Society of Cable Telecommunications Engineers

ENGINEERING COMMITTEE

Energy Management Subcommittee

SCTE OPERATIONAL PRACTICE

SCTE 219 2015

Technical Facility Climate Optimization Methodology

NOTICE

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1. Introduction

1.1. Executive Summary

This Operational Practice is to be used by facility managers and facility design engineers to improve air flow and climate conditions in network centers. This document outlines the basic steps to conduct an assessment of the facilities existing energy efficiency and climate conditions. Recommended actions to improve air flow conditions and environmental conditions are included along with factors to consider in moving to more advanced cooling technologies such as air side and water side economizers. The document is based on industry best practices from sources such as ASHRAE, Green Grid and EU 2015 Code of Conduct.

1.2. Scope

This Operational Practice outlines how to improve cooling and airflow efficiency and provides actions that can be taken to reduce cooling energy consumption and energy costs in order to meet the SCTE 2020 Program goals.

This document contains the definition, energy measurement methodology and reporting requirements. The scope of the document shall include processes and references for the given measurement.

1.3. Benefits

Climate management of critical facilities represents an excellent opportunity for operation cost savings. Cooling in general represents approximately 1/3 of a facility's overall energy load. Over time, equipment and rack spacing, if not kept in check, and changes in equipment without consideration for climate management, could create hot spots or other airflow challenges that impact the entire facility's performance and the cost of operating the facility. Worst case, without climate management assets are at higher risk for failure and ultimately could face shorter life span.

1.4. Intended Audience

Facility design engineers, facility managers

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

This document should serve as a baseline for climate management and change actions. Next steps could include delving deeper into topics such as increasing cooling set points, centralized humidity control, modeling for air flow management, etc. To properly address these areas a short document (2-4 pages) could be added as steps to take in the process.

2. Normative References

The following documents contain provisions, which, through reference in this text, constitute provisions of this document. At the time of Subcommittee approval, the editions indicated were valid. 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.

- 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

The following SCTE standards and/or operational practices are available online. For the most recent publication of these documents listed below as well as subsequent released post publication of this operational practice please see:

http://www.scte.org/SCTE/Areas_of_Interest/Energy_Management/Energy_Standards_and_Operational_Practices/SCTE/Areas_of_Interest/SCTE_Energy_Standards_and_Operational_Practices.aspx

- SCTE 184 2015: SCTE Energy Management Operational Practices for Cable Facilities
- ANSI/SCTE 186 2012: Product Environmental Requirements for Cable Telecommunications Facilities
- ANSI/SCTE 203 2014: Product Environmental Requirements for Cable Telecommunications Facilities —Test Methods
- SCTE 210 2015: Performance Metrics for Energy Efficiency & Functional Density of Cable Data Generation, Storage, Routing, and Transport Equipment
- SCTE 211 2015: Energy Metrics for Cable Operator Access Networks
- ANSI/SCTE 212 2015: Cable Operator Energy Audit Framework and Establishment of Energy Baseline
- ANSI/SCTE 213 2015: Edge and Core Facilities Energy Metrics

3.2. Standards from Other Organizations

- ISO 50001:2011 Energy Management Systems – Requirements with guidance for use. http://www.iso.org/iso/home/standards/management-standards/iso50001.htm
- ANSI/BICSI 002-2014, Data Center Design and Implementation Best Practices https://www.bicsi.org/book_details.aspx?Book=BICSI-002-CM-14-v5&d=0

3.3. Published Materials

- The Green Grid: http://www.thegreengrid.org/
- Air-Side Free Cooling Maps: The Impact of ASHRAE 2011 Allowable Cooling Ranges. https://www.thegreengrid.org/~/media/WhitePapers/WP46UpdatedAirsideFreeCoolingMapsTheImpactofASHRAE2011AllowableRanges.pdf?lang=en
- PUE: A Comprehensive Examination of the Metric. http://www.thegreengrid.org/~/media/WhitePapers/WP49-PUE%20A%20Comprehensive%20Examination%20of%20the%20Metric_v6.pdf?lang=en
- Schneider Electric Guidance for Calculation of Efficiency (PUE) in Data Centers http://it-resource.schneider-electric.com/h/i/40161383-wp-158-guidance-for-calculation-of-efficiency-pue-in-data-centers
- Data Center Design and Operation – ASHRAE Datacom Series. https://www.ashrae.org/resources--publications/bookstore/datacom-series
- 2015 EU Data Center Code of Conduct http://iet.jrc.ec.europa.eu/energyefficiency/ict-codes-conduct/data-centres-energy-efficiency

