer switch
ATTM	access, terminals, transmission and multiplexing
BICSI	Building Industry Consulting Service International
BMS	building management system
BOD	basis of design
BOS	balance of system
BS	British Standard
CAC	cold aisle containment
CAGR	compound annual growth rate
CATV	cable television (originally community antenna television)
CCTV	closed circuit television
CFL	compact fluorescent
CME	coronal mass ejection
CMMS	computerized maintenance management software
CMU	concrete masonry unit
CO_2	carbon dioxide
CRAC	computer room air conditioner
CRAH	computer room air handler
CUE	carbon usage effectiveness
DC	direct current
DCIM	data center infrastructure management
DDC	direct digital control
DEP	Department of Environmental Protection
DOE	Department of Energy
DP	dew point
DVR	digital video recorder
DX	direct expansion
e.g.	for example

ECE	enterprise critical equipment
EERE	U.S. Department of Energy's Office of Energy Efficiency & Renewable Energy
EMR	electromagnetic radiation
EMP	electromagnetic pulse
EPA	Environmental Protection Agency
EPO	emergency power off
ESD	electrostatic discharge
ETSI	European Telecommunications Standards Institute
EU	European Union
FCC	Federal Communications Commission
FMS	facility management system
ft	foot
GHG	greenhouse gas
GWP	global warming potential
HAC	hot aisle containment
HID	high intensity discharge
HOA	hand /off / auto (switch)
HTML	hypertext markup language
HTTP	hypertext transfer protocol
HVAC	heating, ventilation, and air conditioning
IEC	International Electrotechnical Commission
IP	Internet protocol
IR	infrared
ISO	International Organization for Standardization
IT	information technology
ITE	information technology equipment
km	kilometer
kW	kilowatt
kWh	kilowatt hour
LED	light emitting diode
LEED	Leadership in Energy and Environmental Design
m	meter
MEP	mechanical, electrical, and plumbing
MERV	minimum efficiency reporting value
mm	millimeter
MSO	multiple system operator (cable)
MW	megawatt
NAS	network attached storage

NFPA	National Fire Protection Association
NOC	network operations center
NREL	National Renewable Energy Lab
NSI	National Systems Integrator, Inc.
OSHA	Occupational Safety & Health Administration
PDA	personal digital assistant
PDU	power distribution unit
PEM	polymer electrolyte membrane
PM	preventative maintenance
PODS	portable on demand storage
PUE™	Power Usage Effectiveness
PV	photovoltaic
RAM	random access memory
RH	relative humidity
ROI	return on investment
RPC	remote power cabinet
RTU	roof top unit
RU	rack unit
SAN	storage area network
SCTE	Society of Cable Telecommunications Engineers
SOX	Sarbanes-Oxley Act
SPD	surge protection device
STS	static transfer switch
TAC	technical assistance center
TCP/IP	transmission control protocol/Internet protocol
TIA	Telecommunications Industry Association
TPS/W	transactions per second per watt
TVSS	transient voltage surge suppression
UPS	uninterruptable power supply
VED	vertical exhaust duct
VSD	variable speed drive
WC	water column
WUE	water usage effectiveness
XML	extensible markup language

6. General Design Considerations

Planning is a key component to successful energy management in the critical space. Typically, the 24/7 critical space lifecycle is greater than 10 years, and careful planning can prevent financial loss over the course of the lifecycle of the space.

6.1. Best Practices

This document provides an introduction to guidelines and operational practices for design and management of critical hub site facilities supporting the cable industry. The operational practice focuses on information, methods, metrics, and processes that allow for operational energy efficiency and management in balance with mission-critical business availability requirements and infrastructure investment.

Refer to [SCTE 226] for guidance on classifications for a specific site. The information within this document has relevance to guidelines and best practices and requirements for all facilities defined in [SCTE 226].

6.1.1. Flexibility

Within the critical space, the size, placement and capacity of the racks will impact everything from power load distribution to essential airflow and cooling. The infrastructure *should* have the flexibility to accommodate these rack requirements. Support systems for space, power, and cooling (electrical, telecom, HVAC) need to be designed to handle multiple configurations and growth over time with minimal to no retrofit in these services. The logical distribution of the racks on the floor *should* be able to accommodate the necessary load in a safe balanced fashion. Rack selection and placement is important and *should* be implemented following careful study.

6.1.2. Growth & Scalability

The critical space *should* be able to scale in power, cooling, and network capacity load levels. The pace of information technology and network advancement has demonstrated that consumers of cable services will always demand more bandwidth and services.

The services that *should* have capacity to grow include bandwidth, power, cooling, and processing power. Storage is also a major consideration; although it is often more appropriate to plan for scalable storage in a larger data center environment rather than a hub site.

Factors to consider include number of potential customers served in the geographic area, revenue stream produced by that particular site, and overall site fit into the organization’s overall network management strategy/goals.

6.1.3. Availability & Efficiency

In mission-critical space, N+1 *should* be the minimum when deploying components in the infrastructure (UPS, power, cooling, security, and monitoring). Business model and site relevance/importance *should* be used to determine how far beyond N+1 the site *should* be operating. Refer to [SCTE 226] Classifications Table 1 & Diagrams.

Capacity planning is important and making sure energy efficiency is incorporated in the discussion between technical and business teams is essential. The goal of maintaining proper load to power/cooling levels *should* be a primary focus for the critical space manager. Factors to consider that *should* be examined with care include lighting, power distribution, load levels, types of loads and, form of cooling sources. Defining the redundancy, maintainability and scalability will impact efficiency levels throughout the lifecycle of the critical space.

6.1.4. Additional General Considerations

New sites: A new site power density requirements recommendation is 150W/sq. ft.

Existing sites: The load density for expansion and renovation of the existing facility sites could vary from site to site, based on existing conditions and feasibility of new installation. Each site will have to be evaluated separately.

6.1.4.1. Reliability, Maintainability and Availability

All new facility systems *should* be designed and constructed to ensure continuous business operations.

Provide redundancy in building systems components and distribution pathways as recommended in the [SCTE 226].

Design and selection of critical equipment and systems *should* meet the reliability, maintainability and availability requirements as explained in this document.

The power supply system to the network equipment, as determined at the output of the direct current (DC) power plant, ***shall*** have an availability of 99.999%. All power to network equipment *should* have N+1 power redundancy.

6.1.4.2. Future Expandability

The facility *should* be designed with consideration for future expandability. New buildings *should* be designed such that in the event of need for expansion of the building and its information technology equipment (ITE) capacity, it could be easily and rapidly expanded, with shortest possible time to market. The best approach to achieve this goal would be employing modular design concepts, to add additional capacities of ITE PODS and associated electrical and mechanical systems. The overall building layout *should* integrate plans for future additional modular components, corresponding to the project and business plan.

6.1.4.3. Sustainable Design

The facility *should* incorporate measures in the design and construction that facilitate sustainable operations and maintenance of the facility.

The new facilities *should* incorporate the following design characteristics as roadmap to energy efficient design:

- energy efficiency
- expandability
- flexibility
- maintainability

Design and construction of a facility *should* target the following Leadership in Energy and Environmental Design (LEED) areas:

- sustainable site
- water efficiency
- energy and atmosphere
- material and resources
- indoor environmental quality
- reduction in greenhouse gases

The design and construction of the site *should* also comply with the cable operator's corporate sustainability practices.

6.1.4.4. Disaster Preparedness

The new facility will be designed and constructed in accordance with the National Building Code for the given location and the relevant Provincial Building Code as applicable. Post disaster requirements for a new facility *should* be determined on a project basis.

New and existing sites *should* take into consideration possible effect of climate change. Refer to section 8.6 and [SCTE 218] for alternative energy and microgrid information for the cable industry.

6.1.4.5. Flexibility

The new facility *should* be designed with ample flexibility and room for cost effective and quick expansion. All aspects of the building design including, layout, functional space programming, building materials of construction, mechanical and electrical equipment systems *should* be designed to provide flexibility for future expansion with no disruption of the operational data center modules.

The design and construction *should* accommodate future changes and consider the following:

- Utilize modular planning concepts and integration of architectural, structural, mechanical, and electrical building components.
- Minimize interior columns for ease of floor planning and re-planning.
- Provide a simple building perimeter and non-restrictive fenestration pattern.
- Avoid interior load bearing walls.
- Provide and locate main circulation corridors to allow expansion without increasing the complexity of the circulation system.
- Provide additional space within mechanical and electrical service spaces to accommodate future changes to increase the critical power load and planned building expansions.
- Strategically provide additional empty conduit and oversized ductwork, plumbing and other mechanical and electrical distribution systems; or provide suitable space planning for future service pathways, to accommodate future increases of the critical power load.
- Provision of mechanical and electrical distribution pathways and infrastructure to allow for future phases, load growth, and expansions.
- Locate mechanical and electrical components that require frequent service access outside of the network equipment areas.
- Provision of sufficient and redundant infrastructure for power and communications distribution.

7. Site Requirements

Careful consideration is required when selecting where to place a critical facility. The following subsections briefly touch on important approaches.

7.1. Location

Sites *should* be selected based on network requirements and its classification as per [SCTE 226]. Each criterion *may* be assessed against the Cable Operator's business model and the tolerance for risk.

Managing risk is the process of identifying risk, assessing risk and taking steps to reduce it to an acceptable level. The building *should* be located in an area determined by business requirements. For greater details please see, [SCTE 227].

7.2. Ownership

Sites can be purchased and owned (100%) or sites can be obtained under a land lease agreement that suits the business with provisions to expand the facility on the site as required without obtaining any special permission from the owners of the land.

7.3. Selection Criteria

7.3.1. General

The selection criteria will vary as per the site classification. [SCTE 226] sets out requirements for Class A to E sites.

The following criterion is applicable to Class A to C sites and will vary for facilities according to network requirements and risk analysis.

