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# GUIDELINES FOR ENERGY-EFFICIENT DATACENTERS



## **ABSTRACT**

In this paper, The Green Grid™ provides a framework for improving the energy efficiency of both new and existing datacenters. The nature of datacenter energy consumption is reviewed and best practices are suggested that can significantly impact operational efficiencies.

## **ABOUT THE GREEN GRID™**

The Green Grid is a non-profit trade organization of IT professionals formed to address the issues of power and cooling in datacenters. The Green Grid seeks to define best practices for optimizing the efficient consumption of power at the IT equipment and facility levels, as well as the manner in which cooling is delivered at these levels. The association is funded by four levels of membership, and activities are driven by end-user needs. The Green Grid does not endorse any vendor-specific products or solutions, but will seek to provide industry-wide recommendations on best practices, metrics, and technologies that will improve overall datacenter energy efficiencies.



## INTRODUCTION

Power availability is one of the most important challenges facing datacenters today. In the past, datacenter floor space has always loomed as the primary issue. Now, more and more datacenters run out of power availability before they run out of floor space. In addition, cooling requirements for dense servers are driving power demand and taxing the normal datacenter operational procedures. Operations are not properly “tuned” to accommodate the new energy-hungry environment. This paper illustrates existing electrical consumption patterns and suggests various strategies for reducing consumption. Energy improvements can be made from both an equipment-planning perspective and an operational-practices perspective for both IT and physical infrastructure (power, cooling, rack, security, fire suppression, and monitoring) devices.

## ENERGY COSTS AND CONSUMPTION

For years, electrical power usage was not considered a key design criteria for datacenters. Nor was electrical consumption effectively managed as an expense. In fact, many datacenter managers are unaware of what their monthly energy bill is. This is true despite the fact that the electrical energy costs over the life of a datacenter may exceed the costs of the electrical power system including the uninterruptible power supplies (UPS), or even exceed the cost of the IT equipment itself.

The reasons for this situation are as follows:

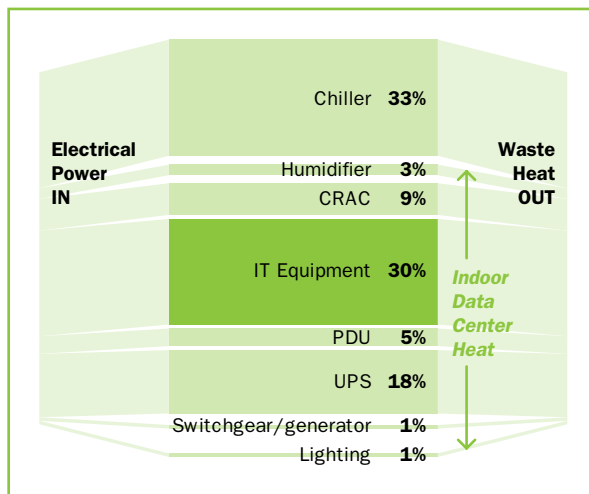
- Electrical bills are sent out long after charges are incurred. No clear link exists between particular decisions, like the installation of a new zone of equipment in the data center or operational practices and the increased cost of the electricity. In fact, electrical bills are viewed as an inevitable event that most people don't consider trying to influence.
- Tools for modeling the electrical costs of datacenters are not widely available and are not commonly used during datacenter design.
- Billed electrical costs are often not within the responsibility or budget of the datacenter operating group.
- The electrical bill for the datacenter may be included within a larger electrical bill and may not be available separately.
- Decision-makers are not given sufficient information during planning and purchasing decisions regarding the energy cost consequences.

If the datacenter were 100% efficient, all power supplied would reach the IT loads. This would represent Power Usage Effectiveness (PUE) of 1.0. PUE is further discussed in the Green Grid white paper entitled “Green Grid Metrics.” In the real world, electrical energy is consumed by devices in a number



of ways before it even reaches the IT loads. Practical requirements such as keeping IT equipment properly housed, powered, cooled, and protected is one example of how energy consumption is sidetracked, or rendered less efficient (see Figure 1).