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 weighted 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*" means that this item is truly optional. One vendor may choose to include the item because a particular marketplace requires it or because it enhances the product, for example; another vendor may omit the same item.
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

AHU	air handler unit
ASHRAE	American Society of Heating, Refrigeration and Air Conditioning Engineers
BDFB	battery distribution fuse bay
BICSI	Building Industry Consulting Service International
BAS	building automation system
BMS	building management system
CCF	cooling capacity factor
CHW	chilled water
CRAC	computer room air conditioner
CRAH	computer room air handler
CFD	computational fluid dynamics
CFM	cubic feet per minute
dPUE	designed power usage effectiveness
IT	information technology
kW	kilowatt
kWh	kilowatt hour
MERV	minimum efficiency reporting value
PDU	power distribution unit
PUE	power usage effectiveness
pPUE	partial power usage effectiveness
SCTE	Society of Cable Telecommunications Engineers
RTU	roof top unit
VFD	variable speed drive
WSE	water side economization
ΔT	delta temperature – temperature differential

5.2. Definitions

computational fluid dynamics	Branch of fluid mechanics that uses numerical analysis and algorithms to solve and analyze problems that involve fluid flows.
power distribution unit	Device fitted with multiple outputs designed to distribute electric power, especially to racks of computers and networking equipment located within a data center.
battery distribution fuse board	Secondary distribution point to distribute DC Power to network equipment.
power usage effectiveness	The ratio of particular sites total energy consumption to the IT equipment energy consumption, calculated, measured or assessed across the same time period.
designed power usage effectiveness	PUE used to define the expected PUE of a project as designed.
energy consumption	The integrated amount of power over a given time interval.
information technology equipment	Servers, optical transmitters or other devices that are supported at any facility addressed in this document
partial power usage effectiveness	PUE within a clearly defined boundary of IT Equipment and shared spaces

6. Overview

Cooling costs in network centers are typically the second highest use of energy and in some legacy network centers are the highest. Most network centers can greatly reduce cooling energy costs by implementing best operating efficiency practices that have been developed over the last few years. To determine the impact and level of improvement achieved through modifications to cooling and airflow management, measurement of current energy consumption, internal and external climate conditions and deployed IT loads must be conducted.

Continuous metering of energy levels will enable the identification of energy reductions due to modifications in facility climate conditions. Measurement and monitoring of facility climate conditions are essential to ensure proper cooling is provided to all rack mounted equipment and that at no times do inlet temperature exceed ASHRAE recommended levels.

6.1. Change Measurement Process

The following process *should* be followed to measure critical space change:

1. Establish baselines for:
   a. Power consumption on an annual basis
   b. Existing facility climate conditions
      i. Temperature
      ii. Humidity
   c. Existing IT load
   d. Peak load for prior 12 months
2. Conduct cooling audit to identify issues reducing cooling efficiency
   a. Verify controls and sensors are calibrated accurately
3. Adopt best practices as outlined in later sections of document
4. Measure changes in baselines conditions to determine
   a. Level of energy consumption change
   b. Changes in facility climate
   c. If additional changes *should* be made to further improve cooling efficiency
5. Calculate energy saving and kWh reductions

7. Baselines – Cooling Systems

Baselines must be established for existing energy usage to identify if changes made have a positive or negative impact on the facility.

Power Usage Effectiveness (PUE) is a widely accepted metric to determine overall facility energy use effectiveness in network centers by comparing energy used to power the IT load relative to the total network center energy consumed. PUE will provide a metric of energy use efficiency throughout the facility.

If PUE is used then the procedure documented in SCTE 2020 Edge and Core Facilities Energy Metric *should* be followed.

