FEMP
Federal Energy Management Program

# Recommendation For Incorporating Data Center Specific Sustainability Best Practices into EO13514 Implementation

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U.S. Department of Energy
Energy Efficiency and Renewable Energy

## INDEX

# 1 Introduction

## 1.1 Background

On October 5, 2009, President Obama signed Executive Order (EO) 13514 to establish an integrated strategy towards sustainability in the Federal government and to make reduction of greenhouse gas (GHG) emissions a priority for Federal agencies.

Section 8 of the EO requires each agency to “develop, implement, and annually update an integrated Strategic Sustainability Performance Plan that will prioritize agency actions based on lifecycle return on investment.” The President’s Council on Environmental Quality (CEQ) and the Office of Management and Budget (OMB) have jointly developed guidance and template for the agency sustainability. The template establishes goals for Electronic Stewardship and Data Centers (Section 9).

Guiding Principles are identified by the OMB’s Memorandum of Understanding published in early 2006. They are:
Employ Integrated Design Principles
Optimize Energy Performance
Protect and Conserve Water
Enhance Indoor Environmental Quality
Reduce Environmental Impact of Materials

In addition The Energy Independence and Security Act of 2007 (EISA 2007) established energy management goals and requirements while also amending portions of the National Energy Conservation Policy Act (NECPA). It was signed into law on December 19, 2007.

It should be noted that the projects shall meet the energy efficiency requirements for the new federal data centers, specifically to comply with Executive Order (EO) 13423 and EPACT 2005. The new construction energy efficiency requirements in EPACT 2005 /10 CFR 433 are less stringent than the requirements for EO13423. Therefore new buildings that meet the savings requirements of EO13423 will automatically be in compliance with the savings requirements in EPACT 2005/ 10 CFR 433.

## 1.2 Purpose of this document

The purpose of this document is to provide guidance on incorporating data center sustainability measures pertaining to specific agency sustainability plans. The energy use reduction directly correlates with the greenhouse gas emission. Although the amount of greenhouse gas emission depends on the source of energy (i.e. coal, natural gas, hydro etc) but any reduction in energy use will reduce the greenhouse gas emission by some measure. The sustainability plan draws on resources developed by the energy consumption reduction best practices as well as other sources where appropriate. The recommendation in this document should assist the agency sustainability plans, following the CEQ-OMB template. Power management, moving to Cloud, monitoring of the power use, overall reduction of number of the data centers, use of EnergyStar IT equipment, increase of utilization of IT equipment, virtualization and finally reducing energy use to achieve PUE of less than 1.5 are the highlights of the requirements.

| ELECTRONIC STEWARDHIP & DATA CENTERS | Units | FY 10 | FY 11 | FY 12 | FY 13 |
|---|---|---|---|---|---|
| % of device types covered by current Energy Star specifications that must be energy-star qualified | % | ? | 90% | 95% | hold |
| % of cloud activity hosted in a data center | % | ? | 30% | 60% | hold |
| % of agency data centers independently metered or advanced metered and monitored on a weekly basis | % | ? | 90% | 100% | hold |
| Reduction in the number of agency data centers | % | ? | 20% | 40% | hold |
| % of agency, eligible electronic products with power management and other energy-environmentally preferable features (duplexing) actively implemented and in use | % | ? | 95% | 100% | hold |
| % of agency data centers operating at an average bandwidth utilization of 85% | % | ? | 33% | 50% | hold |
| % of agency data centers operating with an average CPU utilization of 60-70% | % | ? | 50% | 75% | hold |
| % of agency data centers operating at a PUE range of 1.3 – 1.6 | % | ? | 25% | 50% | hold |
| % of covered electronic product acquisitions that are EPEAT-registered | % | ? | 95% | 95% | hold |
| % of agency data center activity implemented via virtualization | % | ? | 30% | 40% | hold |
| Other, as defined by agency | ? | ? | ? | ? | ? |

This document also lists additional resources for technical information on these strategies.

### 1.3 Impact summary

Data centers consume 10-100 times more power than a typical office building therefore there are ample opportunities for energy savings. This document addresses many of the strategiess along with their energy savings.

## 2 Electronic Stewardship and Data Centers

Template Section 9, Paragraph d indicates that “Goals should identify how the agency intends to meet technology energy consumption reduction goals in its data centers.” This section will identify strategies for reducing data center energy consumption.
The following figure shows a breakdown of power use in a typical data center. Knowing what system consumes what percent of the total energy will help the stake holder to better plan strategies for energy use reduction.

