Federal Energy Management Program

NEW DATA CENTER BUILDING

ENERGY PROGRAMMING GUIDE

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CONTENTS

Summary

This guide addresses the energy issues a data center owner must consider for building an energy efficient data center. The order of topics presented roughly follows the chronological order of the data center design and build process: from site selection to construction and operation. This guide also describes key energy efficiency metrics which help provide basic goals for achieving energy efficient data center design. For metric benchmark values, refer to LBNL's Self-Benchmarking Guide for Data Centers: http://hightech.lbl.gov/benchmarking-guides/data.html . This guide provides a template of basic energy efficient data center design requirements which data center owners are encouraged to incorporate into their project documents such as Requests for Proposal (RFP), Owner's Project Requirements (OPR), and Project Basis of Design (BOD). Important recommendations stated throughout this guide are written in bold text. This guide does not address existing data centers or container style data centers.

Background

Data centers can consume 10 to 100 times electricity as standard office spaces. With such large power consumption, they are prime targets for energy efficient design measures that can save money and reduce energy use. The most effective path towards data center energy efficiency begins with integrating this goal with high level design criteria – chiefly equipment and systems reliability, layout and capacity - at the conceptual stages of the data center design. Carefully chosen energy efficiency metrics and benchmark values communicate clear objective criteria to the designers and builders for meeting an owner's vision of an energy efficient facility.

Site Selection Criteria

Following are several issues of varying impact on energy efficiency to address if more than one data center location can be considered.

Facility Consolidation

Consolidating multiple data centers into fewer facilities that implement best practices can enhance energy efficiency. Real estate, design and construction are expensive. Cost savings in these areas due to combining facilities can allow investment in more energy efficient design and enhanced monitoring for persistent energy efficient data center operation.

- *Data center owners should minimize the number of data center facilities by either minimizing the number of new data centers or by consolidating underutilized, existing data centers into fewer facilities in alignment with the OMB Federal Data Center Consolidation Initiative.*

- *Federal Data Centers Consolidation Initiative (FDCCI) is an important source of information on planning and progress of data centers consolidation activities across federal data centers. http://www.cio.gov/pages.cfm/page/FDCCI*

Climate

Ambient air conditions determine to a large extent the efficiency and corresponding energy use of cooling systems. A site with mild ambient air conditions close to the ideal space operating temperatures

of a data center (see Cooling System Opportunities later in this guide) will require less energy intensive cooling and humidification systems. For example, hot humid climates will require more cooling energy to maintain a data center space's environmental requirements. Mild climates also allow for more hours of air-side and water-side economizer cooling (free cooling). The Green Grid has an on-line tool for computing the number of hours and estimated energy savings due to free cooling at:
http://cooling.thegreengrid.org/namerica/WEB_APP/calc_index.html.

Air currents around a building or site can affect the optimal orientation of outdoor equipment. Cooling tower and air-cooled equipment heat rejection performance can be enhanced by orienting this equipment along air currents to reduce the work required by outdoor heat rejection fans. Orienting cooling towers this way likely increases the need for make-up water as more vapor will be carried away from the tower. On the other hand, air currents can reduce cooling tower or air-cooled equipment performance when outdoor fan exhaust recirculates back into the intake. Placement of diesel generator exhaust stacks relative to outside air intakes should also be considered. This can have impact on free cooling using outside air since during generators operation, free cooling is suspended to prevent fumes entering the building.

- *Data center owner's criteria for choosing a data center location should include the climate's potential for implementing passive cooling strategies. Owners are encouraged to enlist the help of design professionals to provide a comparative analysis between multiple sites based on climate impact as well as availability/cost of power and network.*

Air Quality

The air quality surrounding a site should be evaluated and strategies to deal with concerns over particulates or gaseous pollutants should be determined. Mitigation steps may involve filtration or other measures. Contamination concerns with salt or corrosives and locations near pulp and paper mills or chemical plants should be evaluated. Additional filtration increases the fan power required to draw outside air into the data center space, reducing the energy savings associated with air-side economizers.

