



Learner's Guide

Labs, Data Centers, and High Tech Facilities

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Seminar: Labs, Data Centers, and High Performance Facilities

Background on the FEMP First Thursday Seminars

The **First Thursday Seminars** are designed for Federal Energy Managers but are open to anyone whose scope of responsibility involves influencing decisions to increase energy efficiency, conserve water resources, and meet other Federal sustainability goals.

There are three ways to participate in the seminars.

1. Live streaming video available on the day of the event over the internet to a desktop computer or via a projection system in a conference room;
2. Digital and Analog Satellite downlink technology for group showings; and,
3. Archived streaming video available after the event over the Internet on a desktop computer or via a projection system in a conference room.

To learn more about accessing specific seminars, access <http://www.femp.energy.gov/firstthursday>.

Introduction

The seminar “**Labs, Data Centers, and High Performance Facilities**” is being offered live on Thursday, July 7, 2011 at 1:30 pm Eastern Time. For access and other course information, [seminar’s landing page](#).

This seminar will benefit professionals seeking an introduction to the latest energy efficient measures for high performance laboratories and data centers. The seminar will last 90 minutes.

Learner Objectives

After completing this seminar, the learner will:

1. Discuss the potential benefits and cost savings potential by improving energy efficiency in labs, data centers, and high tech facilities.
2. Suggest technologies for improving energy efficiency in data centers in areas such as IT equipment, software, air management, humidity control, and free and liquid cooling.
3. Suggest technologies for improving energy efficiency in labs and high tech facilities including hoods, ventilation/air changes, and HVAC systems.
4. Discuss ways to improve energy efficiency through improved operations and maintenance.
5. Discuss FEMP tools and resources to support energy efficiency in labs, data centers, and high tech facilities.

Asking Questions

At the end of the seminar, there will be an opportunity for you to ask questions. You will be able to email, fax, or ask questions by phone. You may email or fax your questions anytime during the broadcast. You will be able to speak “live” with the instructor at the end of the presentation. The phone, fax, and email information will be posted on the screen during the seminar.

During the live broadcast, ask questions by either:

- Dialing the toll free number 800-775-3728
- Faxing questions to 865-381-0554
- Or by sending an email to FTS@energyworkshops.org.

Upon Seminar Completion

Each participant who registers for the training via FEMP Central or who signs a Roster (at a satellite broadcast location) will be sent an email with a link to the seminar evaluation and the open book quiz. If you do not have a Roster, they are [available here](#). Please sign the Roster and scan/ email to ruleb@tds.net or Fax to 865-381-0554. Upon completion of the evaluation and the open book quiz, you will be able to print a course completion certificate for your records.

Additional Materials

The materials in this section support the learning in the presentation.

Resources for Your Use

For data centers:

http://www1.eere.energy.gov/femp/program/data_center.html

For labs:

<http://www1.eere.energy.gov/femp/program/labs21.html>

Glossary of Terms

A - Amp, a unit of electrical current.

AC - Alternating Current, the designation given to power that is delivered in the form of a sinusoidal wave form. AC won out over DC as the preferred method of delivering and using power in the industrial age due to the ease of voltage transformation using static devices (transformers).

ACAE - Air Conditioning Airflow Efficiency, the amount of heat removed per standard cubic foot of airflow per minute.

AHU - Air Handling Unit.

Air Mixing - The unintended mixing of cold and hot air.

Airside Economizer - A device consisting of fans, ducting and a control which utilizes outside air directly to cool the data center when environmental conditions allow. Air is typically filtered, brought into existing distribution system and then exhausted back to the atmosphere.

Aisle - The open space between rows of racks. Best-practice dictates racks should be arranged with consistent orientation of front and back to create 'cold' and 'hot' aisles.

ASHRAE - American Society of Heating, Refrigerating and Air-Conditioning Engineers is an international technical society organized to advance the arts and sciences of air management.

Auxiliary Air Hood - A conventional fume hood that has been modified to add supplemental air. This supplemental air reduces the room's air consumption.

