IFMA FOUNDATION
WWW.IFMAFOUNDATION.ORG
EDUCATION • RESEARCH • SCHOLARSHIPS

Sustainability "How-To Guide" Series

Turning Data Centers Green

Bob Brown
Chief Executive Officer
Teladata

Marina Thiry
Independent Consultant

TABLE OF CONTENTS

ACKNOWLEDGEMENTS

The authors would like to thank Dean Stanberry of the IFMA Foundation board of trustees for recommending Bob Brown to write this guide, and for his continued support of Teladata and the work that we do. Subodh Bapat, former vice president of energy efficiency at Sun Microsystems, and Jose Iglesias, vice president of education and enablement services at Symantec, provided technical contributions and invaluable advice and support.

Other Teladata staff contributed to this document, including Kyle Brown, David Calvert, Maricel Cerruti, Steve Clark, Nichole Stephenson and Wade Wilson.

- Bob Brown and Marina Thiry

External Reviewers:

Editorial Board:

ABOUT THE AUTHORS

Bob Brown

CEO, Teladata

Bob Brown oversaw the development of this guide. Bob is CEO of Teladata, a professional services firm providing expert planning, design and project management services for new data center construction, as well as the remodel and retro-commissioning of existing facilities. Bob cofounded Teladata in 1986 to serve as a client advocate and to help clients make crucial decisions on the design of technology infrastructure that best supports business goals. Under Bob's leadership, Teladata developed a process that utilizes easy to understand documentation that translates complex IT and facilities infrastructure concepts and encourages collaboration with all stakeholders – IT, facilities, real estate, finance and construction teams – to ensure their success. Bob and his organization have assessed, designed, constructed, retrofitted and managed hundreds of mission-critical data centers, server rooms, labs and network operations center (NOC) environments for clients worldwide. In addition to speaking at industry events, Bob is chairman of The Technology Convergence Conference, a leading educational conference in Silicon Valley, California, dealing with data center operations. At the conference, IT and facilities professionals come together to learn from their peers.

Marina Thiry

Independent Consultant

Marina Thiry coauthored this guide. As an independent consultant, Marina works closely with customers and technologists to create targeted business solutions from broadly defined technologies, develop business plans and take services to market. Formerly a principal with services marketing at Sun Microsystems, she led the commercialization of an energy efficiency solution for data centers: a real-time power monitoring service built on innovative Sun-patented technologies and delivered over the network.

FOREWORD

It is no secret that a focused, well-defined sustainability strategy is beneficial to an organization's bottom line, whether it is a federal, private-sector, military or nonprofit entity. Sustainable practices are not only the right thing to do for the environment; they also benefit the communities in which they are implemented. Sustainability is the business implementation of environmental responsibility.

Sustainability is all around us. Federal, state and local governments are increasingly applying regulatory constraints on design, construction and facility operations standards. Employees expect their employers to act responsibly, and vice versa. Going green is no longer a fad or a trend, but a course of action for individuals and businesses alike – benefiting the triple bottom line of people, planet and profit.

Today's facility manager needs to be able to clearly communicate the benefits and positive economic impact of sustainability and energy-efficient practices, not only to the public, but also to the C-suite. While there is a dramatic need for each of us – and our organizations – to care for the environment, it is just as important that we convey to executives and stakeholders how these initiatives can benefit our company's financial success.

The document in your hands is the result of a partnership between the IFMA Foundation and IFMA, through its Sustainability Committee, each working to fulfill the shared goal of furthering sustainability knowledge. Conducting research like this provides both IFMA and the foundation with great insight into what each can do as an organization to assist the facility management community at large.

It is my hope that you, as a facility professional, will join us in our mission of furthering sustainable practices. This resource is a good place to start.

Tony Keane, CAE
President and CEO
International Facility Management Association

FOREWORD

IFMA Sustainability Committee (ISC)

The IFMA Sustainablitiy Committee (ISC) is charged with developing and implementing strategic and tactical sustainability initiatives. A current initiative involves working with the IFMA Foundation on the development of a series of "How-To Guides" that will help educate facility management professionals and others with similar interests in a wide variety of topics associated with sustainability and the built environment.

The general objectives of these "How-To Guides" are as follows:

1. To provide data associated with a wide range of subjects related to sustainability, energy savings and the built environment

2. To provide practical information associated with how to implement the steps being recommended

3. To present a business case and return-on-investment (ROI) analysis, wherever possible, justifying each green initiative being discussed

4. To provide information on how to sell management on the implementation of the sustainability technology under discussion

5. To provide case studies of successful examples of implementing each green initiative

6. To provide references and additional resources (e.g., Web sites, articles, glossary) where readers can go for additional information

7. To work with other associations for the purpose of sharing and promoting sustainability content

The guides are reviewed by an editorial board, an advisory board and, in most cases, by invited external reviewers. Once the guides are completed, they are distributed via the IFMA Foundation's Web site (www.ifmafoundation.org) free of charge.

ISC Members

Eric Teicholz, Chair, IFMA Fellow, President, Graphic Systems, Inc.

Charlie Claar, PE, CFM, CFMJ, Director, Academic Affairs, IFMA Foundation

Isilay Civan, PhD[2], LEED AP, Strategic Planner, HOK

Bill Conley, CFM, CFMJ, LEED AP, IFMA Fellow, Managing Director, Sustainable Development, Pacific Building Care

Laurie Gilmer, PE, CFM, LEED AP, Associate, Facility Engineering Associates

Chris Hodges, PE, CFM, LEED AP, IFMA Fellow, Principal, Facility Engineering Associates

Marina Kriticos, Director of Strategic Initiatives - Sustainability, IFMA

Angela Lewis, PE, LEED AP, PhD Candidate, University of Reading; High Performance Buildings Engineer, Building Intelligence Group

Marc S. Liciardello, CFM, MBA, CM, Vice President, Corporate Services, ARAMARK

Robert S. Mihos, CFM, Conservation Programs Manager, Holland Board of Public Works

Patrick Okamura, CFM, CSS, CIAQM, LEED AP, Facility Manager, General Dynamics C4 Systems

Cathy Pavick, Vice President of Education, IFMA

Cynthia Putnam, CSBA, Project Director, Nortwest Energy Efficiency Council

Ron Sachse, CFM, Senior Project Manager, Scitor Corporation

Andrea Sanchez, Director of Communications, Editor-in-Chief, *Facility Management Journal*, IFMA

Jon Seller, Optegy Group

Sarah Slaughter, Professor, MIT Sloan School of Management

Dean Stanberry, LEED AP O+M, Facility Management Professional

Jeffrey J. Tafel, CAE, Director of Councils, IFMA

Wayne Tantrum, Managing Director, New World Sustainable Solutions; Chairman, EuroFM

David Timber, MPA, LEED AP, Supervising Project Manager, County of San Diego, Department of General Services

Pat Turnbull, LEED AP, President, Kayhan International

IFMA FOUNDATION WWW.IFMAFOUNDATION.ORG
EDUCATION • RESEARCH • SCHOLARSHIPS

December 2010

IFMA Foundation

1 E. Greenway Plaza, Suite 1100
Houston, TX 77046-0194
Phone: 713-623-4362

www.ifmafoundation.org

The mission of the IFMA Foundation is to promote and support scholarships, educational and research opportunities for the advancement of facility management worldwide.

Established in 1990 as a nonprofit, 501(c)(3) corporation, the IFMA Foundation is supported by the generosity of a community of individuals – IFMA members, chapters, councils, corporate sponsors and private contributors – and is proud to be an instrument of information and opportunities for the profession and its representatives.

A separate entity from IFMA, the IFMA Foundation receives no funding from annual membership dues to carry out its mission. Supported by the generosity of the FM community, the IFMA Foundation provides education, research and scholarships for the benefit of FM professionals and students. Foundation contributors share the belief that education and research improve the FM profession.

ISC Members (Cont.)

Kit Tuveson, CFM, IFMA Fellow, President, Tuveson & Associates LLC

Brian Weldy, PE, CEM, DGCP, Vice President of Engineering and Facility Management, Hospital Corporation of America (HCA)

Craig Zurawski, Executive Director, Alliance for Sustainable Built Environments (ASBE)

1 EXECUTIVE SUMMARY

'Expand knowledge of the built environment, in a changing world, through scholarships, education and research'

The Vision Statement of the IFMA Foundation

This guide provides key tactical measures to turn a data center green, including defining the starting point for the planning process. Studies have shown a dramatic reduction of energy consumption in data centers can result from low-cost measures that can be applied immediately. However, many data centers require significant reconfiguration and investment to derive maximum energy savings and other long-term benefits. It is important to prepare a plan that communicates all the available solutions and prioritizes each initiative based on cost, return on investment and business impact. While substantial savings can be realized by improving efficiency in the data center, it is often a very low priority due to perceived cost, potential for data center downtime and the cooperation required between information technology (IT) and facilities departments. Additionally, in spite of the potential benefits, the best-laid plans can go unmet without proper execution. It is imperative to gain consensus across departments, clearly understand what it takes to create and run an energy efficient data center, and secure funding to achieve meaningful goals.

To help achieve a successfully executed effort to green a data center, this How-To Guide provides guidance to facility managers and other site infrastructure personnel seeking to reduce data center energy costs by making existing facilities more energy efficient. It focuses on three overarching challenges for improving energy efficiency:

- Obtaining buy-in across departments and securing realistic financing
- Accurately measuring the energy consumed solely by the data center
- Optimizing power consumption in a physical environment that was not originally designed to sustain today's IT energy load

More specifically, this guide discusses the importance of strong project leadership, securing executive support and funding, what power usage effectiveness is and how to calculate it, and strategies to increase data center energy efficiency, modularization and sustainability.

Strong project leadership is essential to align often competing requirements between facilities and IT departments, bridge communication gaps and gain consensus across all stakeholders. Several planning and deployment techniques help maintain a clear vision for data center energy efficiency projects. These techniques include a top-down view of the floor plan, electrical and power monitoring assessment, energy audit, project roadmap and an energy efficiency project plan.

Securing executive endorsement and funding involves correlating data center energy efficiency investments with a company's long-term success. Accurately monitoring power consumption over time provides the visibility necessary to determine the extent of financial and environmental benefits. Identifying financial incentives from government and utilities early in the project planning process can accelerate the payback period.

Accurate measurement and monitoring are fundamental to gain control of power usage. The more precise the understanding of the data center's energy consumption and how it is affected by its physical environment, the more effectively one can optimize usage and more accurately forecast energy requirements.

Power usage effectiveness (PUE) is a measurement of data center energy efficiency. It is the ratio comparing the total data center electrical load to its IT equipment load. A PUE value of 1.0 indicates 100 percent efficiency. A value of 1.0 or higher indicates a lower efficiency. The average data center has a PUE value closer to 3.0 and an average achievable PUE of 1.6.

A shared understanding of a data center's power allocation by facilities and IT personnel can yield more effective energy management strategies. For example, approximately half of the energy consumed in a typical data center is consumed by IT hardware. For every watt of energy used to run computer equipment, an additional watt is required for cooling. Collaboration between departments can help identify the greatest opportunity to optimize IT and cooling systems for energy efficiency gains. In some facilities, free cooling has proven to reduce energy costs by 10 to 50 percent.

Modularized data center architecture is more energy efficient because it is designed to scale with the deployment volume of IT equipment and computational workloads. The principles of modularization should be applied to rightsize the data center's physical layout, facility infrastructure, IT system architecture and power systems.

Sustainable practices encompass the entire company life cycle – from cradle to grave – with a tangible impact on a company's brand value. For example, instead of going straight to landfill, the thoughtful retirement of outmoded equipment reduces toxic waste. Full-service IT asset recovery vendors offer services from residual value recovery, software license recovery, refurbishment and reuse, and responsible e-waste disposal.