In some cases PUE *may* be too broad of a measure and a more micro measurement *may* prove to be more useful. Measuring energy use at the cooling system level will provide a metric specific to cooling energy use and will clearly identify deficiencies and changes that *should* be made to cooling systems. This will provide the necessary baseline information and changes in energy use will be more easily monitored.

Metering can be done at mechanical component level or at the electrical panel branch circuits. Metering must include all mechanical components such as CRAC unit and condenser or chiller power draw and should be logged for a minimum period of one month. Data should be logged preferably with intervals of 10 minutes or less as check points. In territories where seasonal differences can have a major impact on cooling requirements outside temperature differentials should be accounted for as it can affect cooling systems.

8. Baselines – Climate Condition

A baseline of climate conditions is required to ensure the current temperature and humidity conditions in the data center are adaptable to changes such as temperature set point increases and or humidity set point modifications. Temperature and humidity sensors must be installed throughout the network site in the cold aisle. Standalone units or a networked sensor system can be used. If the installation is permanent a networked system would be preferable.

The more data points that can be captured, the better the view of the climate conditions of the facility. Many variables such as number of racks per row, air flow distribution, varying heat densities in racks and under floor obstructions can impact the temperatures in the cold aisle and the number of sensors required. In a networked sensor application in a raised floor facility every third rack *should* have sensors with temperature probes at the top, middle and bottom of the rack. For a networked sensor application the sensors *should* be mounted on rack doors placed 2” from rack mounted equipment inlet providing a temperature profile at top, middle and bottom of rack. Raised floors *should* also have static pressure sensors under the floor to maintain a constant pressure

For a standalone sensor application, temperature measurements in the cold aisle can be used. The sensors *should* be placed in the warmest air inlet location of the rack row. Temperature measurements or thermal imaging can be used to determine the optimal location. The standalone sensors will provide one sensor point and therefore *should* be placed near the top of the rack and within 2” of the equipment inlet or on the rack doors.

In either a networked sensor application or standalone application at least one humidity sensor *should* be used per rack row.

In slab floor environment the networked sensors would be deployed in the same manner. The standalone sensors would be placed near the middle of the rack height to pick up the warmer locations. Temperature measurements or thermal imaging is useful to determine the best location

9. Baselines – IT Equipment Load

The current power draw of the IT equipment *should* be captured before any changes are made. This can most easily be determined by readings on the PDU’s or BDFB’s. The main reason for this is to determine if changes in cooling system energy consumption is attributable to changes in IT load or other factors. A second reading of these components *should* be conducted at the end of the project. If significant changes, increases or decreases in IT power draw, have occurred during the project period then this must be factored into the changes in cooling operation.

10. Cooling Audit

All aspects affecting network center cooling *should* be inspected to identify conditions that negatively affect cooling efficiency. By performing a Cooling Audit all aspects that impact the data center cooling efficiency are reviewed either through visual and physical inspections. The following key areas *should* be included in the inspection.

10.1. Mechanical Components

Check for proper operation on a regular basis by a qualified technician. Items to check include:

- All heat absorption equipment types e.g., CRAC /CRAH, Chiller units, RTUs
- Pumps (chilled water /condensers)
- All heat rejection types e.g., condensers, refrigerant supply and return piping or condenser water supply and return pipes, and cooling towers
- BMS/BAS controls
- Inspection *should* be conducted on fans belts
- Thermal imaging can identify motors or pumps that are overly hot
- Verify controls are calibrated properly

10.2. Airflow Management

In many network centers cooling issues are caused not from the lack of air available but rather the inability to deliver the cooled air to where it is needed. Air flow management is critical to efficient cooling. Obstruction in the supply air plenum such as cabling or cable trays or piping /conduit can greatly impede the air flow and misdirect the air away from perforated tiles.

A variety of methods can be used to measuring air flow at the perforated tile level. A common approach is to use a flow hood that captures the air flow (CFM – cubic feet per minute) of the perforated tile. The flow hood can be used on any perforated tile and can provide temperature and humidity conditions of the supply air. An anemometer is a hand held device that can be used to check the air flow of the perforated tile providing temperature and humidity readings as well.

Pressure sensors in a raised floor supply plenum will provide static pressure information that can be used to determine the underfloor air pressure and any disruption.