BACnet - A data communication protocol for building automation and control networks.

Baffle - A panel located across the back of the fume hood interior that controls the pattern of air moving through the fume hood.

Blanking Panel - A device mounted in unused U spaces in a rack that restricts recirculation airflow, also called blanking or filler plates.

BMS - Building Management System, synonymous with BAS, AMS and other computer-based tools used to manage data center assets.

BTU - British Thermal Unit, a unit of energy. 1kWh = 3412btu. Cooling equipment capacity is commonly specified in btu/hr.

Bypass Airflow - Conditioned air that does not reach computer equipment. With fixed speed fans (common in DX equipment), some bypass air is inevitable and without containment, some bypass air is prudent. Unintended bypass air can occur by escaping through cable cut-outs, holes under cabinets, misplaced perforated tiles or holes in the computer room perimeter walls.

Bypass Fume Hood - A conventional fume hood that has been modified with a compensating opening. This compensating opening maintains a constant volume exhaust regardless of sash position. It also limits the maximum face velocity when the sash is being closed.

C - Degrees Celsius. C/H - Cooling/Heating.

CAC - Cold Aisle Containment system that directs cooled air from air conditioning equipment to the inlet side of racks in a highly efficient manner.

CADE - Corporate Average Data Center Efficiency.

California Fume Hood - A rectangular enclosure to house distillation apparatus. This enclosure provides visibility from two opposing sides by means of horizontal sliding access doors mounted along the length of the assembly. When connected to an exhaust system, this enclosure contains and carries away fumes that were generated from within it.

Canopy Hood - A suspended ventilating device only used to exhaust heat, water vapor, and odors.

Capture Velocity - The fume hood face velocity necessary to contain contaminated air within the laboratory fume hood.

Combination Sash - Horizontally moving panes of glass are built into a vertically moving assembly.

Conditioned Air - Air controlled in terms of temperature, humidity, and particles per thousand.

Conventional Fume Hood - A fume hood that has no provision for airflow control, and is not used with special substance such as radioactive materials or perchloric acid. It is usually connected to a constant volume exhaust system.

CFD - Computational Fluid Dynamics, a numerical analysis technique commonly used in the analysis of airflow in data centers.

CFM - Cubic Feet per Minute, a unit of flow rate, commonly used to specify airflow.

Chilled beams - Units which, by natural convection from a finned heat exchanger, cool the air in a room.

Chiller - A unit consisting of a compressor, a condensing section and an expansion section. The condensing and expansion sections nearly always have water or glycol as the heat transfer agent to the rest of the system; primary water/glycol on the condensing side and secondary water on the expansion side.

Close-Coupled Cooling - Cooling technology that is installed adjacent to server racks, minimizing the path that air must flow from the cooling unit through the IT equipment and back to the cooling unit.

Cold Aisle - An aisle where rack fronts face into the aisle. Chilled airflow is directed into this aisle so that it can then enter the fronts of the racks in a highly efficient manner.

Cold Spot - An area where ambient air temperature is below desired levels. Typically caused by ineffective airflow management necessitating a temperature set point lower than that which would be required with proper airflow management.

Constant Air Volume (CAV) Systems - the temperature of the air supplied to the building can vary, but the air flow rate is kept constant.

Cooling panels - Cold water flows through an aluminum plate, which transfers heat from the air to the cold water. The panel cools the warm room air and also cools the rooms surfaces by low-temperature radiation.

Cooling Tower - A device which cools water via the direct evaporation of some of the water. Water is pumped into the top of the cooling tower and allowed to run down over the fill, typically pads or strips into a sump at the bottom of the cooling tower. Air is drawn in from the sides over the fill by fans in the top of the tower, evaporating some of the water which cools the remaining water. The temperature of the water in the sump is controlled by varying the speed of the fans. The water in the sump is then used to cool the condensing section of a chiller or to cool the secondary loop directly via a heat exchanger (see water side economizer).

CRAC - Computer room air conditioner (pronounced crack) which uses refrigerant and a compressor. Cooling of the air in the data center is accomplished by airflow over the evaporation coils where the refrigerant is being “directly expanded” (see DX).