7.3.2. Natural Events

1. Drought
   - Extended period of months or years leading to a deficiency in water supply.
   - Avoid water-based cooling systems.
2. Earthquake
   - Seismic activity that vibrates and shakes the building.
   - Design to National Building Code (NBC) High Importance Standard.
3. Flood
   - Waterways overflow and submerge land caused by severe storms, snowmelt and other forces of nature. Class A - C facilities *should* be located a minimum distance of 1km from the 150-year flood plain border.
   - All new facilities *should* be located outside the 150-year flood plain border and the ground floor *should* be at an elevation that is a minimum of one meter above the 150-year flood plain elevation.
4. Hurricane
   - A severe storm with heavy rains and winds exceeding 120km per hour.
   - Design facilities with resilience to hurricane wind and water exposures in areas most subject to hurricanes.
5. Ice Storm
   - A winter storm characterized by freezing rain.
   - Assure proper alternate power source design in areas subject to ice storms.
6. Tornado
   - A violent destructive windstorm characterized by a funnel shaped cloud touching the ground visible by condensation and debris.
   - Facilities *should* be low-profile rugged design in areas historically subjected to tornados.

7. CME/Coronal Holes
   - CME (coronal mass ejection) or coronal holes have a severe effect on space weather that can result in a geomagnetic storm. These storms can affect communication systems, satellites, and if severe enough pipelines and power grids.
8. Climate Change
   - Climate change *may* result in abnormal changes to the expected patterns of weather in a region. Over time, this *may* result in changes to the weather-related design conditions stated in this document.
   - Refer section 8.6 and to [SCTE 218] for alternative energy and microgrid information for the cable industry.

7.3.3. Regional

1. Development Trends
   - Confirm that the long-term development plan - official plan, will have compatible uses within the immediate area.

2. Nuclear Plant
   - Facilities site *should* be located outside the 10km mandatory evacuation area around a nuclear plant.

3. A selected site *should* be at least 5km from:
   - Airport and not under takeoff and approach flight paths.
   - A military installation
   - Fuel storage facility
   - Mining operations

4. A selected site *should* be at minimum of 1.5km from:
   - All railway lines
   - Major highways
   - Hazardous cargo route
   - Potable or wastewater treatment facility
   - Hazardous production facility
   - Hazardous materials transmission pipelines

7.4. Infrastructure

7.4.1. Fiber

Research the availability of diverse fiber access in the area under consideration.

7.4.2. Electrical Utility Power

Review with the local electrical utility to confirm it can satisfy the short and long-term power needs of the project:

- What are the distribution voltages?
- What is the outage history?
- What is the charge rate per kWh?
- Are there additional charges such as substation upgrades, pole line construction, security deposits?

7.4.3. Water & Sewer

The site *should* have municipal water and sewer services with connection points available for the site. Verify:

- Water flow rates and pressure
- Water consumption charge rates
- Sewer capacity

7.4.4. Storm Water Management

The site *should* be of sufficient size to handle the 100-year rainstorm on site and release to the municipal or local storm drainage system at rates specified by the municipality.

7.4.5. Local Zoning & Permits

1. **Zoning:**
    - A headend *may* be located anywhere within a municipality as per federal regulations however, a municipality *may* require that the facility to look like a residence if located in a residential area. Residential areas *should* be avoided if possible.
    - Confirm the minimum or maximum setbacks.
    - Confirm restrictions on placement of outside equipment installations.
    - Confirm restrictions on roof mounted equipment.
    - Confirm parking requirements.
    - Confirm the process for variances.
    - Confirm requirements for compliance with local Development Guidelines.

2. **Easements & Right-of-Ways:**
    - Verify if easements and/or right-of-ways exist on the property.
    - Verify if the municipality, utilities, or other authorities having jurisdiction will require an easement or land transfer.

3. **Permits:**

Obtain the requirements for the full scope of potential approval/permit requirements**:**

1. site plan approval/development approval
2. utilities & services
3. environmental—noise and air
4. site access
5. building permit
6. sequential permitting
7. life safety

7.5. First Responders

The availability and time to respond of emergency services such as fire, police and medical services *should* be assessed against the objective of 10-minute response time.

First Responders are defined as the on-call tech first to site. Their response time to each site *may* be factored into equipment selection for fire detection and suppression. Less than 30-minute response time consideration *should* be given when using only aspirating detection systems, without clean agent suppression systems.

7.6. General Site Selection

7.6.1. General

The site *should* be of sufficient size to allow for future expansion and permit the building to be situated to maximize the distance from adjacent properties that pose a risk to the facility. The site *may* accommodate construction staging area for any planned future expansion.

The site *should* meet the requirements of the company's security standard (physical security). The site selection will be a process involving multiple departments.

A threat risk analysis *should* be conducted to assess the required security measures.

The following investigations *should* be conducted during the due diligence period for land acquisition. Assure that sufficient time is allotted for these activities before the closing date.

7.6.2. Existing Buildings

If the site includes any existing buildings and infrastructure that will be utilized as part of the new facility, a due diligence review *may* be completed to ensure that the age and condition of such infrastructure meets the intent of the design criteria.

7.6.3. Environmental Assessment

The site *should* be located within an area that will result in a 'clean' and problem free environmental assessment. Ideally, the site location (greenfield site) *should* be clear of all contaminants and toxins.

Brownfield sites that *may* have contaminants *should* only be considered if steps have been taken to contain the contaminants on the property. Risk mitigation requirements are to be complied with accepted by the AHJ.

7.6.4. Soil Investigation

The site *should* be located within an area that has stable soils that can accommodate standard foundation requirements for industrial type buildings.

7.7. Site Planning

7.7.1. General

The site development plan *should* represent the ultimate site capability and phases of the deployment to match expected growth projections.

7.7.2. Access

The site *should* be accessible 24 hours a day, 7 days a week to authorized personnel.

The site *should* be accessible by vehicles all year around and access roads *should* comply with building code requirements and fire department access requirements.

Automobile access *should* be direct to a conveniently located parking area close to the building entrance. Truck access *should* be provided for expected deliveries that will require truck access.

Plan for construction vehicle access for future building expansions.

7.7.3. Parking

Note that a parking variance *may* be required for reduced parking spaces from the typical zoning bylaw requirements. Electric vehicle charging stations, carpool parking and handicap parking stalls *should* be provided. Parking requirements *should* be determined by the facility capacity.

7.7.4. Construction

Driveways and parking areas *should* have a permeable surface constructed to suit the expected vehicle loading and soil conditions. A concrete curb, a minimum of 155mm above the vehicular surface, *should* bound access roads and vehicular areas.

7.7.5. Site Security

The site *may* meet the company security standard requirements as determined by the site use. The building *should* have no windows on the ground floor.

Access control, surveillance, and perimeter lighting *should* meet the company security standard requirements.

In existing sites with windows, where areas are being converted to facilities, the windows *should* be removed if possible, and filled in to match the existing exterior walls.

1. If removal is not possible (local code issue) the area behind the window *may* be blocked in with concrete, bricks or steel plate.
2. The window is to be coated with impact resistant plastic and security privacy film.

In existing sites with windows, where areas are being converted to tech spaces, the windows *may* have impact resistant plastic and security film.

1. It is recommended that camera monitoring be provided for those windows.
2. Windows *should* not be openable.

All windows *should* comply with the company security standard.

7.7.6. Exterior Lighting

Doors and the perimeter of the building *should* be floodlit, using high-pressure sodium fixtures, so that the average light level at 30-feet from the building is one foot candle. It *should* have photocell control with an override timer controlled via a HOA (hand/off/auto) device.

7.7.7. Landscape

A 10-metre area around the building *should* be free of shrubs and any planting higher than 300mm.

Low maintenance drought resistant planting materials *should* be used such as eco grass.

Roof water leaders *should* terminate at grade unless rainwater storage is mandated by local requirements.

7.7.8. Fence

The need for a perimeter fence *should* be determined on a site-by-site basis as per the company security standard (physical security).

Where chain link security fencing is required, it *should* comply with [ASTM F1712] and [ASTM F 2611]. Refer to [CLFMI], and the [Field Inspection Guide].

If antennas are associated with the facility, a storage yard or outside generator, these facilities *should* be enclosed by a seven-foot high, chain-link fence with three rows of barbed wire above angled to the outside. The gate *should* be twelve feet wide and locked with a hardened steel lock.

If there is an existing fence that is at least five feet high the new fence *may* match it. If the existing fence is not at least five feet in height then any fencing that is added *may* be seven feet high, chain link and with three rows of barbed wire above angled to the outside. It is preferred that the existing fence be replaced and match the new fence but if budget does not permit, the existing can remain in place and recorded as a deficiency in the physical security requirement.

7.7.9. Tower

If a tower is associated with a facility, it *should* be located to avoid the potential hazard of ice falling from the tower onto the building, parking lot, or personnel. The distance from the building is related to the height of the tower and *may* require engineering analysis to develop the proper protection. In all instances, the tower *should* be located downwind of the prevailing winter storm winds.

If a tower is associated with a facility, the following *may* be met:

- The tower *may* meet all federal, state, and environmental regulations
- The tower design *may* be sealed and signed by a licensed professional engineer
- It *may* be located to avoid the impact of falling ice
- The distance from the building is related to the height of the tower and *may* require engineering analysis to develop proper ice protection for life safety and roof and door damage mitigation
- In all instances, the tower *should* be located downwind of the prevailing winter storm winds

7.7.10. Satellite Dish

The preferred location is at grade adjacent to the building and away from towers to avoid the falling ice hazard.

Cable hub sites are mission-critical locations that *may* be carefully designed or selected to support reliable and robust operation under most environmental conditions 24 hours/day and 7 days/week.