Average Data Center Power Allocation

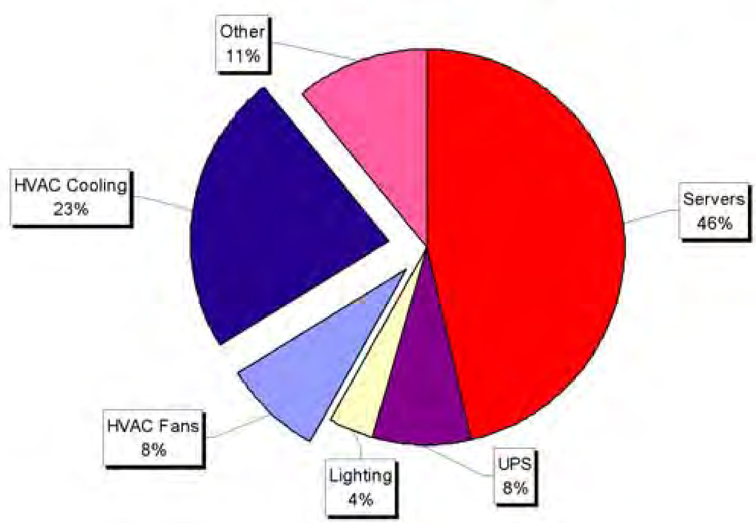


**Figure 1- Average Data Center Power Allocation**

Components of energy pie are:

- HVAC cooling: chillers, pumps, dry coolers, condensers, and/or cooling towers
- HVAC fans: fan energy in air handling equipment
- Lighting: space lighting
- UPS: uninterruptible power supply equipment losses
- Servers: IT equipment (servers, storage, I/O, and networking equipment)
- Other: a catch-all term for all items that do not fall into the above categories including electrical power chain losses

## 2.1 Data Center Energy Use Reduction Strategies for Existing Buildings

Following are the strategies that can assist an agency to meet the reportable percentage of improvements required by EO.

### 2.1.1 Measure, Analyze and Benchmark Datacom Facility Efficiency

Measurement of energy use through monitoring in data center is very important. This will facilitate benchmarking, understanding of system energy inefficiencies and their level of impact. Some inefficiencies result from unplanned part loading of the cooling equipment, improper operation of redundant units, poor sequence of operations, and inadequate scheduled maintenance (i.e. replacing filters, etc). Measurements and interpreting their results helps to pinpoint the most significant sources of energy inefficiencies.

Impact Summary:

Monitoring can impact the energy and cost saving when energy efficiency measures explored as the result of monitoring and implemented. So no energy saving is expected just by monitoring. The level of energy saved varies depending on what is implemented. Cost of running DCPro is around $5,000. Assessment can run as high as $30,000. Deployment of continuous monitoring, specially PUE can cost $75,000 for a typical 500kW IT power use data center

Strategies Summary:

- Use DCPro for profiling
- Perform assessments and audits for engineering of improvements
- Deploy continuous monitoring, specially PUE
- Continuous monitoring is essential to control and improvement of a system

Note: Refer to ASHRAE TC9.9 Datacom book, Real-Time Energy Consumption Measurements in Data Centers

### 2.1.2 Plan for Virtualization and Consolidation

Virtualization is a cost-effective and energy-efficient way to run two or more virtual computing environments, that is, running different operating systems and applications on the same physical hardware. It decouples the user from the physical hardware by providing a virtual system for the user. The physical hardware (made up of processor, memory, and storage resources) are divided into smaller granularities that allow multiple virtual machines to operate simultaneously. Virtualization benefits datacom users by providing flexibility, power management, and scalability. Virtualization provides a way to consolidate applications on a single shared physical system. The savings come in reduced IT power since fewer machines are required to run the applications, and reduced cooling due to reduction in operating IT hardware. Some overhead is required to implement the virtualization through hypervisors, but this is minimal compared to the gain that can be achieved through virtualization.

Impact Summary:

Estimated cost of virtualization is $4,000 to $5,000 per application. Typical simple payback is 1.5years.

Strategies Summary:

- Plan for virtualization. This will eliminate 50-80% of hardware and proportionally increase the loading of servers and increase the efficiency
- Consolidate applications on less equipment reduces IT energy use and cooling energy in support of the IT systems
- Turn off unused equipment
- Possible licensing cost

Note: Refer to ASHRAE TC9.9 Datacom book, Best Practice for Datacom Facility for Energy Efficiency, Section 8.

### 2.1.3 Separate Cold and Hot Air

Separation of cold and hot aisles helps to isolate the supply and return airstreams, thus preventing mixing of hot and cold air. As a result, the airflow rate required to meet the cooling load can be reduced, thus saving air handler fan power. In addition, provision of an overhead ceiling plenum return can provide a separate isolated path for the hot return air. If local air handlers (CRAH/CRAC) are used, alignment of units at the end of the hot aisle also provide an easy path for hot return air back to the air conditioner and can avoid direct short-circuiting of cold air from cold aisles.