Sustainability is no longer a fringe topic. Companies are investing time and resources to understand how sustainability impacts the business. A progressive number of companies are earning Leadership in Energy and Environmental Design (LEED®) certification for green building design, and recently the United States Environmental Protection Agency announced data centers can earn ENERGY STAR® labels. To earn an ENERGY STAR label, data centers must be in the top 25 percent of their peers in energy efficiency.

2 INTRODUCTION

Public awareness of energy efficiency practices has amplified over the past decade. Global market pressures shaping this change include soaring demand for energy, escalating utility costs and a groundswell of the collective conscience focused on mitigating global warming. Companies are finding new ways to leverage online resources to gain efficiencies. A key factor most people fail to realize as resources shift from one arena to the next, such as postal mail to e-mail and business travel to teleconference, is that the demand on data centers is increasing.

Most executives assume their data centers can keep pace with business demand. That assumption no longer holds true for many enterprises. Whether by business consolidation or organic growth, data centers simply are running out of power and cooling capacity to accommodate new systems. Also, electric utilities are nearing their maximum power delivery and are less prepared to meet new demands for power-hungry data centers. Compounding the squeeze on power delivery is the cost of energy. In some regions, many IT departments now rank electricity as the second highest operating expense, behind staff (Symantec 2010).

The net effect of reducing kilowatt hours (kWh) not only improves the bottom line of data center operations and reduces enterprise carbon emissions; it also complements an organization's initiative to integrate sustainability practices into its core business culture. Ultimately, the sum of these benefits measurably enhances an organization's brand and contributes to its long-term success.

3 DETAILED FINDINGS

Data centers consume large amounts of energy. This section provides detailed guidance on a variety of energy efficiency topics. The section first discusses how to develop a data center energy conservation plan, including the importance of working across disciplines and gaining support from upper management. As the plan is implemented, it is important to proactively track the cost and energy savings. Some techniques, including how to measure power consumption, how to calculate power usage effectiveness (PUE) and how to establish a power usage baseline, are discussed. As facility managers may need to oversee a major renovation, design and construction of a new data center or retirement of an old data center, the optimization of data center design and retirements of data centers are also discussed. Topics covered in design optimization include selecting the building location, selection of cooling and air distribution systems, and equipment layout within the data center. Energy efficiency of IT equipment is important to include in design decisions. Current energy efficiency techniques include consolidation, virtualization, clustering and data deduplicaiton. Topics covered in the retirement of data centers include the retirement of both IT and data center infrastructure. Part 3 concludes with a summary of the evolution of green and its impact on data centers, including the ENERGY STAR rating for data centers.

3.1 How to Approach a Data Center Energy Conservation Plan

According to the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), the large, concentrated use of energy in a data center can consume 100 times the watts per square foot (1,000 times the watts per square meter) of an office building (ASHRAE 2009). Most existing data centers were designed at 40 to 50 watts per square foot (430 to 540 watts per square meter) of electrical capacity, instead of the 100 to 200 watts per square foot (1,076 to 2,153 watts per square meter) that is common today. The increasing trend of energy consumption per rack in data centers from 1990 to today is shown in Figure 1. Given the increasing power consumption of server racks, it is clear that as utility fees increase, so will the cost of data center operations. For many companies, the cost of energy for operating a data center is becoming painful.

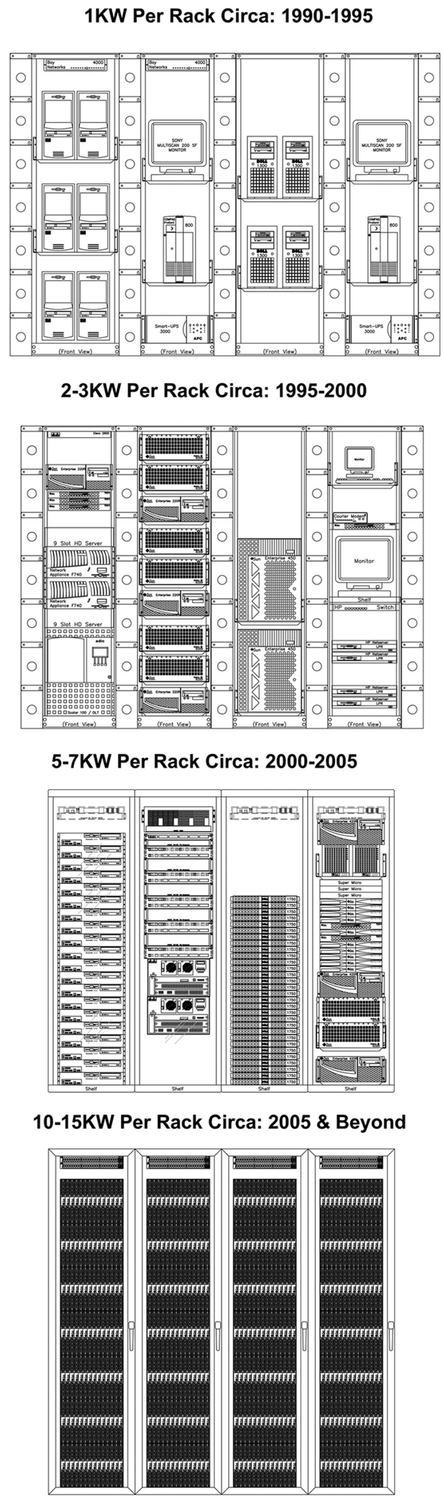


Figure 1: Evolution of power density requirements

The most immediate remedy for the cost pressure is to better manage power as a resource by understanding where, when and at what rate it is being consumed (Bapat et al 2008). The data center is an integrated system of space, power and cooling that should be fine-tuned to match the highly specific operational requirements of IT systems. Facilities and IT personnel must work together to bring transparency to a resource that previously has not warranted collaboration.

Mark Thiele, previously with VMware, discusses how the data center can be thought of as one giant computer:

www.Teladata.com/mark-thiele.html

New collaboration can give rise to overlapping and competing interests. The following recommendations help create transparency, better align strategies, coordinate execution and ensure all parties are happy once the project is complete.

3.1.1 Embrace Change: Work Across Disciplines

The criticality of a thorough planning and buy-in phase cannot be overstated. Achieving the required level of preparedness, or operational maturity, between facility and IT staff begins with a clear understanding of what it takes to run a more energy efficient data center.

Begin by establishing a core team of internal representatives from facilities, IT and finance to evaluate all options according to immediacy and impact. The expertise represented by this team should cover environmental, mechanical and electrical systems, and IT systems and applications, as well as project funding. Strong project leadership is a huge success factor for any data center project. It is essential to obtain buy-in across departments and to communicate expectations plainly and with precision to all stakeholders.

Planning for a data center energy efficiency project is not limited to a discussion about saving kilowatt hours. Planning should also account for transforming and aligning facility and IT disciplines. For example:

- Calibrating workflow operations, such as lead time
- Establishing policies, such as uptime availability and maintenance schedules
- Implementing monitoring instrumentation to baseline and measure power usage
- Conducting regular audits to ensure effectiveness and ongoing improvements

A thorough understanding of data center operations is needed. Questions to ask during the planning process include:

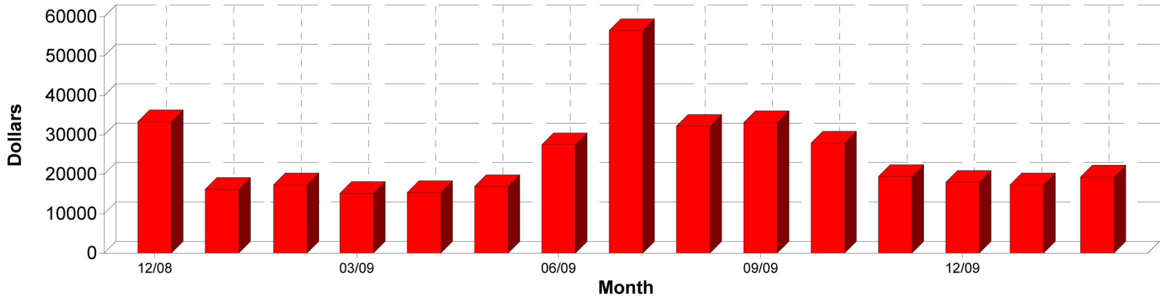
- When to expand?
- When to build?
- When to subscribe to cloud computing?
- What are the uptime requirements?
- When to refresh servers?

The following five techniques can be used to plan and deploy data centers to help maintain a clear vision, foster transparency across departments and contribute to a persuasive business case for securing realistic funding.

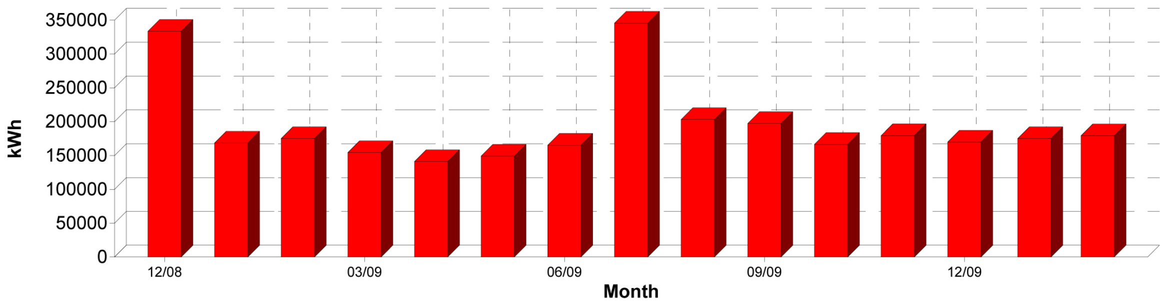
- Electrical and power monitoring assessment: Determine the overall electrical capacity of the data center and subtract the existing load to determine any available room for growth. Assess the reliability of the existing electrical supply. Identify the extent of monitoring points required to baseline power usage.
- Energy audit: Conduct a baseline assessment to identify the data center's present state. Figure 2 provides an example of the type of data to collect to help establish the energy baseline. Identify energy conservation targets, as well as the requirements for arriving at shared expectations for capacity and reliability.
- Roadmap: Create a master plan that identifies the critical path to reach energy conservation goals, including audits and approval milestones, from all stakeholders. This roadmap should also communicate expectations for reliability and capacity, as well as the cost trade-offs for different levels of reliability expectations.
- Energy efficiency plan: Identify the costs, projected downtime and the data points and processes for tracking all projected energy savings, including the incremental savings from any utility and government financial incentives.
- Transparent communication and buy-in: Share information, learn from each other across departments, seek approval from all stakeholders along the way and arrive at a consensus.

Working together to gain consensus, formulate a plan and obtain funding is not a trivial task. However, the benefits accrued are significant. Alex Victor, data center operations manager with Robert Half International, affirmed, "Our data center energy bill escalated to urgent proportions. We knew we had to somehow change – to build in

Monthly Electric Charges:



Monthly Electric Usage:



Details:

Month	kW	kWh	Electric $	Total $	Taxes	$/kWh
02/2010	348	179,100	$19,343	$19,343	$39.40	0.1080
01/2010	352	183,200	$19,786	$19,786	$40.30	0.1080
12/2009	348	169,800	$17,988	$17,988	$37.36	0.1059
11/2009	357	179,400	$19,451	$19,451	$39.46	0.1084
10/2009	411	166,500	$27,921	$27,921	$36.63	0.1677
09/2009	486	197,400	$33,119	$33,119	$43.43	0.1678
08/2009	456	203,100	$32,197	$32,197	$44.68	0.1585
07/2009	417	345,600	$56,495	$56,495	$76.03	0.1635
06/2009	411	165,300	$27,503	$27,503	$36.37	0.1664

Figure 2: Data center energy audits establish baseline energy use

controls. We worked together with our IT vertical teams [business units] to bring transparency and accountability to data center operations. We use hardware maintenance costs, power metrics and scorecards to help drive a justification process for provisioning new equipment, as well as for removing power-hungry legacy equipment out of the data center. If a new server is justified, then a virtual server is preferred over a physical one. At a macro level, this accountability is reaping other significant benefits – from postponing our need to build a new data center, to allowing us to decommission colocation facilities."