In order to control these factors, as well as, to protect and justify the investment in infrastructure and energy-saving features, it is recommended that the critical space be located in an owned facility or long-term lease facility with first right of refusal for renewal.

7.7.11. Climate considerations

The cost of cooling is a major factor in the location of a cable hub site. Locating a hub site in an area where the ambient air temperature is lower, will increase the efficiency of the cooling system. In some rare cases, outside air, once filtered and conditioned, can be used directly for cooling during some seasons; thus, reducing the cost of cooling even further.

8. Electrical Systems

The electrical systems serving the critical facility space are the single most important element for delivery of services and business continuity; all other systems rely on reliable power for reliable operation. As such, significant and proper attention must be paid to develop a system that meets both the availability objectives of the facility as well as to provide efficient operation. In parallel, this system must be maintainable through its life and capable of growing and changing to meet business demand requirements over time.

The industry is going through some massive demand changes on the electrical systems as traditional cable television (CATV) distribution systems and facilities are pressed to deliver the ever changing and higher demand products of the networked age with changes occurring at a much faster pace. The original systems were never conceived to handle the equipment classifications nor provide the power densities now being requested. Electrical systems need to be designed to meet the growing needs of newer equipment and services.

In the past it was economically impractical in many instances to push a completely redundant infrastructure out to the edge across the organization with capacities that meet the future unknowns. Because of this, decisions *may* be made to look at hardening elements to ensure business continuity while balancing against the cost of implementation. Lessons from other industries over the last decade clearly show that overbuilt infrastructure or excessive capital demands for stranded assets can burden an organization to a point that it cannot react to new market opportunities. Overbuilding also has a direct and negative effect on efficient operations.

Efficient operation of the electrical system is directly coupled to the system design, components selection and amount of reserve capacity online. Right sizing power distribution and conversion to optimize efficiency has been identified by the U.S. EPA, energy star program as a key element of energy efficient design. Right sizing the infrastructure is a critical element of efficient operation. Modularity in layout and design allows for installation of equipment that more closely matches the business needs. Modern systems allow for modular growth without interruption to match the need more closely against delivery.

The above section is largely taken from [EPA], the Report to Congress on Server and Data Center Energy Efficiency.

8.1. Electricl System Best Practices

As a result of unique challenges moving towards the edge of the network, a stay-alive capability for the critical components of a particular organization is recommended. Creation of this class of equipment can help an organization better size both the "business as usual" operations as well as "stay alive" capabilities. For reference, in this operational practice, this class of equipment will be referred to as enterprise critical equipment (ECE) and is defined as equipment housed within the critical infrastructure space that if not active would have a detrimental effect on operations of the organization. Hardware within this category is typically considered as network transport gear, commercial services, or other penalty driven items that, if services were lost due to a facility outage, would create significant risk or direct financial burden. The classification is purposely left open for determination by the organization to allow for inclusion of additional items or increase in criticality based on local business needs. Issues such as the number of customers served *may* drive a significant portion of hardware into the ECE category (for example, a primary headend).

Equipment that is classified as ECE will likely need to be served with batteries that have longer duration battery life and be supplied by one or more backup power systems. In addition, this would often allow for growth in deployment as business demand drives funding resources over time.

The diagram below depicts a logical flow for electrical service to a typical hub site. In many instances it can be roughly translated into an electrical single line. Logical adherence to the principles of the distribution system can be obtained with a variety of physical deployments.

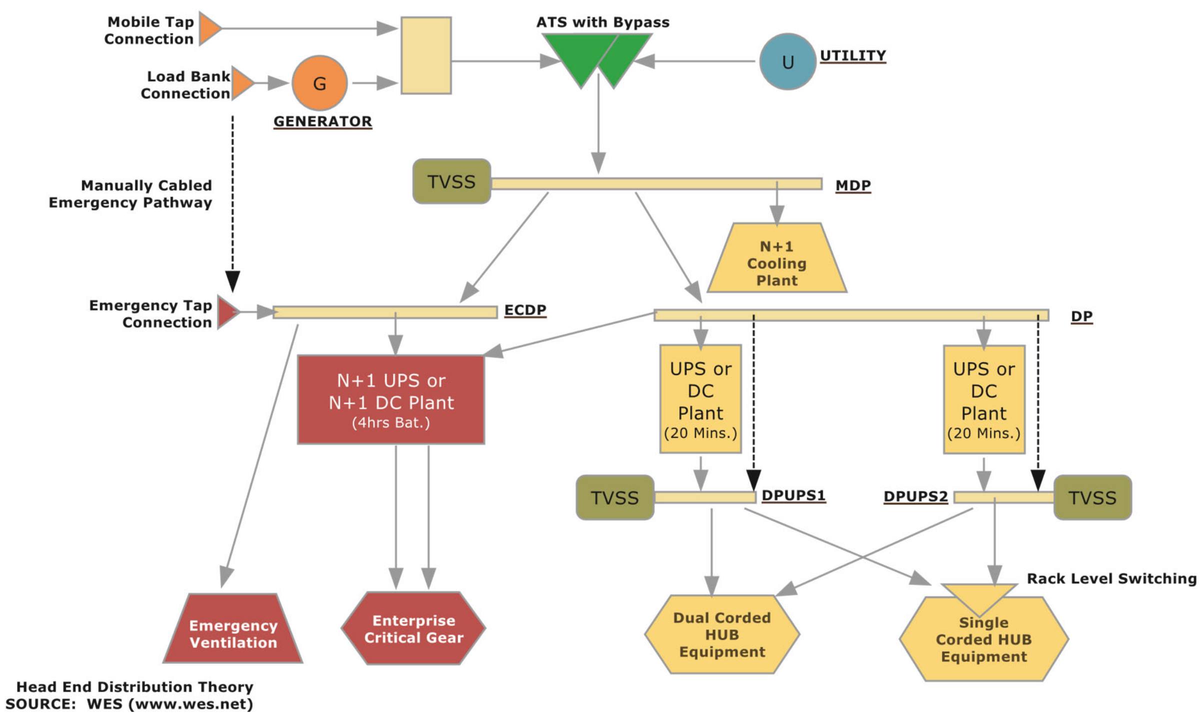


Figure 1 - Hub Site Distribution Theory

In general, the infrastructure design *should* provide:

- Delivery of services with a loss of utility power feed.
- Survival capability through planned response to mitigate need for redundant backup generation. This requires emergency response manual intervention.
- Minimization of single points of failure.
- Ability to maintain systems without interruption of customer services. Increased risk is assumed with an inherent loss of redundancy during many of the maintenance activities likely driving work to approved maintenance windows.
- Extreme measure fallback position to maintain ECE equipment during a catastrophic event.
- Ability to capitalize on existing deployed mechanical and electrical infrastructure (growing load curtailment / response opportunities).

Taking the ECE concept higher in the network will likely result in more equipment being classified as ECE. Figure 2 depicts another concept with the logical flow for electrical service to a typical Headend. In many instances, it once again can be roughly translated into an electrical single line. There are several possible physical deployment configurations possible of the logical distribution system.

In general, the ideal headend is designed to provide:

- Delivery of services with a loss of utility power feed.
- Full pathway redundancy including UPS or DC plant and generator to 2N or N+1 levels.
- Removal of common single points of failure.
- Ability to maintain systems without interruption of customer services. Increased risk is assumed with an inherent loss of redundancy during many of the maintenance activities likely driving work to approved maintenance windows.
- Dual power pathway to all critical infrastructure systems.

