

# Data Centers

U.S. DEPARTMENT OF  
**ENERGY**

Energy Efficiency &  
Renewable Energy



## FEC WEBINAR

November 2010

Will Lintner  
Federal Energy Management Program



*FEMP Facilitates the Federal Government's implementation of sound, cost-effective energy management & investment practices to enhance the nation's energy security & environmental stewardship*

## FEMP is Here to Help You Achieve Results!

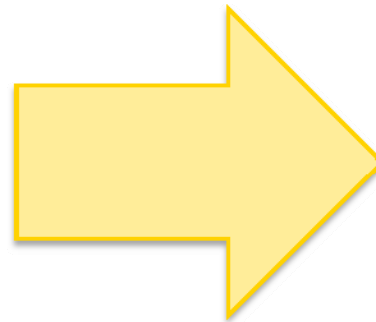
*Get up to speed with guides & resource publications*

*Become engaged with training & awareness workshops*

*Benchmark sites using DCPro*

*Conduct assessments to determine appropriate efficiency measures*

*Implement energy efficiency projects!*



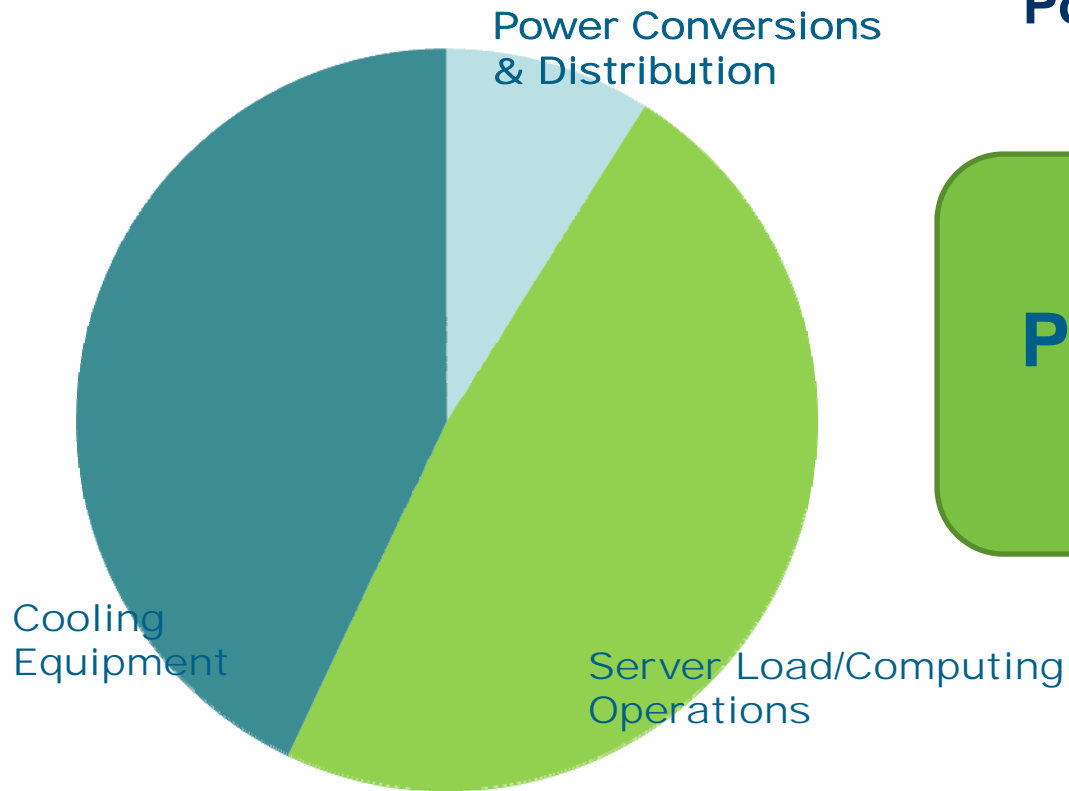
- *Save Money*
- *Reduce Loads*
- *Save Energy*
- *Reduce Emissions*

- The number of Federal data centers and server closets has increased from approximately 400 in 1998 to almost 2100 today.
- Major agencies' IT spending increased from about \$45 billion in 2001 to nearly \$75 billion today.
- Data center energy use doubled from 2000 to 2006. The EPA predicted that under current trends, data center energy use would almost double again between 2006 to 2011.
- Data centers could account for approximately 10 to 15 % of Federal facility energy use.