CRAH - Computer Room Air Handler (pronounced craw) which uses chilled water passing through a heat exchanger to cool air flowing over the heat exchanger.

Critical Load - Computer equipment whose uptime is critical, typically supported by a UPS.

CSI - Cold Supply Infiltration index, quantifies the amount of hot air mixing with cold inlet air prior to entering the rack.

Cutout - An open area in a raised floor that allows airflow or cable feeds.

CW - Chilled Water.

DC - Direct Current, a non-time varying method of delivering power. While slightly more efficient than AC if utilized between the DC portion of the UPS and the power supplies in IT equipment, it has not won wide acceptance in modern data centers.

Dead Band - A control technique which prevents oscillation or unnecessary cycling of a controlled variable. In data center cooling, it typically applies to the action of the CRAC or CRAH relative to the set point. A certain amount of dead band around the set point prevents unnecessary cycling of the compressor or chilled water valve.

Delta T - The difference in temperature across a device. Examples include the temperature difference between the inlet and outlet of piece of IT equipment or between the inlet and outlet of a cooling unit (CRAC or CRAH). Delta T, airflow and thermal dissipation are related: $\text{thermal dissipation} = \text{airflow} \times \text{delta T} \times \text{specific heat of air}$.

Dew point - The temperature at which air reaches water vapor saturation. Dew point is constant for a specific amount of water in a specific amount of air while relative humidity varies with temperature. The latest ASHRAE spec for data center environmental conditions includes an upper limit for humidity based on dew point.

D/H - Dehumidifying/Humidifying.

Dry-Bulb Temperature - The temperature of the air measured using a dry-bulb thermometer such that evaporative cooling has no effect. Typically taken in conjunction with a wet-bulb reading which does include the evaporative cooling effect in order to determine relative humidity.

Dry Cooler - A liquid-to-air heat exchanger that is a radiator over which air is blown via fans. Typically used as the heat rejection device for water or glycol cooled condensers, may also be used as the heat rejection device for liquid cooled coils in an AHU under proper environmental conditions.

DX - An abbreviation for direct expansion. This refers to the use of refrigerant directly expanded into evaporation coils in the supply air.

F - Degrees Fahrenheit.

Ft² - Square feet, a unit of area.

Face - The front or access to a laboratory fume hood.

Face Velocity - Speed of air moving into a fume hood entrance expressed in Feet Per Minute.

Free Cooling - Used in connection with all-air cooling systems, when the cooling requirement can be met solely by outdoor air, and without a mechanical chiller. Also used to describe the process of utilizing the colder outside air to cool a building instead of operating an air conditioning unit.

Fume Hood - A four-sided enclosure with a movable sash or sashes designed to capture, contain, and exhaust fumes.

GPM - Gallons Per Minute, a unit of flow rate.

HAC - Hot Aisle Containment, system that directs heated air from the outlet side of racks to air conditioning equipment return ducts in a highly efficient manner.

Heat Exchanger - A device used to transfer heat energy from one medium to another. Common uses of heat exchangers are water to air heat exchangers in air handling units, plate and frame heat exchangers in economizers, etc.

Hot Aisle - An aisle where rack backs face into the aisle. Heated exhaust air from the equipment in the racks enters this aisle and is then directed to the CRAC return vents.

HPDC - High-Performance Data Center, a data center with above average kW loading, typically greater than 10kW/rack.

Hot Spot - An area, typically related to a rack or set of racks, where ambient air temperature is above acceptable levels. Typically caused by poor airflow management (insufficient cool air supply or an excess of recirculation).

In-Row Cooling - Cooling technology installed between racks in a row that draws warm air from the hot aisle and delivers cool air to the cold aisle, minimizing the path of the air.

