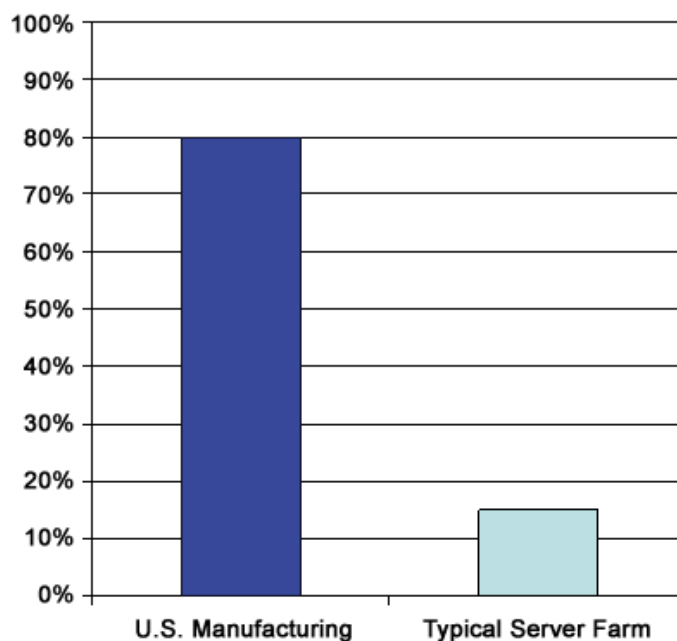# Building the
Green Data Center

This guide covers the essential elements involved in building a green data center, focusing on management, measurement, technology, and best practices. As you read through this report, you will also find links to free downloadable tools to support your green data center initiatives

ITBUSINESSEDGE

Dealing with Information Technology's Power-Hungry Legacy

Until recently, energy efficiency was not a major concern for data center managers. Instead, the focus was on being able to do more, do it more reliably and do it faster.

➤ The primary incentives for IT revolved around meeting SLAs while staying in budget, with initiatives to support new business capabilities a distant third.

➤ This prevailing attitude is reflected by the CIO of a major regional insurance company during the 1990s. "The only thing I ever worried about back then was, whether there would be enough power to do what I needed to do."

➤ This attitude led to common practices that would never be tolerated in any industrial sector. As recently as 2008, IBM estimated that in the traditional IT environment, servers were operating at between **5 and 15 percent of capacity**. In contrast, the capacity utilization figure in the manufacturing sector over the past two decades has been about **80 percent**.

The low capacity utilization of typical servers would not be tolerated in other sectors of the economy

More Resources

The Green Data Center Energy-Efficiency Checklist

To meet new, "green" IT requirements, every aspect of data center operation must be reviewed for energy efficiency.

Virtualization & Carbon Footprint Calculator

Get a quick approximation of the results you can expect from server virtualization.

Making the Case for Green IT

In today's social and political climate, the case for green IT would seem self-evident. But green initiatives still must be justified to senior management. Fortunately, green IT is a rare business situation where "doing good" and "doing well" are not at odds.
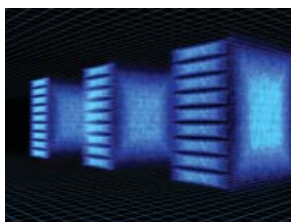
➤ **Practical.** There is substantial room for improvement. In many data centers, capacity utilization alone can be increased by a factor of four.

➤ **Financial.** Reduction in power costs (e.g. with energy-efficient servers) can often justify the cost of substantial investments in green IT with a pay-back in less than one year.

➤ **Business-Related.** In many cases, customers – either manufacturers or major retail chains – now specify green practices as a condition of doing business.

➤ **Moral.** Going green is the right thing to do.

More Resources

Book Excerpt: The Green and Virtual Data Center

Green servers, storage, and networks deliver the performance, availability, and responsiveness for all types of application needs and requirements.

Scheduled Sever Power-Down Calculator

Gives you a quick approximation of the results you can expect from a temporary power-down strategy for resources that aren't needed 24 /7.

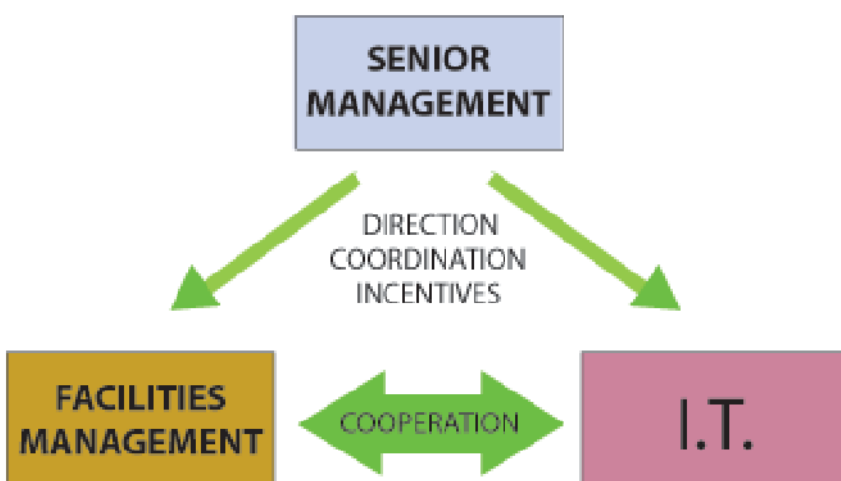**Book Excerpt: Grow a Greener Data Center**