*Federal Leadership in Environmental, Energy & Economic Performance directs Federal agencies to:*

- (i) Promote electronics stewardship, in particular by:**
  - (i) Ensuring procurement preferences for EPEAT-registered electronic products;**
  - (ii) Establishing and implementing policies to enable power management, duplex printing and other energy-efficient of environmentally preferable features on all eligible agency electronic products;**
  - (iii) Employing environmentally sound practices with respect to the agency's disposition of all agency excess or surplus electronic products;**
  - (iv) Ensuring the procurement of EnergyStar and FEMP-designated electronic equipment**
  - (v) Implementing best management practices for energy-efficient management of servers and Federal data centers**

## Typical Data Center Energy End Use



## Power Usage Effectiveness (PUE)

$$\text{PUE} = \frac{\text{Total Data Center Power}}{\text{IT Power}}$$

- Best Practices Guide
- Benchmarking Guide
- Data Center Programming Guide
- Technology Case Study Bulletins

## Quick Start Guide to *Increase* Data Center Energy Efficiency

### A Problem That You Can Fix


Data Center energy efficiency is derived from addressing **BOTH** your hardware equipment **AND** your infrastructure.

Less than half the power used by a typical data center powers its IT equipment. Where does the other half go? To support infrastructure including cooling systems, UPS inefficiencies, power distribution losses

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### Best Practices Guide for Energy-Efficient Data Center Design

January 2010



Prepared by the National Renewable Energy Laboratory (NREL), a national laboratory of the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy. NREL is operated by the Alliance for Sustainable Energy, LLC.

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### Technology Case-Study Bulletin

#### Data Center Airflow Management Retrofit

**1 Introduction**  
As data center energy densities increase, power-use per square foot (PUE), energy savings for cooling can be realized by optimizing airflow pathways within the data center. This is especially important in cooling data centers with typical under-floor air distribution systems primarily due to space constraints from under-floor dimensions, obstructions, and leakage. Fortunately, airflow efficiency can be improved significantly in most data centers, as described below in the airflow management overview. Note, this case study bulletin presents air management improvements that were identified in an older "legacy" data center at Lawrence Berkeley National Laboratory (LBNL). Particular airflow improvements, performance results, and benefits are reviewed that enhanced cooling efficiency at LBNL. In addition, a more generalized list of measures to improve data center airflow is provided. Finally, a series of lessons-learned generated during the retrofit project at LBNL is presented.

**2 Airflow Management Overview**  
Airflow retrofits can increase data center energy efficiency by fixing up standard airflow and cooling



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### Data Center Rack Cooling with Rear-door Heat Exchanger

Technology Case-Study Bulletin



Figure 1: Passive Rear Door Heat Exchanger installed at LBNL.

As data center energy densities increase, power-use per square foot increases, energy savings for cooling can be realized by incorporating liquid-cooling devices instead of increasing airflow volume. This is especially important in a data center with a typical under-floor cooling system. An airflow-capacity limit will eventually be reached that is constrained, in part, by under-floor dimensions and obstructions.

**1 Introduction**  
Liquid-cooling devices were installed on server racks in a data center at Lawrence Berkeley National Laboratory (LBNL) in Figure 1. The passive-technology device removes heat generated by the servers from the airflow leaving the server rack. This heat is usually transferred to cooling water circulated from a central chiller plant. However at LBNL, the devices are connected to a treated water system that rejects the heat directly to a cooling tower through a plate-and-frame heat exchanger, thus easily eliminating chiller energy use to cool the associated servers. In addition to cooling with passive heat exchangers, similar results can be achieved with fan-assisted rear-door heat exchangers and refrigerant-cooled rear-door exchangers.

Server racks can also be cooled with competing technologies such as modular, overhead coolers (in-row coolers), and close-coupled coolers with dedicated containment enclosures.

**2 Technology Overview**  
The rear door heat exchanger (RDHX) devices reviewed in this case study are referred to as passive devices because they have no moving parts; however, they do require cooling water flow. A passive-style RDHX contributes to optimizing energy efficiency in a data center facility in several ways. First, once the device is installed, it does not directly require infrastructure electrical energy to operate. Second, RDHX devices can use less chiller energy since they perform well at warmer (higher) chilled water set-points. Third, depending on climate and piping arrangements, RDHX devices can eliminate chiller energy because they can use treated water from a plate-and-frame heat exchanger connected to a cooling tower. These inherent features of a RDHX help reduce energy use while minimizing maintenance costs.

**2.1 Basic operation**  
The RDHX device, which resembles an automobile radiator, is placed in the airflow outlet of a server rack.

During operation, hot server-rack airflow is forced through the RDHX device by the server fans. Heat is exchanged from the hot air to circulating water from a chiller or cooling tower. Thus, server-rack outlet air temperature is reduced before it is discharged into the data center.