Impact Summary:

Usually this set of strategies does not cost much. Depending on data center state, cost can be $5-$15 per square foot. Simple payback can be as low as few months and usually is below 2years.

Strategies Summary:

- Prevent recirculation of hot air and bypass of cold supply air by installing blanking panels at all open rack locations and within racks
- Seal all the penetrations through the tiles
- Use return air plenums and duct the returns of cooling units to draw the warmest air from the top of the space.
- Install airflow barriers such as hot aisle / cold aisle containment to reduce mixing of hot exhaust air with cooler room air
- Seal openings in ceilings and raised floors.

Note: Refer to ASHRAE TC9.9 Datacom book, Best Practice for Datacom Facility for Energy Efficiency

### 2.1.4 Replace Constant Speed Motors with VFDs for Pumps and Fans

With proper control, running pumps and fans with VFD will reduce energy use drastically while system is not fully loaded.

Impact Summary:

Installed cost of a VFD for CRAH is between $5,000 and $8,000 per unit. This strategy, especially in data center with more than 6 CRAH units and mostly air cooled IT equipment can result in very attractive simple payback. In data center with 2N redundancy requirement, this will deliver fantastic energy saving results. CRAH fans are responsible for about 7% of total energy use in a typical data center. Cutting the air flow in half in each unit will cut energy use by about 1/8. So CRAH energy use is dropped by about 66% which results in a saving of 5 Watts/ square feet, or 44 kWh/year-sf. With respect to total data center energy use, this is a reduction of 5%.

Strategies Summary:

- Control quantity of supply air based on static pressure in the supply air plenum if CRAC/CRAH units have VFDs or VFDs are planned to be installed
- In this case all cooling units are run with one central signal
- Reset the pressure setpoint based on the highest temperature readings of the racks

Note: Refer to ASHRAE TC9.9 Datacom book, Best Practice for Datacom Facility for Energy Efficiency, Chapter 3

### 2.1.5 Improve Air Management

The choice of cooling system directly affects energy consumption through fan power (the energy required to deliver cooling air to and capture warm exhaust air from equipment) and cooling power (the power required to cool the warm rack exhaust air back to the required supply temperature). With fan power, the greater the pressure drop the fan must overcome, the greater the energy consumption. With cooling power, within some practical limits, the greater the degree of separation between the cool supply and the warm return streams, the greater the operating efficiency of the cooling units. The dimensionless indices return temperature index (RTI) and rack cooling index (RCI) calculated during data center assessment or estimated by DC Pro Air Management Assessment Tool quantify the degree to which the cold and hot streams are separated from one another

Impact Summary:

These strategies provide data. Actual savings come from energy efficiency measures explored using the data.

Strategies Summary:

- Measure temperature at intake and discharge of each rack or at list one out of three racks in different elevations for monitoring.
- Calculate RCI and RTI using DCPro Air Management Spreadsheet and/or actual measurement.

Note: Refer to ASHRAE TC9.9 Datacom book, Thermal Guidelines for Data Processing Equipment

### 2.1.6 Server Intake Air Temperature and Humidity

It is important to know the real cooling requirement of datacom equipment. Consult with the IT equipment manufacturer to negotiate the actual suitable temperature for reliable operation. There are more opportunities for energy savings with higher IT equipment intake air temperatures.

Impact Summary:

These strategies usually are implemented after implementation of monitoring. There is no cost associated with them except for programming. The impact on saving can be great. For example, for a data center located in a mild climate (Denver, Colorado), increasing intake air temperature by 10$^{o}$F (from 60$^{o}$F to 70$^{o}$F) can result in 1,300 hours of additional free cooling with a saving of 11 kWh/Year-sf. With respect to total data center energy use, this is a reduction of 1.25%.

Strategies Summary:

- Understand the actual tolerable conditions of IT Equipment
- Raise cooling air supply temperature to increase energy use efficiency while satisfying the needs of IT equipment
- Economizer (air, water, or adiabatic) hours will increase by increasing air supply temperature
- Be aware of ASHRAE recommended and allowable conditions
- Most datacom equipment do not require humidity control except for extreme conditions. Disable humidification components of the data center air handling units. If control of humidity is required, treat only the ventilation air.

Note: Refer to ASHRAE TC9.9 Datacom book, Datacom Equipment Power Trends and Cooling Applications, Chapter 4

### 2.1.7 Increase the Chilled Water Supply Temperature (CHWST)

The thermodynamic efficiency of a chiller is sensitive to the difference in temperature between the chilled water and the condenser water. Chiller efficiency can increase dramatically if this differential temperature is lowered.