It's now possible to design a data center that consumes fewer resources, costs less money to run, has a longer usable lifespan, and can even highlight a company's social responsibility.

Management Considerations

IT energy management has long been a classic example of an issue that "falls between the cracks."

➤ Responsibility for paying the IT electricity bill typically falls on a facilities-management organization, which has no power to control IT energy consumption.

➤ Responsibility for controlling IT energy consumption falls on the IT organization, which often doesn't even see the electricity bill.

➤ Senior management must therefore intervene to:

- Facilitate cooperation and information sharing.

- Create incentives for IT to control energy efficiency and, equally important, eliminate disincentives.

Green initiatives require cooperation between senior management, facilities management and IT.

More Resources

Decommissioning "Comatose" Servers

Gives you a quick approximation of the results you can expect from tracking down and turning off servers no longer performing useful work.

Virtualization & Carbon Footprint Calculator

Get a quick approximation of the results you can expect from server virtualization.
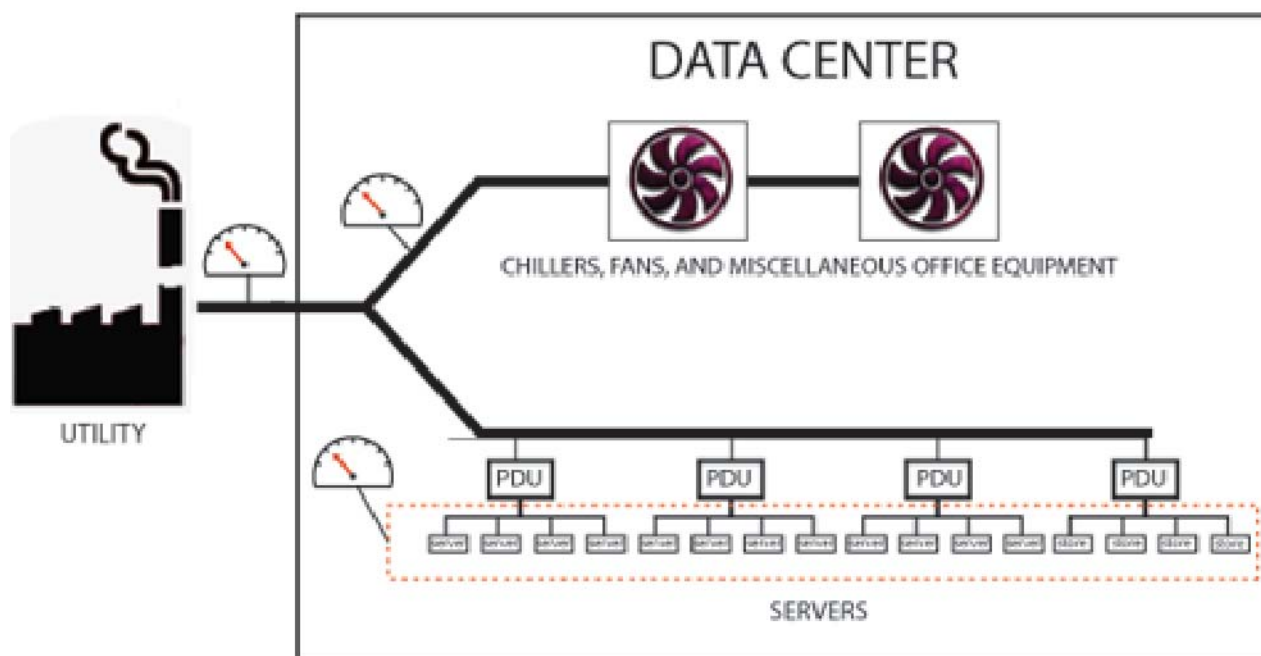
Establishing a Baseline

The "greenness" of a data center is directly proportional to its energy efficiency, which has a much greater potential impact on the environment in general — and carbon footprint in particular — than the other green issue, asset disposal. Unfortunately, many CIOs don't even have access to their data centers' electricity bills.