**2.2 Technology Benefits**  
RDHX cooling devices can save energy and increase operational reliability in data centers because of straightforward installation, simple operation, and low maintenance. These features, combined with compactness, indirect evaporative cooling, make RDHX a viable technology in both new and retrofit data center designs. It may also help eliminate the complexity and cost of under-floor air distribution.

**Reduce Maintenance**  
Because passive RDHX devices have no moving parts, they require less maintenance compared to computer room air conditioning (CRAC) units. RDHX devices will require occasional cleaning of dust and lint from the air-side of the coils. RDHX performance also depends on proper water-side maintenance.

**Reduce or Eliminate Chiller Operation**  
RDHX devices present an opportunity to save energy by either reducing or

## DOE/ASHRAE Awareness Training



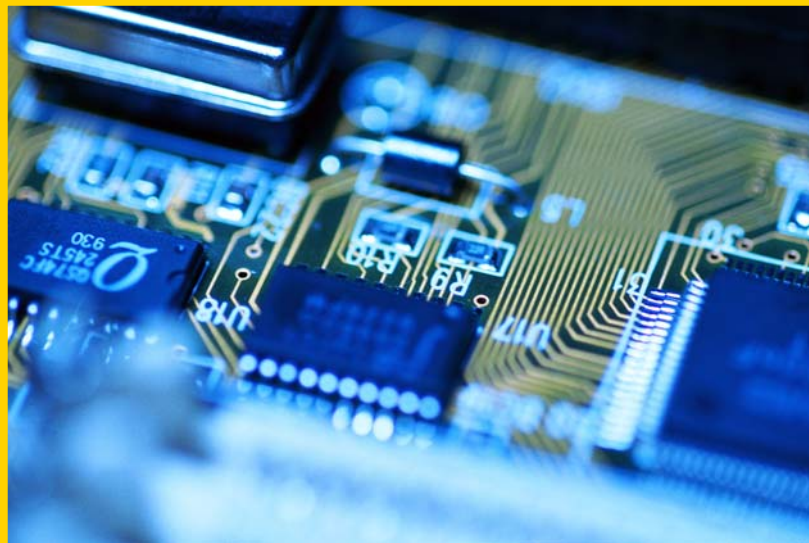
- *One-day training*
- *Target audience: data center operators*
- *No prequalifications*

## Data Center Energy Practitioner (DCEP) Program - Generalist

- Three-day workshop with two options:
  - Training certificate (not yet available)
  - Training & exam (In pilot stage)
- Target audience: DC personnel, consultants, & service providers.
- Next: **San Francisco, November 15-18**

## DCEP - SPECIALIST

- Pre-qualifications: *Pass Generalist exam*
- Practitioner tracks:
  - HVAC
  - Electrical & IT coming soon



# Metrics & Benchmarking

## Data Center Profiling Suite (DC-PRO)

- Designed for data center owners & operators
- Diagnoses how energy is used within a data centers
- Determines ways to save energy and money.
- Contains additional components for more detailed air management & electrical assessments - IT & HVAC components coming soon