Impact Summary:

For a constant speed chiller, increasing chilled water supply temperature from 44$^{o}$F to 60$^{o}$F will reduce the power use from 0.63kW/ton to 0.4kW/ton. This is equal to 50 kWh/Year-sf energy saving. With respect to total data center energy use, this is a reduction of 5.7%.

Strategies Summary:

- Based on increased cooling air supply temperature, increase the chilled water supply temperature to improve chiller efficiency. For each degree Fahrenheit CHWST increase, chiller efficiency improves approximately 1-1.5%.
- Water Economizer hours will increase by increasing CHWS temperature

Note: Refer to ASHRAE TC9.9 Datacom book, Best Practice for Datacom Facility for Energy Efficiency, Chapter 4

### 2.1.8 Consider Localized Cooling For High Density Areas

A conventional air cooled datacenter is usually controlled to maintain the same temperature throughout the data center. When load densities are different from one rack to the other, this will cause over cooling and waste of energy. Localized cooling is a solution and it can be accomplished by zoning and controlling air flow to different zones. If the load density is so high that cooling cannot be practically and efficiently provided by the existing system, local cooling should be installed. Examples of how local cooling can be provided are an auxiliary cooling coil on the back of the rack, over head or rack mounted refrigerant cooling unit, in-row. Localized cooling will save the energy otherwise used to overcool parts of a data center just to accommodate a high density area.

Impact Summary:

This strategy is very specific to data center layout and equipment diversity. Benefit of retrofit will be much more if a data center has only one cooling system and only small part of it houses a high density computing system.

Strategies Summary:

- Create different load zones and control air flow to different zones independently.
- Local cooling can be provided by auxiliary cooling coil on the back of the rack, over head or rack mounted refrigerant cooling unit, etc.

Note: Refer to ASHRAE TC9.9 Datacom book, Best Practice for Datacom Facility for Energy Efficiency, Chapter 4

### 2.1.9 Replace existing electrical equipment with high efficient ones, use modular system

Legacy electrical power equipment including Uninterruptable Power Supply Unit (UPS), transformer including that in Power Distribution Unit (PDU), and server power supply (PS) can be inefficient.

Impact Summary:

Replacing these equipments with the more efficient units will save energy since power loss is about 10% of the total energy use in a typical data center. 50% reduction in power chain loss by utilizing high efficiency components and planning for modularity to be able to increase load factor(percent loading) can save 44 kWh/Year-sf. With respect to total data center energy use, this is a reduction of 5%.

Strategies Summary:

- Replace existing equipment with more efficient equipment such as EnergyStar certified equipment
- Refer to ASHRAE TC9.9 Datacom book, Datacom Equipment Power Trends and Cooling Applications, Chapter 3

Note: Refer to ASHRAE TC9.9 Datacom book, Best Practice for Datacom Facility for Energy Efficiency, Chapter 8,11

### 2.1.10 Improve Lighting System

Lighting is a small portion of total energy use in a data center (2%), but since it takes minimum effort and capital to convert it to a more efficient system, it is highly recommended to address lighting efficiency.

Impact Summary:

With the cost of an occupancy sensors system, 5 kWh/Year-sf energy can be saved. With respect to total data center energy use, this is a reduction of 0.6%.

Strategies Summary:

- Replace lighting fixtures with more efficient alternatives
- Switch off lights in unused / unoccupied areas or rooms (UPS, Battery, Switchgear, etc.).
- Deploy lighting controls such as occupancy sensors
- Refer to ASHRAE TC9.9 Datacom book, Datacom Equipment Power Trends and Cooling Applications, Chapter 4

Note: Refer to ASHRAE TC9.9 Datacom book, Best Practice for Datacom Facility for Energy Efficiency, Chapter 8,11

## 2.2 Data Center Energy Use Reduction Strategies for New Building and Major Retrofit

Following are the strategies that can assist an agency to meet the reportable percentage of improvements required by EO.

### 2.2.1 Utilize virtualized high density datacom equipment

Virtualization enables data center owners to install only 20-50% of the hardware that otherwise would have been required and proportionally increase the loading of servers and increase the predicted efficiency of the datacom equipment as well as cooling systems. High density equipment needs more cooling in a smaller foot print. While this potentially increases cooling system efficiencies, the potential limitation of air cooling for a high load density application needs to be considered. Application of liquid cooling should be investigated as an alternative to standard air-based cooling.

Impact Summary:

Estimated cost of virtualization is $4,000 to $5,000 per application. Typical simple payback is 1.5years.