3.1.2 Secure Executive Endorsement and Oversight

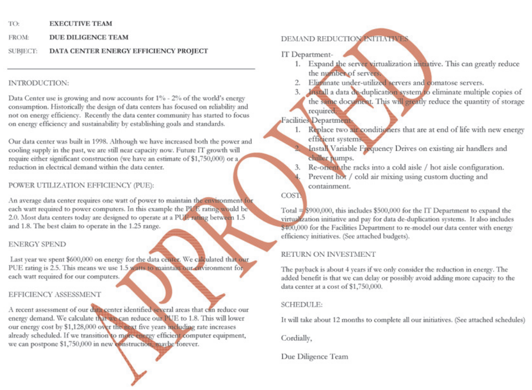
Executive endorsement enables the commitment required to support the successful outcome of green data center projects. "The key is to tie sustainability projects with a company's long-term success," advises Jose Iglesias, vice president of education and enablement services, at Symantec. Iglesias explains, "Executive endorsement and oversight are necessary for establishing business priorities and the internal mechanisms or processes to show a favorable return. For an energy conservation project, for instance, justify the payback period and show how it will defer capital expenses of new hardware and data center expansion. Also, demonstrate indirect capital gains and operating savings from reduced energy consumption. And, for some green data center projects, such as the proper retirement of IT assets, you can show – with careful planning – how it can even be self-funding."

Beyond the data center, sustainable practices encompass the entire business life cycle with a tangible impact on a company's brand value. For example, more companies are asking suppliers to demonstrate their carbon footprint. Some companies select their suppliers not only on quality and cost of goods and services rendered, but also based on their supply chain operations. "We chose our printer ink supplier, in part, because of their green supply chain and recycling practices," says Iglesias. "Upholding green decision criteria is meaningful to employees and to customers. Prospective employees, especially new graduates entering the work force, want to feel good about working for an eco-responsible company," he says.

Dr. John Koomey, from Stanford University, discusses the common language of dollars in the data center:

www.Teladata.com/john-koomey.html

Along these lines, it is equally important to provide executive management with specific detail about the anticipated return of the green IT investment as it is to provide the project implementation requirements. Include both direct and indirect benefits. When this information is provided, it is more likely the team will receive the necessary approvals (Figure 3 and Appendix D).



TO: EXECUTIVE TEAM
FROM: DUE DILIGENCE TEAM
SUBJECT: DATA CENTER ENERGY EFFICIENCY PROJECT

INTRODUCTION:

Data Center use is growing and now accounts for 1% - 2% of the world's energy consumption. Historically the design of data centers has focused on reliability and not on energy efficiency. Recently the data center community has started to focus on energy efficiency and sustainability by establishing goals and standards.

Our data center was built in 1998. Although we have increased both the power and cooling supply in the past, we are still near capacity now. Future IT growth will require either significant construction (we have an estimate of $1,750,000) or a reduction in electrical demand within the data center.

POWER UTILIZATION EFFICIENCY (PUE):

An average data center requires one watt of power to maintain the environment for each watt required to power computers. In this example the PUE rating would be 2.0. Most data centers today are designed to operate at a PUE rating between 1.5 and 1.8. The best claim to operate in the 1.25 range.

ENERGY SPEND

Last year we spent $600,000 on energy for the data center. We calculated that our PUE rating is 2.5. This means we use 1.5 watts to maintain our environment for each watt required for our computers.

EFFICIENCY ASSESSMENT

A recent assessment of our data center identified several areas that can reduce our energy demand. We calculate that we can reduce our PUE to 1.8. This will lower our energy cost by $1,128,000 over the next five years including rate increases already scheduled. If we transition to more energy efficient computer equipment, we can postpone $1,750,000 in new construction, maybe forever.

DEMAND REDUCTION INITIATIVES

IT Department-
1. Expand the server virtualization initiative. This can greatly reduce the number of servers.
2. Eliminate under-utilized servers and comatose servers.
3. Install a data de-duplication system to eliminate multiple copies of the same document. This will greatly reduce the quantity of storage required.

Facilities Department-
1. Replace two air conditioners that are at end of life with new energy efficient systems.
2. Install Variable Frequency Drives on existing air handlers and chiller pumps.
3. Re-orient the racks into a cold aisle / hot aisle configuration.
4. Prevent hot / cold air mixing using custom ducting and containment.

COST:

Total = $900,000, this includes $500,000 for the IT Department to expand the virtualization initiative and pay for data de-duplication systems. It also includes $400,000 for the Facilities Department to re-model our data center with energy efficiency initiatives. (See attached budgets).

RETURN ON INVESTMENT

The payback is about 4 years if we only consider the reduction in energy. The added benefit is that we can delay or possibly avoid adding more capacity to the data center at a cost of $1,750,000.

SCHEDULE:

It will take about 12 months to complete all our initiatives. (See attached schedules)

Cordially,

Due Diligence Team

APPROVED

Figure 3: Approved letter

3.1.3 Take Advantage of Rebates and Incentive Programs

Government and utilities are providing financial incentives and penalties to encourage new behaviors and achieve a cleaner planet and stronger economy through environmental sustainability practices. Enterprises with data centers are particularly circumspect of these incentives and penalties, since collectively data centers contribute approximately 2 percent of greenhouse gas emissions worldwide.

A financial incentive is based on the buyer's performance, such as achieving a lower power consumption target based on a calculation or plan. The key is to identify applicable programs early in the planning phase of an energy project. Eligibility for financial incentives often requires an application to be submitted to the utility or government authority prior to modifying existing systems. Build these incremental savings into the budget to track and validate operating expense improvements.

3.1.4 Track Financial Benefits

Operating expenses can be reduced by managing data center energy consumption: decreasing energy demand, improving the ratio of computer performance per watt and avoiding supplemental power fees from unexpected overages. Additionally, capital expenses can be reduced by extending the life of the data center and the IT assets and facility equipment it contains (Washburn 2009).

Accurately monitoring power consumption over time provides the visibility needed to determine the extent of financial benefits. Figure 4 provides an example of how to track financial benefits incurred from a data center power conservation program. Alternatively, depending on the extent of a company's overall environmental sustainability initiatives, investing in a dedicated energy usage and enterprise carbon accounting tool can help integrate data with financial reporting.

"Energy efficiency projects will always pay off, sooner or later," says Subodh Bapat, the former vice president of energy efficiency for Sun Microsystems. "The return on investment of energy projects pays back in a few years, and sometimes in months. Power optimization on the facilities side, like more efficient uninterruptible power supplies [UPSs], variable frequency drives [VFD] and air-side economizers, requires up-front invest-

Tracking Financial Benefits

Data Center Upgrade Projects	Project Cost Phase 1	Project Cost Phase 2	Total Cost	Utility Rebates & Incentives	Cost After Rebate	Expected Annual Savings	Expected ROI Months
Phase 1	$138,252		$138,252	$50,000	$88,252	$35,754	30
Phase 2		$182,202	$182,202	$50,000	$132,202	$98,884	17
Lighting	$3,270		$3,270	$450	$2,820	$956	36
Variable Frequency Drives	$58,886		$58,886	$20,000	$38,886	$18,671	25
Totals	**$200,408**	**$182,202**	**$382,610**	**$120,450**	**$262,160**	**$154,265**	**21**

Figure 4: Tracking financial benefits

ment, but pays back handsomely in the long run. Power optimization on the IT side, like server refresh, consolidation and virtualization, can pay back even quicker. And of course, there are many green IT projects that require very little investment. For example, obtaining an ENERGY STAR certification for your data center costs very little, but pays off handsomely in contributing to a better power usage effectiveness [PUE], as well as the discipline it enforces in maintaining the certification. Don't forget, the price of electricity goes up on the average of 6 percent every year. If you are designing your data center to last 12 years, remember that at the end of the data center's service life you will be paying twice as much for power as you are now – even if you don't upgrade or add any IT load."

3.2 How to Measure Power

Accurate measurement and monitoring are fundamental to gaining control of power usage (Bapat et al 2008). Since it is impossible to manage what cannot be measured, it is essential to understand what to measure and how to measure it.

Following are key definitions and distinctions for measuring data center energy consumption as presented by The Green Grid, a standards organization comprised of IT companies and professionals seeking to improve energy efficiency in data centers and business computing ecosystems worldwide (The Green Grid 2009).

- Data center facility energy load is the total power delivered to the site infrastructure equipment supporting the IT equipment load, such as lighting, power delivery and cooling equipment. Distinguishing between total facility power and the power usage exclusive to the data center is critical to calculate an accurate energy efficiency rating of the data center.
- IT energy load is the total power delivered to the equipment used to manage, process, store or route data in the data center, including keyboard, video, mouse (KVM) switches, monitors, workstations and laptops.

For comprehensive and accurate energy measurement, it is important to factor micro data centers into the data center facility and IT energy load (Figure 5). A micro data center includes technology closets and annexes spread throughout an enterprise.

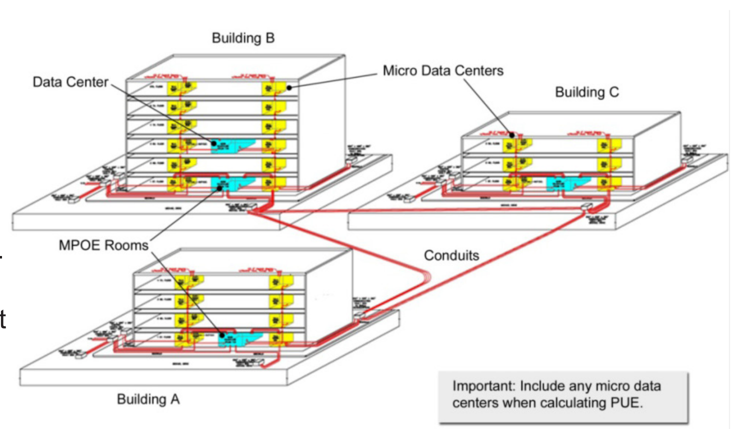


Figure 5: Technology rooms
Note: MPOE stands for minimum point of entry

3.2.1 Understand Power Usage Effectiveness (PUE)

Power usage effectiveness (PUE) is a measurement of data center energy efficiency. It is a ratio comparing data center facility load to its IT load, calculated as follows:

Data Center Facility Energy Load ÷ IT Equipment Energy Load = PUE

PUE quickly gained acceptance across industry communities (The Green Grid 2009). It provides a simple way to gauge the energy efficiency of a data center and allows constructive discussion about improving energy consumption management.

A PUE value of 1.0 indicates 100 percent efficient, with the total data center facility load consumed by IT equipment. A value higher than 1.0 indicates the data center is less efficient. Preliminary research by The Green Grid indicates many data centers may have a PUE of 3.0 or greater: for every 3 watts entering the data center, only 1 watt goes to IT equipment (Figure 6). With proper design and best practices, it is possible to achieve a PUE of 1.6 (Silicon Valley Leadership Group 2008).

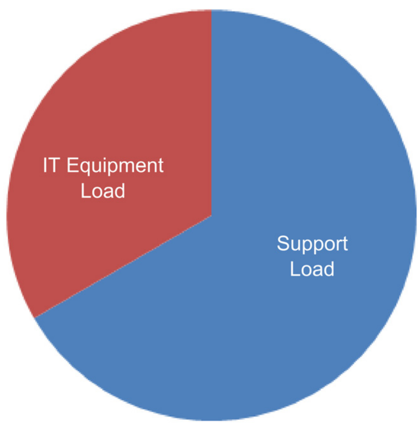


Figure 6: Example of an inefficient PUE value of 3.0

Despite arguments challenging the validity or accuracy of the PUE metric, from the authors' perspective, it remains the most useful measurement from which to benchmark data center improvements. Use PUE appropriately; for instance, use PUE only when comparing "apples to apples" in a similar fashion to comparing the mileage between two vehicles. For example, there is little value in comparing the miles per gallon between a car and a school bus. Likewise, PUE is not weighted to scale for efficiencies when comparing a 3,000 square foot (288 square meter) data center with a 30,000 square foot (2,787 square meter) data center.

