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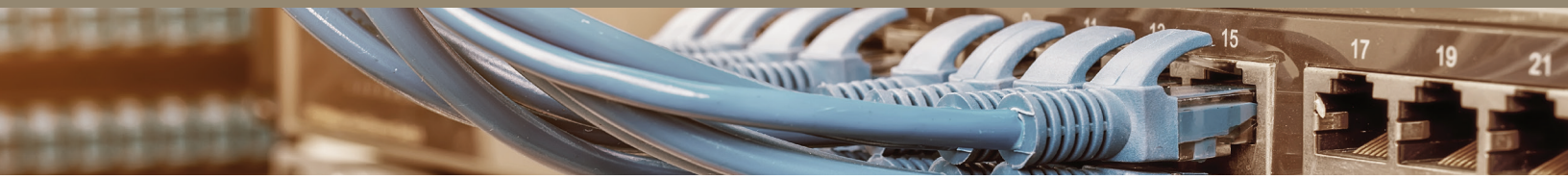
SCE Energy Conservation Series

Computing The Benefits:
Solutions for Creating Energy-Efficient Data Centers



Changes in equipment, facility layout and procedures can have a big impact on energy costs.

Computers and data have become a virtual necessity—in homes and certainly in a typical business setting. Increasingly, data is housed in data centers, which account for a significant amount of U.S. energy consumption. In fact, it is estimated that 3% of the nation's electricity goes to powering these centers.[1]

Additionally, experts project data center electricity consumption to increase to approximately 140 billion kilowatt-hours (kWh) annually by 2020—the equivalent annual output of 50 power plants.[2]

IT Energy Managers Can Raise Their Energy IQ

While the macro trend may be hard to reverse, there are ways for businesses to decrease energy use. New technology, equipment upgrades, select equipment decommissioning, along with changes in facility layout and procedures can all have a positive impact on energy-efficiency.

These measures include:

- Energy-optimized data center configuration
- Decommissioning or consolidating IT equipment
- Installing solid state storage (SSD), ultrasonic humidifiers, or Variable Frequency Drives (VFD)
- Adopting passive and close-coupled cooling
- Server power management
- Airflow optimization
- Optimizing uninterruptible power supplies (UPS)

Improvements like these can produce significant energy savings, help individual data centers reduce their energy bill, and help us reduce the load on the electric grid.

We have compiled this handy guide to provide some tips to help IT energy managers like you succeed in improving energy efficiency.

First Things First: What Makes Data Centers So Energy-Intensive?

Data centers are prime targets for reducing corporate energy consumption simply because they are energy-intensive. What makes them so? For one, they typically house a high density of machinery, notably servers, spinning storage devices, high-speed microprocessors, and other equipment.

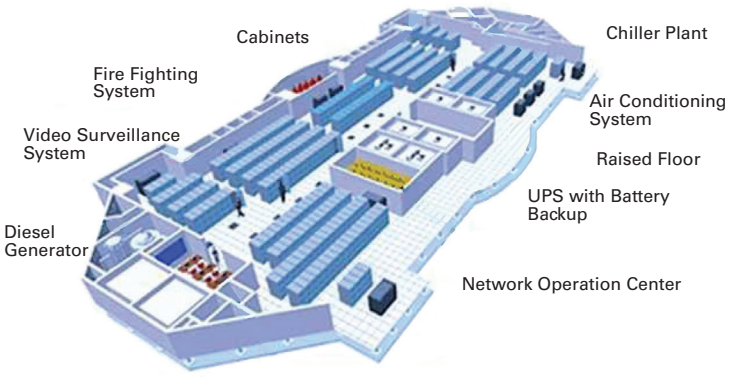
Such equipment not only draws lots of power, but just as important for this discussion, it also generates tremendous heat. This heat usually necessitates an extensive air cooling system to maintain optimal operating temperatures inside the center to prevent data loss.

Powerful Insights

In 2013, U.S. data centers consumed an estimated **91 billion kWh of electricity**, equivalent to the annual output of 34 large 500-megawatt (MW) coal-fired power plants.[3]

[1] Energy 101: Energy Efficient Data Center. U.S. Dept. of Energy.
[2] Delforge, Pierre. Critical Action Needed to Save Money and Cut Pollution. NRDC. February 06, 2015.
[3] Ibid.