Strategies Summary:

- Make virtualization the backbone of datacom design

Note: Refer to ASHRAE TC9.9 Datacom book, Best Practice for Datacom Facility for Energy Efficiency, Section 8.4.7

### 2.2.2 Utilize Manufacturer's Measured Power / Thermal Data

Generally the name plates are used in calculation of datacom equipment power requirement. This practice is the main reason for oversized and inefficient cooling systems in legacy data centers. By utilizing the measured numbers a more efficient power distribution chain and cooling system with lower CTO will result.

Impact Summary:

If a 20% over sizing can be avoided because of following this strategy, efficiency of electrical components that otherwise would be lightly loaded will increase. A 5% increase in power components efficiency is equal to 20 kWh/year-sf energy saving. With respect to total data center energy use, this is a reduction of 2.3%.

Strategies Summary:

- Utilize Manufacturer's Measured Power / Thermal Data in lieu of the equipment nameplates

Note: Refer to ASHRAE TC9.9 Datacom book, Thermal Guidelines for Data Processing Equipment

### 2.2.3 Design for Implementation and separation of Cold and Hot Air

Separation of cold and hot aisles help in keeping the two airstreams separated without mixing. In addition, provision of an overhead ceiling plenum return can provide a separate isolated path for the hot return air. Central air handler units in lieu of local units are strongly recommended. Local air handlers (CRAH/CRAC) can be used effectively deployed provided that the alignment of the units at the end of the hot aisle provide an easy path for hot return air back to the air conditioner; thus avoiding recirculation of hot air to the cold aisles.

Impact Summary:

Depending on data center state, cost can be $5-$15 per square foot. Simple payback can be as low as few months and usually is below 2years.

Strategies Summary:

- Design for contained cold or hot aisles

Note: Refer to ASHRAE TC9.9 Datacom book, Best Practice for Datacom Facility for Energy Efficiency

### 2.2.4 Investigate Each Cooling Component for Improved Efficiency

Considering that data center cooling equipment uses about one third of the total power in a typical data center, selection of efficient cooling equipment can reduce the energy use substantially.

Impact Summary:

A magnetic levitation chiller for example is about 10%-15% more efficient than a conventional chiller. This would result in 17 kWh/year-sf energy saving. With respect to total data center energy use, this is a reduction of 11%.

Strategies Summary:

- Install Energystar certified equipment if applicable
- Provide Minimum COP requirements to the bidders/contractors

Note: Refer to ASHRAE TC9.9 Datacom book, Best Practice for Datacom Facility for Energy Efficiency, Chapters 3 and 5

Note: Refer to EnergyStar list of certified equipment/manufacturers

### 2.2.5 Optimized Air Management

The choice of cooling system architecture directly affects energy consumption through fan power (the energy required to deliver cooling air to and capture warm exhaust air from equipment) and cooling power (the power required to cool the warm rack exhaust air back to the required supply temperature). With fan power, the greater the pressure drop the fan must overcome, the greater the energy consumption. With cooling power, within some practical limits, the greater the degree of separation between the cool supply and the warm return streams, the greater the operating efficiency of the cooling units. The DCPro air management tool dimensionless indices return temperature index (RTI) and rack cooling index (RCI) quantify the degree to which the cold and hot streams are separated from one another and effective delivery of the required air temperature to the IT equipment inlets.

Impact Summary:

Depending on data center state, cost can be $5-$10 per square foot. Simple payback based on implementation of energy efficiency measures resulted from the studies can be as low as few months and usually is below 2years.

Strategies Summary:

- Simulate air flow in the data center using CFD (Computational Fluid Dynamics) or granular monitoring systems to optimize cooling air delivery to the IT equipment.

Note: Refer to ASHRAE TC9.9 Datacom book, Thermal Guidelines for Data Processing Equipment

### 2.2.6 Utilize Economizers to Save Energy

Air-side economizing is the utilization of outdoor air under certain conditions to allow chillers and/or other mechanical cooling equipment to be shut off or operated at reduced load. Operating in an economizer mode is often also known as “free cooling.” There are a number of different ways to achieve free cooling, and applicability to a specific project is a function of climate, codes, performance, and preference. Data centers differ from office environments in:

- The higher cooling load densities which do not vary with ambient air conditions,
- Less need for humidification control,
- The potential in some centers to provide higher supply air temperatures, which can, in turn, increase economizer cycle hours on an annual basis.