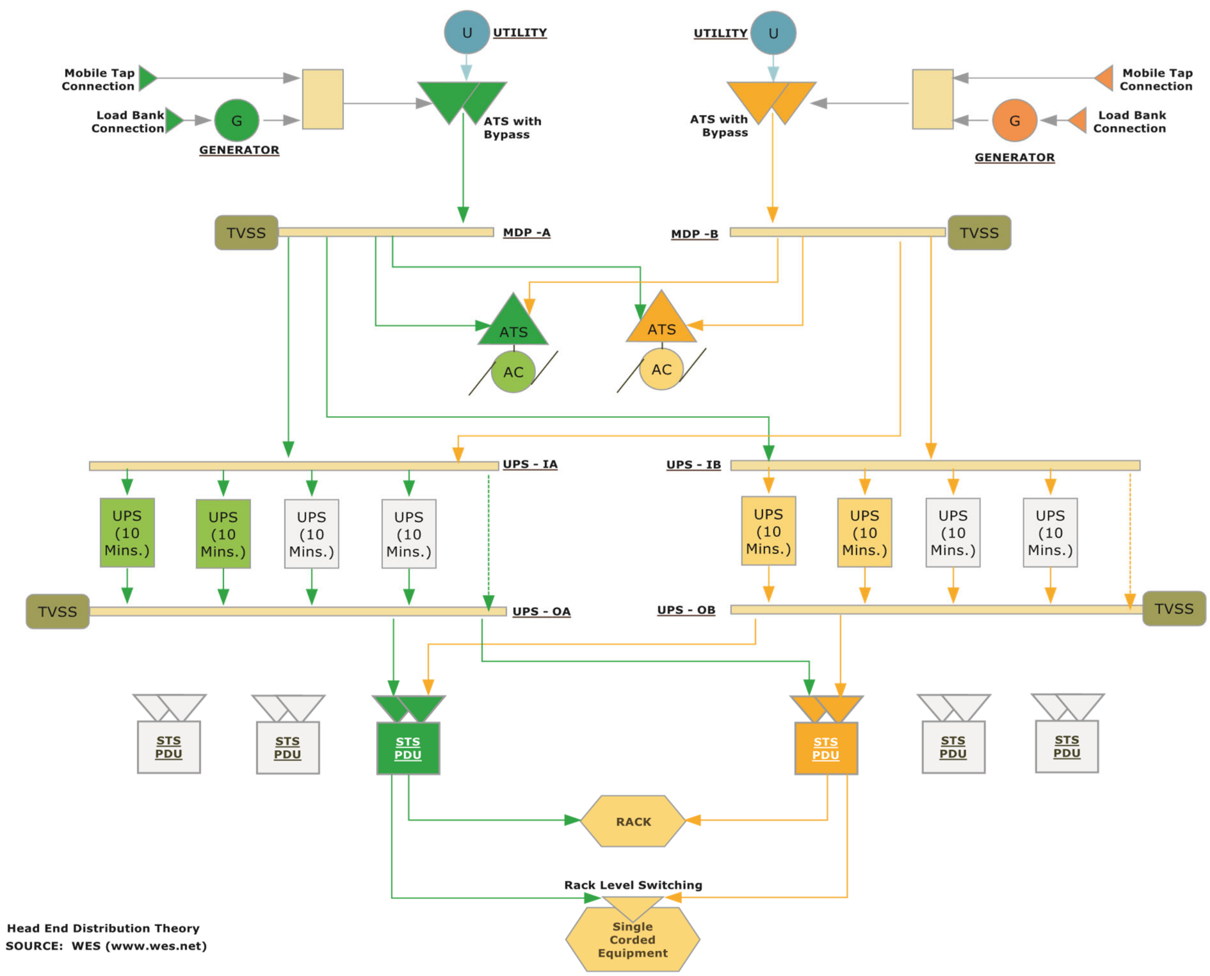


Figure 2 - Headend Distribution Theory

8.2. Utility Power

Proper selection of utility voltage and class of service can have a dramatic effect on future operations. Care *should* be taken during times of utility upgrade or installation to determine and understand the impacts of the configuration and class of utility service selected. Traditionally, smaller facilities have had single phase, split service power service commonly used for residential applications. This system selection will ultimately limit both the size and efficiency of infrastructure support equipment connected to it. Moving to three-phase service opens selection options for infrastructure equipment that operates more efficiently and allows for greater expansion of electrical distribution capacity. Further, increasingly, HVAC suppliers for commercial applications are deprecating 240V service feeds for smaller commercial air handlers and A/C compressors in favor of 208V service rating for single phase equipment.

Higher voltage distribution reduces the size of the copper conductors utilized, allowing for designs with less system loss. Consideration *should* be given at larger facilities to provide 480V three-phase class of service. All critical facilities *should* be provided with a dedicated transformer serving the facility.

In addition to the technical aspects, good relations with the local electric utility company are necessary. Upgrades and improvement projects can be very expensive. Joint projects or trading work with other community projects can go a long way in saving large sums of money when the time comes to depend on the electric utility company for a project. Not all electric utilities will automatically watch out for the best interest of their customers when they size electrical service. Transformers and electrical service components *may* not operate at the end user's desired capacity but are at the control of the supplying utility, either in excess of rating or below rating point. Finding a good, reputable, and knowledgeable electrical engineering contractor is helpful in evaluating service requirements, service application and lobbying the power company to size and replace their equipment to better meet project needs and growth schedule.

The utility feed from utility distribution to the structure *should* be routed via underground pathway wherever possible to limit unintended disruption.

8.3. Backup Power Generation

Traditional backup power sources for critical environments have relied on diesel, natural gas, or propane generators for a reliable backup power source. These machines work when they are well maintained and tested. Many operators have experienced failures when incomplete maintenance programs are in place or system tests miss operational modes. Beyond adding modularity and properly sizing the equipment, there is not much that can be done to improve efficiency among the products that are on the market today.

The backup generator source *should* be sized to include all contingencies for battery recharge, HVAC unit start up and walk-in plans, and UPS/DC plant transition back to input power source to support all critical infrastructure environmental systems including UPS/DC plant, cooling, humidification, reheat, control systems, fire suppression, and security. Operationally, there *should not* be reduced level of environmental support regardless of generator or utility operation. The generator *should* be supplied with sufficient fuel storage to support a minimum 24 hour run time at full load. A fuel maintenance program *should* be in place for testing of fuel supply, fuel delivery contract in place and emergency delivery defined with time guarantees.

Generator start batteries *should* be monitored by automatic systems with an alarm and monitored to provide indication of reliable operation. The generator battery charger *should* also be monitored to provide indication of reliable operation. Mandating testing of the generators *should* be accompanied by verification (such as through use of a remedy ticket system and coordination with network operations center or technical assistance center to ensure it is completed. The testing results *should* be evaluated to understand whether changes to design or operations are required at a particular site or as part of an organizational strategy.

All backup generation systems *may* be equipped with auto-start and run features to exercise the prime mover, and generator driven by it, no less than once per month, preferable weekly, for a minimum period of time necessary for the prime mover to obtain steady-state operating temperature. The auto-exercise controller utilized *should* ensure proper operation for genset cranking, starting, generator output frequency and voltage, genset run (i.e. oil pressure, water temp, alternator charge winding output, etc.), cool-down, and prime mover shutdown. The consideration of whether to also include the provision to schedule live switchover and genset load take-up, or load-bank testing of genset switchgear is optional and *should* be discussed with the electrical engineering contractor selected for backup system design.

The above section is largely referenced from [NFPA 70](*the National Electrical Code*), [NFPA 110] (*Standard for Emergency and Standby Power Systems)* and, [NFPA 111] (*Standard on Stored Electrical Energy, Emergency, and Standby Power Systems*).

8.4. Uninterruptible Power Supply (UPS)

According to the U.S. Department of Energy, "Increasing the UPS system efficiency offers direct, 24-hour-a-day energy savings, both within the UPS itself and indirectly through lower heat loads and even reduced building transformer losses."

Modern transformer less UPS systems are common to the marketplace and offer efficiency ratings in the mid 90% range for lower load values. Low load efficiencies vary by manufacturer and final electrical system topology can affect ultimate utilization rates. Consideration *should* be given to select products that offer high efficiency during all modes of operation.

Some UPS units are incorporating high efficiency modes of operation with ratings around 99% that blur the line between online and offline UPS systems. Utilizing advanced control algorithms, power is transferred between the internal bypass and electronics section based upon input conditions. Proper investigation into a particular manufacturer's control scenario and method is required to understand system operation and potential risk.

A newer approach to UPS system efficiency is to allow the deactivation of modules that are not needed for redundancy or capacity, such that the system will maintain internal module redundancy without sacrifice of a redundant component. This allows a modular UPS system to match equipment against load for real time optimization.

To the maximum extent possible, UPS systems *should* allow for redundant distribution to critical loads. While extended battery times are available, practical application is usually in the 10-20 minute range with reliance on a backup energy source for extended outages.

Energy storage solutions for UPS systems also include flywheel technology which has a higher initial cost but offers some advantage in footprint and long-term maintenance costs. Runtimes on flywheel systems can range in the order of seconds to a few minutes, so additional reliable backup generation is critical.

Minimally, bi-annual maintenance is critical for UPSs to function properly over time. Battery testing and replacement is critical to ensure the UPS is working when commercial power is lost. A UPS *may* be installed with external disconnect switches and bypasses to isolate the unit for repair or replacement. Any work to a UPS *may* be done in the nighttime maintenance window since there's always a chance of triggering an outage.

UPS system topologies *should* be developed around equipment that is both modular and scalable to best match load against utilization. In addition, future expansion can be planned that uses overall distribution topologies that incorporate block modular approaches or non-centralized bypass arrangements with redundancies based upon individual organization's risk tolerance. This would further reduce the chances of failures.

The above section is largely referenced from [USDOE], Best Practices Guide for Energy Efficient Data Center Design.

8.5. Uninterruptible Power (DC Plant)

Legacy direct current (DC) distribution (nominal -48 volt) to the rack level *should* be considered where applications of extended runtime are critical and the business risk of interruption is unacceptable. There are inherent advantages of operating a lower voltage DC distribution system that allow for maintenance, increased modularity and increase runtime. Modern rectifier efficiencies are comparable to UPS system efficiencies and allow for easy N+1 redundancies.

Since DC systems deliver power at a lower distribution voltage, there is a requirement that larger power conductors are necessary to handle the increased current. Conductor increases can be significant across a larger system (range from 4 to 16 times the amount of copper) over the AC systems. However, the installation methods typically employed utilizing open cable in tray systems (DC) in lieu of conductors in conduit (AC) can help defer some of the added conductor costs. Voltage drop *may* be considered as well on DC systems with the lower distribution voltage.

Manufacturers are offering new products to address the mix of AC and DC available equipment and developing inverter options that scale into the DC plant systems allowing for reduced rectifier loading during normal operations.

Organizations *should* examine the balance between AC and DC distribution based upon a particular facility's equipment load profile, availability requirements, and anticipated outage duration.

DC power distribution's greatest strength is the ease of installation for additional storage capacity. This *may* be balanced however, with the thermal loading of a facility and the ability to reject heat during an outage event. Modern equipment densities can overheat an environment in less than an hour without adequate cooling making any additional installed capacity unusable.

DC plant redundancy and distribution pathways *should* be examined to limit potential single points of failure and in some instances redundant DC plant busses and distribution pathways *should* be established.

8.6. Alternative Energy and MicroGrid Power Source Options

[SCTE 218] is a comprehensive reference regarding alternative energy and microgrid development for the cable industry. Further, [SCTE 218] provides cable operators with references and resources to evaluate alternative energy and microgrid technology options based on a given geographic location, facility type, and existing or planned infrastructure. It functions as a tutorial and selection tool to aid in describing various alternative energy and microgrid technologies by recognizing which resources would have the greatest impact on reducing energy costs, electrical grid dependency and environmental impact, as well as improving system reliability, resiliency, and mitigating climate change risks.