Anatomy of a Data Center



Outdated operational practices can also make certain data centers energy-inefficient. These include:

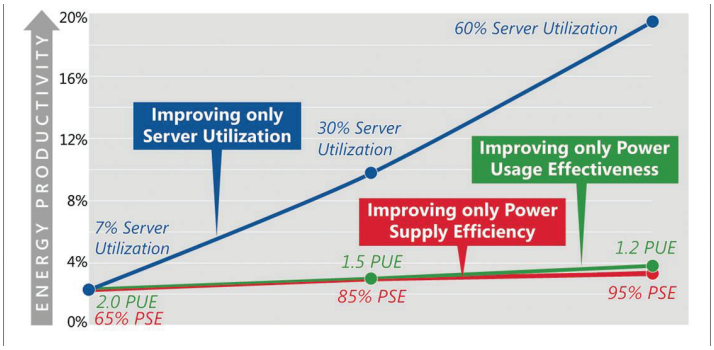
- Imbalanced redundancy
- Over-cooling
- Aversion to free-cooling

Energy-Saving Options Abound

The good news is that forward-thinking IT operations may have a number of options at their disposal for reducing data center energy usage, the most important of which this guide will explore. In many cases, IT energy managers will discover that these solutions provide many benefits beyond simple energy savings, potentially helping the organization:

- Enhance operational efficiency
- Improve bottom-line profitability
- Accomplish corporate green initiatives

Effect of Data Center Improvements on IT Energy Productivity[4]



Solution: Server Power Management

While rack servers tend to account for the largest portion of energy usage in a typical data center, the majority of servers usually run at or below 20% utilization.[5] Yet they can still draw full power the entire time. This presents a unique opportunity to save energy through what is called server power management practices.

Variable-Speed Fans

When purchasing new servers, it's a good idea to look for models that include variable — as opposed to fixed-speed fans for the internal cooling component. These fans modulate RPMs according to the demand on the server, and can save significant amounts of energy, especially when multiplied across an entire array of servers.

Room for Improvement

The majority of data center servers usually run at or **below 20% utilization**, yet they can still draw full power the entire time.[5]

Throttle-Down Drives

So-called throttle-down drives are also excellent ways to better manage server power. These devices cut energy consumption by putting idle processors to "sleep". Thus, when a server is running at its typical 20% utilization, it is not drawing full power. Since servers are engineered to handle tens of thousands of on-off cycles, this has minimal effect on data reliability.

Did You Know?

ENERGY STAR® provides **free phone and email consultations** to help IT energy staff with planning computer power management or data center energy-efficiency projects![6]

[4] www.microsoft.com/environment/IT_Energy/IT_Energy.aspx. Accessed May 22, 2015.
[5] Best Practices Guide for Energy-Efficient Data Center Design. National Renewable Energy Laboratory. U.S. Department of Energy. March 2011.
[6] energystar.gov/products/low_carbon_it_campaign/contact_energy_star_free_tech_support.

Software Power Cyclers

Server power consumption can also be reduced by installing "power cycler" software, which works by directing individual devices on the rack to power down during periods of low demand.

Solution: Data Center Infrastructure Management (DCIM)

Software-based data center management tools are part of a growing trend of solutions that allows managers to take a holistic view of their operation, not just in terms of energy consumption, but overall systems and building management as well.

Specifically, DCIM applications monitor, measure, manage, and control facility performance, equipment utilization, and energy consumption. Although these tools do not reduce energy usage in and of themselves, they do provide critical feedback and help to drive data center optimization, which can save energy by means of:

- Thermal management
- Airflow optimization
- Better server utilization
- Server consolidation

> DCIM applications monitor, measure, manage and control facility performance, equipment utilization, and energy consumption.

Solution: Airflow Optimization

The average data center has a rated cooling capacity that is more than three times what the IT load demands. As a result, there is an enormous potential for many data centers to save energy through airflow optimization.[7]

Cooling Capacity Factor (CCF) Assessment

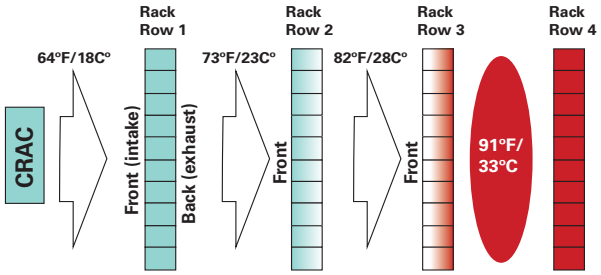
A simple Cooling Capacity Factor (CCF)[8] assessment can help quantify your current cooling distribution efficiency and uncover the actual cooling effectiveness of your data center. These assessments measure your cooling output relative to IT load, and help adjust your cooling infrastructure.