Air-side economizer (uses outdoor air for air cooling) can be used if the outdoor temperature is less than that of supply air set point for temperature. An enhancement of an air-side economizer is an adiabatic air-side economizer which increases the number of hours of free cooling. In this case water spray is used for cooling of supply air. Water use and water treatment needs to be considered in design. Water-side economizers use low outdoor temperature to cool cooling water. This application might be in the form of direct use of the cooled water such as in liquid cooling of the datacom equipment or in an indirect form through use of a heat exchanger. If humidification control is used in the data center, adiabatic air-side economizer might be used. A high dewpoint temperature lockout to minimize humidification energy should be considered in this case. Conventional electric-based humidifiers can increase overall energy use in some climate zones when air-side economizers are used without low dewpoint temperature lockout.

Impact Summary:

Case studies of 12 data centers by LBNL found that the cooling plant accounted for an average of 23% of the total energy consumption of a datacom facility (Fig. 1). A 15% reduction in total energy use based on 6,750 hours operation of airside economizer in a year saves as much as 130kW/year-sf.

Strategies Summary:

- Design for air-side economizer (uses outdoor air for air cooling)
- An enhancement of an air-side economizer is an adiabatic air-side economizer which increases the number of hours of free cooling.(uses water spray for cooling supply air) or
- Design for water-side economizer
- Design for direct cooling tower water use or water-side economizer if liquid cooling is employed for datacom equipment cooling
- Most datacom equipments do not require humidity control except for extreme conditions. If control of humidity is required, treat only the ventilation air.

- If humidification control is used in the data center, use adiabatic air-side economizer and a high dewpoint temperature lockout

Note: Refer to ASHRAE TC9.9 Datacom book, Best Practice for Datacom Facility for Energy Efficiency, Chapter 3

### 2.2.7 Inlet Air condition is Most Important for IT Equipment

ASHRAE recommended and allowable conditions are published in the TC9.9 Datacom Book, Best Practices for Datacom Facility Energy Efficiency. Request should be made to the manufacturer of equipment for the actual tolerable conditions under which their equipment can operate reliably. There is a good chance that their requirement is even more relaxed than ASHRAE numbers.

Impact Summary:

For each degree of intake air temperature, there is a possibility to increase the chilled water supply temperature setpoint by one degree. That will increase chiller efficiency by 1-1.5%. At the same time, if economizer is being utilized, the number of hours of compressorless cooling is increased by 100-150 hours for a site in mild climate. These improvements will result in 4kW/year-sf of saved energy. With respect to total data center energy use, this is a reduction of 0.5%.

Strategies Summary:

- Design and select datacom cooling equipment to actual reliable conditions

Note: Refer to ASHRAE TC9.9 Datacom book, Datacom Equipment Power Trends and Cooling Applications, Chapter 3

Note: Refer to ASHRAE TC9.9 Datacom book, Best Practices for Datacom Facility Energy Efficiency, Page 19

### 2.2.8 Deploy Highly Efficient Electric Power Components

About 8-13% of total energy use in a data center is due to losses in electrical power chain equipment. Conventional electrical power chain includes but not limited to switch gear, Uninterruptable Power Supply Unit (UPS), transformer including that in a Power Distribution Unit (PDU), and server power supply (PSU). Acquire rated power and efficiencies during design for efficient power chain. Since power conversion is one of the main reasons for power energy loss, consider those alternates with minimum voltage conversions.

Impact Summary:

Legacy electrical components power loss is about 10-13% of the total energy use in a typical data center. 50% reduction in power chain loss by utilizing high efficiency components and planning for modularity to be able to increase load factor (percent loading) can save 44 kWh/Year-sf. With respect to total data center energy use, this is a reduction of 5%.

Strategies Summary:

- Utilize EnergyStar certified equipment

- Require manufacturer tested ratings during design

Note: Refer to ASHRAE TC9.9 Datacom book, Datacom Equipment Power Trends and Cooling Applications, Chapter 3
Note: Refer to ASHRAE TC9.9 Datacom book, Best Practice for Datacom Facility for Energy Efficiency, Chapter 8,11

### 2.2.9 Right sizing of the components.

The efficiencies of electrical power chain components suffer when they operate in partial load.
Redundancy should be used only up to the required level; there may be an efficiency penalty for additional redundancy because of reduced loading on each operating component. Mechanical system efficiency on the other hand might not be as negatively impacted by part load operation. Use of VFD in chillers, pumps and fans can actually improve efficiency of mechanical equipment if they are sized correctly.

Impact Summary:

Legacy electrical components power loss is about 10-13% of the total energy use in a typical data center. BY right sizing, efficiency can improve as much as 4% of total energy use (loading UPS up to 70% instead of normal 30%). Reduction in power loss can save 35 kWh/Year-sf. With respect to total data center energy use, this is a reduction of 4%.