➤ The first step is to determine the power usage of your IT equipment only: servers, storage devices, networking gear, KVM switches, monitors, etc. "IT Equipment Power" specifically excludes support equipment such as power-delivery components (e.g. PDUs), chillers, other air conditioning, pumps, fans and the like.

➤ The second step in measuring improvement is to obtain baseline information on power consumption for everything that supports the IT equipment, such as cooling equipment.

➤ The third step is to calculate your Power Usage Effectiveness ratio, or PUE as described in the following slide

"**The Green Data Center Energy-Efficiency Checklist**" provides a list of the systems that most likely need attention.

To calculate data center efficiency, is important to measure the power consumed by IT equipment separately from the power consumed to cool that equipment.

The Importance of PUE

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

PUE, Power Usage Effectiveness, is defined by the formula above. The PUE ratio is a good measure of the energy efficiency of your data center as a whole.
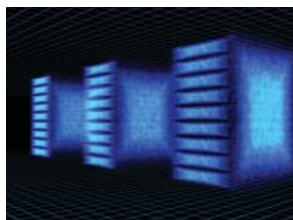
➤ The lower the PUE, the better.

➤ For calculation purposes, **IT Equipment Power** is defined as the power draw associated only with CPUs (servers), storage modules, networking gear and supplemental equipment directly associated with the IT equipment, such as KVM switches.

➤ **Total Facility Power** includes "everything else" required to support IT equipment:

  • Power-delivery equipment (UPS, PDUs, switching gear, generators, etc.)

  • Cooling equipment: chillers, air conditioning (CRAC), fans, pumps, and cooling towers

  • Other miscellaneous loads such as the power used to heat and light an office

More Resources

Book Excerpt: The Green and Virtual Data Center

Green servers, storage, and networks deliver the performance, availability, and responsiveness for all types of application needs and requirements.

Scheduled Sever Power-Down Calculator

Gives you a quick approximation of the results you can expect from a temporary power-down strategy for resources that aren't needed 24 /7.

Be sure to download the
Green Data Center Energy-Efficiency Checklist

A full review of your data center operations is a painstaking task, but our "**Green Data Center Energy-Efficiency Checklist**" gives you the guidance you need to make the process as painless — and profitable — as it can be.

Key issues covered include:

➤ Organization issues

➤ Strategic considerations

➤ Metrics to be tracked

➤ Potential equipment upgrades

More Resources

Decommissioning "Comatose" Servers

Gives you a quick approximation of the results you can expect from tracking down and turning off servers no longer performing useful work.

The Green Data Center Energy-Efficiency Checklist

To meet new, "green" IT requirements, every aspect of data center operation must be reviewed for energy efficiency.

Book Excerpt: Grow a Greener Data Center

It's now possible to design a data center that consumes fewer resources, costs less money to run, has a longer usable lifespan, and can even highlight a company's social responsibility.
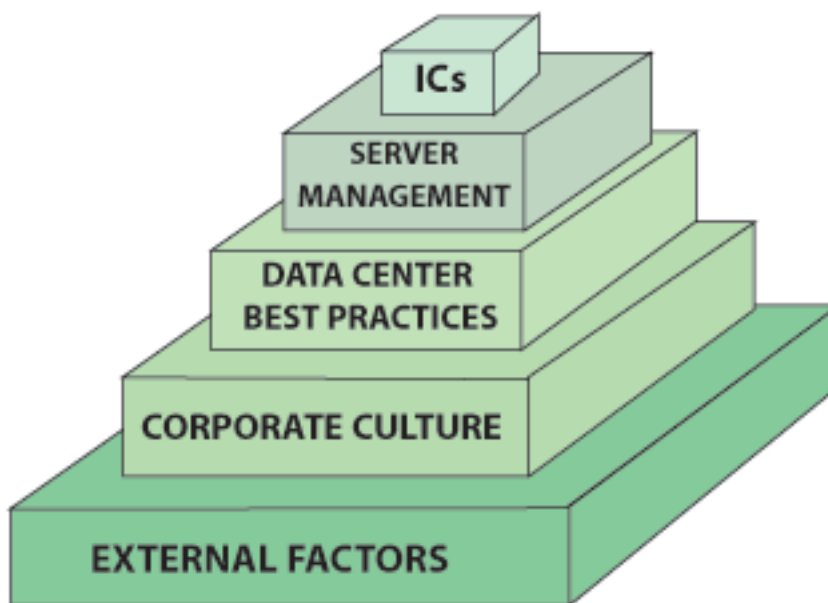
The Pyramid of Influences

As a green IT manager trying to reduce data center energy consumption you have two goals:

➤ Reduce your total energy consumption
   ("Total Facility Power" + "IT Equipment Power" in the PUE equation)

➤ Reduce your PUE

There are five levels at which you can act to conserve energy. They are shown in the Pyramid of Influences below.