- *Data center owners should invest in a professional environmental review of a site's ambient particulate and gaseous contaminants and evaluate their potential to exceed acceptable data center air quality criteria recommended by ISA Standard S71.04 -1985. If a coupon survey yields corrosion rates above the ISA G1 level, additional and more detailed analysis of air contaminates should be conducted or an alternate site considered. Standard filtering (MERV 11), as evaluated by ASHRAE Standard 52.2 Test Procedure, should be used for incoming air.*

Available Water Resources

Consider the availability of potable or non-potable water for water-cooled chiller plant cooling towers and evaporative-based cooling and humidification media. After extensive investigation of acceptable environmental impact, large bodies of water such as rivers or lakes could be used as heat sinks for data center waste heat. Ground water can be a source for heat rejection as well.

Renewable Energy Possibilities

Wind and solar energy should be considered for lowering environmental impact. Wind and solar sources provide energy while not emitting any carbon dioxide into the atmosphere. Solar-thermal energy can be used in conjunction with absorption chillers, and/or heating for domestic water or space conditioning in office areas.

- *Federal data center owners should consult Federal Renewable Production and Consumption Requirements for guidance on incorporating renewable energy resources into data center design. See: http://www1.eere.energy.gov/femp/technologies/renewable_requirements.html*

Electrical Grid

According to the Electric Power Research Institute, deficiencies in local and regional transmission are the biggest obstacle to the growth of renewable energy. Locating a data center in close proximity of clean sources of power can benefit the data center owner as well as the overall CO_2 reduction strategies. An example of a high concentration of renewable energy is in Texas for wind power and in the south west for solar power. On the other hand, data center siting should plan to avoid areas with the grid mostly sourced by power plants run entirely or partially on coal or other high CO_2 emission rate fuels.

Noise Constraints

Ensure that sound emitted from mechanical equipment and generators will comply with the local noise ordinance. Determine in advance if air intakes and exhausts require sound attenuation measures, which often cause increased energy use due to the added resistance that must be overcome by HVAC fans. Identifying sound attenuation requirements early on allows for designing to minimize the impact on fan power or reduced equipment efficiency.

- *The design team should investigate any local sound ordinances whose compliance may require sound mitigation measures on mechanical and generator equipment. Avoiding any sound mitigation measures is optimal. If implementing sound mitigation measures is unavoidable, the designers should design mitigation without adversely affecting the system energy efficiency.*

Conceptual Design Goals and Their Impact on Energy Efficiency

Optimizing a data center's energy efficiency begins while formulating conceptual design goals. Choices in data center layout, equipment selection and operation impact the data center energy efficiency. Thus, the goal of energy efficiency should be integrated into the programming decision making process.

Information Technology (IT) Equipment Selection

In a typical data center with a standard efficient cooling system, IT equipment electrical loads account for considerably more than half of the entire facility's energy use. Use of efficient IT equipment will significantly reduce the power requirement within the data center, which consequently will downsize the upstream electrical distribution equipment as well as the systems needed to cool them. For a data center with typical infrastructure efficiency, saving one KW of server power can save more than $12,000 over a three year sever lifespan; assuming infrastructure costs of $6.00/Watt and an annual average electric rate of $0.10 per kWh. For efficient data centers the percentage of saving will be high since most of the energy is associated with the IT equipment.

- *Owner/contractors should purchase servers equipped with energy efficient processors, fans and power supplies along with power management. The Energy Star program aids consumers by recognizing high efficiency servers. High-efficient network equipment, consolidating storage devices, consolidating power supplies, and implementing virtualization are among the most advantageous ways to reduce IT equipment loads within a data center.*

- *Ideally, the design team should have a list of IT equipment for all project phases. The list should include the actual cooling load and environmental requirements for each piece of equipment. Often, however, this information is not available so alternatively, the number of racks with assumed loading (kW per rack) should be provided to the design team by the owner. In case none of the above information is available, based on the type of data center, the design team should estimate the total IT load using typical Watts per square foot compared with similar data centers.*

Availability/Reliability and Redundancy Options

Carefully consider the acceptable availability and reliability levels for the data center. Uptime Institute has created a Tier Classification System as a benchmark for reliable data center infrastructure design. In many cases the Tier level specified may be different for various systems. For example, the electrical distribution system may be designed for a 2N redundancy, whereas the mechanical systems could be designed for N+1 redundancy. Systems built with very high reliability involve built-in redundancy at all system levels. The level of built-in redundancy influences efficiency by way of limiting the maximum load factor under which some components will operate. For instance, designing an Uninterruptible Power Supply (UPS) system for 2N redundancy often results in equal sized UPS systems operating below 50% capacity; hence lowering its operating efficiency. Careful consideration of the efficiency at various load factors can lead to more efficient redundancy options. Use only the level of redundancy required to meet well justified availability requirements.