Modeling of air flow is becoming more common. Using Computational Fluid Dynamics (CFD) software the air flow patterns can be viewed and problem areas identified which cause poor cooling effectiveness. The CFD modeling provides a number of metrics related to cooling effectiveness, supply air temperature relative to ASHRAE recommendations, air bypass or air recirculation conditions as well as air flow patterns.

10.3. Visual Inspection of Equipment Layout and Placement

A visual inspection of equipment layout and placement can identify a number of issues that negatively impact cooling efficiency. Below are some of the more common areas that can be inspected.

1. Obstruction to airflow
    a. Cable trays in supply plenum
    b. Other obstructions such as conduit or water piping
    c. Overhead cable trays *should* be parallel to racks and air flow
2. Perforated Tiles
    a. Reserved for cold aisle only
    b. Placed in front of racks
3. Rack Placement

   a. Parallel to air flow
   b. Rack rows *should* be continuous with no opening between racks
   c. Front of racks at front edge of perforated tiles
4. Rack Integrity
   a. Blanking panels in all open spaces between equipment
   b. Side panels on all racks
5. Cooling System Placement
   a. Perimeter cooling equipment *should* be placed along opposite walls rather than adjacent walls
   b. Airflow *should* be parallel to rack layout
6. Room Integrity
   a. Opening in raised floor *should* be sealed
   b. Ceiling tiles *should* be in place

11. Summary of Best Practices

The following highlights the climate management industry best practices designed to improve cooling efficiency in network centers.

11.1. Environmental Conditions

11.1.1. ASHRAE Recommended temperature and humidity levels

In the latest ASHRAE publication TC 9.9 2011 the recommended and allowable inlet supply temperatures and humidity ranges for data center equipment were increased and broadened as noted in Figure 1. ASHRAE is recommending the move to the use of dew point rather than humidity. Dew point provides a more consistent measure of actual humidity in the air accounting for temperature changes. A1 to A4 includes the most commonly used equipment in network centers. Legacy equipment *may* have a lower tolerance range which *should* be verified prior to making significant changes to these settings.

Classes (a)	Equipment Environmental Specifications							
	Product Operations (b)(c)					Product Power Off (c) (d)		
	Dry-Bulb Temperature (˚F) (e) (g)	Humidity Range, non-Condensing (h) (i)	Maximum Dew Point (˚F)	Maximum Elevation (f)	Maximum Rate of Change(˚F/hr) (f)	Dry-Bulb Temperature (˚F)	Relative Humidity (%)	Maximum Dew Point (˚F)
Recommended (Applies to all A classes; individual data centers can choose to expand this range based upon the analysis described in this document)								
A1 to A4	64.4 to 80.6	41.9°F DP to 60% RH and 59°F DP						
Allowable								
A1	59 to 89.6	20 to 80% RH	62.6	10,000	9/36	41 to 113	8 to 80	80.6
A2	50 to 95	20 to 80% RH	69.8	10,000	9/36	41 to 113	8 to 80	80.6
A3	41 to 104	10.4˚F DP & 8% RH to 85% RH	75.2	10,000	9/36	41 to 113	8 to 85	80.6
A4	41 to 113	10.4˚F DP & 8% RH to 90% RH	75.2	10,000	9/36	41 to 113	8 to 90	80.6
B	41 to 95	8% RH to 80% RH	82.4	10,000	NA	41 to 113	8 to 80	84.2
C	41 to 104	8% RH to 80% RH	82.4	10,000	NA	41 to 113	8 to 80	84.2

Figure 1 - ASHRAE Temperature and Humidity Recommendations

11.1.2. Temperature Conditions

The key objective of supply air is to provide air to equipment inlets at a consistent temperature level and within the higher ends of the ASHRAE recommended levels. Inlet temperatures can vary widely due to obstructions in pathway, different temperature setting across cooling units and volume of air supplied. Implementing best practices will help keep the inlet temperatures across the facility within a narrow range. Temperature sensors *should* be used across the facility to actively monitor conditions and identify potential hot spots.