Inlet Air - The air entering the referenced equipment. For air conditioning equipment this is the heated air returning to be cooled, also called return air. For racks and servers this is the cooled air entering the equipment.

kCFM - Kilo-Cubic Feet per Minute, one thousand CFM (see CFM).

kV - Kilovolt, one thousand volts, (see V).

kW - Kilowatts, one thousand watts (see W).

kWh - Kilowatt-Hour, one thousand watt hours (see Wh). kWh is a common unit of electrical energy.

kVA - Kilovolt Amperes = voltage x current (amperage) (see VA).

Latent Cooling - The process of condensing water out of air, then evaporating the water later. Energy is given up by the water during condensation. If the water is then later evaporated (such as from a drip tray), the amount of energy used to evaporate the water is the same as the amount of energy given up by the water vapor to the cooling equipment when it was condensed. Cooling is occurring later in time, hence the name “latent cooling”. In a system where condensed water is pumped or drained away, the cooling that may occur from evaporation does not cool the environment where the condensation took place so the cooling capacity spent condensing the water vapor is wasted energy.

Latent Cooling Capacity - Cooling capacity related to wet bulb temperature and objects that produce condensation.

Liner - The interior surface of a laboratory fume hood.

Liquid Cooling - A general term used to refer to cooling technology that uses a liquid evacuate heat. In data centers, the two prevalent forms of heat evacuation are liquid (chilled water) and refrigerant (DX).

Load - The demand placed on a system, typically used to describe the electrical demand on the electrical supply system or the cooling demand on the cooling system. Units are power such as kW, BTU/hr, Tons, etc.

MAH - Makeup Air Handler, an air handler that conditions and delivers outside air into an occupied space.

Make-Up Air - The conditioned air delivered by a MAU or MAH.

MAU - Makeup Air Unit, synonymous with MAH.

Maximum Temperature Rate of Change - An ASHRAE standard established to ensure stable air temperatures. The standard is 9 degrees F per hour.

MERV - Minimum Efficiency Reporting Value, ASHRAE 52.2, for air filtration measured in particulate size.

Nominal Cooling Capacity - The total cooling capacity of air conditioning equipment, includes both latent cooling and sensible cooling capacities.

Overcooling - A situation where air is cooled below optimum levels. Typically used in reference to rack inlet temperatures.

PDU - Power Distribution Unit, this typically refers to one of two pieces of equipment in the power delivery chain. One is the combination transformer/breaker panel that is often used between a UPS supplying voltage higher than that used by the IT equipment and the cabinets. The other is the smaller “power strip” like device that is used inside the rack to distribute power to the IT equipment.

Pressure Differential - The difference in pressure between two locations in the data center. Air flows from higher pressure areas to lower pressure areas. Often times, the pressure differential between the under-floor plenum and the above-floor space is controlled by varying the speed of the fans supplying air to the under-floor plenum. This allows the addition of vented floor tiles to occur without affecting the air delivered to existing vented floor tiles so that additional IT load may be placed on the floor without disturbing the tuning of the existing floor.

Plenum - A receiving chamber for air used to direct air flow.

Primary Loop - Refers to the water loop which cools the condenser side of a chiller. This loop is cooled by dry coolers or cooling towers.

PU - Packaged Unit, an air handler that is a complete device shipped ready for use rather than a custom device that is assembled on-site from components.

PUE - Power Usage Effectiveness, a measure of data center efficiency calculated by dividing the total data center energy consumption by the energy consumption of the IT computing equipment.

Rack - Device for holding IT equipment, also called a cabinet.

RAH - Recirculation Air Handler, a device that circulates air but does not cool the air.

Raised Floor - Metal flooring on stanchions that creates a plenum for airflow and cabling, synonymous with RMF.

Recirculation - Air which exits IT equipment and then re-enters either the same IT equipment or another piece of IT equipment without being cooled. Typically caused by poor control of airflow due to missing blanking panels, gaps in rows, insufficient air supply, etc.

Return Air - The heated air returning to air conditioning equipment.

Rh - Relative Humidity.

RMF - Raised Metal Floor, an alternate term for the more commonly used term 'raised floor'.

RPM - Revolutions per Minute, a unit of angular velocity.

RPP - Remote Power Panel.