➤ External factors include options for power sources, the local regulatory environment, customer demands, the climate and other factors over which you have no control.

➤ Your corporate culture and management structure can be a critical success factor for any green initiative.

There is a hierarchy of influences that affect and support the success of a green IT initiative.

➤ Data center best practices refer to your data center's physical layout, its cooling equipment and other factors not related to the servers and other IT equipment.

➤ Server management refers to server utilization rates and choices related to purchasing and life cycle management. Be sure to download "**Decommissioning 'Comotose' Servers**" to determine the value of powering down non-critical resources.

➤ Many of the ICs (processors) available today have been specifically designed for energy efficiency and offer configuration options that can significantly improve performance per watt.

External Factors

External factors are factors that, by definition, you cannot control. Nonetheless, these factors can play a role in your success, both in terms of building consensus for change, and executing that change.
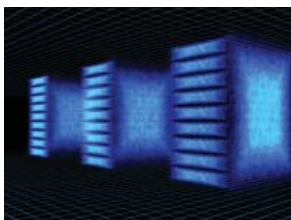
➤ **Customer demand.** Many customers now include "green" clauses in their specifications. The ability to demonstrate environmentally sustainable practices can help you win business, and thus serve as a motivator for senior managers to support green IT initiatives.

➤ **Regulatory mandates.** Some jurisdictions, particularly municipalities, have created regulatory environments that favor energy efficiency. Again, this can motivate senior managers to support green IT initiatives

➤ **Alternate power sources.** Some businesses have the option of choosing where they buy their power – and can make the green choice.

➤ **Climate.** Ambient temperatures fall low enough in some locations that there are times when ambient air can be used to supplement chillers. (Today's servers are much less sensitive to air quality than those of only a few years ago.) Other climates may lend themselves to solar energy.

More Resources

Book Excerpt: The Green and Virtual Data Center

Green servers, storage, and networks deliver the performance, availability, and responsiveness for all types of application needs and requirements.

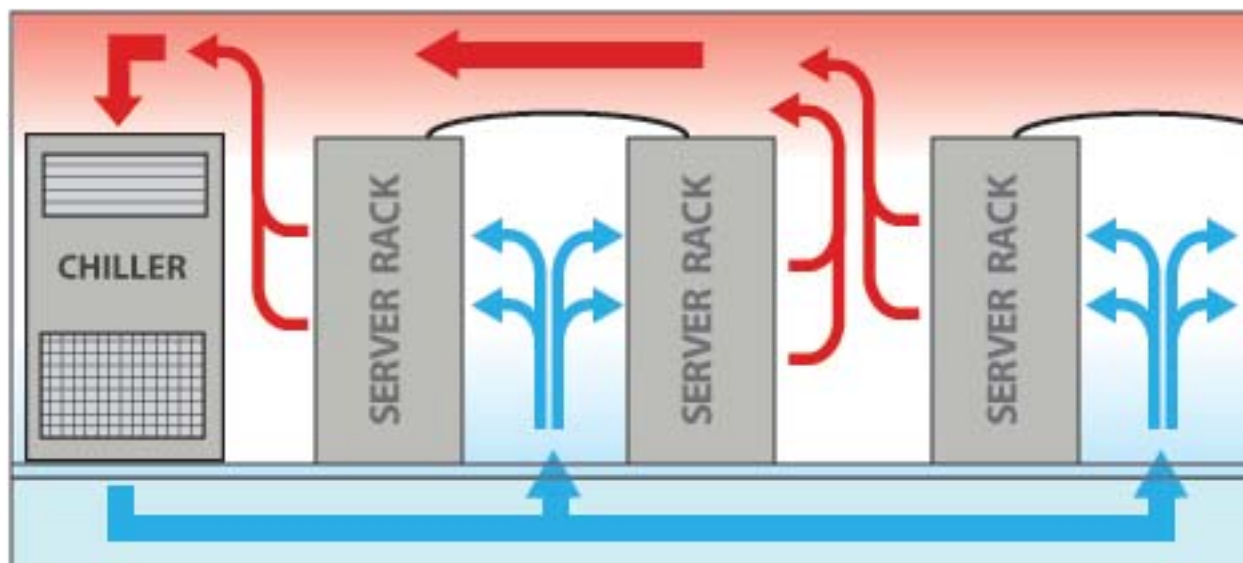### Scheduled Sever Power-Down Calculator

Gives you a quick approximation of the results you can expect from a temporary power-down strategy for resources that aren't needed 24 /7.

Data Center Best Practices: Airflow Management

Properly managed airflow is one of the most important factors in improving the energy efficiency of a data center.

➤ Separate the hot air exiting servers from the cool air entering them

- Purchase servers with front-to-back airflow to simplify airflow management

- Mount servers with the air-intake vents facing "cold aisles" and the exhaust vents facing "hot aisles."