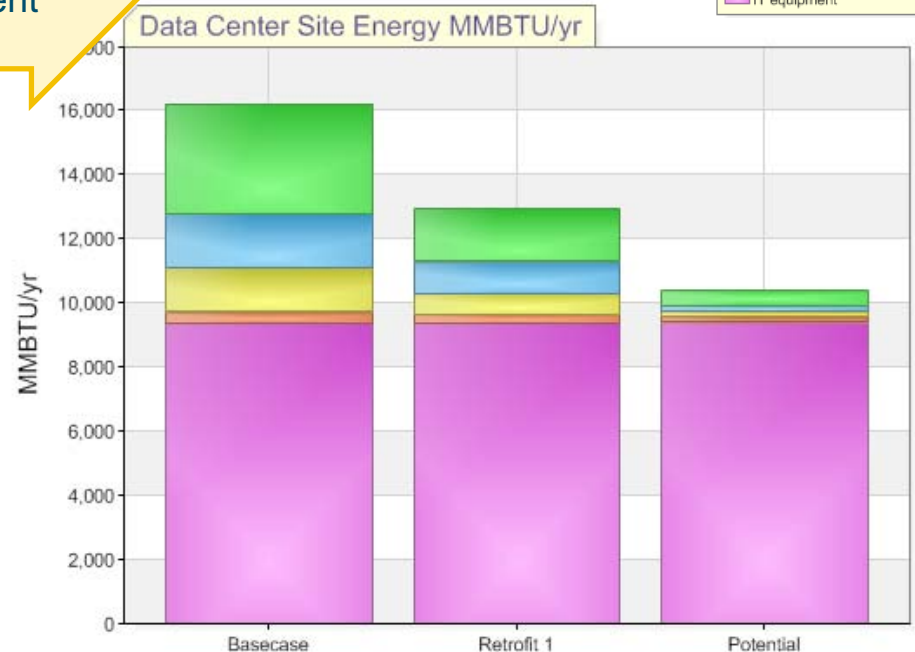


### Inputs

- Utility bill data
- Systems information
- Facility description

### Outputs

- End-use break out
- Energy reduction potential
- Areas for improvement



## Power Usage Effectiveness

$$PUE = \frac{\text{Total Facility Power}}{\text{IT Equipment Power}}$$

Standard	Good	Better
2.0	1.4	1.1

## Heating, Ventilation & Air-Conditioning System Effectiveness

$$\text{Effectiveness} = \frac{\text{kWh/yr}_{IT}}{\text{kWh/yr}_{HAVAC}}$$

Standard	Good	Better
0.7	1.4	2.5

## Airflow Efficiency

$$\frac{\text{Total Fan Power (W)}}{\text{Total Fan Airflow (cfm)}}$$

Standard	Good	Better
1.25W/cfm	0.75 W/cfm	0.5 kW/cfm

## Cooling System Efficiency

$$\frac{\text{Average Cooling System Power (kW)}}{\text{Average Cooling Load (ton)}}$$

Standard	Good	Better
1.1 kW/ton	0.8 kW/ton	0.6 kW/ton

## FEDERAL PARTNERSHIP FOR GREEN DATA CENTERS

- The Federal Partnership for Green Data Centers was created in 2009 to advance the energy efficiency and renewable energy use goals of the Energy Independence and Security Act of 2007 (EISA 2007) as they relate to data centers.
- The group meets these goals by
  - Facilitating communication between member agencies.
  - Disseminating best practices for data center energy efficiency
  - Working with private sector to share information on new technologies with the Federal Government

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

## ENERGY EFFICIENT HIGH PERFORMANCE COMPUTING WORKING GROUP (EE HPC WG)

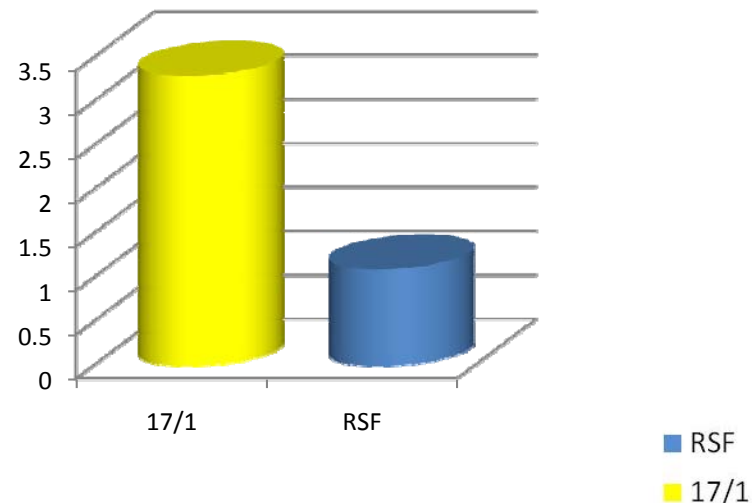
- The Energy Efficient HPC Working Group (EE HPC WG) will target both public and private HPC owners, operators and users to increase collective knowledge and stimulate demand for energy efficient HPC.
- Three sub-groups
  - Infrastructure
  - Computing systems
  - Conferences

<http://eehpcwg.lbl.gov/home>

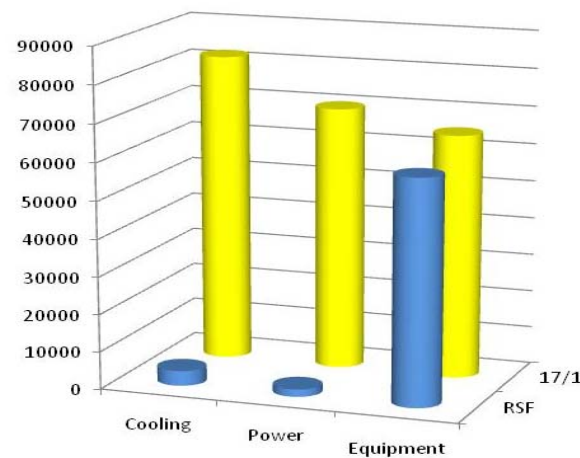


- Innovative cooling techniques
- State-of-the-art power management systems
- Data Center heat recovery
- Energy-efficient IT equipment
- Virtualization