Note that all energy consumed by the datacenter in Figure 1 ends up as waste heat, which is rejected



**Figure 1: Where Does It Go?**

outdoors into the atmosphere. This diagram is based on a typical datacenter with 2N power and N+1 cooling equipment, operating at approximately 30% of rated capacity.<sup>1</sup>

System design issues that commonly reduce the efficiency of datacenters include:

- Power distribution units and/or transformers operating well below their full load capacities.
- Air conditioners forced to consume extra power to drive air at high pressures over long distances.

- Cooling pumps which have their flow rate automatically adjusted by valves (which dramatically reduces the pump efficiency).
- N+1 or 2N redundant designs, which result in underutilization of components.
- The tradition of oversizing a UPS to avoid operating near its capacity limit.
- The decreased efficiency of UPS equipment when run at low loads.
- Under-floor blockages that contribute to inefficiency by forcing cooling devices to work harder to accommodate existing load heat removal requirements. (This can lead to temperature differences and high-heat load areas might receive inadequate cooling).

## BEST PRACTICES

Right-sizing the physical infrastructure system to the load, using efficient physical infrastructure devices, and designing an energy-efficient system are all techniques to help reduce energy costs. A successful strategy for addressing the datacenter energy management challenge requires a multi-pronged approach that should be enforced throughout the lifecycle of the datacenter. The following categories of practices serve as cornerstones for implementing an energy-efficient strategy: engineering, deployment, operations, and organization.

## ENGINEERING FOR EFFICIENCY



### SYSTEM DESIGN

In datacenters, system design has a much greater effect on the electrical consumption than does the efficiency of individual devices. In fact, two datacenters comprised of the same devices may have considerably different electrical bills. For this reason, system design is even more important than the selection of power and cooling devices in determining the efficiency of a datacenter.

### FLOOR LAYOUT

Floor layout has a significant effect on the efficiency of the air conditioning system. Ideal arrangements involve hot-aisle/cold-aisle configurations with suitable air conditioner locations. The primary design goal of this floor layout approach is cool air and warm air segregation.

### PROPER CONFIGURATION OF SERVER SOFTWARE

When configuring servers, many datacenter managers are not careful about how they configure the power-related software. Power-economizer modes should always be selected to ensure more efficient operation of the server.

### LOCATION OF VENTED FLOOR TILES

In an average datacenter, many vented tiles are either placed in incorrect locations or an insufficient or excessive number of vented tiles is installed. By using Computational Fluid Dynamics (CFD) in the datacenter environment, the designer can optimize datacenter cool air flow by “tuning” floor tiles by varying locations and by regulating the percent of vents that are open at any given time or can optimize CRAC (Computer Room Air Conditioning) unit locations. Some vendors offer cooling optimization services and have demonstrated over 25% energy savings in real-world applications.<sup>2</sup>

### RIGHTSIZED PHYSICAL INFRASTRUCTURE COMPONENTS

Of all of the techniques available to users, rightsizing the physical infrastructure system to the load has the most impact on physical infrastructure electrical consumption. There are fixed losses in the power and cooling systems that are present whether the IT load is present or not, and these losses are proportional to the overall power rating of the system. In installations that have light IT loads, the fixed losses of the physical infrastructure equipment commonly exceeds the IT load. Whenever the physical system is oversized, the fixed losses become a larger percentage of the total electrical bill.

Rightsizing has the potential to eliminate up to 50% of the electrical bill in real-world installations. The compelling economic advantage of rightsizing is a key reason why the industry is moving toward modular, scalable, physical infrastructure solutions. The very nature of the modular, scalable infrastructure implies that new physical infrastructure equipment is added only when additional IT loads are added.

The ability to predict future power and cooling loads is also key in managing an energy-efficient datacenter. The American Society of Heating, Refrigeration & Air Conditioning Engineers (ASHRAE) offers a series of design guides that provide help in this task. The additional work performed up front to accurately predict the datacenter power and cooling load will pay for itself in both reduced capital and operational expense.

