Data Center Building Energy Programming Guide

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

U.S. Data Centers

Save Energy Now

Why Data Centers?

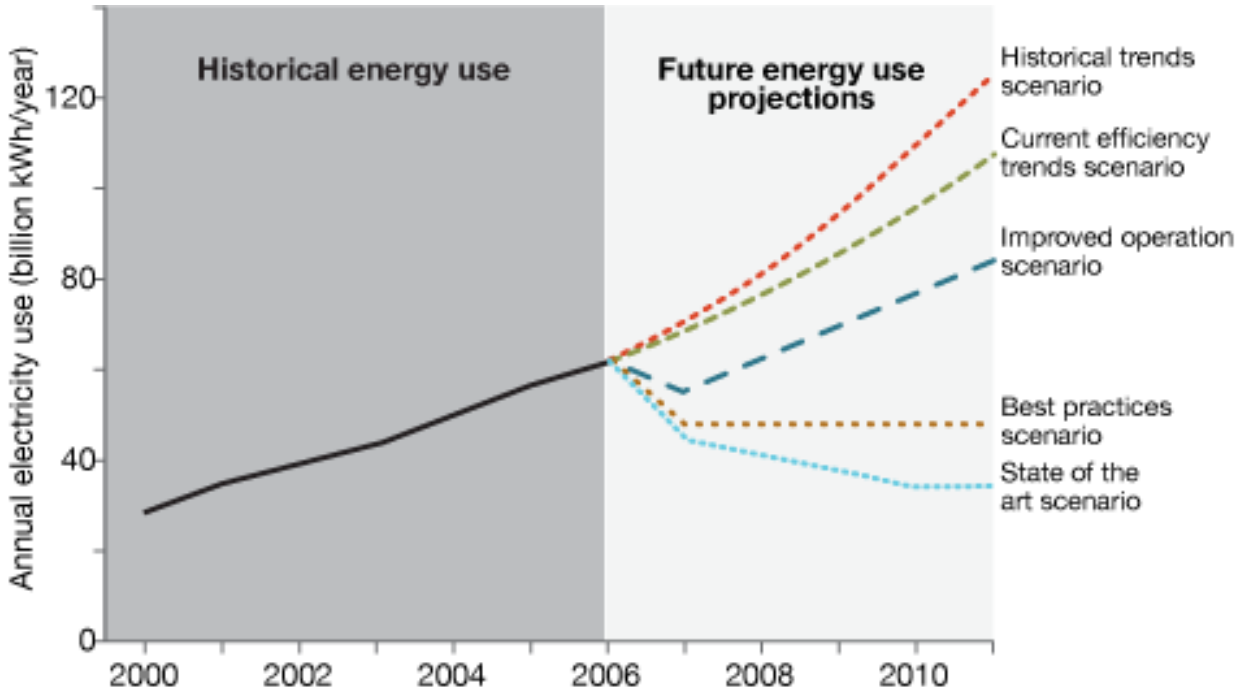
Annual source energy use of a 2MWh data center is equal to the amount of energy consumed by 4,600 typical U.S. cars in one year.

2MW data center

=

4,600 typical U.S. cars

Why Data Center Efficiency Now?



U.S. data center energy use could increase to

90-100 billion kWh in 2011

Google consumed

2.3 billion kWh in 2010

Consolidation, Cloud, efficient serves, efficient power chain, and cooling might reduce the total energy use in next 5 years

FEMP and Save Energy Now Activities

- DC Pro Software Tool Suite for identifying and measuring data center savings
- Energy assessment protocols and methodologies
- Metrics to benchmark and track performance of overall data center energy intensity
- Data Center Certified Energy Practitioners
- Training curriculum for data center personnel
- Case studies and guidelines for “best in class” data centers
- R&D program

What Guide does?

- The guide addresses the energy issues a data center owner must consider for building an energy efficient data center.
- This guide might be used for major modifications to an existing data center.
- Also in a reverse approach, the guide might be used in planning for consolidation.
- The guide also describes key energy efficiency metrics which help provide basic goals for achieving energy efficient data center.