Immediate and long-term benefits of utilizing [SCTE 218] include:

- Potential for reducing electricity costs over conventional electric grid; lower transmission and distribution charges.
- Potential for reducing carbon fuel consumption and emissions.
- Potential for reducing dependency on the utility based electrical grid.
- Potential for reducing purchase of high cost per kilowatt hour (kWh) power during peak usage periods.
- Time saving in researching alternative energy technologies.
- Time saving in identifying additional state and federal alternative energy incentives availability.

[SCTE 218] impacts the industry and cable's energy roadmap by potentially reducing the industry's impact on the electrical grid during peak usage periods, enhancing the customer experience by improving reliability by generating power on site with less grid dependence, reducing the environmental impact, and mitigating adverse climate change risks.

Some of the key provisions of [SCTE 218] are as follows:

- Provides background and history of existing electrical grid and the challenges being faced.
- Introduces alternative energy sources and microgrids and how they can benefit the cable industry.
- Outlines decision making priorities, evaluation strategies, provides rules, regulations, and policies for both energy efficiency, alternative energy technologies and microgrid technologies.
- Provides a summary roadmap of Federal and State incentives and policies with links to further information.
- Includes links to the U.S. Department of Energy's Office of Energy Efficiency & Renewable Energy (EERE), National Renewable Energy Lab (NREL) research and development, and other alternative energy financial modeling tools.

The document can be used as a collaboration tool across regions either internally or with other multiple system operators (MSOs) to leverage lessons learned by in house personnel, project managers, and vendors from prior MSO alternative energy and microgrid deployments.

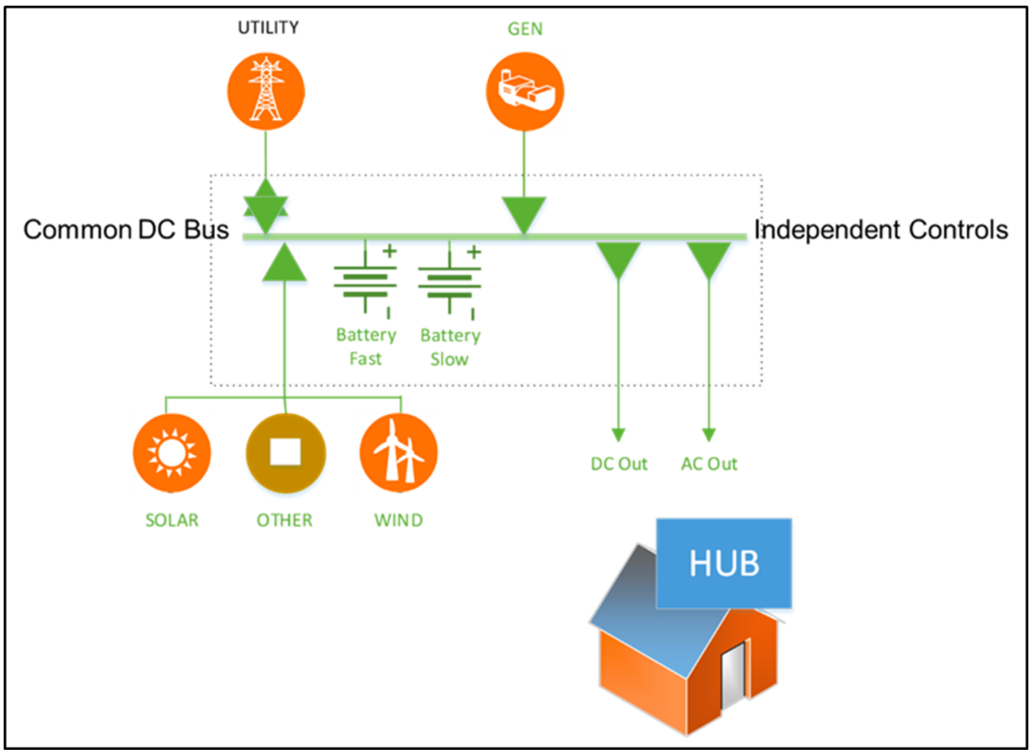


Figure 3 - Microgrid Topology Example

As the cable industry looks to further standardize on strategic energy concepts like microgrids, opportunity presents itself for continued development, trial, and ultimate deployment of microgrid technologies. It has been shown that microgrids are being deployed within many industries and use cases globally. Economics, the rising cost of electricity, and the focus on a more sustainable future are the drivers for the widescale deployment of solar, wind and other distributed energy resources. New technology large scale energy storage is also becoming more cost effective and is playing a bigger role in the new energy future. These will enable a foundation of new network ideas, as envisioned and embodied in the announcement early in 2019 of the broadband 10G platform.

8.7. Grounding & Bonding

[SCTE 275] is a comprehensive standard, the document provides a description of basic practices to obtain a reliable, low impedance grounding and bonding system in communication networks.

There are five principal objectives for providing a dependable low impedance grounding and bonding system. These include:

1. Personnel safety: Minimize the development of electrical potential that could create a shock hazard to personnel, within and between metallic frames and structures.

2. Equipment protection: Provide adequate fault current paths so any installed overcurrent devices can disconnect faulted circuits to reduce the possibility of fire and limit damage to the critical equipment.

3. Equipment operation: Provide an equalized ground reference to electronic communication circuits connected to the ground plane.

4. Electrical noise reduction: Assist in the reduction of electrical interference by maintaining low impedance paths between ground points throughout the communication system.

5. Reliability: Provide a grounding system that resists deterioration and requires minimal maintenance.

[SCTE 275] includes practices for exterior system grounding and bonding, interior grounding systems, surge protection, roof mounted lightning protection, environmental handling for electric static discharge (ESD) sensitive equipment, commissioning, and maintenance.

Broadband networks become more dependable when appropriate standardized grounding and bonding procedures are followed. The recommendations also ensure operational safety.

8.8. Power Quality (SPDs)

Surge protective device (SPD) and transient voltage surge suppression (TVSS) equipment *should* be installed at the service entrance equipment and at the distribution boards serving electronic equipment and incorporated into the power distribution units (PDU). The SPD at the service entrance will serve to eliminate voltage spikes and transients emanating from the utility. The SPD at the distribution panel level will serve to attenuate transients and noise that are generated internally within the building.

8.9. Power Wiring & Cabling

Energy lost within the distribution portion of the electrical system is generally a result of the transport of the power (conductors) or the transformation of voltage (transformers) or frequency (e.g. UPS or DC plant, alternative energy sources and microgrids). All components *should* be selected with proper examination of individual component efficiencies.

For efficiency of distribution, electrical systems *should* be well organized across the building or room to limit pathways to the shortest runs and limit the distances lower voltage conductors need to run. Power losses in the distribution system become heat that *may* need to be removed by the air conditioning systems. Depending upon the component, or locations, specific considerations *may* be made during the sizing of cooling systems. Any savings achieved within the electrical system will have the direct result of cooling savings within the overall system.

When sizing conductors, consideration *should* be given to voltage selection, voltage drop characteristics and thermal efficiencies. Voltage drop for a conductor is the product of the conductor's resistance and the current, where the power lost for a given conductor is the product of the conductor's resistance and the square of the current. Cable length is an inherent part of the resistance of the conductor and is therefore accounted for in the calculations. In practical terms, an appropriately sized conductor can provide better voltage characteristics and account for less energy loss in the system.

To allow for better metering and monitoring of system performance and improve operational availability and maintainability, dedication, and optimization of distribution components to systems *should* be considered.

Cable lengths *should* be maintained at the minimal necessary length. Avoid coiled lengths and excessive loose cable. All cables *should* be dressed neatly and *should* not block equipment airflow.

8.10. Maintenance Considerations

Routine inspection of electrical distribution components, including internal conditions and an infrared (IR) scan of connections of the electrical distribution pathway *should* be conducted annually.

A spare parts program for critical electrical components *should* be provided; a more centralized (regional) program can be applied to allow for diversity.

Provide a bypass feature on all transfer switches that are single pathway devices. Allow the load to remain energized during maintenance activities with reduced redundancy availability, and still allow for manual transfer between utility & generator.

An up-to-date short circuit analysis, coordination and a flash study (power study) *should* be performed and available indicating appropriate equipment ratings, equipment labeling, and all adjustable devices are set to study values.

9. Cooling Systems

The design and operation of cooling systems for critical space represent an area of significant energy utilization as well as an opportunity for implementation of efficiency measures and savings.

There are also important variables to consider and appropriate design decisions for one location, or facility type, will not necessarily be the same for another. A small hub site will have very different characteristics and requirements than a large regional or national data center. In addition, the benefits of certain efficiency measures will be greatly affected by local climate conditions.

10. Control Systems Design & Maintenance

Sensor accuracy and correct control settings are a critical aspect of efficient utilization of cooling systems. This is an area that is often overlooked in both the design/specification phase and ongoing operations. In the most basic sense, it will be difficult or impossible to control conditions as intended if the regulating sensors are registering incorrectly or have inadequate accuracy. This can lead to excessive, unnecessary conditioning, humidification or reheat. It can also lead to individual units fighting each other with conflicting functions. All these conditions result in unnecessary energy utilization and costs. Verification of sensor accuracy and control set points *should* be incorporated into the regular maintenance of the mechanical systems for the critical space. This verification *should* be included in the preventative maintenance schedule for the equipment as well as part of any audit of the infrastructure or environment.

Advanced monitoring and trending functionality are recommended. These will provide the tools necessary to evaluate conditions and regulate system functions to maximize efficiency efforts such as economizer functions.

11. Isolation Approach Overview

The isolation approach involves full containment of both the hot and the cold aisles. This approach does not employ a raised floor or ceiling plenum return. For delivery of supply air and removal of exhaust, aisles perpendicular to the hardware rows and hot / cold aisles are used. The cold aisle doors will typically be louvered with dampers to control supply airflow. This design allows for very efficient fan operation. In addition, this approach typically uses highly filtered outside air using adiabatic cooling. These aspects allow for extremely efficient operation with very low PUE™. It is not typical for this approach to be retrofitted into an existing facility but is typically an engineered solution.