Upsite Technologies® offers a convenient CCF Calculator to help you begin your assessment.

Proper Server Rack/Row Orientation

The orientation of server racks and rows also makes a difference in the amount of energy your data center consumes. Most commonly, equipment takes in cold air through the front of the unit and expels hot air out the back. If your servers are arranged with the fronts of racks and the fronts of servers facing one another, you will achieve a consistent airflow.

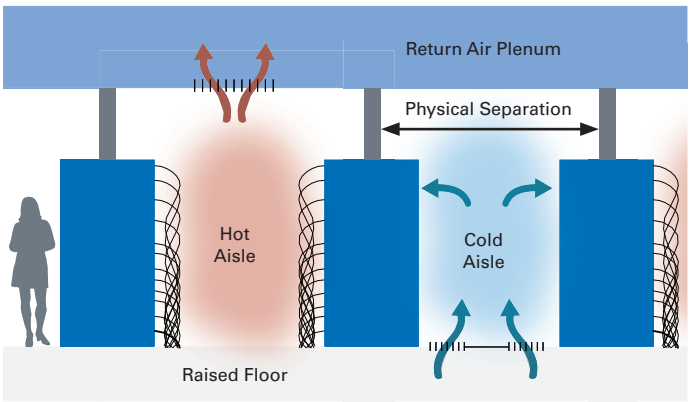
Poor Rack Orientation Can Lead to Hot Spots[9]



But if several rows are set up in the same orientation, the second row of racks takes in hot exhaust air from the first row. The problem is magnified with each progressive row, as the air temperature becomes hotter, causing more energy usage from A/C to keep the data center cool.

The solution? Racks should always be oriented so that the fronts of the servers face each other. This so called "hot aisle/cold aisle" approach can reduce energy losses, and may also extend the life of your servers.

Hot Aisle/Cold Aisle Approach to Server Orientation[10]



[7] Upsite Technologies. upsite.com.
[8] Ibid.
[9] Bouley, Dennis, APC, et al. Fundamentals Of Data Center Power And Cooling Efficiency Zones. The Green Grid. 2009.
[10] Best Practices Guide for Energy-Efficient Data Center Design. National Renewable Energy Laboratory. U.S. Department of Energy. March 2011.

How Cool Is This?

A recent case study conducted by the U.S. Dept. of Energy showed that airflow optimization strategies **increased cooling capacity by 21%** and **decreased fan energy by 8%.**[12]

Optimized Airflow Within Aisles

Depending on the design, A/C units in data centers can be placed outside of racks along the perimeter, mounted overhead, under the raised floor, or installed among the rows of IT racks. As explained earlier, minimizing the mixing of hot and cold air increases airflow efficiency, which usually equates to energy savings.

Other simple modifications allow airflows to be much more predictable, enabling a greater portion of the cool air to be utilized, and higher power densities achieved. These include:

- Blanking panels, which fill spaces around equipment
- Air dams to seal the tops, bottoms, and sides of equipment
- Brush grommets, which fill open spaces around floor cable cut-outs
- Cabinet chimneys to contain hot return air

Correcting Raised Floor and Rack Airflow

In many older data centers, the space beneath the raised floor has been used to route cabling. However, this obstructs airflow, making the A/C unit work harder. It is more efficient energy-wise to place cabling overhead, or run it under the hot aisle if a "hot aisle/cold aisle" strategy is being used.

Rearranging Out-Of-Rack Equipment

Equipment such as large tape libraries or mainframe computers can cause airflow inconsistencies within any data center, leading to wasted energy. To remedy this issue, all devices that can be mounted in four-post enclosed racks should be. Other such equipment should all be placed in the same area of the data center to avoid disturbing optimal rack airflow.

Solution: Variable Frequency Drives (VFDs) and Electronically Commutated (EC) Motors

Some experts believe the era of "containment" as an airflow optimization technique — separating cool supply air and warm exhaust air — is over, and that bigger gains can be achieved through the use of VFDs and EC fan motors.

Research indicates, a decrease of merely 10% in fan speed may result in as much as a 27% reduction in energy use — and serve to prolong the life of the equipment.[13]

Fans and ducting play a big role in data center design. However, traditional fans operate at full speed even when the supported loads require less capacity. Matching fan output to the load with an EC motor or a VFD may result in energy savings equal

Did You Know?