Data Center Building Energy Programming Guide Content

- Site Selection Criteria
- Conceptual Design Goals and Their Impact on Energy Efficiency
- Design Topics/Strategies for Energy Efficiency
- Owner's Energy Efficiency Data Center Project Performance Targets
- Metrics Table

Site Selection

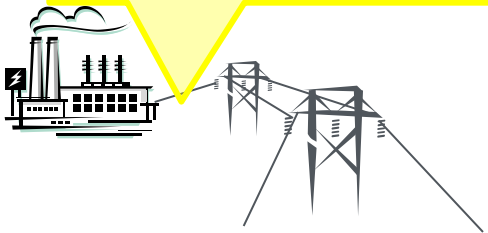
- Facility Consolidation
- Climate
- Air Quality
- Available Water Resources
- Renewable Energy Possibilities
- Electrical Grid
- Noise Constraints

Conceptual Design Goals / Impact on Energy Efficiency

- Information Technology (IT) Equipment Selection
- Availability/Reliability and Redundancy Options
- Monitoring and Automation
- Expandability and Modularity Energy Impacts
- Capital and Operating Costs
- Human Issues: Data Center Working Conditions
- Carbon Reduction and Renewable Energy Options
- Environmental Performance Criteria (EPC) and Related Rating Systems (LEED™)
- Energy Star: Buildings and Product Ratings

Design Topics/Strategies

Source and transmission losses



- Power management
- Virtualization
- Server innovation
- Heat recovery

- Better air management
- Better environmental conditions
- Move to liquid cooling
- Optimized chilled-water plants
- Use of free cooling
- Reuse of waste heat