It is advisable to use PUE to measure data center improvements in energy effectiveness against itself rather than making comparisons with other data centers. It should be calculated under similar conditions, using the same monitoring points and in a consistent manner to ensure accurate trending and reporting.

3.2.2 Consider the Method of Measurement

Measuring the power usage of a data center provides the insight necessary to improve energy efficiency. Yet, not every measurement technique is sufficient. For example, a static power reading – a single instance of power measurement – provides limited value for troubleshooting power anomalies and administering changes with regard to optimizing power and other resources. For example, some power calculators use look-up tables that do not account for configuration specifics, or rely on users to provide estimations. A static estimation cannot account for real-time variations in workloads for central processing units (CPUs), fan speeds or temperature. Similarly, handheld power meters provide accurate readings, but only for a particular moment in time.

In contrast, dynamic power monitoring, the continuous recording of power, overcomes static power reading limitations by supplying an accurate chronological record of actual power usage. However, the approach to dynamic power monitoring can impact the extent of benefits gained. To gain the benefits desired, an investment in dynamic power monitoring solutions is often needed to pinpoint issues that compromise energy efficiency at system and component levels. One example of using dynamic power monitoring to find sources of inefficiency is locating underutilized servers or an improperly operating fan in a computer room air conditioning (CRAC) unit.

When asked how much monitoring data is necessary, Chris Noland, with Cisco's data center strategy group, quipped, "You can never have too much insight into the data center to help manage resources more effectively."

3.2.3 Determining a Baseline and Optimization

Arriving at an accurate baseline of energy consumption is an essential first step to reining in the data center power bill. A baseline serves as the basis, or benchmark, for measurement. A power utilization baseline identifies where, when and at what rate energy is consumed.

However, most data centers, including micro data centers, are not equipped with power monitoring capabilities. For instance, a mixed-use facility typically has a single point of entry for power distribution that delivers electricity from the power utility to the entire building, or to multiple buildings located at the facility site, without distinguishing where the energy is consumed.

Thus, arriving at a baseline may require the installation of additional meters or sub-meters or temporary use of dataloggers to measure power consumed solely by the data center. For example, sub-meters can be installed to distinguish among the data center facility load, the data center IT load and the power draw from other areas of the building or campus. Figure 7 shows potential monitoring points for a sample data center. As shown, monitoring temperature and humidity at the IT monitoring region can also help to optimize data center performance while minimizing energy consumption.

Once a baseline is established, comparisons can be made against it to determine the effectiveness of power optimization strategies. Figure 8 provides an example of the results of baseline measurement and PUE calculations for one facility. As shown in the figure, there is 13 kW of available capacity for additional data center loads. The more precise the understanding of the energy consumption of a data center and how it is affected by its physical environment, the more effectively one can reduce excess, optimize usage and more accurately forecast power requirements.

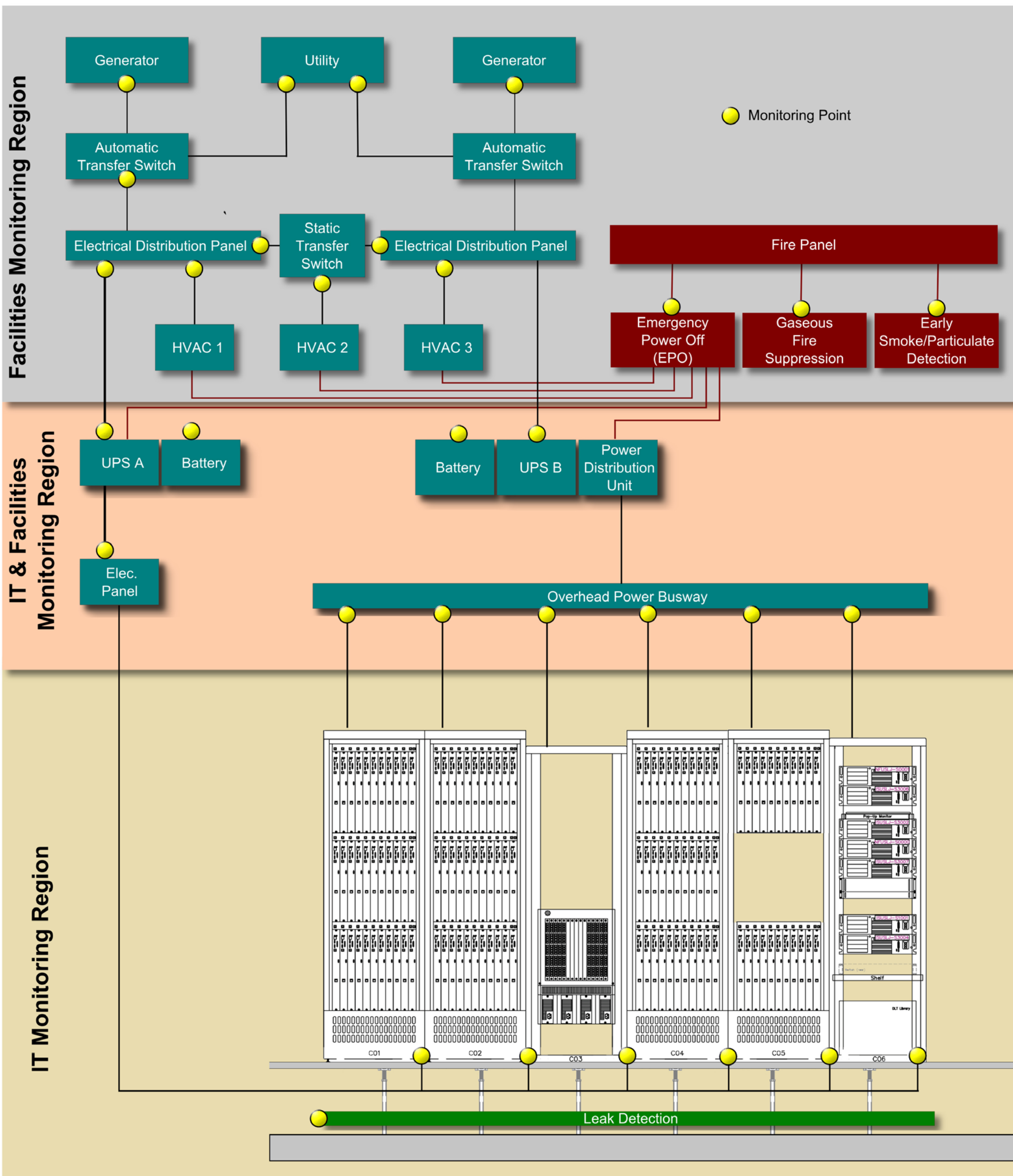


Figure 7: Data center infrastructure monitoring points

Baseline Measurements				Measured Improvements			
Measured Data Center Loads	Percentage	kW	Annual $	Annual $	kW	Percentage	Measured Data Center Loads
Mechanical Equipment Load	30%	153	$ 134,028	$ 74,460	85	17%	Mechanical Equipment Load
UPS / Transformer Loss	25%	124	$ 108,624	$ 68,328	78	16%	UPS / Transformer Loss
Lighting Load	2%	12	$ 10,512	$ 10,512	12	2%	Lighting Load
IT Equipment Load	40%	198	$ 173,448	$ 173,448	198	40%	IT Equipment Load
Available Capacity	3%	13			127	25%	Available Capacity
Total Data Center Load		487	$ 438,000	$ 326,748	373		Total Data Center Load
Total MEP Support Load	57%	289	$ 253,164	$ 153,300	175	35%	Total MEP Support Load
Total IT Equipment Load	40%	198	$ 173,448	$ 173,448	198	40%	Total IT Equipment Load
PUE Calculations		2.46			1.88		PUE Calculations

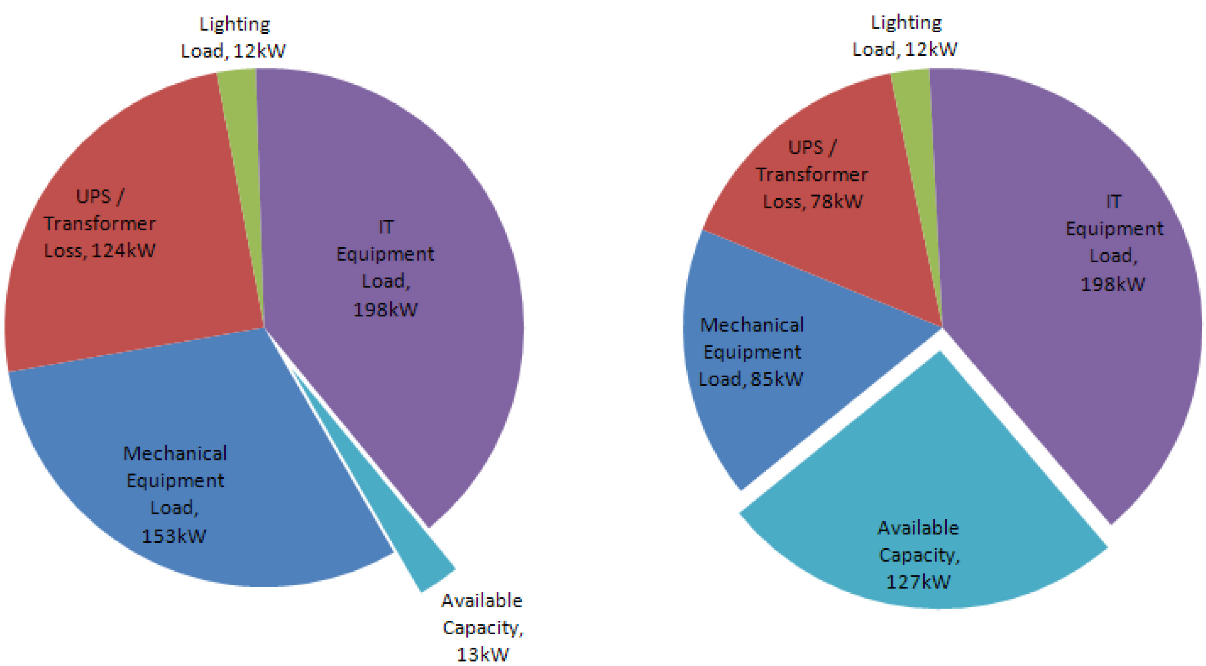


Figure 8: PUE values optimized for energy efficiency

Optimization requires granular visibility for gaining the insight required to analyze the power consumption profile of the data center. Branch circuit and environmental meters may need to be installed. In addition, consider wiring closets, labs and server rooms when evaluating a power monitoring system. Rooms in a mixed-use facility often share systems and subsystems that can affect overall data center operation and energy efficiency calculations.

It is worth noting that a building management system (BMS) should not be confused with a power monitoring solution, although it can be part of the overall solution. An effective power monitoring solution makes it possible to:

- Ensure critical infrastructure and IT systems are used at optimum efficiency
- Proactively detect faults and determine the root cause of power and thermal events before they occur
- Know whether green IT investments return a real energy savings
- Plan more effectively for capacity expansion or unexpected changes
- Provide the evidence required to take advantage of energy incentives and rebates

3.3 How to Optimize for Energy Efficiency: Building Systems

The challenge with data center energy optimization lies not in what to do, but how to do it in a dynamic and complex environment. This section focuses on sustainable energy efficient building systems and techniques that can help create a green data center – one that produces less waste, works more efficiently and costs less to run. By examining the entire building life cycle, its regional climate and the application of design innovations, facilities personnel can discover a wider range of energy-saving options that would not have otherwise surfaced.