Cooling can account for 44% of a data center's energy consumption.[11]

Energy savings from using VFDs can range from **20% to as much as 80%.**[15]

[11] Klaus, Jeff. New Categories for Data Center Best Practices. Data Center Journal. April 15, 2013.
[12] Bell, Geoffrey C., P.E. Data Center Airflow Management Retrofit.
[13] Hassen, Marcus. Ten Tips To Make A Legacy Data Center More Energy Efficient. FacilitiesNet.com. February 2009.
[14] Bouley, Dennis, APC, et al. Fundamentals Of Data Center Power And Cooling Efficiency Zones. The Green Grid. 2009.
[15] Variable-Frequency Drives Spin Up Energy Savings for Data Centers. 2015 ABB Inc.

A decrease of just 10% in fan speed may result in as much as a 27% reduction in energy use and prolong the life of the equipment.[13]

Did You Know?

An ENERGY STAR-qualified UPS can **cut energy losses by 30-55%.**[16]

to 50% or more of certain other part load control strategies.[14] DCIM software plus thermal sensors utilize these devices even more effectively.

Solution: Efficient Uninterruptible Power Supplies (UPSs)

UPSs maintain data center performance and business continuity in the event of an electrical disruption or major disaster.

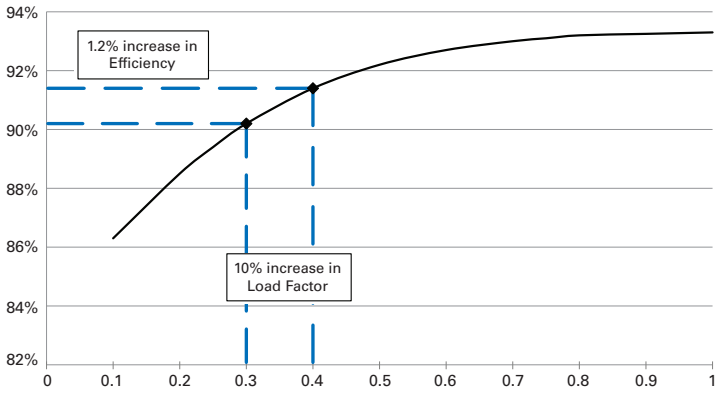
Transformer-based legacy UPS systems are adept at providing the highest efficiency at full loading— however, few data centers are actually able to achieve full load. Newer energy-smart units reach high efficiency at more common operating conditions. This can equate to less heat dissipation, lower cooling requirements, and reduced energy usage.

Along with better efficiency, modern UPSs also offer a smaller footprint and improved flexibility while providing high levels of reliability.

To help reduce data center energy costs through UPS usage, we recommend that you:

- Match UPS loads as closely as possible to your IT loads
- Utilize the Eco Mode on these devices
- Consider scalable UPSs to allow for a coordinated growth path of UPS capacity and IT load

Potential Utility Savings from UPS[17]



Solution: Close-Coupled Cooling

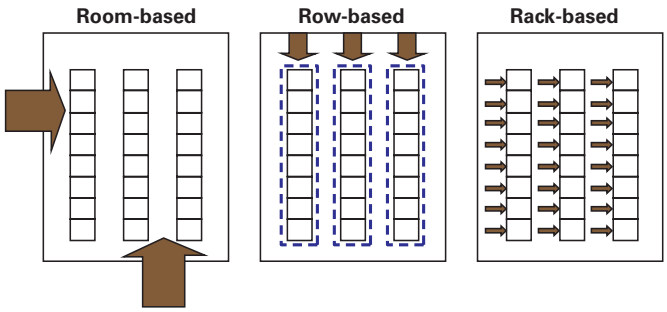
Overall, power usage per-square-foot is increasing in data centers across the country. But instead of increasing airflow volume (and power usage) to compensate, IT energy managers have the opportunity to save energy by incorporating so-called close-coupled cooling devices.

Close-coupled cooling dictates that the cooling unit be moved from the perimeter of the data center to a position that is in the row or above the racks. This improves energy-efficiency by capturing hot exhaust before it has a chance to mix with the surrounding air, or recirculate to the front of the rack. This arrangement also makes it easier to add capacity to the server room.

[16] Purchasing More Energy-Efficient Servers, UPSs, and PDUs. Energy.gov.

[17] Best Practices Guide for Energy-Efficient Data Center Design. National Renewable Energy Laboratory. U.S. Department of Energy. March 2011.