Power Conversion & Distribution

Server Load/ Computing Operations

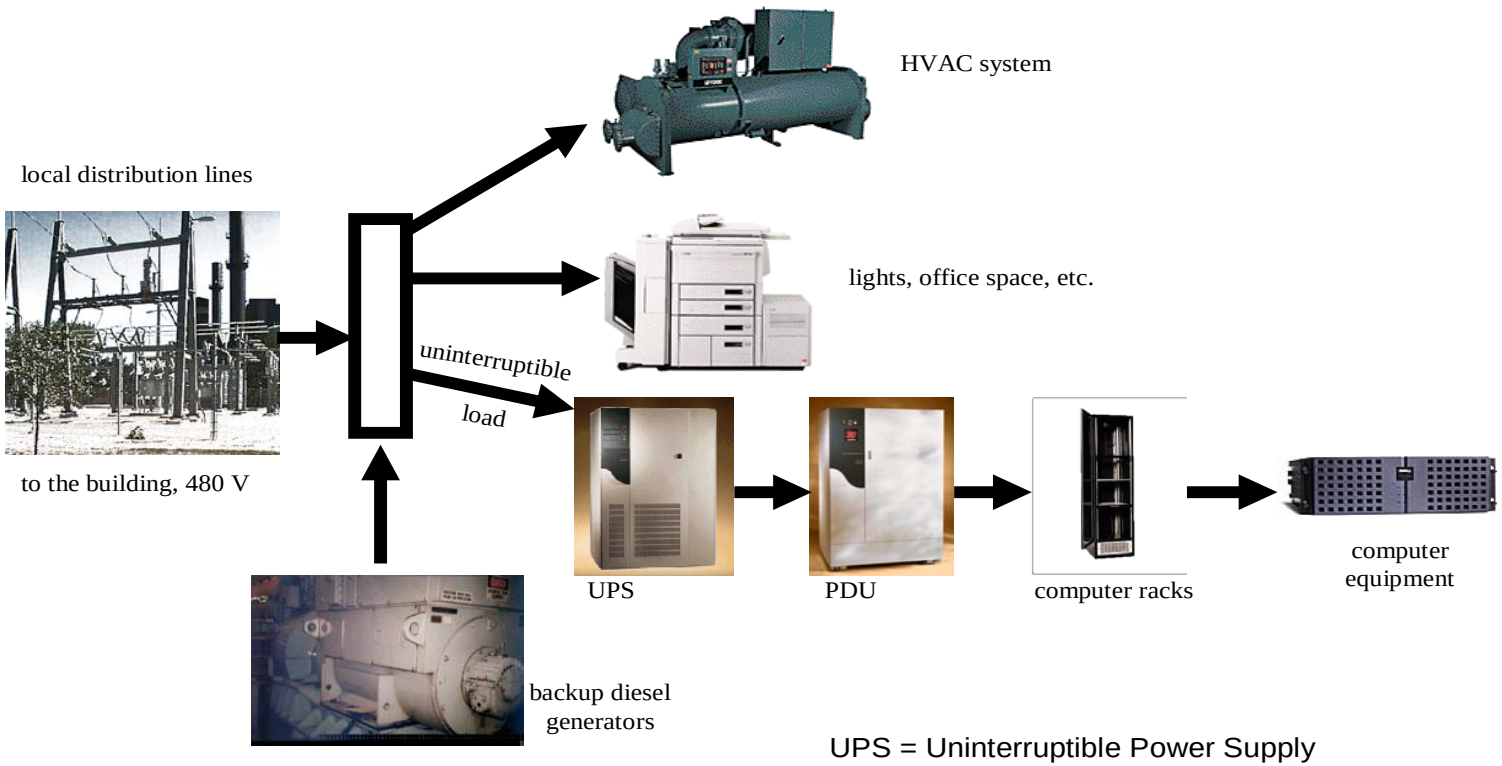
Cooling Equipment

- High voltage distribution
- Use of DC power
- Highly efficient UPS systems
- Efficient redundancy strategies

On-site generation

- Rejected heat for cooling
- Use of renewable energy/fuel cells
- Eliminate transmission losses

Electricity Flows in Data Centers



UPS = Uninterruptible Power Supply

PDU = Power Distribution Unit;

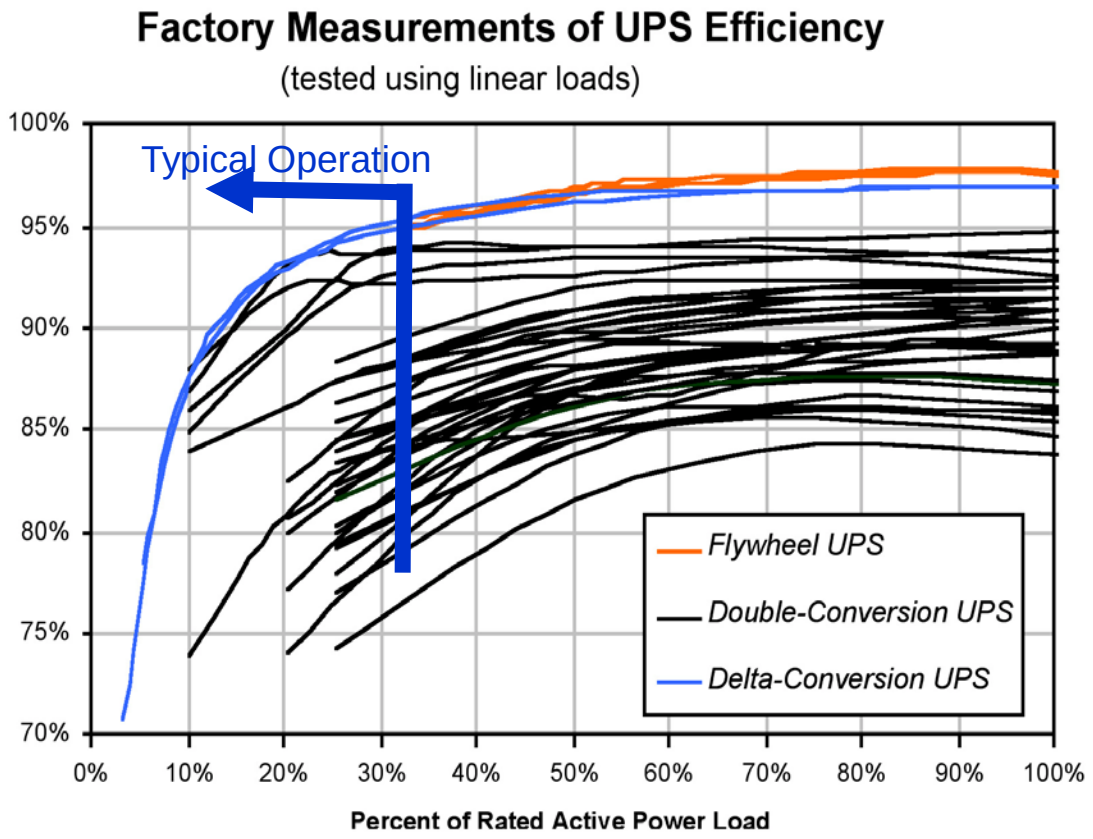
Every power conversion (AC-DC, DC-AC, AC-AC) loses some energy and creates heat