11.1.3. Humidity Conditions

ASHRAE recommended levels *should* be followed. Facility humidity conditions *should* be controlled centrally rather than at the individual cooling unit. Humidity control *should* be of ultrasonic type and installed on the fresh air make-up unit, centralized air handling unit or wall mounted. New cooling units *should* not be equipped with humidity control, including reheat capability.

11.2. Raised Floor Facilities

The following outlines best practices for raised floor facilities.

11.2.1. Airflow Management

- Blanking panels in all open rack spaces
- All racks *should* have side panels

- Grommets and brushes to close floor holes
- Perforated tiles in cold aisle only
- Perforated tiles *should* be selected based on the maximum anticipated heat load at a given ΔT. 25, 32 and 56% perforated tiles and directional air flow tiles are available
- If used, under floor cable tray placement *should* be not be placed below the perforated tiles but rather in the hot aisle
- Overhead cable trays *should* run parallel to racks
- RTUs *should* not be used in raised floor cooled facilities
- Aisle containment – *should* be considered as a sustainable option and certainly used in higher density rack rows either end row doors or full containment
- Cable management - removal of abandoned cables in supply plenum
- Minimize cables in exhaust path of racks
- Airflow supply volume *should* be slightly above IT load requirements.

11.2.2. Equipment Placement

- Rack alignment – hot aisle cold aisle
- Cooling equipment *should* be placed at the end of hot aisles and positioned to provide airflow parallel to rack rows
- No racks within 4 tiles of CRAC/CRAH unit

11.2.3. Rack Mounted Equipment

- Higher density equipment in middle of rack toward middle of row
- Side flow equipment in isolated area to prevent air mixing or baffles installed to prevent hot air flow into cold aisle
- Decommissioning program for comatose, zombie, unused equipment
- Perforated doors of at least 50% on inlet and exhaust
- No glass or solid doors on racks
- If racks are chimneyed to ceiling return plenum solid rear doors are required

11.3. Overhead Cooled Facilities

The following outlines best practices for overhead cooled facilities.

11.3.1. Airflow Management

- Blanking panels in all rack openings
- Side panels on racks
- Ducting designed to maximize air flow capacity
- Ducting directing air into cold aisle only
- Cold aisle or hot aisle containment *should* be considered for all facilities
- In dropped ceilings facilities the overhead space can be used as a return plenum to remove hot air. CRAC/CRAH/AHU units will need to be ducted into space.

11.3.2. Cable Management

- Management of cables at back of rack
- Cable trays above racks, parallel to racks
- Reference ANSI/BICSI 002-2014, *Data Center Design and Implementation Best Practices*

11.3.3. Equipment Placement

- Cold aisle hot aisle design
- CRACs placement at end of hot aisles

11.3.4. Rack mounted equipment

- Higher density equipment in middle or top of rack
- Side flow equipment in isolated area to prevent air mixing
- Decommissioning program for comatose, zombie, unused equipment
- Perforated doors of 50% inlet side of cabinet opening
- Select equipment with proper air flow for facility i.e., front to back. If side flow equipment is used ducts or baffles *should* be used to properly direct air flow.

11.4. Cooling Systems

11.4.1. Mechanical Cooling

The following provides best practices for mechanical cooling systems.

11.4.1.1. General Cooling Approaches

- Temperature set points and sensitivity range or dead-band consistent across all cooling units
- Set point dead-band *should* be at least 2-3°F
- Humidity set points and sensitivity range or dead-band common across all cooling units
- Humidity dead-band *should* be at least 5%
- Humidity can be controlled by centralized system
- Cooling *should* be implemented in a modular arrangement as rack loads increase
- 20°F delta T of supply and return air
- Regular maintenance must be conducted on cooling units and associated components
- Filters inspected and replaced on regular basis
- Use of VFDs on fans and pumps

11.4.1.2. Specific to CRAC Units

- Condition of compressors, condensers and refrigerant supply and return inspected regularly
- Adaptable to VFDs on fans
- Use of water / air side econophase units

11.4.1.3. Specific to Chilled Water Systems

- Condition of chillers, chilled water supply and return piping and condensers inspected regularly
- Use of VFDs on CRAH fans and pumps
- Two way vs three way CHW valves
- Use of water / air side economizers
- Review chilled water temperature and if possible increase to take advantage of freer cooling