RTU - Rooftop Unit, an air handler designed for outdoor use mounted on a rooftop.

SCFM - Standard Cubic Feet per Minute, the volumetric flow rate of a gas corrected to standardized conditions of temperature, pressure and relative humidity.

Sash - The movable panel(s) in the fume hood entrance.

Secondary Loop - Refers to the water which is used to cool the heat exchangers in AHUs and is cooled via the expansion unit in a chiller.

Sensible Cooling - The action of lowering the dry bulb temperature of air without condensation taking place.

Set Point - In a control system, this is the value against which the variable that is being controlled is compared. Temperature and humidity set points are common in the cooling system for a data center.

Short Cycling - Chilled airflow returning to cooling units without passing through IT equipment, also referred to as bypass.

Single Exhaust - When each fume hood is exhausted by way of its own fan and duct system.

Sub-Floor - The open area underneath a raised computer floor, also called a sub-floor plenum.

Supply Air - The cooled airflow emitted from air conditioning equipment.

Thin Provisioning - Thin Provisioning, in a shared storage environment, is a method for optimizing utilization of available storage. It relies on on-demand allocation of blocks of data versus the traditional method of allocating all the blocks up front. This methodology eliminates almost all whitespace which helps avoid the poor utilization rates, often as low as 10%, that occur in the traditional storage allocation method where large pools of storage capacity are allocated to individual servers but remain unused (not written to). This traditional model is often called “fat” or “thick” provisioning.

UPS - Uninterruptible Power Supply, a device placed in series with the supply of power from the utility which contains energy storage such that the supply of power from the UPS is continuous even when the utility supply is removed. While battery-based energy storage is the most common, flywheel-based energy storage is gaining in popularity due to the reduced maintenance cost.

V - Volt, a unit of electrical potential.

VA - Volt-Amp, a unit of apparent power. In AC circuits, the magnitude of the voltage across a circuit times the current through the circuit is the apparent power. Including a representation of the angle between the two waveforms in the form of power factor (see PF) yields the real power.

Variable Air Volume (VAV) System - A method of control that continually adjusts air flow to satisfy the changing conditions of the space.

VAV Fume Hood - A fume hood with controls that adjust the volumetric exhaust airflow rate in response to sash position changes. This adjustment in exhaust airflow maintains a constant average face velocity.

Velocity - A speed of airflow expressed in Feet Per Minute (FPM).

VFD - Variable Frequency Drive, a device which supplies AC power of varying frequency, typically used to control the speed of induction motors. In the data center, it is common to vary the speed of fans, pumps, and chillers.

Volumetric Air Flow - The volume and speed of air being transported; expressed in Cubic Feet per Minute.

W - Watt, a unit of power, commonly used in electrical discussion, watts are the product of potential (volts, see V) and current (amps, see A). If the current and voltage are AC, the relationship between watts, volts and amps includes power factor (see PF), $\text{watts} = \text{volts} \times \text{amps} \times \text{PF}$.

Waterside Economizer - A system which uses a source other than a chiller to cool the secondary loop water used by the AHUs. This typically consists of either a dry cooler or cooling tower, piping, valves and in the case of a cooling tower, it also includes a heat exchanger since the secondary loop water is treated completely differently than the primary loop water and is typically much “better” water.

Wet-Bulb Temperature - The temperature of the air measured using a wet-bulb thermometer, that is, the temperature to which a wet surface can be cooled by evaporation. This temperature is affected by both the dry bulb temperature and the dew point of the air. Dryer air has a lower wet bulb temperature. This is a design constraint when utilizing cooling towers or evaporative pads in the cooling process.

Wg - Inches of water column, a unit of pressure based on the height of a column of water supported by the pressure differential between the top and bottom of the column. 1 inch wg = .036 psi.

WPSF - Watts per Square Foot, a unit of power density. In a data center this is a bulk term that refers to the total load in a particular space divided by the total area of that space. This is a design parameter for total capacity of the cooling and power systems and is used in conjunction with point load (the amount of load in a small space such as a rack).