30% improvement is possible

Efficiency decreases when UPS is lightly loaded

Distributing higher voltage is more efficient and saves capital cost

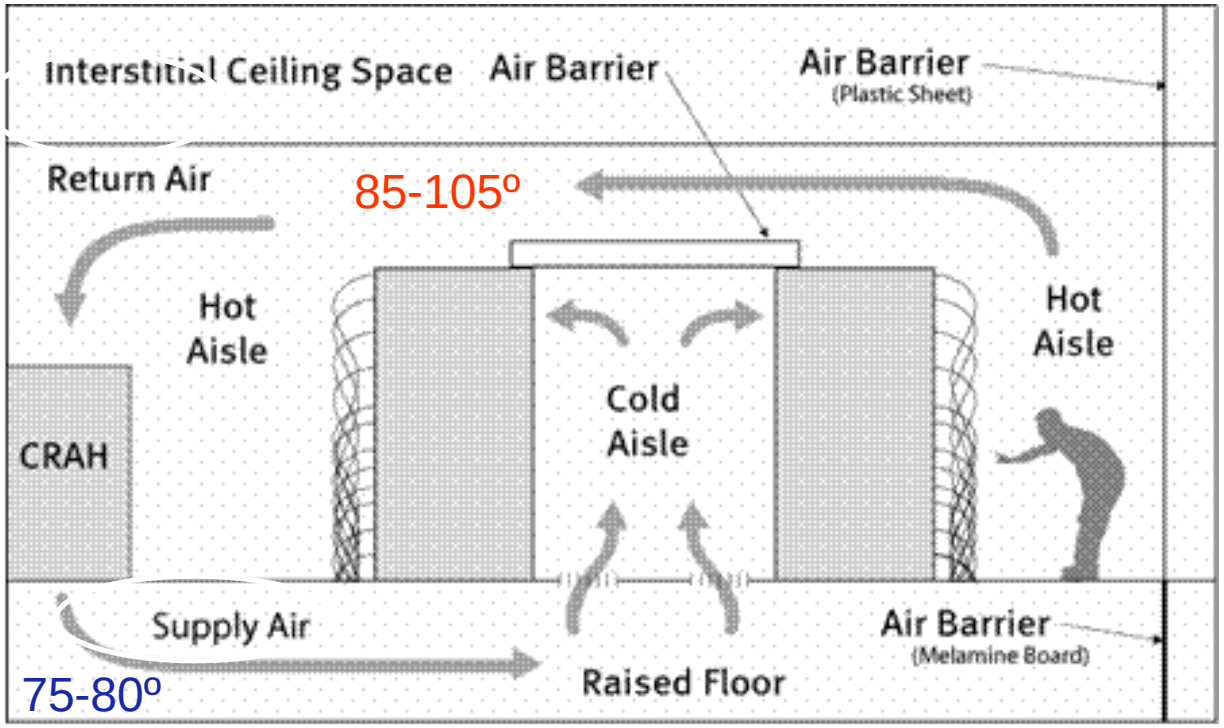
Transformer and PDU efficiency varies with load



- Efficient power supplies have large annual savings
- Efficient IT equipment reduces infrastructure power consumption
- EnergyStar and 80Plus Program are good sources for identifying such efficient systems and components
- Utility incentives may be available
- Virtualization can eliminate many servers
- Software to limit spinning discs has large promise
- Saving one watt at the server saves 2 watts at site and 6 watts at source (coal used for source).