## Power Usage Effectiveness



## Data Center Power Usage





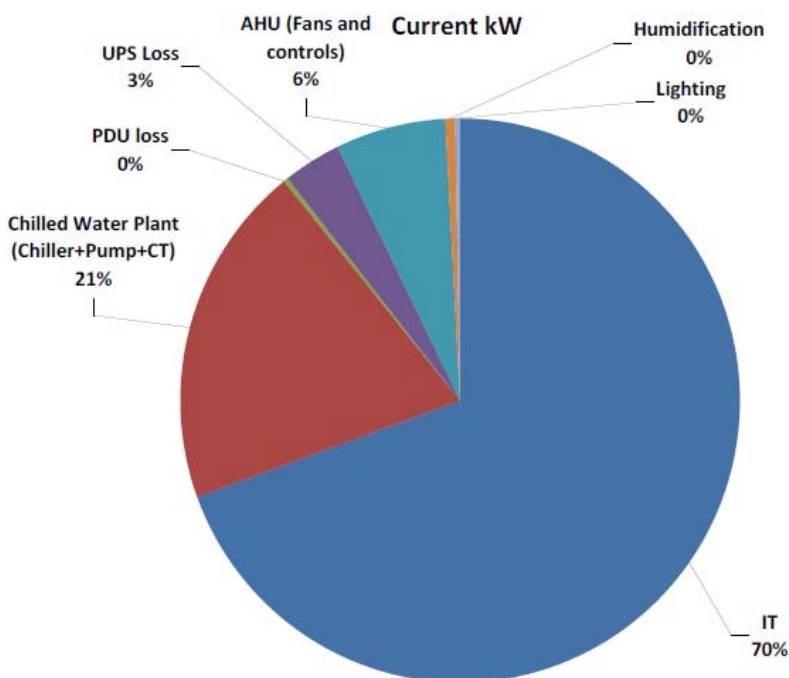
Argonne  
NATIONAL  
LABORATORY

## Sample Recommendations

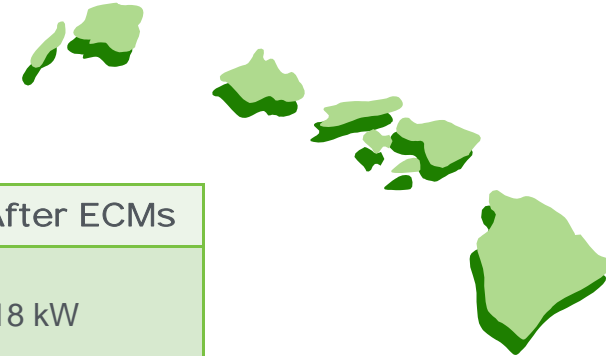
- Disable dehumidification
- Seal floor leaks
- Add integrated waterside economizer to CHW plant
- Install occupancy sensors to control lights
- Optimize cooling plant controls

Argonne	Current	After ECMs
Total Electrical Demand	1,866 kW	1,718 kW
PUE	1.46	1.34
Annual CO2 Emissions	15,200 tons	13,980 tons

**Implementing suggested changes would decrease facility power from 1,866 kW to 1,718 kW, curbing emissions by 1,220 tons of CO<sub>2</sub> per year.**



## Data Center Assessments



Proposed ECMs:

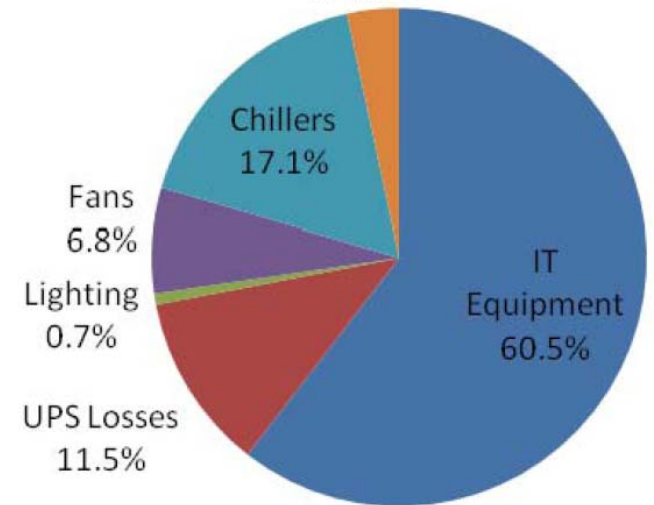
- Full cooling system retrofit
- Installation of supply ducts in electrical room
- Retrofit lighting