- Prevent air from flowing over the tops of the server racks or around the rows with curtains, plastic sheeting or other such means.

- Blank open slots in racks to prevent the mixing of hot and cold air.

- Replace missing tiles and block cable openings in the raised floor that could result in the misdirection of cold air into hot aisles.

One of the most basic, and most important best practices in a data center is the creation of hot and cold aisles to maximize cooling efficiency.

Data Center Best Practices: Airflow Management II

➤ Make sure that air can flow without restriction.

- • Position CRAC units for maximum efficiency

- • Route cables to avoid blocking the flow of air

- • Make sure the return (hot) air plenum is adequate to accommodate the required airflow

More Resources

Decommissioning "Comatose" Servers

Gives you a quick approximation of the results you can expect from tracking down and turning off servers no longer performing useful work.

The Green Data Center Energy-Efficiency Checklist

To meet new, "green" IT requirements, every aspect of data center operation must be reviewed for energy efficiency.

Book Excerpt: Grow a Greener Data Center

It's now possible to design a data center that consumes fewer resources, costs less money to run, has a longer usable lifespan, and can even highlight a company's social responsibility.

Data Center Best Practices: Chillers

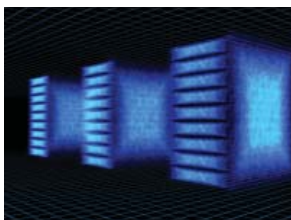Chillers are the most important component of a data center's total HVAC system.

➤ Chillers are typically responsible for one-third of total power consumption.

➤ Chillers are relatively simple mechanically, but they are complex thermodynamic systems that require the attention of an expert.

➤ In many cases, chillers can be operated at less-aggressive levels and still maintain appropriate temperatures at the rack.

➤ The guidelines below are based on a study of roughly two dozen data centers, but will not apply in all cases.

- Adjust the chiller set points for water in the 50° to 55° F range.

- Set cooling towers for a 5° to 7° F approach (the difference between the cooled-water temperature and the entering-air wet bulb temperature).

- Make sure chillers are equipped with variable-speed (variable-frequency drive or VFD) technology. This is extremely important.

- Make sure the temperature of the cooling coils is above the dew point to prevent undesired dehumidification.

- Monitor the efficiency of the chillers directly.

More Resources

Virtualization & Carbon Footprint Calculator

Get a quick approximation of the results you can expect from server virtualization.

Scheduled Sever Power-Down Calculator

Gives you a quick approximation of the results you can expect from a temporary power-down strategy for resources that aren't needed 24 /7.

Data Center Best Practices: Other Important Adjustments

In addition to the chillers, other adjustments can be made to improve efficiency.

➤ Centralize dehumidification and use the ventilation air system, not the chiller.

➤ Re-evaluate humidity-control requirements to reflect current server requirements rather than the older and stricter mainframe requirements.

➤ Make sure that the under-floor pressurization is neither too high nor too low.

➤ Adjust the set point for heaters in engine-driven backup generators for UPS systems to 70° F.

More Resources

Decommissioning "Comatose" Servers

Gives you a quick approximation of the results you can expect from tracking down and turning off servers no longer performing useful work.