- Minimizing the distance (shorter air path, cables)
- Grouping equipment with similar heat load densities and environmental requirements (Zoning)

Data center can be operated at 85-105degF



Designing for the upper end of the recommended range will result in more energy efficient systems.

Centralized systems and/or use of VFD for air delivery will save energy

Air management for air cooled IT equipment is very important

Compressorless operation can reduce energy use by 15-20%

ASHRAE Recommended and Allowable Intake Air Conditions

@ IT Equipment Intake	Recommended	Allowable
Temperature	65° – 80°F	59° – 90°F
Humidity (RH), Dew Point	42°F DP – 60% or 59°F DP	20% – 80% and 63°F DP

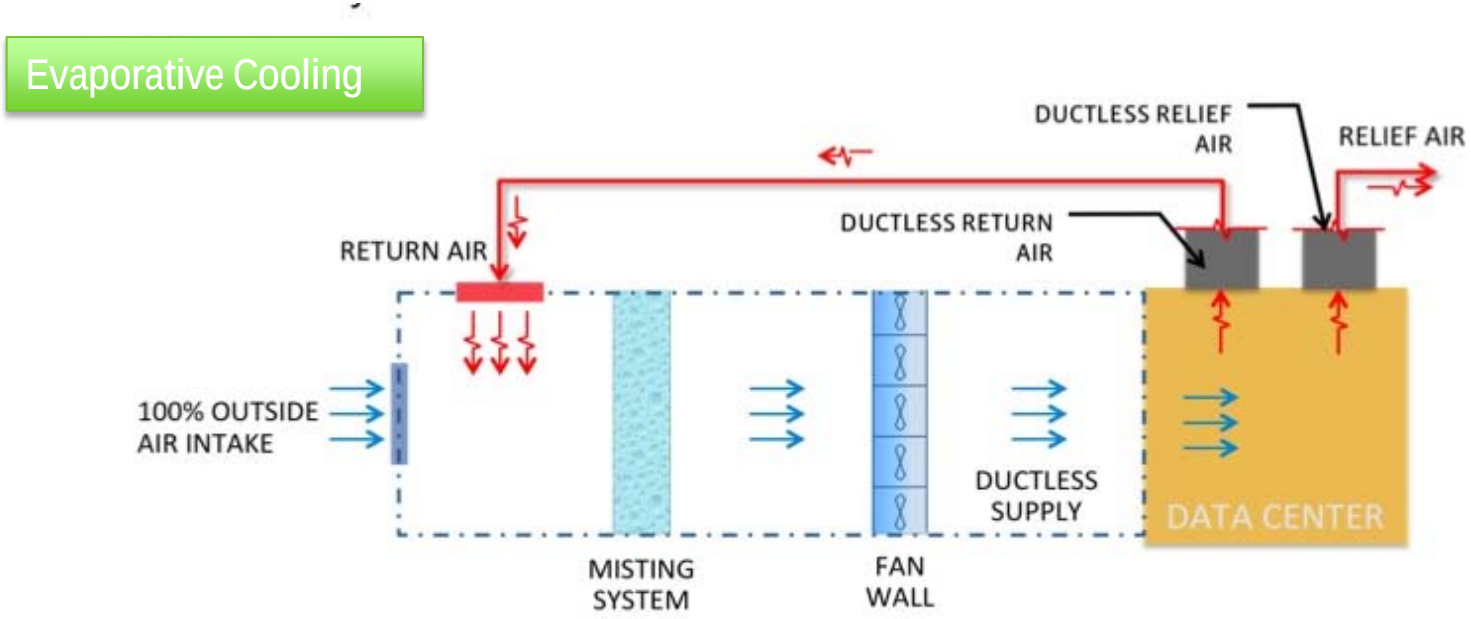
Facebook Data Center in Oregon

Server design will allow the equipment to run in higher temperature.