3.3.1 Location and Building Selection

Building a new data center requires thoughtful consideration about how the geographic location and physical layout of the building can be maximized to support its long-term sustainability. Frequently, the cost of power (unit of currency per kWh) and its emissions factor (kilograms CO_2 per kWh) are important decision factors in selecting a data center site. For example, factors such as how a region's climate, source energy and utility infrastructure will impact the facility's energy, cooling and water requirements must be considered. Progressive data center design can further reduce energy costs and carbon emissions by using free cooling, or clean energy sources, such as hydropower. Moreover, new construction can accommodate advanced reuse techniques, such as reusing waste heat and graywater.

Even small efficiency measures can yield substantial energy and cost savings when compounded over time.

3.3.2 Cooling Systems

After the power draw from IT equipment, cooling the data center frequently consumes the largest amount of energy. As such, it represents a significant opportunity to improve efficiency. Traditional office buildings maintain the same temperature throughout for the comfort of occupants. Computer rooms and data centers often are equipped with separate thermostats and are often over cooled. Today, new techniques focus on controlling temperature in smaller zones for maximum efficiency. Furthermore, depending on the regional climate, free cooling can be used to meet part of a facility's cooling requirements.

The use of economizers in data centers has proven to reduce energy costs by 10 to 50 percent or more. However, concerns about outside humidity and pollutants have stymied wide adoption. Recent studies conducted by Lawrence Berkeley National Laboratory (LBNL 2007) examined concerns about the impact on IT assets from particulate contamination and humidity control associated with air-side economizers. Proper design and maintenance results in energy savings without compromising IT assets. Although initial results are favorable, LBNL recommends further studies to examine longer-term effects.

In addition to air-side economizers, there are water-side economizers that follow the same principle of using cool outdoor conditions to generate free cooling. Water-side economizers generate cool water that can partially or fully meet the facility's cooling requirements. There are several types of water-side economizers. The most common method is to use the cooling tower to make chilled water, instead of using the chiller, which provides mechanical cooling. This method requires the use of a plate and frame heat exchanger to circulate the water through the cooling tower when the cooling system is operating in economizer mode. A second option that works well in dry climates is to spray air through a media to pre-cool the air. A third, newer option is to order the chiller with an economizer mode. Direct water-side economizers are generally more efficient, but operations are more complex. When evaluating economizers, compare anticipated energy savings with the potential added costs of maintenance, building space and equipment reliability.

Other considerations for water cooling systems include rising power densities and the heat load of computers. Liquid cooling is much more effective in the removal of heat than air. For example, the heat-carrying capacity of water is 3,500 times

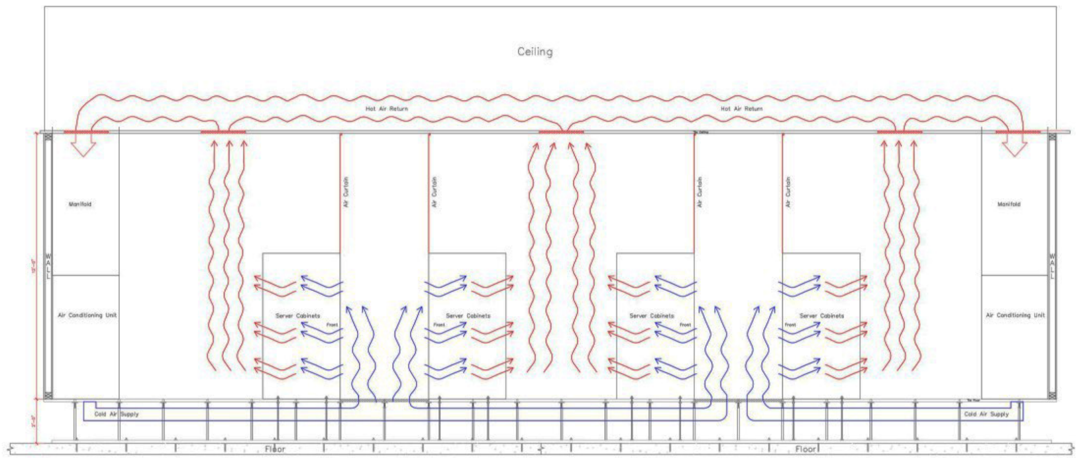


Figure 9: Elevation of a hot and cold aisle configuration

greater than air (Rumsey Engineers 2006). These thermal properties enable significant energy-saving advantages:

- The water temperature can be warmer than the temperature of chilled air while still effectively removing heat.
- Reducing the temperature change between condensation and evaporation reduces the energy required in the cooling cycle.
- Localizing cooling at the equipment level enables more use of free cooling.
- Using water-chilled cooling enables greater use of waste heat.

While most data centers are cooled with forced air, today there is more evidence for evaluating the energy effectiveness of data center liquid cooling systems. Thus, when conducting an energy efficiency assessment, consider whether a new air or liquid cooling technique, or a combination thereof, may be more suitable for the facility and its climate.

3.3.3 Airflow Distribution and Space Management

One of the more complex data center challenges is managing airflow distribution. The electrical energy consumed by all systems in the data center is converted into heat that is exhausted into the air in the data center by internal fans within the IT equipment. The air carries heat and moisture, directly impacting HVAC performance. If cooling systems and fans are working continuously at capacity, it is likely there is an airflow problem that needs to be corrected. If left unchecked, it can take a serious toll on the energy bill.

As a data center is a dynamic environment, optimizing airflow distribution is an ongoing battle. How space is managed, such as the positioning of air-conditioning units and the arrangement of IT assets, can impact airflow distribution. Less obvious factors that can disrupt airflow patterns include temperature fluctuations that result from asset turnover, system power density and variable system processing loads.

The key to effective airflow distribution is to avoid mixing warm and cool air by proactively managing the physical space. Several tools and techniques enable a higher degree of separation between warm and cool air, such as:

- Equipment configurations: Arrange IT equipment to avoid mixing cool supply air and warm exhaust air. For example, a common configuration is alternating hot and cold aisles (Figure 9). The cold aisle comprises two facing rows of IT equipment wherein cool supply air is introduced for air intake. The exhaust from these systems is delivered to the adjacent hot aisles. Be sure to provide enough space to achieve maximum airflow.
- Air leakage: Several actions can be taken to reduce air leakage: minimize air mixing by installing blanking panels in open locations on rack fronts, including side panels between racks; eliminate gaps in cabinet doors and door jambs; seal around conduits; replace missing ceiling and floor tiles; use sealing grommets or pillows for any cable cutouts in the floor tiles; and ensure perforated tiles are used appropriately, for example, in the cold aisle and not the hot aisle.
- Cable management: To manage cables do not coil or bundle long data or power cords; only use the appropriate cable length and care-

fully route and secure cables within the racks to avoid obstructing the airflow intake and exhaust passages; and ensure cable bundles below the raised floor or in conduits do not obstruct air passages.

- Clear path enablement: To create clear paths for air to travel within the data center, remove obstructions below the raised floor in the data center and in overhead plenums, and create clear paths from the source of cool air to system inlets and from the exhaust to the return air ducts of the CRAC units or heat recovery units.
- Hot and cold air containment: To contain hot and cold air, maintain boundaries between warm and cool air with physical barriers, such as containment curtains, plenums, perforated cooling doors and temperature-controlled enclosed cabinets or pods.

3.3.4 Modularization and Rightsizing of Systems

Traditional data centers typically were based in one giant room with a single, integrated power and cooling system to service the entire room. This meant the energy expended to cool the room was fairly constant regardless of the actual need. Modularized data center architecture is more energy efficient. It is designed to scale with the deployment volume of IT equipment. As IT equipment and computational workloads ebb and flow with business cycle fluctuations, so should the energy consumption of the data center.

Rightsizing, which is sizing systems to meet current needs, the facilities infrastructure follows the modularization of the physical layout. As the modules, zones or pods are created for the physical layout, the power and cooling infrastructure are deployed in corresponding units that independently service each module. Separate UPSs, PDUs and power systems, along with CRAC units, condensers and chillers, are sized appropriately for each module. This allows the scalable expansion of the facilities infrastructure as IT equipment expands.

As with rightsizing, the principles of modularization should be considered in the early stages of any data center project. Modularization can help make energy usage truly proportional to the computational demand and less wasteful. The following describes how the principles of modularization can be applied:

- Physical layout: Just as one manages power usage in a home by turning out the lights in unoccupied rooms, one can also manage data center power. By compartmentalizing the data center into energy zones or modules, with independent controls for power, cooling and humidity, each module can be independently “lit up” as needed. Modularization can be achieved by erecting walls, hanging containment curtains or by using pods.
- IT systems architecture: IT infrastructure can be modularized, and should be done in conjunction with IT staff and end-user customers (business units) that own applications deployed on the servers. IT modularization involves grouping together servers, storage and networking equipment that can be logically deployed in the same module. For example, when business computational demands are moderate, all corporate applications, such as the corporate intranet, internal e-mail, external Web presence, e-commerce site, ERP applications and more, can be deployed on the same module while the other modules in the data center remain off to save energy. As the business grows, more servers are deployed and additional modules are commissioned for IT use, and IT applications can be further modularized. For instance, all corporate intranet applications can be deployed in one module with external applications deployed in another module.
- Power efficiency: The power systems supporting the data center infrastructure and IT assets merit close inspection. Over the last six years, many power efficiency advancements have been made by global providers of power equipment and services, which have committed to environmentally responsible practices. According to a study by Emerson (Britt 2009), the typical data center has IT equipment with power supplies running at 79 percent efficiency, with new power supplies operating as high as 90 percent efficiency (Silicon Valley Leadership Group 2008). Through the use of more efficient power-conditioning equipment and power supplies, low-power processors, and increasingly sophisticated power management, data centers can continue to wring efficiencies from every electrical device.

3.4 How to Optimize Energy Efficiency for IT Systems

According to numerous industry reports, IT assets consume nearly 50 percent of a data center’s energy allocation. Furthermore, for every watt of energy consumed to run IT hardware, an additional watt is required to cool it. Yielding the greatest energy efficiency gains for the facility requires better energy management of data center IT systems.

Consequently, facility management personnel can benefit from the knowledge of general concepts employed by their IT cohorts to make IT systems more energy efficient. For example, through collaboration of facilities, IT and finance personnel, Symantec successfully consolidated its data centers worldwide. As a result, Symantec closed its second-largest production data center, located in Sunnyvale, California, reducing that data center's hardware count from 1,635 to 352 devices and realizing significant energy, IT and real estate cost savings. Among these was a reduction of more than 300,000 kWh per month (Symantec 2008).

Below are descriptions of effective techniques to improve the efficiency of IT assets, thus reducing the corresponding requirements for power and cooling in the facility. Although these energy efficiency remedies are outside of the purview of facilities management, they are presented to:

- Raise awareness about the impact of energy usage of IT assets
- Encourage a dialog between IT and facilities personnel about measures that can be taken to reduce a facility's power draw significantly

To gain an appreciation of the efficiency techniques described below, first consider the operating characteristics of a server. A server is a computer that provides applications, data storage, networking or other services for computers connected to it via a network. Servers take up about two-thirds of the floor space of a typical data center (Digital Realty Trust Webinar 2010). Historically, servers in a typical data center operate at only 15 to 30 percent utilization, which has been common practice due to staggered implementation and competing business requirements. New technologies, such as virtualization, now make it possible to get much more productivity from each server. For instance, in the example above, Symantec was able to achieve a 4.64 to 1 server reduction by virtualizing and decommissioning 1,283 servers. The following sections describe these and other techniques.

3.4.1 Consolidation

Consolidation is an approach to reducing the total number of physical servers and the space required to house them. The practice developed in response to server sprawl: an ever-increasing number of servers consume more space and resources than can be justified by the workload performed. Server sprawl is especially problematic. Even an idle server can draw up to 70 percent of the power used for a full load, and requires a commensurate amount of cooling for the heat expended.