The Green Data Center Energy-Efficiency Checklist

To meet new, "green" IT requirements, every aspect of data center operation must be reviewed for energy efficiency.
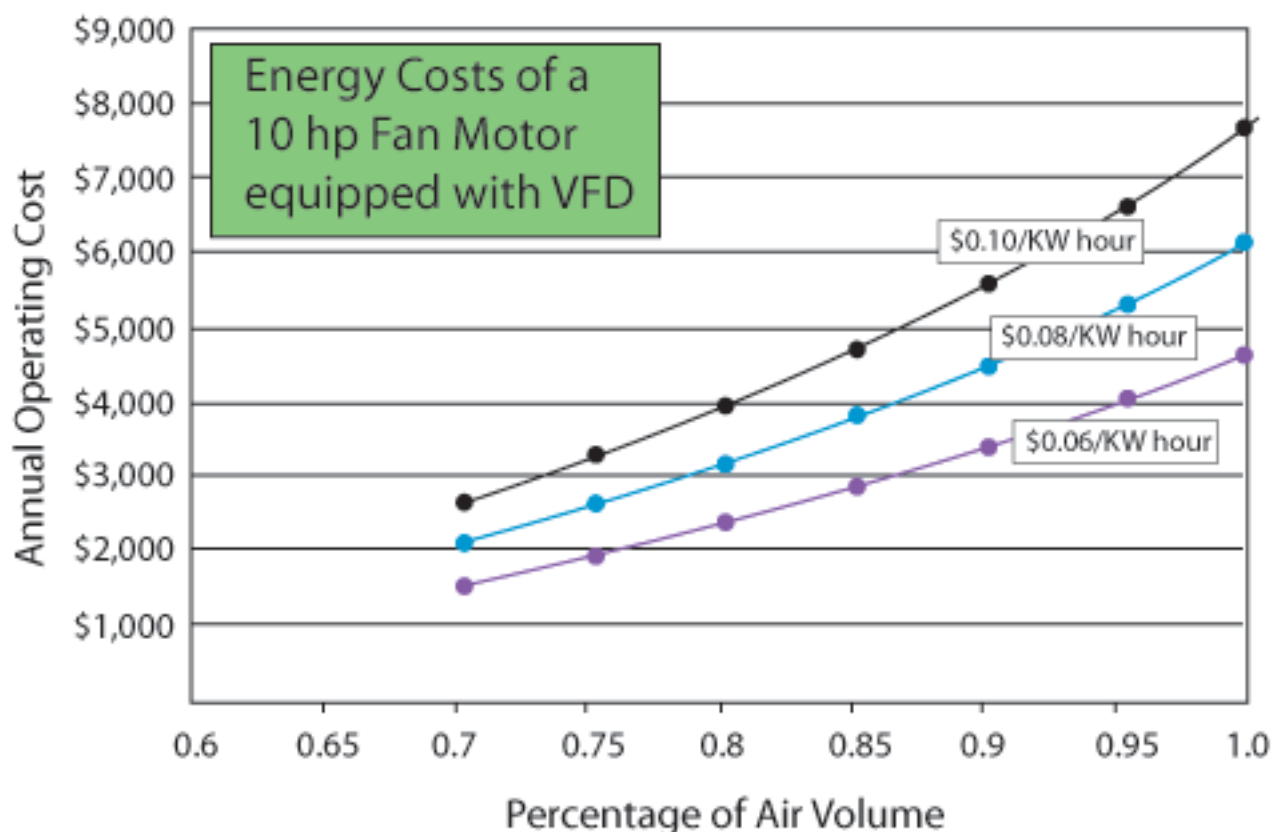

Book Excerpt: Grow a Greener Data Center

It's now possible to design a data center that consumes fewer resources, costs less money to run, has a longer usable lifespan, and can even highlight a company's social responsibility.

Data Center Best Practices: Equipment Upgrades

While some components and systems can be adjusted to improve efficiency, others need to be modified or replaced.

➤ Some items, such as variable-speed drive (VFD) fans can be retrofitted into existing systems. Specific examples:

- Variable-speed drive(VFD) cooling tower fans.

- Variable-speed drive(VFD) pumps.

- Mechanical systems sized to operate efficiently below maximum load.

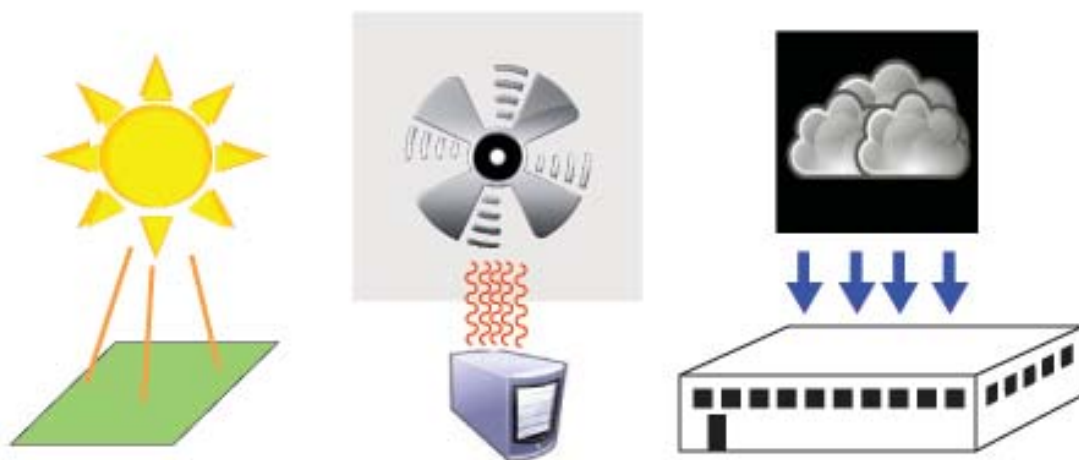- Electrical components (UPS, PDUs) sized to operate efficiently below maximum load.

Variable-frequency drive (VFD) fans dramatically reduce power consumption in the data center by decreasing the load when not operating at full power.

Data Center Best Practices: Equipment Upgrades

➤ The payoff for other ambitious projects is measured in years. Examples:

- Solar power (where practical) can be used for some portion of total load.