Figure 4 - Isolation Approach

Image Courtesy of BladeRoom USA

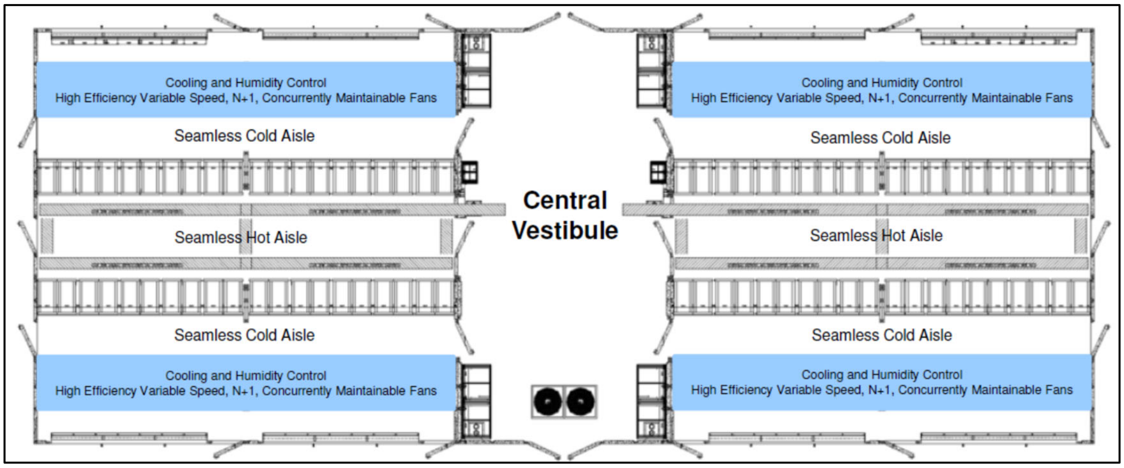


Figure 5 - Hot Aisle Cold Aisle Containment

Image Courtesy of CommScope

12. Environmental Monitoring & Building Management

Environmental monitoring and building management systems (BMS) are typically computer-based direct digital control (DDC) systems that are found more often in larger buildings. They can also be found in smaller buildings but are often scaled down systems with less functionality, control and monitoring capabilities. BMS are designed to control and monitor the building's mechanical and electrical equipment including electrical distribution systems, mechanical systems such as heating, ventilation and air conditioning, fire detection system, fire suppression system, and sometimes security and card access systems.

Primary functions of the BMS include controlling and monitoring the operations, performance and status of the systems and system components of building systems. This includes maintaining the desired environmental conditions of space temperature and humidity set points. The BMS maintains the desired space temperature and humidity set points by controlling the heating, cooling, humidification and dehumidification systems, managing the distribution of air to people and equipment space by modulating outside air, return / mixed air and supply air dampers. The BMS *may* also be used to control indoor or under floor static pressure, monitoring and controlling indoor air quality, and controlling CO_2 levels.

Additional functionality of a BMS includes controlling, monitoring and reporting the status of the electrical distribution system and the electrical distribution components including utility power availability, main switchgear – automatic transfer switch (ATS), generator, uninterruptable power supply (UPS), static transfer switch (STS) and power distribution units (PDU). Indoor and outdoor lighting can be controlled utilizing on/off schedules that mirror occupancy. Lights are turned on when buildings are occupied and turned off when they are unoccupied.

The communications network or backbone of the BMS can be constructed with twisted pair copper wire or fiber. Retrofitted systems *may* contain pneumatic components. Twisted pair copper is often used in smaller systems that have a minimum number of devices being monitored or controlled. Twisted pair backbones are less expensive but have limitations with data processing speed and data capacity. If a balanced twisted pair copper cabling backbone is installed, the minimum standard wire *should* be *6A*. *Category 6A* cabling for an entire network will improve support for higher data rate applications.

BMS fiber backbones are typically installed in larger systems that monitor and control large, complex building systems. Primary advantages for installing fiber backbones are data processing speed and data processing capacity. *OM4 laser optimized multimode fiber* can support higher speed applications while also providing backward compatibility to most existing applications. However, fiber backbones *may* be more expensive due to the media conversion devices required to convert fiber technology to copper technology and copper technology to fiber technology.

Building systems that are controlled and monitored by the BMS are typically the largest consumers of power or energy within the building. Therefore, they are an integral part of controlling and reducing utility costs and operating expenses. Installed, maintained and operated correctly, the BMS can optimize energy efficiency without impacting comfort or reliability.

The following general best practices are defined based on their value in providing opportunities for energy efficiency while still maintaining base requirements for availability, maintainability, and security.

12.1. Building Management Systems

As with all capital expenditures specifying and installing a BMS requires a detailed financial analysis – identifying the type of system and functionality that will provide the best return on investment (ROI) is imperative. If capital funding is not available for installing a complete system, then consideration *should* be given to installing a scalable system that can be supplemented when capital funds do become available.

Small scale BMS *should* be designed to control and monitor the most critical building systems including power systems, cooling and heating systems, security systems, fire detection, and fire suppression systems as well as provide real time and historical energy efficiency data. Small scale BMS are suitable for the multitude of smaller headend and hub sites, which in aggregate, use a large percentage of the overall cable operator facility energy. A few well placed, inexpensive power sensors will give a comprehensive picture of the energy usage profile of a site and can be used to track and manage energy efficiency such as PUE™.

Full scale BMS are often found in larger and newer headends or mission-critical sites such as data centers. Similar to small scale BMS, these systems *should* be designed to control and monitor the most critical building systems including power systems, cooling and heating systems, security systems and fire systems as well as provide real time and historical energy efficiency data. They *should* also provide additional operability and functionality to include control and monitoring of lighting systems, exhaust fans, and other non-critical equipment.

Building system components or points that *should* be monitored and controlled include:

12.1.1. Electrical System

- utility power
- generator
- main switchgear/automatic transfer switch (ATS)
- HVAC distribution switchgear
- UPS – kW & maintenance bypass
- DC plant with batteries
- DC distribution system/s
- static transfer switch (STS)
- power distribution units (PDU) /remote power centers (RPC)
- emergency power off (EPO)

- power strip
- receptacle / outlet
- renewable energy and microgrid systems/components

12.1.2. Mechanical System

- chiller
- on/off status
- chilled water supply temperature
- chilled water return temperature
- condenser water supply temperature
- condenser water return temperature
- high head pressure –condenser
- low pressure – evaporator
- chilled water pump
- condenser water pump
- cooling tower
- inlet water temperature
- outlet water temperature
- boiler
- heating water supply temperature
- heating water return temperature
- steam pressure
- high temperature and/or pressure limit
- low temperature limit
- hot water pump
- sump pump
- computer room air conditioning (CRAC)/computer room air handling (CRAH) units
- discharge air temperature
- return air temperature
- roof top unit (RTU)
- discharge air temperature
- return air temperature
- exhaust fans
- supply air filters

12.1.3. Environmental

- indoor air temperature (multiple zones)
- outdoor air temperature
- humidity
- CO_2
- CO
- smoke
- gaseous contaminants
- water sensors

12.1.4. Fire Systems

- fire detection
- fire suppression
- fire pump

12.1.5. Energy Efficiency

- Power Utilization Effectiveness (PUE™)

12.1.6. Design Criteria and Certifications

Design criteria and certifications provide definition and consistency for repeatable implementation of tested best practices.

- Some data center builders and operators are looking to the LEED building standard to prove their data centers are green. The strength of LEED is that it takes a holistic approach to evaluating the green credentials of a building, and considers materials, location, water use and indoor environmental air quality, along with energy efficiency. Buildings that achieve enough points under these five categories are certified by the U.S. Green Building Council.
- The Environmental Protection Agency's energy star certification, which is widely used for electronics and personal computers, can also be used for stand-alone data centers and buildings that house large numbers of data centers. If a data center ranks in the top 25 percent of their peers in the EPA's rating system, then the site obtains an Energy Star label.
- The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) updated the "90.1 building efficiency standard" for data centers. Revisions were also made to the ASHRAE Thermal Guidelines for Data Processing Environments to accommodate a wider range for hardware operations and definitions of different classes of facility.

12.1.7. Local Facility Alarming

Building management systems (BMS) can provide immediate notification of operational abnormalities.

Local facility alarming includes reporting alarm conditions for standalone, non-web based BMS. They are classified as "local" because the alarms are only broadcast to the internal core management or maintenance personnel of the building. The alarm reporting can be dispatched via cell phone, pager, email, or onsite personnel including building engineers or security personnel. It is recommended that multiple building personnel receive the alarm notifications to assure adequate coverage and response.

Alarms are generated due to a change of state (*on to off* or *off to on*), due to conditions that are outside the normal operating range (pressure, temperature or humidity) or due to failure of systems or their components. Building system components that *should* be alarmed include, but are not limited to, electrical system components, mechanical system components, environmental, fire detection, fire suppression, and security. A detailed list of alarm points can be found in the best practices section.

Alarm notifications can be simple such as Chiller 1 Off, RTU 2 Hi Temp, Utility Power Off, Generator 1 Run, etc. or can be somewhat complex which requires deciphering such as CHLR1 Off, RTU2 HiTemp, UtilOff, Gen1Run. Regardless of the type of notification, alarming provides an immediate notification of abnormalities.

12.1.8. Multi-Site Monitoring Systems

Facility management, data center management and real estate management companies that have multi-building portfolios often have multi-site monitoring systems. Multi-site monitoring systems include local, standalone systems that can be monitored individually or collectively and can be accessed locally or remotely through a web-based architecture.