Server consolidation requires taking inventory of the servers, including the services provided and utilization profiles, and determining which servers should be decommissioned or replaced with more energy efficient models, and which ones should be physically consolidated. Consolidation allows servers to run at a higher average load for more energy-efficient business computation. With fewer servers accomplishing the same work, less energy is needed to power and cool equipment. Consolidation also allows organizations to defer or eliminate capital expenses that otherwise may be needed to expand or build a new data center.

3.4.2 Virtualization

Virtualization makes use of unused server capacity. Through software technology, a single physical server can be configured to share its resources to run multiple operating environments and applications. Each server appears to be not one, but multiple, virtual servers. In short, virtualization decouples a software application from the resources of a dedicated physical server, making it possible to run more applications on fewer servers. Not all systems or applications can be virtualized. Nevertheless, fewer servers require fewer resources to run and cool them.

3.4.3 Clustering

Clustering allows two or more interconnected servers to access a common storage pool. Server clustering reduces the number of standby servers needed for availability, or backup servers needed for reliability, and provides additional computing power. Like virtualization, clustering helps make the most efficient use of hardware and the energy required to power it. For example, traditionally data centers use one backup server for each primary server. Instead, with N+1 server clustering technology, only one backup server is needed per group of primary servers.

3.4.4 Data Deduplication

Data deduplication is an approach to reducing data storage by eliminating unnecessary copies. This method of storage reduction is referred to as intelligent compression or single-instance storage. Redundant data is replaced with a pointer to the unique data copy (Chi Corporation 2010). For example, a companywide e-mail with attachments may be saved by 100 employees. If the e-mail platform is archived, all 100 instances of the attachments are saved. Deduplication software has condensed data by more than 90 percent for many companies, simply by finding and eliminating unnecessary copies. Similar to server consolidation, data deduplication helps reduce storage sprawl.

3.5 How to Retire Data Center Assets

Sustainable practices encompass data center assets from cradle to grave. Beyond the ongoing pursuit of operational efficiencies, turning a data center green includes the thoughtful retirement of outmoded equipment.

An estimated 75 percent of retired IT assets is stored, donated or becomes landfill (TechTurn 2010). Most enterprises have an end-of-life asset management solution, yet stop short with minimal consideration given to reuse and recycling. In some cases, the foresight to keep a small inventory of outmoded equipment for replacement parts unintentionally grows into a stockpile of warehoused electronic waste, commonly referred to as e-waste.

3.5.1 Retiring IT Assets

Industry guidelines, such as those published by the EPA's Responsible Recycling (R2) Practices (EPA 2010) and the International Association of Information Technology Asset Managers (IAITAM) (www.iaitam.org/IT-Asset-Management-Home.htm), offer comprehensive guidance about proper e-waste disposal, with the latter also providing methods that maximize the financial return derived from an asset's life cycle. Additional assistance from full-service IT asset recovery vendors helps companies manage the proper retirement and disposal of IT assets. Moreover, these resources help companies recover the full extent of value of their capital equipment. For example:

- Software license recovery: Certification of the removal of commercial software through a certified data sanitation process, such as government security-compliant disk wipes, helps prove the status of a software license during an audit. Since the software license is registered to a particular system, proof of software removal enables the license to be reassigned to another system or canceled.
- Refurbishment and reuse: Upgrades and simple repairs can extend the life cycle of some outmoded equipment. Reuse can be better than recycling. However, the roadblock to reuse is the time needed to acquire parts and refurbish systems. Asset retirement solution vendors have extensive parts inventory and repair capabilities to extend the working capital of IT assets.
- Residual value recovery: If a system is beyond refurbishment, it can be broken down for components, including metals that can be recycled. Value recovery of components requires responsible parts harvesting practices, a supply chain network and the know-how to maximize the residual value of these items. Full-service IT asset recovery vendors have the resources and capabilities to responsibly harvest parts and often pay companies upfront for reusable materials.

For all of the benefits mentioned above, turning to a reputable IT asset recovery vendor is a wise choice. Moreover, e-waste is heavily regulated with violations prosecuted by law. At the time of this publication, 23 US states have passed legislation mandating statewide e-waste recycling. Presently the US Congress is working on federal regulation of e-waste recycling and disposal. For more information about US e-waste regulations, visit www.computertakeback.com/legislation/state_legislation.htm. The Electronics TakeBack Coalition (ETBC) promotes responsible recycling in the electronics industry and maintains links to e-waste legislation, policies and programs.

3.5.2 Retiring Data Center Infrastructure Equipment

Data center infrastructure equipment, such as HVAC equipment and UPSs, have long required responsible disposal and proper destruction of the hazardous materials contained within, such as gasses, refrigerants, oils and acids. However, today more thoughtful consideration is given to recycling. For instance, there is an active market for reclaimed refrigerants, oils and other materials due in large part to commercial Leadership in Energy and Environmental Design (LEED) projects. Using a percentage of reclaimed materials and resources is a possible criterion for achieving the USGBC's internationally recognized green building certification.

For responsible disposition and recycling of infrastructure equipment, start by contacting the manufacturer to understand environmental guidelines and determine whether the company will dispose of obsolete equipment. For example, Carrier Corporation, the world's largest provider of HVAC systems, employs extensive environmental health and safety guidelines for its service technicians. Prescriptive management for the environmental portion of this program covers the handling of used oil, refrigerant and waste, as well as water pollution control, shipping and disposal. Depending on the manufacturer's program, liability for the proper handling of hazardous waste, such as used oil, may remain with the customer and not the manufacturer servicing the transport, disposal and recycling. Therefore, invest the time and effort required to become knowledgeable about the steps needed to retire assets, and seek assurances of strict adherence to federal and local regulations.

Companies can find responsible equipment disposition and recycling services through the FM Guide Online, an online searchable directory maintained by the International Facility Management Association (IFMA). The guide is available at onlinefmguide.com. Additionally, Table 1 provides estimates of the median life of typical HVAC equipment.

3.6 The Evolution of Green

Sustainability is no longer a fringe topic. Companies that invest the time to understand how sustainability drivers impact their business discover a wider range of business options and marketing opportunities that otherwise go unnoticed. Sustainability practices have become synonymous with forward-looking behavior: enduring practices that effectively utilize resources and reduce the carbon footprint while remaining competitive in the marketplace. Since companies rely upon their data centers as a means to compete and thrive, sustainable data center practices have become a mainstream strategic initiative.

As the notion of green evolves, so will its energy efficiency practices and tools of the trade. Following are two examples of data center efficiency programs that present business opportunities that can and will shape the success of a company over the long term.

Table 1: Asset life expectancy (ASHRAE 2010)

Equipment item	Median years
Air conditioners	
Residential	15
Through-the-wall	15
Water-cooled package	15
Computer room	15
Heat pumps	
Air to air	12
Water to air	19
Commercial package units	
Single zone	15
Multizone	15
Boilers	
Steel water-tube	24
Cast iron	30
Electric	15
Furnaces	18
Unit heaters	18
Air terminals	
Induction fan coil units	27
VAV boxes	20
Fans	
Centrifugal	25
Axial	20
Propeller	15
Ventilating	20
Coils	
Direct expansion (DX), water, steam	20
Electric	15
Heat exchangers	24
Pumps	20
Controls	
Pneumatic	20
Electric	16
Electronic	15
Air-cooled condensers	20

3.6.1 ENERGY STAR Ratings for Data Centers

ENERGY STAR is a United States Environmental Protection Agency (EPA) program established to help save money and protect the environment through energy efficiency products and practices. In June 2010, the EPA announced data centers can now earn ENERGY STAR labels. To earn the label, data centers must be in the top 25 percent of their peers in energy efficiency according to the EPA's energy efficiency rating system.

The EPA uses the PUE metric to determine whether a data center qualifies for the ENERGY STAR label. The energy performance of the data center is expressed on a 1 to 100 scale. For example, a rating of 75 indicates the data center performs better than 75 percent of similar data centers nationwide. Data is collected for a 12-month period and a licensed professional engineer must independently verify the energy performance of the data center, sign and seal the application document, and send it to the EPA for review and approval.

To compute the ENERGY STAR rating, estimates for the IT energy load are permitted for the first two years of this new program (until June 2012) to allow users to get proper IT energy monitoring in place. After that time, IT energy monitoring will be required.

The ENERGY STAR for Data Centers program provides a proven energy management strategy and free tools for public and private organizations to save energy and money through increased energy efficiency. For more information about ENERGY STAR ratings for data centers, refer to www.energystar.gov/index.cfm?c=prod_development.server_efficiency#rating. For more general information about the ENERGY STAR labeling process, see the IFMA Sustainability How-To Guide: EPA's ENERGY STAR Portfolio Manager found at www.ifmafoundation.org/programs/sustain_wp.cfm.

The EPA is developing ENERGY STAR specifications for servers, storage devices and uninterruptable power supplies.

3.6.2 LEED Certification for Green Building Design

LEED, the Leadership in Energy and Engineering Design building certification program developed by the U.S. Green Building Council (USGBC), provides an internationally recognized rating system for identifying and implementing measurable green building design, construction, operations and maintenance strategies. LEED certification provides third-party verification that a building was designed and built using strategies aimed at improving performance criteria for environmental sustainability, including:

- Energy savings
- Water efficiency
- Carbon emissions reduction
- Improved indoor environmental quality
- Stewardship of resources and sensitivity to their impacts

LEED was originally designed for residential and commercial office buildings. A coalition of data center industry groups, in conjunction with Lawrence Berkeley National Laboratory (LBNL), released a draft proposing to expand the LEED rating system with customized energy efficiency specifications for data centers. For more information about the proposed LEED criteria for data centers, see the LBNL project page at hightech.lbl.gov/dc-epc.html. Additionally, more information about LEED can be found in the IFMA Foundation Sustainability How-To Guide: Green Building Rating Systems: www.ifmafoundation.org/programs/sustain_wp.cfm.

4 MAKING THE BUSINESS CASE

As data centers are a critical, but often costly, part of a business, building a strong business case is important. To successfully build the business case, there are several key points that should be summarized:

- Business problem or opportunity that will be addressed
- Capacity projections, including equipment, power and space
- Reliability requirements
- Readiness assessment
- Recommendation
- Schedule
- Cost-benefits, including both direct and indirect costs

This section focuses on how to work with the local power utility to apply for possible financial incentives for managing demand and reducing energy consumption, and summarizes a high-level action item list that can be used as a starting point to green a data center.

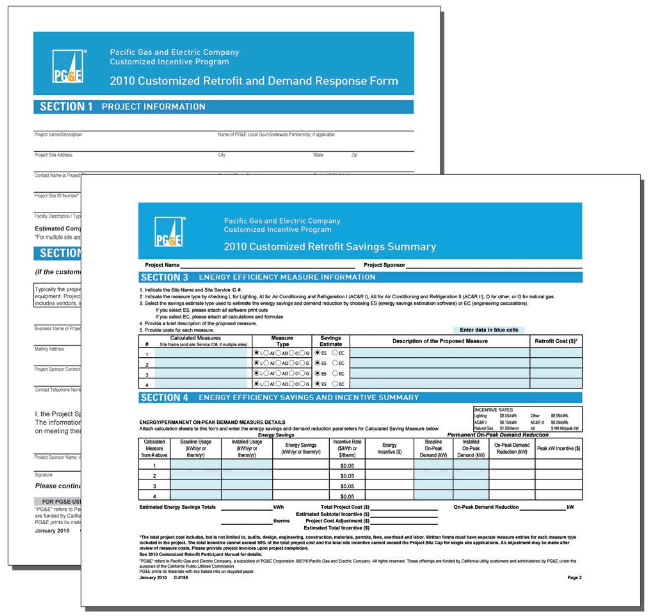


Figure 10: Sample forms to apply for financial incentives from a utility

4.1 How to Get the Most From the Power Utility

In the United States, power utilities are often an underutilized resource when determining energy efficiency strategies. Bill Dunckel, with the customer energy efficiency group at Pacific Gas and Electric Company (PG&E), a utility servicing Northern California, invites facility management and data center operators to reach out to their local utility representative during the early planning stages of a project. "I work with PG&E business customers to help promote the design of commercial buildings and industrial processes that are more energy efficient than required by law. I can help you with power conservation projects, apply for cash incentives, and even access free engineering services from the utility to achieve energy savings" (Figure 10).