Strategies Summary:

- Right size the electrical and mechanical components considering start up load and future upgrades while designing data center
- Redundancy should be used only up to the required level and only based on real need and tier level of the data center

Note: Refer to ASHRAE TC9.9 Datacom book, Datacom Equipment Power Trends and Cooling Applications, Chapter 3
Note: Refer to ASHRAE TC9.9 Datacom book, Best Practice for Datacom Facility for Energy Efficiency, Chapter 8, 11

### 2.2.10 Liquid Cooling

Direct liquid cooling refers to a number of different cooling approaches that all share the same characteristic of transferring waste heat to a fluid at or very near the point the heat is generated, rather than transferring it to room air and then conditioning the room air. With high rack heat loads, many data centers are experiencing difficulty in cost-effectively meeting datacom equipment's required inlet air temperatures and airflow rates. Therefore, more and more facilities are considering design for liquid cooling of the racks. While the initial rationale for liquid cooling has been to improve cooling and compaction, liquid cooling can also reduce the energy consumption of the "HVAC Cooling" and "HVAC Fans" components because transferring heat close to the source allows for hotter fluid temperatures and therefore higher cooling efficiencies due to higher heat rejection effectiveness to ambient air. Together, these two slices represent 31% of the energy consumption in an "average" datacom facility.

A liquid-cooled rack/cabinet defines the case where liquid must be circulated to and from the rack or cabinet for operation. This definition can be expanded to liquid-cooled datacom equipment and liquid-cooled electronics. An example is a rack with a back door heat exchanger. Cool room air enters the front of the cabinet, absorbs heat as it passes over the electronics, then it passes through the heat exchanger in the rear door before it exits. In this scenario the liquid is removing some or all of the heat from the rack/cabinet and relieving the load on the room air-conditioning system.

Impact Summary:

Liquid cooling can eliminate fan power use (normally 7% loss of total energy) and minimize or even eliminate compressor cooling. To calculate the saving, it is assumed that cooling energy use is reduced from normally 23% to 7%. This provide a total of 23% of total energy used saving of about 200 kW/year-sf.

Strategies Summary:

- Deploy liquid cooling in lieu or as complement to air cooling

Note: Refer to ASHRAE TC9.9 Datacom book, Best Practice for Datacom Facility for Energy Efficiency, Chapter 9

### 2.2.11 Select Motors with VFDs for chillers, Pumps and Fans

Running chillers, pumps and fans with VFD will reduce energy use drastically while system is not fully loaded. The capital cost of a chiller with a VFD drive is greater, but the significant increase in part-load efficiency possible with the VFD drive will pay for additional cost. Based on fan laws, the power use is proportional to the cube of the fan speed. This means reducing fan flow by half, fan speed will be reduced by half and power use is reduced close to 1/8.

Impact Summary:

CRAHs equipped with electronically commutated motor (ECM) and VFD are about $5,000 more expensive than the conventional motors. CRAH fans are responsible for about 7% of total energy use in a typical data center. Cutting the air flow in half in each unit will cut energy by about 1/8. So CRAH energy use is dropped by 66% which results in a saving of 5 Watts/ square feet, or 44kWh/year-sf. With respect to total data center energy use, this is a reduction of 5%.

Strategies Summary:

- Select Motors with VFDs for chillers, Pumps and Fans

Note: Refer to ASHRAE TC9.9 Datacom book, Best Practice for Datacom Facility for Energy Efficiency, Chapter 3

### 2.2.12 Plan for Optimized Chilled Water Plant Operation

Warmer chilled water temperatures and/or colder condenser water temperatures lower the lift and therefore chiller power use. Primary-Only Variable Flow pumping instead of constant primary, variable secondary pumping saves energy because fewer pumps are in operation and pumping is done only as much as needed. Proper control of VFD is required.

Impact Summary:

A 20% improvement in chilled water plant energy use delivers 40kWh/year-sf of saved energy. With respect to total data center energy use, this is a reduction of 4.5%.

Strategies Summary:

- Increase chilled water temperatures, reduce condenser water temperatures to lower the lift and therefore chiller power.
- Select Primary-Only Variable Flow pumping instead of constant primary, variable secondary pumping.
- Select more advanced optimization strategies like implementing Hartman Loop controls.

2.2.13 Use DC Powered Systems

Every power conversion (AC-DC, DC-AC, AC-AC, DC-DC) decreases overall efficiency and creates heat. Distributing DC power can eliminate several stages of power conversion, saving energy to the IT equipment and cooling. DC power distribution can have a lower capital cost. Experience with DC Power in US is limited and extensive feasibility study before commitment to DC power distribution is recommended.

Impact Summary:

If the loss in electrical power chain reduced by 30% since conversions are eliminated, a saving of 35 kWh/year-sf can be achieved. With respect to total data center energy use, this is a reduction of 4%.