Once the acceptable redundancy level has been established, consider different electrical distribution topology options. The best options minimize the power path and power conversions while operating equipment at higher load factors.

Monitoring and Automation

Data Center monitoring and control is a critical element of maintaining maximum availability for the owner's critical operations. Utilizing IP and Web technologies to oversee and control critical support systems remotely is an important factor.

Criteria should be created for both infrastructure systems monitoring and information technology monitoring. It is vital that monitoring and control systems be cost effective, quickly deployed and implemented, easy to use, utilize intuitive alarming and escalation methodologies and provide robust reporting all from a central and secure location. Ideally, the IT and Infrastructure systems are monitored and controlled through a single system with "dashboard" displays for ease of understanding.

Mission critical services require sophisticated monitoring. Monitoring systems should provide proactive management and enable the quick assessment of the data center present situation and notify the appropriate personnel should situations that threaten availability.

Design and implementation of monitoring and control systems should provide, at least, Infrastructure Management & Control (environmental monitoring, cooling systems, and electrical power chain) and Performance Management / Capacity Planning (server utilization, virtualization, and growth) including ability to monitor and track real time PUE.

Expandability and Modularity Energy Impacts

Due to the typically shorter life cycle of IT hardware and software compared to cooling equipment, data center design requires planning to accommodate several major IT hardware and software refreshes. As IT equipment power densities and physical location of the load concentrations evolve with each refresh, the installed data center infrastructure must be flexible enough to accommodate these changes while maintaining energy efficiency and availability.

Modular systems can address future upgrades in an energy efficient manner. For instance, installing smaller UPS modules allows this equipment to operate at higher load factors, and therefore higher efficiencies. The same can be said about chillers which operate more efficiently at higher load factors although in this case, operating at 75% load factor might be the optimum operational efficiency. On the other hand, larger equipment such as fans, pumps and compressors tend to be inherently more efficient. Maximizing efficiency through modularity of the cooling system becomes a balancing act which requires careful study of equipment efficiency curves versus load factor for both current and future loads.

The important issues to consider regarding expandability involve considering the percentage of the anticipated future cooling capacity to be initially installed and the percentage of this capacity to be initially provisioned. For example, should the initial construction include build-out to accommodate the next five years or should it provide for only the next 2-3 years with an upgrade within 5 years?

- *Owners should specify minimum energy efficiency requirements at a variety of data center loads, from initial start up to full build out, rather than just the projected full build out which may never occur. The Energy Efficiency Performance Table in appendix A provides typical figures as the criteria.*

Capital and Operating Costs

Total cost of ownership (TCO), similar to life cycle costing (LCC), is a financial estimate intended to assess all costs – including the purchase cost as well as indirect and cost of the money. Energy cost for operating a data center is an increasing component of TCO. Therefore, minimizing a data center's TCO while maintaining required levels of reliability and availability requires a strong emphasis on data center energy efficiency. The US Department of Energy building life cycle cost (BLCC) calculator can be used to evaluate energy efficient design alternatives from the perspective of total cost of ownership. See http://www1.eere.energy.gov/femp/information/download_blcc.html

There is a common misconception that energy efficient design necessitates added capital cost. Rather, there are often capital cost savings associated with an energy efficient measure that reduce or even offset the measure's primary cost. For instance, additional engineering time spent to produce an efficient data center layout will shorten mechanical and electrical distribution paths – saving on construction costs. As another example, consider that air handler fan power can be reduced by "over sizing" the air handler to reduce the air velocity across the cooling coil and filters. The standard arguments against this approach are high first cost and excessive space requirements due to a larger air handler. Consider that a modest reduction in face velocity by 20% requires a 25% increase in air handler cross-sectional area but will yield about 36% fan energy savings. A detailed look at the true cost changes in the larger air handler reveal the following initial cost savings:

- The cooling coil has more area but fewer rows, as the load it needs to serve is still the same. The coil cost increase should be minimal.
- The fan motor size can often be reduced. This means a smaller motor starter or variable speed drive (VSD), smaller wires, and smaller circuit breaker and other electrical components in the chain. In some cases, the generator and/or building transformer sizes can be reduced significantly; offsetting the air handler cost. There is often a 'sweet spot,' for the face velocity that allows for the next smaller motor size to be used or that permits dropping a circuit breaker and wire size.
- More filters are required, but they will load up more slowly, as the air volume is still the same. The filter change interval can be increased proportionally.