Total Cost of \$252,499

# 1	Current	After ECMs
Total Electrical Demand	775 kW	718 kW
PUE	1.65	1.53
Annual CO2 Emissions	5,771 tons	5,346 tons

Pumps  
3.4%

**Implementing suggested changes would save \$160,020 and decrease emissions by 425 tons of CO<sub>2</sub> per year.**





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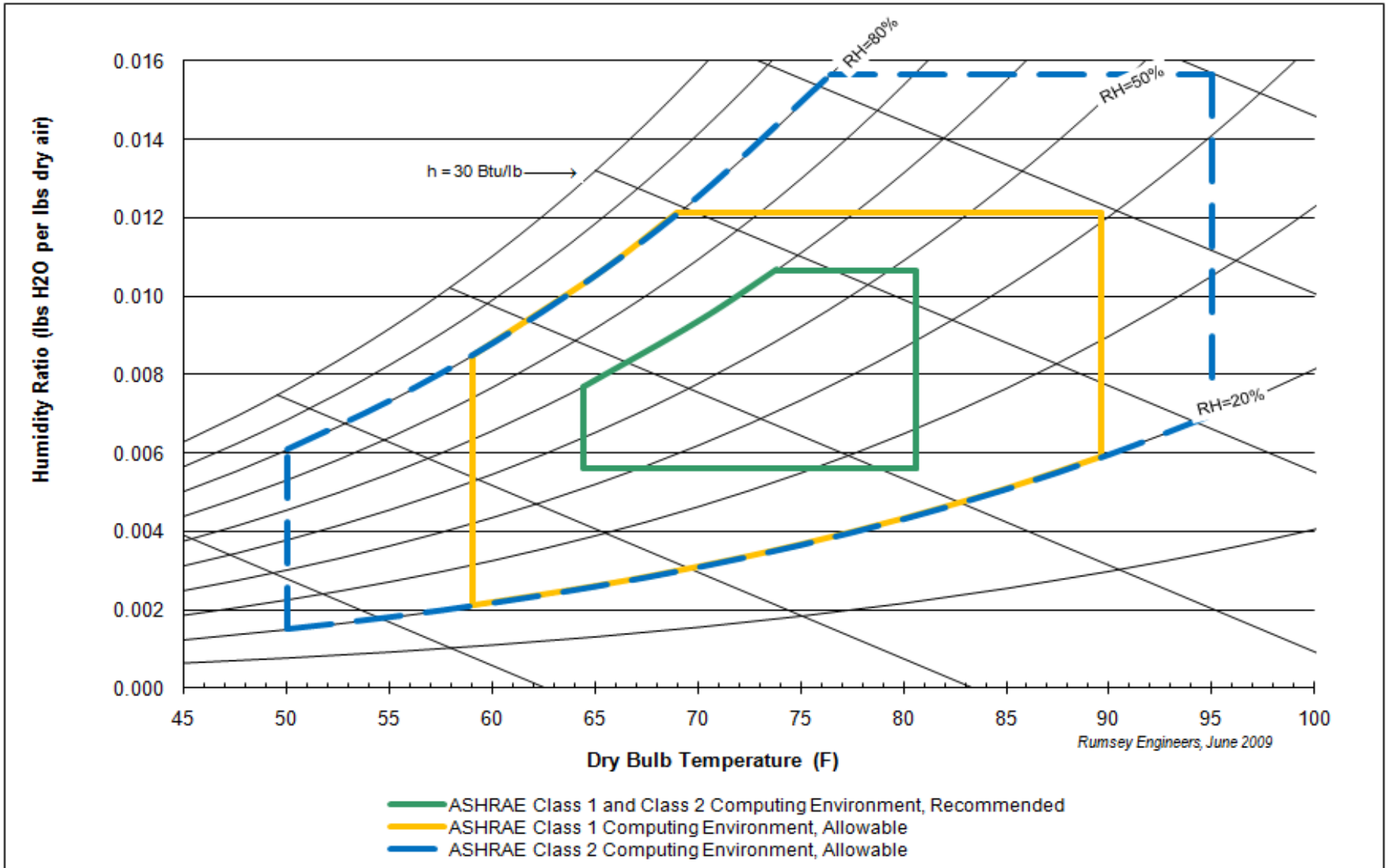