Multi-site monitoring systems can monitor and dispatch alarm notifications locally through audible means or via cell phone, pager or e-mail to on-site personnel including building engineers or security personnel or the alarms can be dispatched remotely to on-call personnel, to an operations center or to an alarm monitoring site. Personnel or vendors can then be dispatched to investigate the alarm and take corrective action to fix the problem. It is recommended that multiple building personnel receive alarm notifications to assure adequate coverage and response.

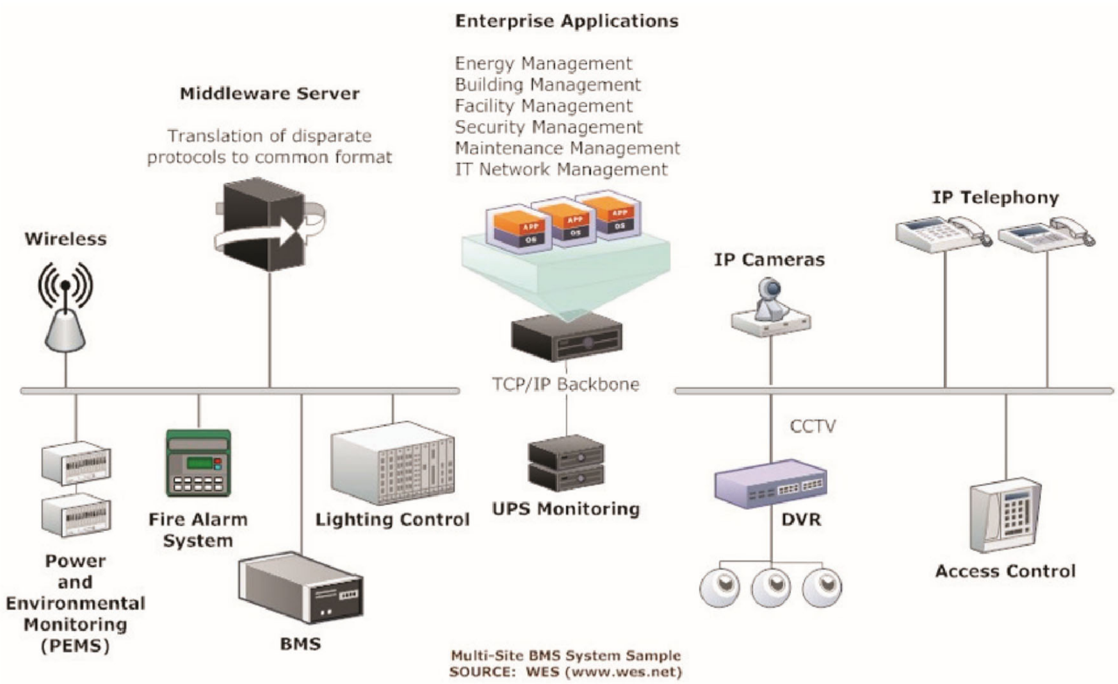


Figure 6 - Multi-Site BMS System Sample

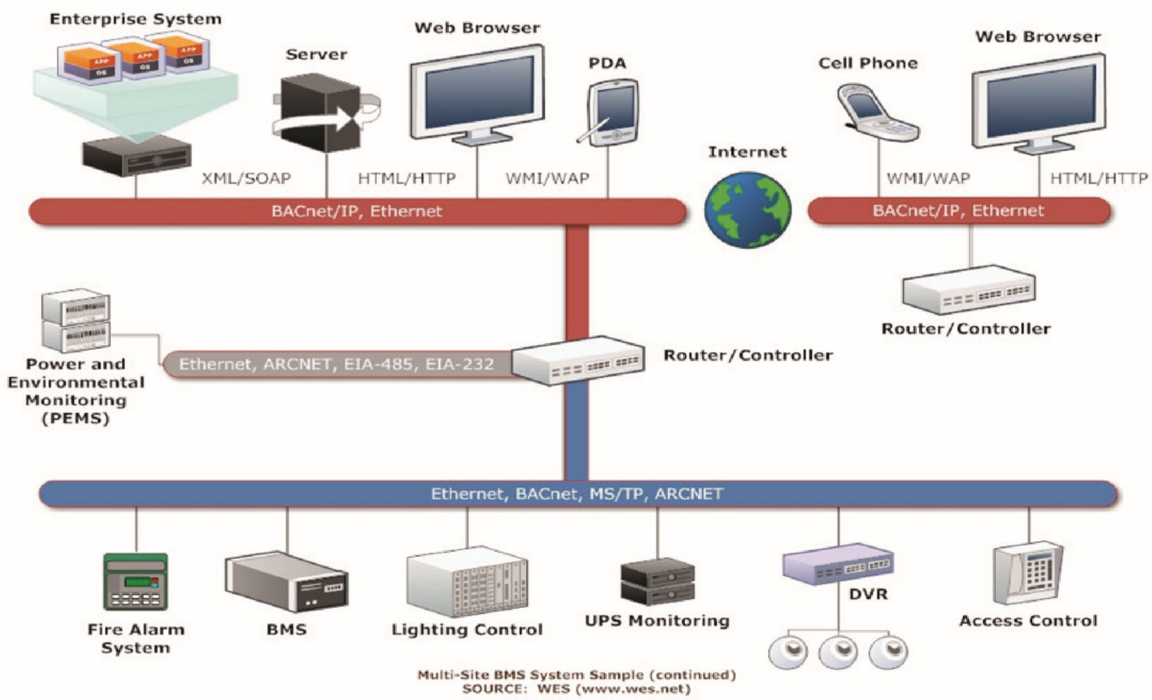


Figure 7 - Multi-Site Monitoring and Control Systems

12.1.9. Trending & Reporting

Most BMS have reporting and trending functions that are useful management and troubleshooting tools. Some of the reporting and trending functions are "canned" or are already available in the software and program functionality, although the reports and trending functions that are required *may* not be available and *may* have to be custom developed. Newer BMS systems have report and trending functions that can be custom built by the operator. Types of reports, amount of detail, date, and time ranges required *should* all be considered when purchasing and installing a BMS.

There are ample opportunities for trending and reporting usage and efficiency. This section includes examples of trending and reporting metrics that can be generated from data provided by the BMS.

These charts and graphs were not developed by the BMS but are derived from data trended and reported on by the BMS.

Objective: Report the Data Center Facilities YTD total availability / reliability hours per site

Source: Building Monitoring System

Date: YTD thru March 2011

Data Center	West	East
Actual Reliability	100%	100%
Benchmark	99.98%	99.98%

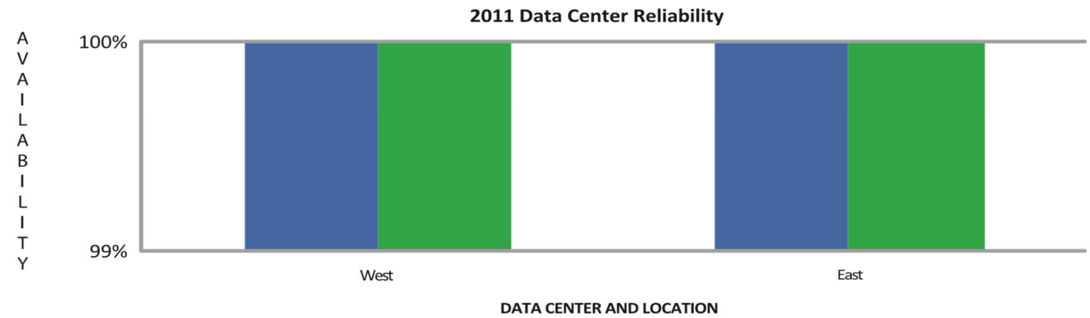


Figure 8 - Data Center Management Facilities Metrics: Reliability

Objective: Report the Data Center Facilities monthly and 6 month average electrical costs per Kilowatt Hour (kWh)

Source: Monthly Electric Utility Invoices

Date: Oct., 2010 – March, 2011

Data Center Monthly Cost Per Kilowatt Hour

	2010			2011			
Data Center	Oct	Nov	Dec	Jan*	Feb	Mar**	6 Month Avg
West	$ 0.0825	$ 0.0773	$ 0.0719	$ 0.0719	$ 0.0861	$ 0.0815	$ 0.0836
East	$ 0.0706	$ 0.0691	$ 0.0646	$ 0.0661	$ 0.0704	$ 0.0691	$ 0.0683

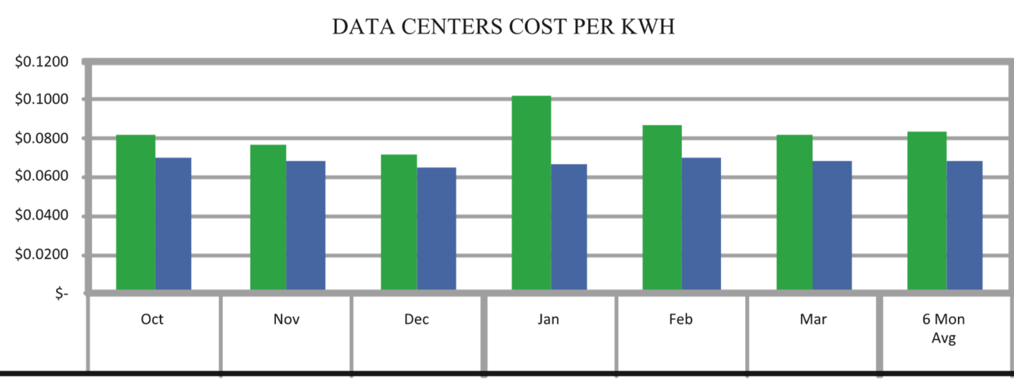


Figure 9 - Data Center Management Facilities Metrics: Cost Per kWh

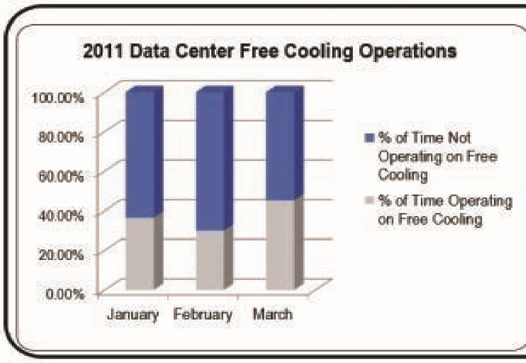
Objective: Report the monthly Data Centers Free Cooling savings from utilizing cool outside air to cool the Data Center

Source: Building Management System & Monthly Electric Utility Invoices

YTD Date: YTD thru March 2011

Calculation: Total monthly savings = electricity saved (kWh) operating on free cooling system reported by the Building Management System "x" the "all inclusive" cost per kWh calculated from the monthly Electric Utility invoice.