- Cogeneration (use of server-generated heat) can be used to drive the chiller instead of electricity

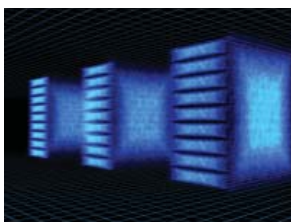- Use of water-side and air-side economizers can provide "free cooling" as ambient temperatures permit

Long-term energy efficiency strategies include solar, cogeneration using the heat from servers, and "free cooling" provided by cold ambient air.

More Resources

Virtualization & Carbon Footprint Calculator

Get a quick approximation of the results you can expect from server virtualization.

Scheduled Sever Power-Down Calculator

Gives you a quick approximation of the results you can expect from a temporary power-down strategy for resources that aren't needed 24 /7.

Server Management

One of the most important factors in server management is server utilization.

➤ Server utilization can be improved by decommissioning so-called "zombie" servers – servers running applications that are no longer used. Locating these servers, however, is not an easy task, and efficiency improvements are not dramatic.

➤ Server utilization can be improved by simply powering down servers during time periods when they are not used. This approach works with servers running applications that are used only during working hours and is relatively easy to implement. Be sure to download the "**Scheduled Server Power-Down Calculator**" to evaluate cost-savings from this practice.

➤ The most effective way to improve utilization is through virtualization. Be sure to download the "**Virtualization & Carbon Footprint Calculator**" to help quantify the benefits of virtualization.

More Resources

The Green Data Center Energy-Efficiency Checklist

To meet new, "green" IT requirements, every aspect of data center operation must be reviewed for energy efficiency.
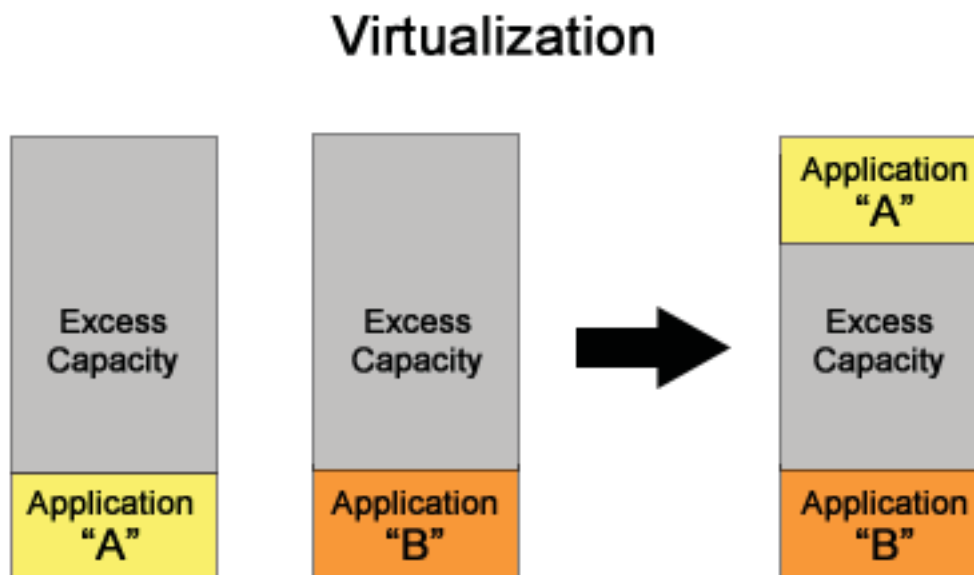

Virtualization & Carbon Footprint Calculator

Get a quick approximation of the results you can expect from server virtualization.

Virtualization

Virtualization can improve server utilization by ratios as high as 15:1, which means that one server is accomplishing the workload previously allocated to 15 servers. The diagram below is a simplified example of the principle of virtualization.

Virtualization

The essential concept behind virtualization is running multiple applications on one server to increase server-utilization rates.

➤ The business case for virtualization is almost always attractive, with significant ROI.

➤ Virtualization has become a common practice, with tools and a knowledge base that make implementation relatively painless.

➤ Virtualization has implications for cooling. Although the net result is always a lower cooling requirement, adjustments may be needed to handle new "hot spots."
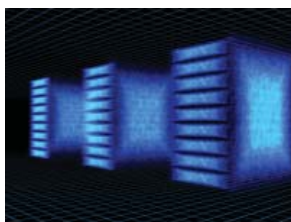
Server Replacement Cycles

➤ Modern servers have been redesigned to maximize energy efficiency and facilitate virtualization.

➤ Many state-of-the-art servers adjust their performance based on demand.

➤ Due to servers' improved energy efficiency, many data centers can save money by speeding up replacement cycles rather than slowing them down.

➤ In some cases, break-even can be achieved in one year. It is important to do the math.