For these reasons, the cost increase of an "oversized" air handler can be negligible.

- *When evaluating the costs of energy efficient design alternatives, owners through their design team should evaluate options based upon life cycle costs. For first cost estimates, design team should make sure that cost estimators account for all possible cost reductions associated with energy efficient alternatives.*

Human Issues: Data Center Working Conditions

In data centers implementing hot/cold aisle isolation (see discussion under Design Topics), hot aisle temperatures should exceed 85°F and can exceed temperatures over 100 °F. IT personnel who are expected to work within the data center should be provided temporary solutions when they occupy spaces whose design temperatures fall outside of the human comfort envelope. An example of such a solution is temporary removal of floor tiles to cool the immediate hot aisle area in which personnel are working.

Carbon Reduction and Renewable Energy Options (Source Energy Evaluation)

Renewable energy options such as wind power, solar and solar-thermal as mentioned under Site Selection Criteria can be considered as possible candidates for reducing the data center's carbon footprint.

In October 2009, an Executive Order was signed to require federal agencies to measure, manage, and reduce greenhouse gas emissions toward agency-defined targets.

- *Owners should refer to the October 5, 2009 Executive Order 13514 on Federal Leadership in Environmental, Energy, and Economic Performance for specific goals in carbon reduction. http://www.whitehouse.gov/the_press_office/President-Obama-signs-an-Executive-Order-Focused-on-Federal-Leadership-in-Environmental-Energy-and-Economic-Performance/*

Environmental Performance Criteria (EPC) and Related Rating Systems (LEED™)

A coalition of data center industry groups released draft data center environmental performance criteria for consideration by the United States Green Building Council to expand its Leadership in Energy and Environmental Design (LEED) ™ program for labeling "green" buildings. These criteria were developed to serve as a voluntary guide for early adopters of sustainable data center design. These criteria, meant to be a starting point for establishing a version of LEED ™ certification for data centers, is published by Lawrence Berkeley National Labs (LBNL) and can be found here: http://hightech.lbl.gov/dc-epc.html. For more information on LEED ™ building certification, see http://www.usgbc.org/DisplayPage.aspx?CategoryID=19.

Energy Star: Buildings and Product Ratings

The US Environmental Protection Agency (EPA), which offers an ENERGY STAR certification program for commercial buildings, has developed an infrastructure efficiency standard specific to data centers. ENERGY STAR currently includes servers in the program. Information on the Energy Star server specification can also be accessed at the following URL.
http://www.energystar.gov/index.cfm?c=prod_development.server_efficiency#rating_dcdp

Design Topics/Strategies for Energy Efficiency

This section summarizes several data center energy efficient design measures that data center owners and their design teams should consider. For a more complete treatment, refer to the FEMP Best Practices Guide for Energy-Efficient Data Center Design, listed in the references section at the end of this guide. There are numerous energy efficiency opportunities in all areas of data center design and operation. Figure 1 identifies those systems and components that consume power (power chain, IT and cooling system). Load management, virtualization, consolidation, and use of efficient components are the most important factors to be considered for better energy efficiency of IT systems. Use of DC power, use of high voltage (480V), better redundancy planning, and use of highly efficient UPS units and other power distribution components are recommended for energy efficient power distribution systems. Optimization of environmental conditions, better cooling air management, liquid cooling, and free cooling (economizers) are recommended for energy efficient cooling system. In addition alternative power generation might save energy and reduce green house gas (GHG) emission. The suggested areas are site power generation, clean source of energy, CHP application, use of renewable energy such as solar and wind, and use of waste heat.