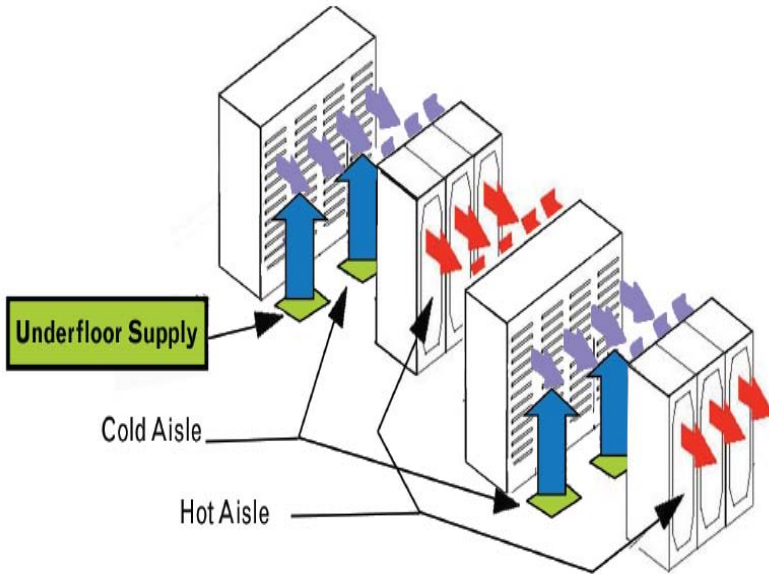
[http://www1.eere.energy.gov/femp/program/data\\_center.html](http://www1.eere.energy.gov/femp/program/data_center.html)



<http://www1.eere.energy.gov/industry/datacenters/>

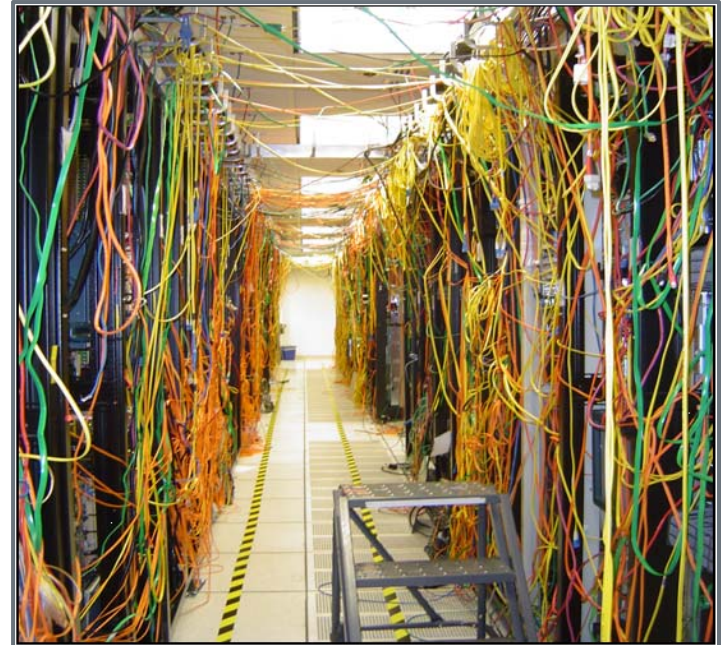
# Supplemental Slides: Best Practices





Hot aisle / cold aisle isolation decreases mixing of intake and exhaust air, promoting efficiency.

- Ensure cables are well managed
- Use a minimum clear height of 24 inches under raised floor installations.