For example, Dunckel advises companies to contact their local utility representative to help arrive at an appropriate electricity rate schedule for their data center power requirements, and adds, "It is the company's responsibility to arrive at an optimal rate." A number of market factors influence electricity rate schedules and tariffs, which are subject to change over time, including changes that encourage certain behaviors. Since the cost of energy fluctuates, companies should work periodically with utility representatives to maintain an optimal rate.

Beyond arriving at the best possible pricing, engaging early with the local utility representative is essential for project preparedness. For instance:

- Lead time: During the planning phase of a project, determine the lead time required by the utility to apply for incentives or deliver additional electricity load. Lead time varies according to the size and condition of the distribution system in the area. Depending on the variables, it could take from weeks to months.
- Power assessments and forecasts: Planning future power needs involves understanding the limitations and options of the local power utility. For example, in some areas the power generation plant may be nearing maximum capacity, or the transformers and power lines may be reaching maximum allocations. Work with local utility representatives to learn about near-term and long-term power delivery capabilities and options.

- Alternative energy sources: Self-generated clean energy sources, such as solar, wind and fuel cells, must be certified to operate in parallel with the electric system grid (not backup generation) and meet other criteria established by the local public utilities commission (PG&E 2010). Some utilities offer incentive programs for businesses and large institutional customers who install approved distributed generation facilities to handle some or all of their energy needs. Utility representatives can help determine whether companies have the right connectivity to correctly switch from utility power to another energy source, as well as advise on the certification process.

4.2 Energy Optimization Cheat Sheet

Table 2 summarizes a list of high-level actionable items that can be used to green a data center and effectively reduce energy consumption. This list provides a starting point. However, each facility manager will need to prioritize these tasks for his or her own unique situation. Anything that is categorized as no to low cost can be considered low hanging fruit. Items categorized as moderate or moderate/high require additional cost and/or effort.

Table 2: Energy optimization cheat sheet

Cost	Task	Benefits
None	Turn off or turn down the lights in data centers or areas that are not continually occupied.	Reduce lighting costs by up to 30%.
None	Adjust ambient air temperature and humidity set points with current ASHRAE recommendations.	Increasing set point temperatures reduces operating costs by allowing air conditioner equipment to run less frequently.
None	Check power management settings on servers and storage equipment.	Some equipment can monitor requested CPU and disk usage and adjust the power supply levels accordingly.
None	Turn off unneeded/unused equipment.	It is estimated that up to 10% of servers in a typical data center are not actively in use (Sun Microsystems study).
None - Low	Establish a procurement process that integrates IT and facilities to replace obsolete equipment with systems that have higher efficiency ratings.	Initial cost will vary, but replacing IT equipment could yield a rapid return on investment from the energy savings. In some instances it even makes sense to replace IT equipment using facilities' budget.
Low	Report, report, report. Publish energy and efficiency goals within the enterprise. Report energy usage as a function of business units or applications suites within the data center.	Making information available within the enterprise will 'incentivize' users to be more efficient.
Low	If air-side economizers are used, check to make sure that dampers and linkages are fully operational.	Malfunctioning equipment can introduce hot air into the cooling cycle.
Low	Check inlet and outlet temperatures at CRAC units.	CRAC units run less efficiently when the inlet air temperature and the cold air set point are too close together. Temperatures that are within 15°F (-9°C) of each other may indicate that the cold air supply and hot air exhaust are mixing. This can account for 5% of the total cooling energy costs.
Low	Replace light bulbs with more energy-efficient light bulbs.	Improvements in lighting technology offer much improved energy efficiency; the same level of lighting generates less heat and outlasts older obsolete light bulbs.
Low	Check the filters and coils in mechanical equipment.	Filters should be changed at least monthly depending on the environment and outside air quality. Coils should be cleaned at least yearly during a low load period. Recover 15-20% of mechanical energy costs.
Low	Balance air by using lower flow tiles and higher flow tiles only where needed.	Ensure that under floor airflow is optimized for the equipment that is served.
Low	Install blanking panels on cabinets.	Further enhances the reduction of hot and cold air mixing. Hot-cold aisle configuration is required.
Moderate	Re-commission the facility.	It could improve overall energy efficiency by 10-15%. Costs can add up quickly depending on the amount and size of electrical, mechanical and control systems in the facility. Intrusiveness increases with the level of commissioning.

Cost	Task	Benefits
Moderate	Replace end-of-life equipment with higher-efficiency equipment and/or equipment that can run efficiently with variable loads.	Replacing electrical and mechanical equipment that needs to be decommissioned and replaced in any case is a sound strategy to implement energy efficiency.
Moderate	Measure, measure, measure.	Continuous measuring of temperature, humidity and airflow provides vital information about the health of the data center.
Moderate	Use 208V power on servers wherever possible.	Most IT equipment has auto-switching power supplies that can work either at 120V or 208V. If the rack PDU already supplies mixed 120V/208V power, simply changing the power cord can improve the efficiency on a server by 2-3%.
Moderate/High	Retrofit existing mechanical equipment with variable speed pumps, chillers, blowers, etc.	Equipment that increases or reduces capacity as needed offers a level of efficiency not available to continuously running equipment.
Moderate/High	Virtualize storage and servers.	Combining applications and data, especially rarely used instances, on virtualized platforms can eliminate underutilized hardware and reduce electricty consumption.
Moderate/High	Orient server and storage cabinets into hot-cold aisle configuration.	Alternating rows of cold air intake and hot air exhaust helps reduce unwanted mixing of hot and cold air. IT equipment may need to be relocated or reoriented. Mechanical air supplies/returns may need to be modified for the aisles.
Moderate/High	Implement hot aisle/cold aisle containment.	Aisle containment is the most aggressive method to eliminate the mixing of hot and cold air. The containment strategy, materials, options and method of deployment will directly effect cost and intrusiveness. Check with local fire authority for permitting requirements.
Moderate/High	Install close-coupled cooling.	This can be one of several different solutions, all of which are based on the concept of locating cooling equipment as close as possible to the heat load. Solutions range from in-row cooling cabinets that capture, cool and circulate exhaust air from adjacent equipment cabinets, to self-contained equipment cabinets that include mechanical cooling components, to overhead supplemental cooling units that increase the amount of cool air that is delivered to individual cabinets. This can also allow zones of higher capacity/load to be created without affecting the mechanical design of the rest of the facility.
Moderate/High	Install monitoring sensors to measure power, temperature, humidity and airflow throughout the facility.	Just being able to accurately measure usage allows changes in inefficiency due to malfunctioning equipment and/or controls to be detected, as well as the ability to fine tune systems to changing IT loads.

5 CASE STUDIES

To showcase different approaches to greening data centers, four case studies are briefly presented. The first case study provides an overview of an energy audit completed for a large database technology center. Two case studies describe rebate programs available through utilities. The final case study quantifies data center energy savings from the use of free cooling.

5.1 Sybase Energy Audit Case Study

Sybase, a database technology center in Dublin, California, that employs 4,000 people in 60 countries, conducted an energy audit in 2005. The results of the audit found that the data center N+1 cooling capacity was at risk due to rapid growth of the facility. Working with a local utility, Sybase was able to determine how to save almost 2.3 million kWh per year and has regained N+1 cooling capacity.

Sybase Data Center
- **16,000 SF (1,486 m^2)**
- **440 racks and 100 cabinets**
- **3 dedicated chillers**

Greg Bush, senior manager, real estate and facilities, at Sybase observed that the lack of operational processes between facilities and IT staff can result in inefficient configurations or unanticipated hardware costs. "It's an invisible cost," he remarked, "and contributes to inefficient energy consumption that compounds over time." A veteran of data center energy efficiency practice, Bush participated in an energy efficiency program that yielded a direct, year-to-year energy savings of $262,000 (US dollars) with a payback period of just over two years. An additional $100,000 (US dollars) savings resulted from reduced stress on mechanical systems that eliminated annual repairs and replacements (DOE 2009).

5.2 Utility Rebate Programs

Below are two examples that illustrate the types of financial incentives available through utility rebate programs. These examples were sourced from the Database of State Incentives for Renewables & Efficiency (DSIRE) at www.dsireusa.org. DSIRE catalogs incentive programs offered by major utilities and governments. The catalog also includes energy regulations and policies. For good measure, check with local utility representatives for the latest programs that may not be updated in the DSIRE catalog.

5.2.1 Pacific Gas and Electric

Pacific Gas and Electric (PG&E) provides a retro-commissioning (RCx) incentive program. RCx is a systematic process for identifying less-than-optimal performance in a facility's existing equipment and control systems and making necessary repairs or enhancements to save energy and cost. Whereas retrofitting involves replacing outdated equipment, RCx focuses on improving the efficiency of what is already in place.

Incentives are paid directly to the customer based on energy savings at the rate of $0.09/kWh, $1.00/therms, and $100/on-peak kW (US dollars), capped at 50 percent of the measured cost. In addition to the incentive, PG&E provides diagnostic, engineering and cost estimating resources to identify and analyze potential energy-saving projects from retro-commissioning measures. Other project ideas, such as retrofits, demand response and self-generation, are also identified.

5.2.2 New York State Energy Research and Development Authority

The New York State Energy Research and Development Authority (NYSERDA) has funding available for capital improvement projects that save energy and improve productivity for existing facilities or new construction. Energy savings projects can fall into different categories:

- Projects that reduce overall electric consumption
    - Energy-efficient lighting
    - Motors and variable speed drives
    - HVAC
    - New buildings that are more energy efficient than the building code

- Projects that reduce energy use per production unit:
    - Increased throughput
    - Reduced scrap
    - Increased energy efficiency versus the existing or standard method of production
- Data center projects that reduce energy per unit of data processed
    - Virtualization
    - Application management
    - Cooling efficiency
    - Improved airflow

5.3 NetApp Free Cooling Case Study

NetApp is a storage and data management solutions company headquartered in Sunnyvale, California. The facility has a data center with capacity to house more than 720 high-powered server racks, but rarely requires the use of mechanical cooling equipment. Instead, outside air is used to cool the servers. This technique, free cooling, drastically reduces the amount of energy used for cooling. Free cooling is especially effective in the Silicon Valley climate because outdoor air temperatures are suitable year round. The use of free cooling at the NetApp facility is estimated to save more than $1.1 million (US dollars) annually. Additionally, NetApp has received a $1.4 million (US dollars) rebate from the local utility, Pacific Gas and Electric (PG&E), under the Nonresidential New Construction Program, for the last several years, as a result of the energy efficient design of the data center (Silicon Valley Leadership Group 2008).

5.4 Conclusion

The evolution of green indicates a transition from merely reusing resources to restoring the physical environment and even regenerating new resources from those consumed. Advancements of clean energy, such as generating electricity from waste heat or converting carbon dioxide emissions to useful resources, are no longer backroom science projects and now attract huge investments from the business community. Furthermore, advancements in monitoring instrumentation and green IT are propelling new techniques and behaviors that are causing a real paradigm shift in how businesses are run. New concepts like “negawatt power,” a term coined to describe electricity that was not created due to energy efficiency, are giving rise to new markets. Ultimately, these advancements should inspire a new generation of green data centers.

6 APPENDICES

6.1 Appendix A: References

ASHRAE (2009). *Best Practices for Datacom Facility Energy Efficiency.* 2nd Edition. p 1.

ASHRAE (2010). *ASHRAE Owning and Operating Cost Database Equipment Life/Maintenance Cost Survey*. xp20.ashrae.org/publicdatabase/service_life.asp. Accessed November 14, 2010.