	JAN-2011	FEB-2011	MAR-2011	YTD Total
Monthly Savings	$ 7,790.48	$ 6,183.84	$ 10,554.92	$ 24,671.77
% of Time Not Operating on Free Cooling	63 %	70 %	55 %	
% of Time Operating on Free Cooling	37 %	30 %	45 %	



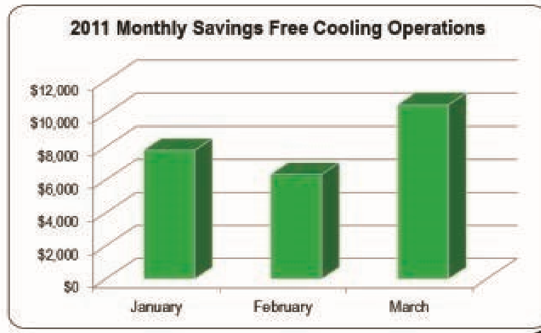
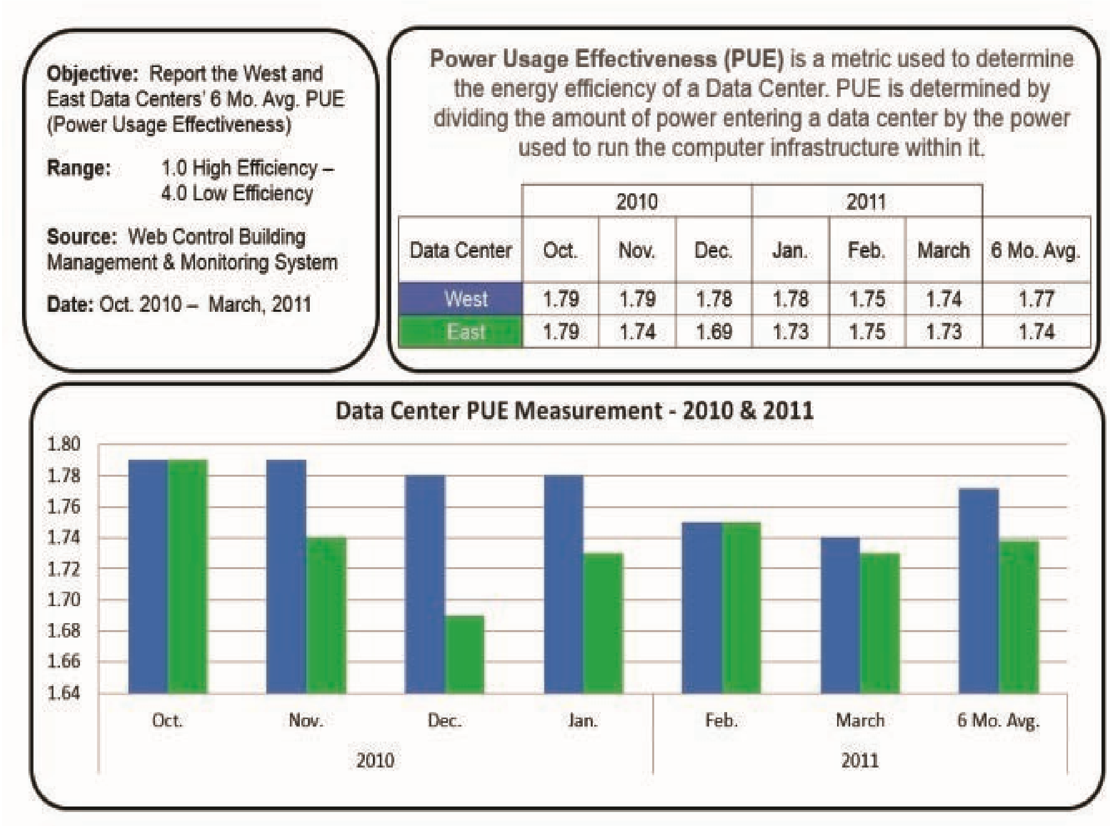


Figure 10 - Data Center Management Facilities Metrics: Free Cooling Savings



	2010			2011			
Data Center	Oct.	Nov.	Dec.	Jan.	Feb.	March	6 Mo. Avg.
West	1.79	1.79	1.78	1.78	1.75	1.74	1.77
East	1.79	1.74	1.69	1.73	1.75	1.73	1.74

Figure 11 - Data Center Management Facilities Metrics: PUE™

12.2. Site Auditing & Compliance Tracking

There has been an increase in pressure on facility managers due to audit/ compliance tracking and regulatory reporting requirements. These audit/compliance tracking and regulatory reporting requirements are a result of increased internal and external influences such as Occupational Safety & Health Administration (OSHA) workplace safety requirements, insurance, and risk management requirements, Federal and State EPA / DEP Clean Air and Clean Water regulations, and shareholder, government financial and operational reporting transparency mandates such as the Sarbanes-Oxley Act (SOX).

Here are some of the auditing and compliance reporting requirements that an organization *may* be subjected to, this list *should not* be considered all inclusive:

- Occupational Safety & Health Administration
- workplace safety reports
- indoor air quality reports
    - Sarbanes-Oxley Act
    - financial & operational reports
- State EPA / DEP
- generator, chemical and other operationally required storage tanks
- Greenhouse gas (GHG) emissions monitoring and reporting
- FCC
- equal access requirements

- antenna electro-magnetic radiation (EMR) studies and reports
- insurance/risk management inspections & reports
- city/municipal
- elevator inspections
- domestic water back flow preventer inspections and reports
- fire prevention / life safety
- fire department/fire inspector assessments and reports
- health department
- internal company
- phase 1 & 2 environmental audits
- safety & fire inspections

With the increase in audit/compliance tracking and regulatory reporting requirements comes an increased potential that an audit, inspection or report filing due date could get missed. This could create a non-compliance situation with potential negative financial implications. To reduce or minimize the possibility of a non-compliance situation, Facility managers are relying more frequently on automated notifications and reminders that are tied to due dates, expiration dates or mandated frequencies.

Due to the breadth of audit/compliance tracking and regulatory reporting requirements, there *may* not be a single computer program or system capable of providing “all inclusive” capabilities. Typically, the auditing, tracking and reporting functions reside in multiple programs or systems or with multiple departments within a company, making it difficult to manage and maintain compliance with all requirements. However, facility managers are better prepared to monitor and maintain compliance with all internal company, local city or municipal, state and federal regulations by automating the notifications and reminders and proactively managing the audit and compliance tracking and regulatory reporting requirements.

12.3. Maintenance & Management Programs

Maintenance and management programs are identified by many names including enterprise management programs, facility maintenance programs and computer aided facility management program, but they are most commonly referred to as computerized maintenance management systems (CMMS). Although some CMMS programs focus on a particular industry, such as hospitals or health care, most are industry neutral and are designed to assist all facility maintenance personnel with managing and maintaining facilities, facilities equipment, and property.

CMMS Programs typically include a database of assets and equipment and their associated preventative maintenance (PM) routines that consolidate an organization’s maintenance operations. They can be stand-alone systems supporting a single facility or web-based supporting multiple facilities in various local, regional, national and/or global configurations.

They are intended to be a tool utilized by facility maintenance personnel to manage:

- asset management
- inspections–documenting the condition of assets
- scheduling and tracking of PM routines
- breakdown data
- capital budgets-life cycle repair/replace decision making
- maintenance & management costs
- maintenance personnel staffing levels

- regulatory compliance – fire/life safety inspections
- work order tracking – tenant requests
- reports and metrics documentation
- personnel assignments

A CMMS is an integral part of facility management. This tool can improve asset return on investment (ROI), optimize limited maintenance personnel and assets while automating necessary documentation and metrics reporting information.

12.4. Facilities Management System (FMS)

Facility management systems provide a useful tool to facilities management and maintenance departments and personnel. These systems can be sophisticated and include functionality that provides automatic vendor dispatching, work order and invoice generation, automated tenant, or occupant request generation, etc. or they can be simplistic and provide minimal functionality with limited access and remedial automated processing and reporting functions.

They are typically utilized for the following:

- real estate portfolio planning
- space planning and seat assignment
- strategic planning
- furniture asset tracking
- work order–occupant request tracking
- project management
- vendor dispatching & scheduling
- facilities maintenance management
- sustainability program tracking
- report writing
- cost tracking
- purchase order tracking
- record keeping

12.4.1. Inspection and Validation

In addition to the recommended tools and systems for monitoring and maintaining the facility, it is also recommended that a program be put in place to periodically inspect, evaluate, and validate the conditions and operations of the critical space. This program *should* look at the intended basis of design (BOD) to identify gaps that have occurred through implementation, operations, or changes in conditions. The program is used to establish a baseline or to evaluate against a previously established baseline, it provides real-world verification of individual facilities as well as the opportunity to identify changes in the BOD and maintenance approach that can be implemented proactively across all sites.