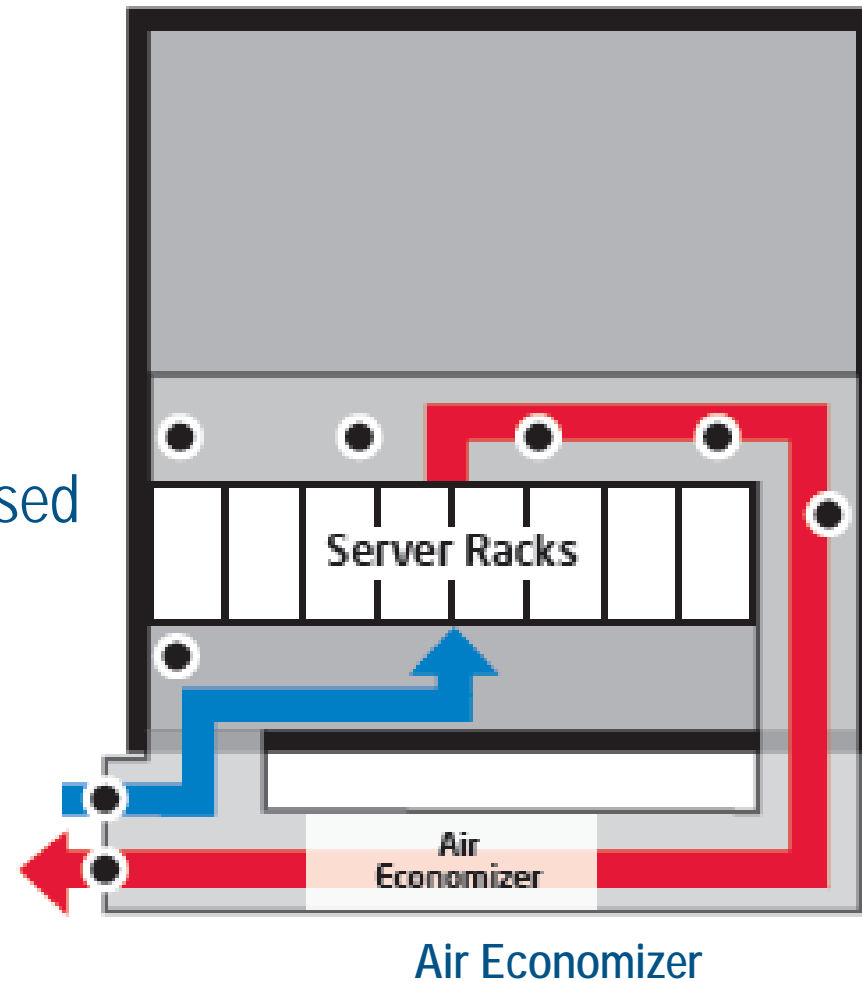


## Direct Liquid Cooling

- Transferring waste heat to a liquid at or near the server, rather than exhausting it into the room.

## Free Cooling

- In mild climates, outside air can be used to cooled with an airside economizer
- Evaluate humidity and contamination concerns



## UPS

- Critical loads only on UPS

## Redundancies

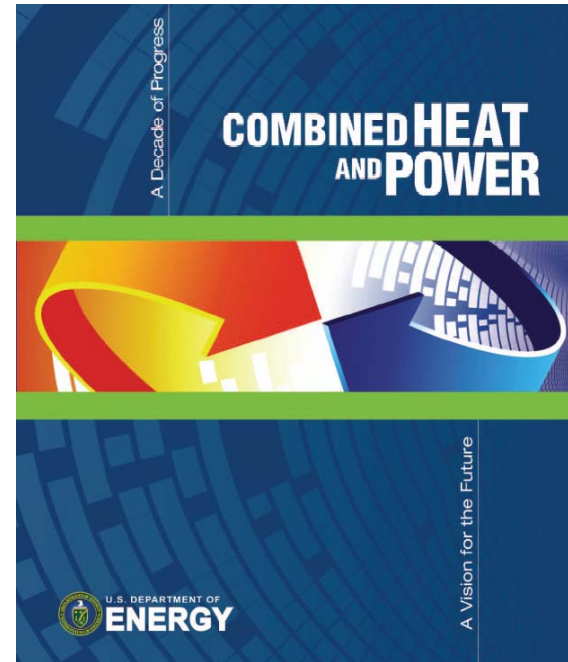
- Eliminate redundancies wherever possible

## Lighting

- Install occupancy sensors
- Install lights in aisles, not over racks

## On Site Generation

- On site generation can expand options for data center location
- Renewable energy possibilities – on site renewable energy
- Combined Heat & Power (CHP) – generates energy & useful heat at once



## Energy Reuse

- Waste heat from data centers can most effectively be used for low temperature heating applications such as preheating ventilation

## Servers



- Choose *variable speed fans*
- Enable *power management capabilities!*
- EnergyStar Servers

## Power Supplies



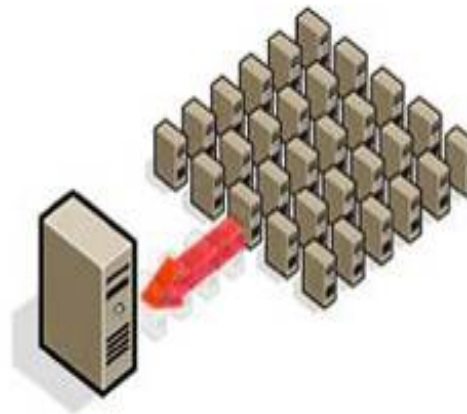
- Optimal load level: 40-60%
- 80 PLUS Program offers certification of efficient power supplies

## Storage Devices



- Take superfluous data offline
- Use thin provisioning technology

## Consolidation



- Group hardware with similar heat load densities
- Practice virtualization