More Resources

Book Excerpt: The Green and Virtual Data Center

Green servers, storage, and networks deliver the performance, availability, and responsiveness for all types of application needs and requirements.

Scheduled Sever Power-Down Calculator

Gives you a quick approximation of the results you can expect from a temporary power-down strategy for resources that aren't needed 24 /7.
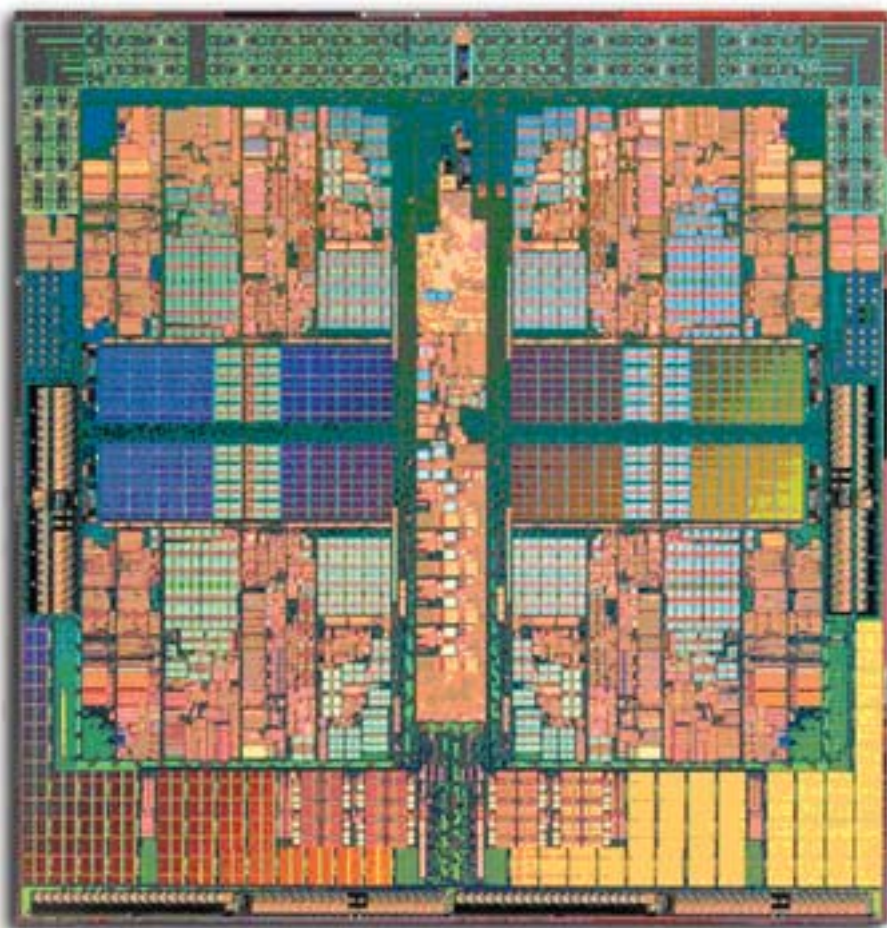
Book Excerpt: Grow a Greener Data Center

It's now possible to design a data center that consumes fewer resources, costs less money to run, has a longer usable lifespan, and can even highlight a company's social responsibility.

IC Innovations

➤ Intel's Xeon processors automatically increase or decrease processor frequency to meet the current need, resulting in lower power consumption overall.

➤ Intel's Power Technology automatically puts its Xeon® processors and memory into the lowest available power state, again reducing the cooling burden.

➤ AMD's Opteron processors allow each core to vary its frequency based on the specific needs of the application to lower power consumption.

➤ AMD CoolCore™ technology can cut power to unused transistor areas to reduce power consumption and lower heat generation.

AMD Opteron processor with energy-efficient features

Summary

➤ Use external factors (government regulations, customer requirements) to build consensus for green initiatives.

➤ Find champions in upper management.

➤ Make physical modifications in the data center to maximize cooling efficiency.

➤ Adjust equipment parameters with energy efficiency in mind.

➤ Run servers closer to their total capacity through virtualization.

➤ Make purchasing decisions based on the energy efficiency of servers and the ICs that power them.

More Resources

Decommissioning "Comatose" Servers

Gives you a quick approximation of the results you can expect from tracking down and turning off servers no longer performing useful work.

Virtualization & Carbon Footprint Calculator

Get a quick approximation of the results you can expect from server virtualization.

Be Sure to Check Out These Additional Tools

➤ **Scheduled Sever Power-Down Calculator**

➤ **Excerpt from "Grow a Greener Data Center"**

➤ **The Green Data Center Energy-Efficiency Checklist**

➤ **Virtualization & Carbon Footprint Calculator**

➤ **Excerpt from "The Green and Virtual Data Center"**

➤ **Decommissioning "Comatose" Servers Calculator**