11.4.2. Free Cooling Systems

Free Cooling encompasses a wide range of options available to use outside air to provide some or all of the cooling requirements of a facility. Many mechanical cooling systems have the option to use economizers or econophase systems that use the outside air to supplement the mechanical cooling system. Airside free cooling is the practice of using outside air to cool a facility instead of running mechanical cooling which can significantly reduce energy cost by limiting the run time of the mechanical cooling equipment. Depending on the climate, cable facilities are well suited to take advantage of seasonal and nighttime temperature variations to cool the space. Mechanical back-up systems *should* be installed to provide supplemental cooling during periods of outside high temperatures. Higher efficiency air filters *may* be necessary depending on ambient conditions.

Water side economizers use the evaporative cooling capacity of a cooling tower to produce chilled water and can be used instead of the chiller during the winter months. Water-side economizers are best suited in climates where the wet bulb temperature is lower than 55°F for 3,000 hours or more.

11.4.2.1. Air Side Free Cooling Systems

1. Periodic maintenance and inspection. Part of the challenge of making economizers work is recognizing that even the best design and components will eventually fail if hands-on testing and maintenance are ignored.
    a. The economizer damper, linkage and motor must be inspected regularly to ensure proper operation. HVAC systems with economizers that are not functioning properly has the potential to waste far more energy than HVAC systems without economizers.
    b. Have your HVAC technician inspect the dampers to make sure they are not stuck. A damper stuck open will cause your cooling compressor to operate harder to cool hot or humid air when typically the economizer would be disabled.
    c. Verify the linkage between the damper and the damper motor are connected and adjusted properly.
    d. Verify the control settings for the economizer are set for the maximum available economizer run time for the climate zone your facility is located in.
2. The Energy Management System (EMS) on larger HVAC systems *may* also be able to provide help in maintaining certain economizer components by reporting improperly operating dampers or actuators. For example, the EMS could be instructed to fully open and then fully close the outside-air damper each morning prior to HVAC system operation. This daily “exercise” will keep the damper from sitting in one position too long, which *may* reduce the likelihood of the damper freezing up. Also, actuators that can report their position back to the host computer can be used to determine if the control system is operating properly during different weather conditions. Finally, electronic switches can be installed on dampers to keep track of whether they are open, closed, or at some point in-between.
3. Outside air quality and filtration must be closely monitored.
    a. This prevents dust and dirt from entering the facility. In corrosive environments such as near the ocean or industrial areas, special precautions should be taken to prevent corrosive air from entering the facility.
4. Indoor air quality *should* be monitored for contaminants, temperature and humidity
5. Filters
    a. Type and MERV rating of filters determined by external air conditions
    b. Regular replacement intervals
6. Economizer operation considerations

a. High Temperature Limit Shutoff – to disable economizer mode when the outside air temperature reaches this maximum limit. This *should* be set based upon your climate zone and the type of control available on your economizer.
b. Humidity control (high and low)
c. Freeze protection – to combat losing control of environment, air dampers *should* always fail close
d. Automatic changeover from Airside to mechanical
e. Mixed air temperature control – by controlling the amount of return air and outside air being used, you can regulate the mixed air temperature. That is the mixture of outside air to air being returned from the conditioned space. This will reduce cooling requirements and prevent outside air that is too cold from harming the HVAC equipment.
f. Contaminant monitor in outside air damper recommended