Strategies Summary:

- Utilize DC powered equipment and distribution
- Use DC for lighting & variable speed drives to further improve efficiency.

Note: Refer to ASHRAE TC9.9 Datacom book, Datacom Equipment Power Trends and Cooling Applications, Chapter 4

Note: Refer to ASHRAE TC9.9 Datacom book, Best Practice for Datacom Facility for Energy Efficiency, Chapter 8,11

2.2.14 Distribute high voltage AC power to the point of use.

Every power transformation decreases overall efficiency and creates heat. Also, high voltage means less copper and with less copper, less energy is wasted.

Impact Summary:

If the loss in electrical power chain reduced by 15% since transformations are eliminated and less heat is generated with less copper, a saving of 18 kWh/year-sf can be achieved.

Strategies Summary:

- Distribute high voltage AC or DC power to the point of use

Note: Refer to ASHRAE TC9.9 Datacom book, Datacom Equipment Power Trends and Cooling Applications Chap. 4
Note: Refer to ASHRAE TC9.9 Datacom book, Best Practice for Datacom Facility for Energy Efficiency, Chapter 8,11

### 2.2.15 Improve Lighting System

Lighting is a small portion of total energy use in a data center (about 2%), but saving by designing an efficient lighting system will lower the CTO. Layout, intensity, and control have major impact on energy use and should be considered in design.

Impact Summary:

An efficient lighting system can reduce the energy use by 75%. That translates to 8 kWh/year-sf of saved energy. With respect to total data center energy use, this is a reduction of 0.9%.

Strategies Summary:

- Design for automatic switch off for lights in unused / unoccupied areas or rooms (UPS, Battery, Switchgear, etc.).
- Lighting controls such as occupancy sensors are well proven.

Note: Refer to ASHRAE TC9.9 Datacom book, Datacom Equipment Power Trends and Cooling Applications, Chapter 4
Note: Refer to ASHRAE TC9.9 Datacom book, Best Practice for Datacom Facility for Energy Efficiency, Chapter 8,11

### 2.2.16 Control Generator Block Heaters

Consult generator manufacturer to reduce energy use by block heaters e.g., temperature control or disabling of heaters if regionally is possible.

Impact Summary:

A typical generator has a 5-10kW block heater. By controlling the heating or using a waste heat source, energy use can be reduced by 80%. If we assume it is on 10% of the time (2 hours a day) , the saving per generator is 6 kWh/year-sf. With respect to total data center energy use, this is a reduction of 0.7%.

Strategies Summary:

- Reduce energy use by block heaters e.g., temperature control or disabling of heaters if regionally is possible.
- Investigate energy efficient alternatives to electric resistance based block heaters, especially solutions using heat recovery of data center waste heat. For example, an air-to-water heat pump could be used to recover waste heat from the data center and provide heating hot water to the engine block.

## 2.3 Resources

**Links to additional information**

EO 13514 Website: http://www.fedcenter.gov/programs/eo13514/
DOE Website: www.eere.energy.gov/datacenters
Lawrence Berkeley National (LBNL): http://hightech.lbl.gov/datacenters.html
LBNLBestPracticesGuidelines(cooling,power,ITsystems):http://hightech.lbl.gov/datacenters-bpg.html
ASHRAE Data Center technical guidebooks: http://tc99.ashraetcs.org/
TheGreenGridAssociation–Whitepapersonmetrics: http://www.thegreengrid.org/gg_content/
EnergyStar® Program:
http://www.energystar.gov/index.cfm?c=prod_development.server_efficiency
Uptime Institute white papers: www.uptimeinstitute.org

**Guides**

Data Center Owner Programming Guide - www.eere.energy.gov/datacenters
Best Practices Guide for Energy-Efficient Data Center Design-
http://hightech.lbl.gov/DCTraining/Best-Practices.html
Self Benchmarking Guide for Data Centers
http://hightech.lbl.gov/documents/DATA_CENTERS/self_benchmarking_guide-2.pdf

**ASHRAE TC9.9, Datacom Series**

The books that are referenced throughout this guide can be purchased from ASHRAE. www.ashrae.org

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For more information or comments contact:

Rod Mahdavi, P.E. LEED AP
Lawrence Berkeley National Laboratory
One Cyclotron Road
Berkeley, CA 94720
510.495.2259
rmahdavi@lbl.gov

For more information on FEMP contact:

Will Lintner, P.E.
Federal Energy Management Program
U.S. Department of Energy
1000 Independence Ave., S.W.
Washington, D.C. 20585-0121
202.586.3120
william.lintner@ee.doe.gov