Bapat, S., K. Gross, P. Morris, V. Srinivasan, and M. Thiry (2008). *Sun's Approach to Intelligent Power Monitoring*. August 5, 2008. wikis.sun.com/download/attachments/43779039/820-5826.pdf?version=1

Britt, P. (2009). "Solve the Power Puzzle." *Data Center Management Magazine*. September/October 2009. p. 32.

Chi Coproration (2010). DeDuplication. www.chicorporation.com/index.php?option=com_content&task=view&id=90&Itemid=128. Accessed October 22, 2010.

Digital Realty Trust Webinar (2010). Attended April 26, 2010.

DOE (2009). "Data Technology Company Saves $262,000 Annually." U.S. Department of Energy, Energy Efficiency & Renewable Energy. www1.eere.energy.gov/industry/saveenergynow/pdfs/45814.pdf. Accessed October 22, 2010.

EPA (2010). "Responsible Recycling (R2) Practices for Use in Accredited Certification Programs." U.S. Environmental Protection Agency. www.epa.gov/epawaste/conserve/materials/ecycling/r2practices.htm. Accessed October 22, 2010.

LBNL (2007). *Data Center Economizer Contamination and Humidity Study*. Lawrence Berkeley National Laboratory. March 13, 2007. hightech.lbl.gov/documents/data_centers/economizerdemoreport-3-13.pdf.

PG&E (2010). Self-Generation Incentive Program – Program Background. www.pge.com/b2b/newgenerator/selfgenerationincentive/programbackground.shtml. Accessed October 22, 2010.

Rumsey Engineers (2006). *High Performance Data Centers: A Design Guidelines Sourcebook*. January 2006. p. 32

Silicon Valley Leadership Group (2008). *Data Center Energy Forecast, Final Report*. July 29, 2008.

Silicon Valley Leadership Group (2008). *Case Study: NetApp Air Side Economizer*. https://microsite.accenture.com/svlgreport/Documents/pdf/case%20study_NetApp.pdf. Accessed December 28, 2010.

Symantec (2010). *A How-To-Guide for Greening IT in Government*. p 6.

Symantec (2008). *Greener IT: Ideas for Saving Money and the Environment, A Symantec Advisory Guide*. p. 26.

TechTurn (2010). TechTurn. www.techturn.com. Accessed October 22, 2010.

The Green Grid (2009). The Green Grid. www.thegreengrid.org. Accessed October 22, 2010.

Washburn, D. (2009). *Q&A: The Economics of Green IT*. Forrester Research, Inc. February 10, 2009. p. 2.

6.2 Appendix B: Additional Resources

Data Center Energy Efficiency

Building Industry Consulting Services International, Inc. (BICSI): www.bicsi.org/default.aspx

Data Center Pulse: datacenterpulse.org

ENERGY STAR Data Center Energy Efficiency Initiatives: www.energystar.gov/index.cfm?c=prod_development.server_efficiency

Grow a Green Data Center by Douglas Alger: www.ciscopress.com/bookstore/product.asp?isbn=1587058138

High Density Data Centers – Case Studies and Best Practices: www.ashrae.org/publications/detail/16759

NCAR-Wyoming Supercomputing Center: www.cisl.ucar.edu/nwsc

Silicon Valley Leadership Group (SVLG): www.svlg.org

Technology Convergence Conference: www.teladatatcc.com

The Data Center Energy Efficiency Project, an initiative led by the Silicon Valley Leadership Group: dcee.svlg.org/dcee-project.html

The Green Grid hosts a rich library and tool set to help determine and compare data center operational efficiency: www.thegreengrid.com

Whole Building Design Guide Quick Start Guide to Increase Data Center Energy Efficiency:
www.wbdg.org/research/energyefficiency.php?a=12

- Emerson Global Data Center case study: www.wbdg.org/references/cs_egdc.php
- Strategic Computing Complex case study: www.wbdg.org/references/cs_scc.php

Green and Sustainable Building Resources

Electronics TakeBack Coalition (ETBC): www.computertakeback.com/index.htm

ENERGY STAR – Green Buildings and Energy Efficiency: www.energystar.gov/index.cfm?c=green_buildings.green_buildings_index

High Performance Buildings: www.hpbmagazine.org

Leadership in Engineering and Environmental Design (LEED): www.usgbc.org/displaypage.aspx?cmspageid=222

U. S. Environmental Protection Agency (EPA) Responsible Recycling (R2) Practices: www.epa.gov/epawaste/conserve/materials/ecycling/r2practices.htm

U.S. Green Building Council www.usgbc.org

World Green Building Council: www.worldgbc.org

Mission Critical Facilities

7x24 Exchange: www.7x24exchange.org

Critical Facilities Roundtable (CFRT): www.cfroundtable.org

Mission Critical Magazine: www.missioncriticalmagazine.com

General Industry Resources

American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE): www.ashrae.org

International Organization for Standardization: www.iso.org/iso/home.html

- ISO 23045:2008: Guidelines to assess energy efficiency of new buildings
- ISO 16818:2008: Energy efficiency terminology applicable to new buildings and retrofitting existing buildings
- ISO 14000: Various environmental management standards

6.3 Appendix C: Glossary

Air-side economizer: A mode of control that uses outdoor air for cooling, as opposed to mechanical cooling (use of a chiller). The use of air-side economizer mode requires a method to introduce outside air into the areas of the building to be cooled and a method to return or exhaust the air using fans and dampers.

Deduplication: An approach to reduce the amount of electronic data stored by eliminating unnecessary or duplicate copies.

Economizer: A mode of control used by a building cooling system that uses outdoor air for cooling, as opposed to mechanical cooling. Also commonly called free cooling. There are two types of economizers: air-side and water-side.

Pods: Enclosed compartments of IT racks that employ a centralized environmental management system to provide cool air at intake and keep warm air at the exhaust.

Virtualization: A server configuration method that decouples a software application from the resources of a dedicated physical server. Using virtualization, a single physical server can be configured to share resources to run multiple operating environments and applications.

Water-side economizer: A mode of control that uses outdoor air for cooling, as opposed to mechanical cooling (use of a chiller). When using water-side economizer mode, chilled water is cooled by circulating it through the cooling tower, as opposed to the chiller. This requires the use of a plate and frame heat exchanger.

6.4 Appendix D: Sample Approved Letter

Securing executive endorsement is an important step to a successful green data center project. The letter below provides one example of communication with the executive team. For further information, see Section 3.1.2.

TO: **EXECUTIVE TEAM**

FROM: **DUE DILIGENCE TEAM**

SUBJECT: **DATA CENTER ENERGY EFFICIENCY PROJECT**

APPROVED

INTRODUCTION:

Data Center use is growing and now accounts for 1% - 2% of the world's energy consumption. Historically the design of data centers has focused on reliability and not on energy efficiency. Recently the data center community has started to focus on energy efficiency and sustainability by establishing goals and standards.

Our data center was built in 1998. Although we have increased both the power and cooling supply in the past, we are still near capacity now. Future IT growth will require either significant construction (we have an estimate of $1,750,000) or a reduction in electrical demand within the data center.

POWER UTILIZATION EFFICIENCY (PUE):

An average data center requires one watt of power to maintain the environment for each watt required to power computers. In this example the PUE rating would be 2.0. Most data centers today are designed to operate at a PUE rating between 1.5 and 1.8. The best claim to operate in the 1.25 range.

ENERGY SPEND

Last year we spent $600,000 on energy for the data center. We calculated that our PUE rating is 2.5. This means we use 1.5 watts to maintain our environment for each watt required for our computers.

EFFICIENCY ASSESSMENT

A recent assessment of our data center identified several areas that can reduce our energy demand. We calculate that we can reduce our PUE to 1.8. This will lower our energy cost by $1,128,000 over the next five years including rate increases already scheduled. If we transition to more energy efficient computer equipment, we can postpone $1,750,000 in new construction, maybe forever.

DEMAND REDUCTION INITIATIVES

IT Department-

1. Expand the server virtualization initiative. This can greatly reduce the number of servers.
2. Eliminate under-utilized servers and comatose servers.
3. Install a data de-duplication system to eliminate multiple copies of the same document. This will greatly reduce the quantity of storage required.

Facilities Department-

1. Replace two air conditioners that are at end of life with new energy efficient systems.
2. Install Variable Frequency Drives on existing air handlers and chiller pumps.
3. Re-orient the racks into a cold aisle / hot aisle configuration.
4. Prevent hot / cold air mixing using custom ducting and containment.

COST:

Total = $900,000, this includes $500,000 for the IT Department to expand the virtualization initiative and pay for data de-duplication systems. It also includes $400,000 for the Facilities Department to re-model our data center with energy efficiency initiatives. (See attached budgets).

RETURN ON INVESTMENT

The payback is about 4 years if we only consider the reduction in energy. The added benefit is that we can delay or possibly avoid adding more capacity to the data center at a cost of $1,750,000.

SCHEDULE:

It will take about 12 months to complete all our initiatives. (See attached schedules)

Cordially,

Due Diligence Team

If you find this publication useful, there is something you should know…

This publication was made possible by the support of people like you through the IFMA Foundation.

Established in 1990 as a nonprofit, 501(c)(3) corporation, and separate entity from IFMA, the IFMA Foundation works for the public good to promote priority research and educational opportunities for the advancement of facility management. The IFMA Foundation is supported by the generosity of the facility management community including IFMA members, chapters, councils, corporate sponsors and private contributors who share the belief that education and research improve the facility management profession.

By increasing the body of knowledge available to facility professionals, the IFMA Foundation advances the profession and potential career opportunity.

IFMA Foundation contributions are used to:

- Underwrite research — to generate knowledge that directly benefits the profession
- Fund educational programs — to keep facility managers up-to-date on the latest techniques and technology
- Provide scholarships — to educate the future of the facility management profession

Without the support of workplace professionals, the IFMA Foundation would be unable to contribute to the future development and direction of facility management. That is why we need your help. If you are interested in improving the profession and your career potential, we encourage you to make a donation or get involved in a fundraising event. To learn more about the good works of the IFMA Foundation, visit www.ifmafoundation.org.

2009 – 2010 IFMA Foundation

Major Benefactors
Bentley Prince Street

Platinum Sponsors
LA Chapter of IFMA
Greater Philadelphia Chapter of IFMA
Corporate Facilities Council of IFMA
Steelcase Inc.
Utilities Council of IFMA

Gold Sponsors
ARAMARK Management Services
Acuity Brands
Greater New York Chapter of IFMA
Graphic Systems, Inc.
Denver Chapter of IFMA
Kayhan International Limited
Facility Engineering Associates, P.C.
Greater Triangle Chapter of IFMA - Scholarship Sponsor

Silver Sponsors
Central Pennsylvania Chapter of IFMA - Scholarship Sponsor
Dallas Fort Worth Chapter of IFMA - Scholarship Sponsor
East Bay Chapter of IFMA
Kent Miller, FMP
Kimball Office Furniture Co.
NW Energy Efficiency Alliance
San Francisco Chapter of IFMA
San Diego Chapter of IFMA
SoCal Office Technologies
Sodexo Inc. - Scholarship Sponsor
West Michigan Chapter of IFMA - Scholarship Sponsor

IFMA FOUNDATION
WWW.IFMAFOUNDATION.ORG
EDUCATION • RESEARCH • SCHOLARSHIPS

Guides can be downloaded, free of charge, on the IFMA Foundation Web site
1 E. Greenway Plaza, Suite 1100 | Houston, Texas 77046 USA | +1.281.974.5600 | www.ifmafoundation.org

The IFMA Foundation would like to thank its Corporate Contributors, the IFMA chapters, councils and members, as well as other organizations and individuals for their sponsorship. Your generous support helps to make the foundation's education, research and scholarship initiatives possible.

IFMA FOUNDATION
WWW.IFMAFOUNDATION.ORG
EDUCATION • RESEARCH • SCHOLARSHIPS