## DEPLOYING FOR EFFICIENCY



### INSTALLATION OF MORE EFFICIENT POWER EQUIPMENT

New best-in-class UPS systems have 70% less energy loss than legacy UPS at typical loads.<sup>3</sup> Average “light” load efficiency is the key parameter, not the full load efficiency. In addition UPS losses must be cooled, doubling system energy costs.

### CLOSELY COUPLED COOLING

Due to increasing density in the datacenter, a trend towards closely coupled cooling solutions has developed. Close-coupling targets specific areas where cooling is needed (such as an individual row, rack, or server) as opposed to a large open space (such as the datacenter room). In addition, close-coupling can result in shorter air paths that require less fan power. Close-coupled heat removal minimizes and almost eliminates the mixing of cool and hot air, since the airflow is completely contained in the row or rack.

Traditional datacenters that move to high-density server implementations without close-coupled cooling typically attempt to modify existing infrastructure through additional construction. Those modifications for high density rarely improve the efficiency of the datacenter. However, new datacenter designs, where the focus is on matching the room airflow to server airflow and on preventing the mixing of cool and warm air, can be quite efficient.<sup>4</sup>

Most of today’s existing datacenters attempt to cool equipment by flooding the air supply with as much cool air as possible. The cool air produced by CRAC units mixes with the heat produced by the load. This system makes it difficult, if not impossible, to target specific heat sources within the datacenter. The closely coupled approach greatly increases the efficiency of the cool air distribution and hot air removal systems. Due to the close coupling of CRAC units to the load, all of the capacity can be delivered to the load up to power densities on the order of 25 kW, or approximately 4X the practical density capacity of room-oriented architecture.<sup>5</sup>

### VIRTUALIZATION

Virtualization consolidates existing and expected future workloads. This reduces the number of physical servers required, thereby reducing floor space, cooling, and capital costs. It also increases the utilization of servers to improve energy efficiency. Furthermore, virtualization can also serve as an effective means for placing additional compute capability into production.

### INSTALLATION OF ENERGY-EFFICIENT LIGHTING

Other facility savings can be realized through devices such as timers or motion-activated lighting. Lighting power produces heat which, in turn, must be cooled—doubling the cost. The benefit of energy-efficient lighting is larger on low-density or partly filled datacenters.



### INSTALLATION OF BLANKING PANELS IN RACKS

Airflow dynamics can be improved by utilizing blanking panels on racks. The panels are an inexpensive way to decrease server inlet temperature while increasing the CRAC return air temperature—thereby reducing energy consumption.

### PLUMBING FOR CLOSELY COUPLED COOLING

Deployment of rack and server (chip-level) cooling systems in closely coupled cooling solutions requires delivery of facility water (chiller or condenser water) to the racks in question. A variety of options are available for delivering the water to these racks, including hard plumbing and soft or flexible plumbing. Delivery of water away from the periphery of the datacenter into the heart of the datacenter may be cause for concern for some datacenter operators. These concerns can be allayed by deploying sound engineering practices. The following best practices are suggested when preparing a datacenter for the deployment of closely coupled cooling solutions:

- Insulate plumbing to prevent condensation (if water has to be below the facility's dew point).
- Ensure piping is easily accessible for service and repairs, and to minimize disruption to existing datacenter infrastructure (power, communications, HVAC, etc.).
- Include stub-outs with shut-offs from periphery plumbing at necessary intervals to allow isolation of each rack row and each rack.
- Run plumbing in a direction parallel to that of the CRAC air flow to minimize air-flow blockage, or

place plumbing in floor recesses (where possible) to prevent air-flow blockage (i.e., air damming).

- Provide leak-containment features around water line components, such as drip pans, pipe wraps, and gravity drains.
- Utilize home-run flexible piping to minimize the number of pipe joints (and thus, the risk of leaks) near critical components.
- Isolate plumbing from electrical wiring (place plumbing in floor recesses, where possible, below the elevation of power cables and components).
- Employ leak-detection systems and reaction plans to minimize or eliminate impact of leaks on datacenter operations.