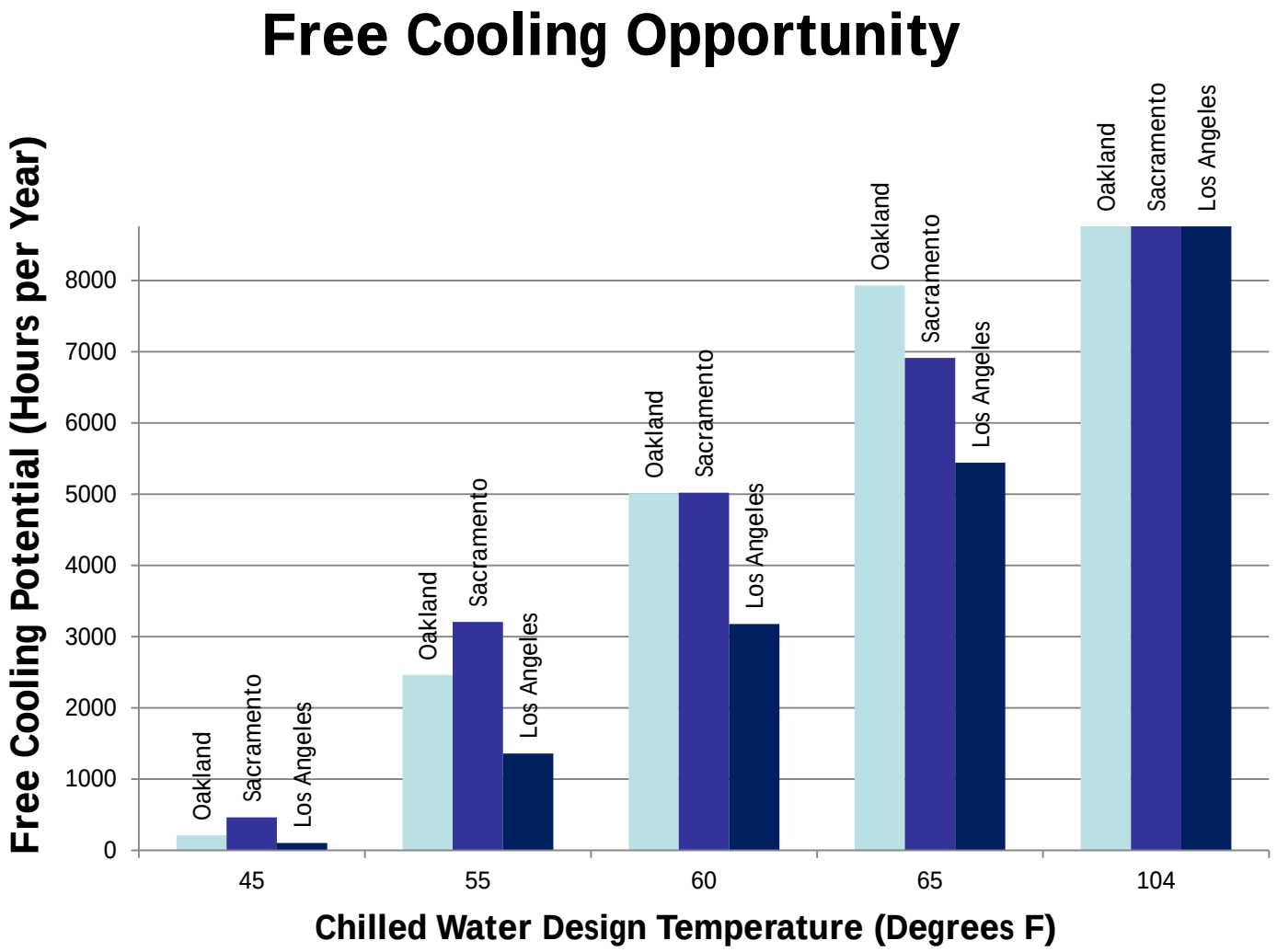
The Prineville data center cold side runs at 85°F with a 65 percent relative humidity

Only evaporative cooling is used.