Illustrations of Room-, Row- and Rack-based Cooling[18]



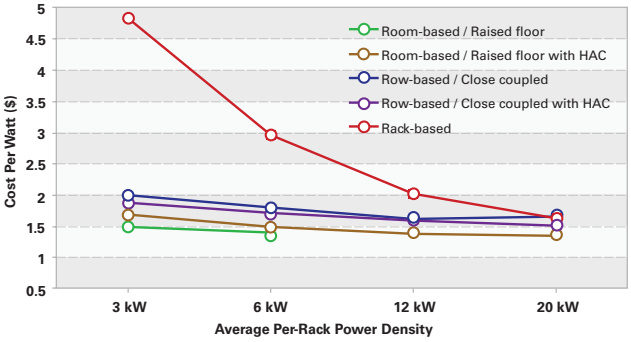
There are basically three types of close-coupled cooling configurations:

Room-Based Cooling

With a room-based approach, cooling units are associated with the room and work in tandem to reduce the total heat load of the room. They can be located in or outside the data center, and are effective with or without a raised floor.

Aisle and/or rack containment is recommended for such arrangements.

Cost Per Watt Comparison of Three Main Close-Coupled Cooling Technologies[19]



Row-Based Cooling

Row-based cooling saves energy by shortening the airflow path, which reduces the fan power required to move the cool air. Cooling units may be located in between racks, or mounted overhead.

IT equipment—notably servers and data storage devices—account for at least 50% of the energy consumption in the average data center.[20]

This approach allows cooling to be targeted to actual needs of specific rows. For example, you might be running a high-density blade server on one row and a lower-density communication enclosure on another.

Rack-Based Cooling

With cooling units directly mounted to or within the IT racks, rack-based cooling is the most energy-efficient of all the configurations, and allows you to achieve the highest rack power densities. Compared with room- or row-based cooling, airflow paths are even shorter, and become a non-factor in installation variation or room constraints.

Hybrid Cooling Systems

Data centers that have a mix of high and low rack power densities can often enjoy the greatest energy savings by applying a combination of room-, row-, and rack-based cooling technologies.

Solution: Decommission Or Consolidate "Zombie" IT Equipment

IT equipment—notably servers and data storage devices—account for at least 50% of the energy consumption in the average data center.[21] Yet studies show that up to one-third of this equipment is unused but powered on, taking up space, and often utilizing network ports and other resources, all of which wastes precious energy.

Did You Know?

Studies show that up to **one-third of the equipment** supported in the average data center is **unused**.[22]

[18] Dunlap, Kevin, et al. Choosing Between Room, Row, and Rack-based Cooling for Data Centers. Schneider Electric. 2012.
[19] Ibid.
[20] Report to Congress on Server and Data Center Energy Efficiency. U.S. EPA ENERGY STAR Program. August 2, 2007.
[21] Ibid.
[22] Patrizio, Andy. Research Finds One-Third Of Data Center Servers Are Idle. ITWorld.com. June 10, 2015.

Often, these IT "zombies" are only discovered through Mergers & Acquisitions activities, data center moves, or other large-scale events. Fortunately, tools like DCIM applications are available to help you detect, manage and, if necessary, rid yourself of these potential energy wasters.

Potential Solution: Storage

Information in data centers is typically stored on traditional, inexpensive spindle or spinning hard disc drives (HDD). Yet, technological advances in tape libraries and an "Archive Cloud" provide today's most cost-effective and reliable archive storage solutions.

In addition, auto deduplication reduces the amount of network traffic and energy consumed by storage devices in your data center.

Potential Solution: Ultrasonic Humidifiers

Tightly controlling the climate inside your data center is essential to maintaining facility performance. Humidity in particular is traditionally added to air streams to reduce the risk of electrostatic discharge (ESD). This despite the fact that modern IT equipment is much more resilient to what was once considered adverse environmental conditions. What's more, better equipment design and insulation standards have reduced the risk of ESD even in low-humidity environments.

Many data centers still use electric resistance heaters to create steam for humidification. Yet, by atomizing water through vibration, ultrasonic humidifier technology uses much less electricity, and can be a smart addition to your energy efficiency program.

Make Your Data Center Energy-Smart

Modern data centers have become essential storehouses of information for doing business and powering our everyday lives. Nonetheless, such demands require large amounts of power, plus a significant investment in time and money to sustain properly.

Fortunately, smart improvements, energy upgrades, modifications in procedures and practices, plus configuration changes discussed here may help you reduce energy usage in your data center.

Additional Resources

Best Practices Guide for Energy Efficient Data Center Design. **National Renewable Energy Laboratory. U.S. Department of Energy. March 2011.**

Energy.gov

Report to Congress on Server and Data Center Energy Efficiency. **U.S. EPA ENERGY STAR Program. August 2, 2007.**

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- Agricultural Pumping: Pumped and Primed to Save Energy
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