### DEVELOPMENT OF NEW SERVER REPLACEMENT POLICIES

Server consolidation, if properly executed, can also contribute to the overall high efficiency of the datacenter. Below are examples of how to leverage efficiency during server consolidation:

- Use a two-way server or a single-processor dual-core server to replace two or more old servers.
- Replace an old server with a blade based on a low-voltage or mid-voltage processor.
- Replace a dual-processor server with a single, dual-core processor.
- Use a two-way dual-core server in place of a four-way server.

## OPERATING FOR EFFICIENCY



### UTILIZATION OF AIR CONDITIONING

#### ECONOMIZER MODES

Many air conditioners offer economizer options. This can offer substantial energy savings, depending on geographic location. Although some datacenters have air conditioners with economizer modes, the economizer operation is often disabled.

#### COORDINATION OF AIR CONDITIONERS

Many datacenters have multiple air conditioners that actually fight each other. One may actually heat while another cools and one may dehumidify while another humidifies. The result is gross waste that may require a professional assessment to diagnose.

## ORGANIZING FOR EFFICIENCY



### ALIGNMENT OF STAFF

To properly engineer the migration from a traditional energy-consuming datacenter to a modern energy-conserving datacenter requires an organizational alignment that facilitates such a migration. Figure 2 illustrates an IT organizational structure that integrates the expertise of personnel who understand both IT systems and physical infrastructure systems. The new organizational wrinkle involves the integration of an IT facilities arm to the rest of the IT organization.

This organizational alignment presents several advantages. For years, IT and facilities departments have operated as separate entities and evolved

separate cultures and even separate languages. As a result, most datacenter design/build or upgrade projects are painful, lengthy, and costly.

This new IT facilities group is a separate group from the traditional “building” facilities group. The IT facilities group acts as a liaison between IT and the facilities building group, but is under the direct control of IT.

The IT facilities group addresses datacenter issues specific to hardware planning, electrical deployment, heat removal, and physical datacenter monitoring. This organizational alignment allows a datacenter team to rapidly deploy an energy-efficient datacenter upgrade policy that addresses both IT systems and physical infrastructure systems.

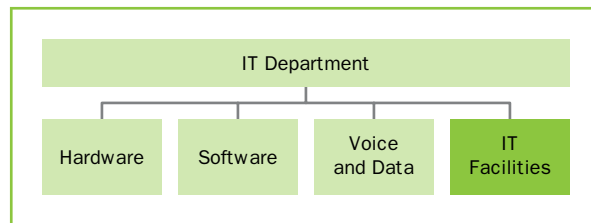


Figure 2: Aligning for Energy Efficiency<sup>6</sup>

## CONCLUSION



Check-off Box	Efficiency Best Practice	Date Executed
<input type="checkbox"/>	Itemized datacenter electric bill in hand	_____
<input type="checkbox"/>	Optimization of datacenter design	_____
<input type="checkbox"/>	Optimization of data equipment floor layout	_____
<input type="checkbox"/>	Proper location of vented floor tiles	_____
<input type="checkbox"/>	Rightsizing of UPS	_____
<input type="checkbox"/>	Installation of “green” power equipment	_____
<input type="checkbox"/>	Installation of a close-coupled cooling architecture	_____
<input type="checkbox"/>	Deployment of server virtualization	_____
<input type="checkbox"/>	Installation of energy-efficient lighting	_____
<input type="checkbox"/>	Installation of blanking panels	_____
<input type="checkbox"/>	Installation of efficient plumbing	_____
<input type="checkbox"/>	Efficient server consolidation practices	_____
<input type="checkbox"/>	Utilization of air conditioner economizer modes	_____
<input type="checkbox"/>	Coordination of air conditioners	_____
<input type="checkbox"/>	Proper configuration of server software	_____
<input type="checkbox"/>	Proper alignment of datacenter staff	_____

**Figure 3: Datacenter Energy Efficiency Checklist**

These strategies are effective for new datacenters, and some can be deployed immediately or over time in existing datacenters (see Figure 3 for printable checklist). Simple no-cost decisions made in the design and operation of a new datacenter can result in savings of 20–50% of the electrical bill, and, if deploying a systematic approach, up to 90% of the electrical bill can be avoided.

For more information concerning Green Grid activities, go to [www.thegreengrid.org](http://www.thegreengrid.org)

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