Uses 277 volt electrical distribution, reducing the amount of energy lost in conversion Down to 7 percent *of the power coming into the facility.*



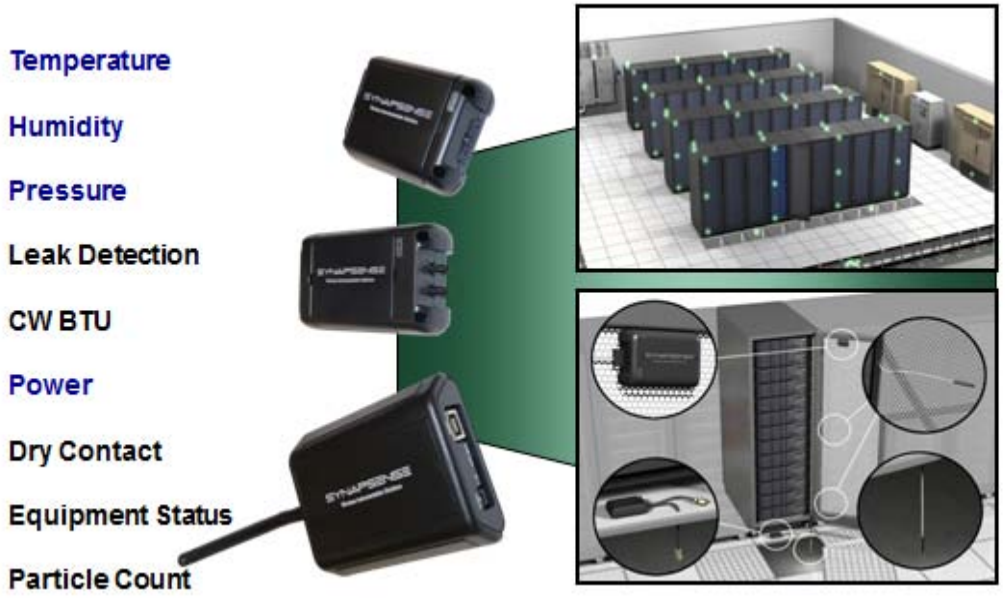
Free Cooling, Air or Water Side



Design Topics/Strategies
Monitoring Enables the stakeholders to:

- Baseline energy utilization, identify improvement opportunities and monitor and validate the implementation of energy saving measures
- Measure real-time PUE(Power Usage Effectiveness), which is the ratio of total power used in the data center over IT power
- Monitor environmental conditions compared to ASHRAE ranges
- Control HVAC based on air intake temperature

Ideally, the IT and Infrastructure systems are monitored and controlled through a single system with "dashboard" displays for ease of understanding of the status and efficiencies



Stakeholders should provide an inventory list of IT equipment to energy modeler.

Model should include energy use and energy rate schedule for CTO calculation, and provide an easy tool to evaluate options while considering Future expansion.

EQUIPMENT	MAKE	MODEL	QTY	POWER Per unit	Airflow , CFM	Maximum Intake Air DB TEMP	Intake Air % RH Range	Intake Air Dewpoint Temp Range
SERVER								
STORAGE								
NETWORK								

Performance Targets

- General Energy Efficiency
  - LEED Platinum
  - PUE
- HVAC
  - High efficiency system
  - Zoning for different IT equipment
- Electrical
  - Modularity
  - Redundancy
- Controls and Monitoring
  - Real time monitoring of PUE
  - Even CPU

Metrics Template

Parameter Name	Units	Level		
		Good	Better	Visionary
Overall Data Center Performance Metrics				
IT Power Load , Percent Utilization (CPU use)	*%*	>20[1]	>30[1]	>60[1]
Data Center Power Usage Effectiveness (PUE)	$\frac{\text{Total Facility Energy}}{\text{IT Equipment Energy}}$	1.43	1.26	1.09
Air Management Metrics If applicable				
Minimum Supply Air Temperature (SAT)	°F	75	80	85
Return Temperature Index (RTI)	%	85< 115>	95< 105>	100
Cooling Metrics including Fan power				
Data Center Cooling PUE	$\frac{\text{Average Cooling System Energy (kWh)}}{\text{Average IT Power (kWh)}}$	0.35	0.2[1]	0.05[1]
Minimum compressorless operation hours per year	*hours*	4380[1]	6570[1]	8760[1]
Electrical Power Chain Metrics				
Data Center Power PUE(includes lighting and other electrical us related to data center)	$\frac{\text{Average Electrical Energy Loss (kWh)}}{\text{Average IT Power (kWh)}}$	0.08	0.06[1]	0.04[1]
Waste Heat Reuse Efficiency (ERF)				
Efficiency of reuse of energy	$\frac{\text{Average ReusedEnergy (kWh)}}{\text{Average IT Power (kWh)}}$	0[1]	.05[1]	.25