11.4.2.2. Water Side Free Cooling Systems

1. Design and Installation
   a. A typical water side economizer (WSE) design *should* include a cooling tower, condenser water pump, plate and frame heat exchanger, and chiller (optional).
   b. Install the plate-frame heat exchanger in-series rather than parallel to allow for partial economization in a wide range of wet bulb conditions.
   c. The sequence of operations *should* allow for seamless transition in and out of water side economization. If a chiller is used for partial economization the WSE design *should* account for the chiller's operating parameters during low lift and low load conditions.
   d. The chilled water pumps and condenser water pumps *should* be equipped with variable speed drives.
   e. If a chiller is installed in-series with the heat exchanger to provide partial economization, the chiller *should* be equipped with a variable speed compressor to provide energy efficient operation during low load conditions.
   f. Cooling tower fans *should* be equipped with variable speed drives.
   g. Proper filtration of condenser water is required to keep the heat exchanger clean and help maintain its thermal performance. A side-stream filter or in-line filter capable of filtering the water to 500 microns (35 mesh) is recommended. If a side-stream filter used the heat exchanger's inlet *should* also be supplied with an inline strainer. The heat exchanger *should* be equipped with automatic bypass valves to allow for automatic transition in and out of free cooling. In addition, manual isolation valves on both side of the heat exchanger *should* be provided for maintenance purposes.
   h. Install differential pressure sensors, flow meters and/or temperature sensors and connect to an Energy Management System (EMS) to effectively monitor and log system performance.
   i. Since the WSE performance is heavily dependent on seasonal and outdoor ambient conditions, it is recommended the WSE be commissioned at least twice to make any necessary seasonal adjustments. On-going commissioning at least quarterly is highly recommended to ensure the WSE captures all the available free and partial economization hours.
   j. During hours when the water side economizer alone can meet chilled water set point, the flow can be bypassed around the chiller(s).
   k. The heat exchanger *should* be sized to handle the entire cooling load during the period when the WSE will be operating in 100% free cooling mode. If cooling

load changes in the future, consider adding plates to the existing heat exchanger. Another (possibly more cost-effective) option is to add another heat exchanger in lieu of adding plates.

2. Operations and Maintenance Consideration
    a. Check with the heat exchanger manufacturer to confirm the cooling tower water chemical treatment's compatibility with the plates and gaskets.
    b. Perform regular scheduled maintenance on the heat exchanger and any filtration system.
    c. Verify the accuracy of all key control devices (e.g., chilled water supply, condenser water supply, outside air temperature, humidity) at least semi-annually, especially those that are directly used to staging the WSE.
    d. Use chiller head pressure control or vary the condenser water flow using pump VFDs to ensure the chillers are sufficiently loaded during low load conditions.
    e. Insulate condenser water piping if their location is prone to high humidity
    f. Use appropriate freeze protection measures for the free cooling tower for winter operations (heat trace, basin heaters, reverse fan defrost cycle) since the bulk of the free cooling will be happening during winter months.
    g. Raising the chilled water set point from 45°F to 50°F (or higher) will increase the number of WSE operating hours and improve overall system performance. If raising the chilled water set point is not feasible, consider a chilled water reset strategy during low load conditions.

11.4.2.3. When Not to Use Economizers

It *may* not always be in a project's best interest to use an economizer. Though they can provide energy savings when functioning properly, there are circumstances that lead to economizer failures more often than not. An economizer *may* not be a reliable energy efficiency measure under the following new-construction or retrofit circumstances:

- When it is located in an especially corrosive environment (for example, close to the ocean or in a heavily industrialized region).
- When it is made from inadequate materials (for example, when upgraded economizer components are not offered, such as on smaller capacity cooling units).
- When it is capable of producing only inconsequential energy savings due to building usage or location (for example, a hot, humid climate or a manufacturing facility that requires constantly low relative humidity).
- When the economizer components will be installed in a way that makes access for regular service difficult.
- When the maintenance department is too understaffed to supply a trained technician to service an economizer system.

11.5. Facility Monitoring

Continuous metering and monitoring of facility conditions are essential to identify changes that *may* affect cooling and the ultimate operation of the facility. Increases in rack loads, installation of more cabling, removal of blanking panels, removal of ceiling tiles or perforated tiles are all everyday occurrences that can negatively impact the cooling operation of the facility.

Continuous monitoring of temperature, humidity and energy consumption *should* be conducted to avoid disaster or downtime.

During periods of change or adjustments, temperature and humidity conditions can fluctuate considerably. Continuous monitoring will identify any condition that *may* impact the operation of the facility.

12. Conclusion

One third or more of the critical facility energy load is represented by climate management. The collection of operational practices contained in this document *should* serve as a single reference point to help optimize climate management in an energy focused manner and drive the achievement of the 2014 published SCTE Energy 2020 goals.