Questions/Comments/Discussions

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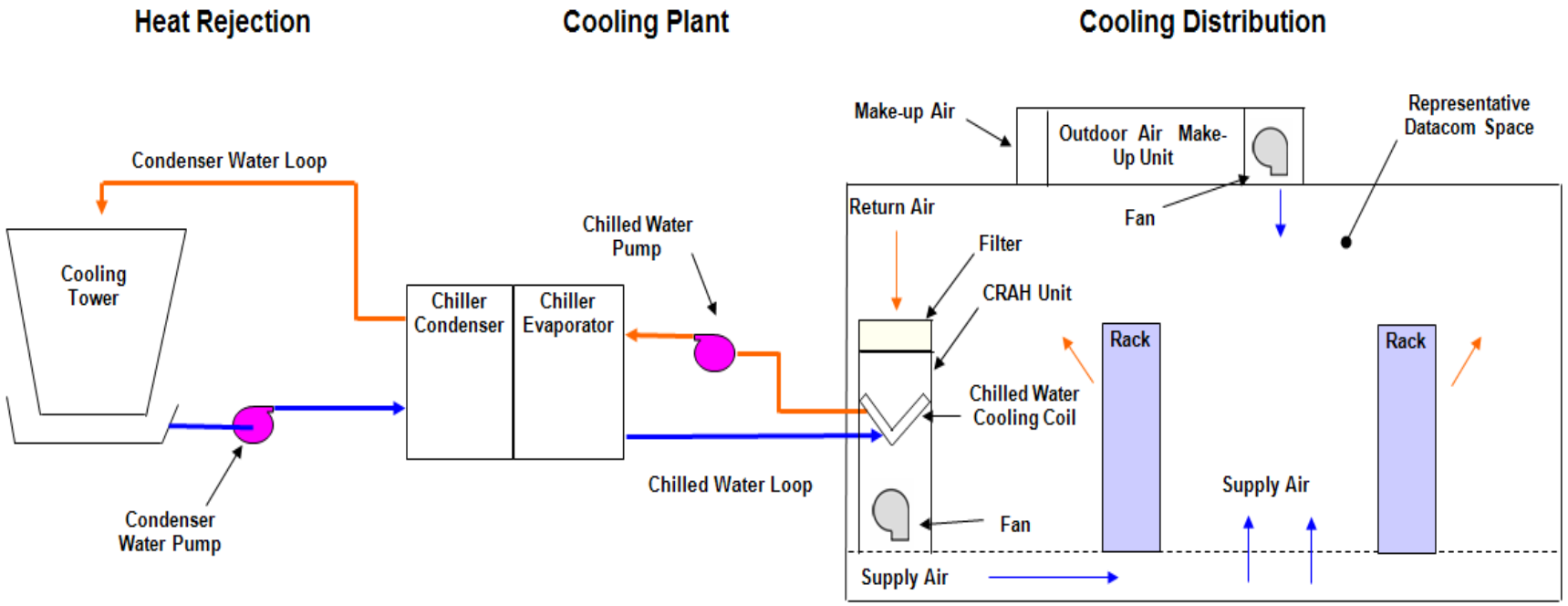
www.eere.energy.gov/industry/saveenergynow

BERKELEY LAB

Rod Mahdavi, PE, LEED AP

HVAC system overview



Heat Rejection Alternatives:

High Eff

- Water Cooled Direct (shown)
- Water Cooled Indirect (with HX)
- Evaporatively Cooled
- Air Cooled
- Dry Cooler (Air Cooled with Glycol)

Low Eff

Cooling Plant Alternatives:

- Water-Side Economizer (HX)
- Chiller (shown)
- Direct Expansion (DX)

Terminal Unit Alternatives

- Liquid Cooling
- Central AHU
- CRAH Unit (shown)
- CRAC Unit (DX)

Distribution Alternatives

- On Board
- In Rack
- In Row
- Overhead Air
- Underfloor Air (Shown)

High Eff

Low Eff