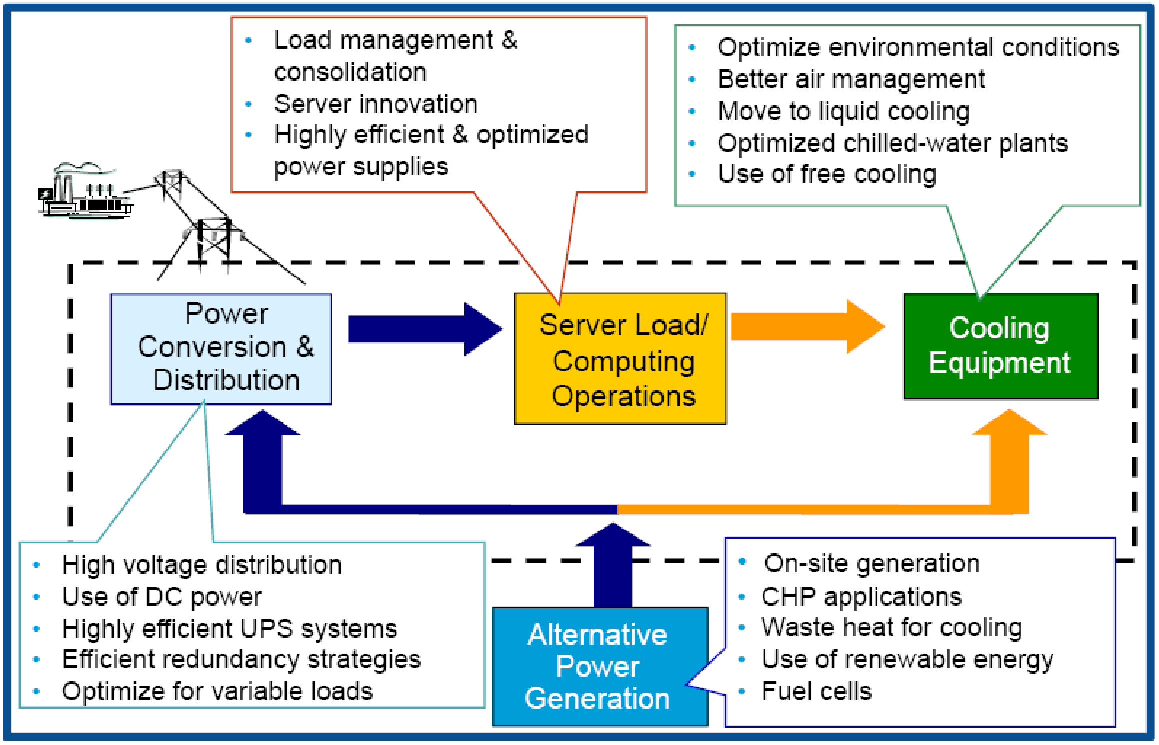

Figure: 1 Summary of key energy efficient design measures

Electrical power Chain

Power Conversion system has potential for 10 to 30% improvement. Strategies for minimizing power losses along the electrical power chain to the IT equipment involve minimizing the number of power conversions/transformer losses and consolidating power supplies wherever possible. Use of DC power distribution can eliminate the need for conversions between AC and DC power.

In contrast to air delivery systems, modular Uninterruptible Power Supply (UPS) systems generally offer more efficient operation. To minimize the losses inherent with UPS systems, carefully consider which IT equipment must require UPS backup.

Alternative power generation has potential of saving energy. Examples are: On-site generation (eliminates transmission losses), CHP applications and use of waste heat for cooling, use of renewable energy, PV, and fuel cells.

Information Technology (IT) Equipment

Although conventional data center programming can be initiated only after the IT equipment is selected, a pre-programming phase will enable owners and their engineers plan for installing servers equipped with energy-efficient processors, fans, and power supplies. Server throttle-down devices and software ("power cycler software") can be installed to direct individual servers to power down during low computational demand. This plan will result in installation of fewer servers.

Efficient power supplies usually have a minimal incremental cost at the server level. Power supply efficiencies typically peak around a load level range between 40% and 60%. Power supplies should be selected and configured to offer the best efficiency at typical load levels. EnergyStar and 80Plus Program are good sources for identifying such efficient systems and components and should be consulted.

Space Orientation and Layout

Careful planning of the layout of IT, mechanical and electrical equipment can significantly reduce the power required to operate the data center infrastructure. Minimizing the distance and number of turns for liquid or air systems, and electrical distribution improves the overall efficiencies of the cooling and electrical systems. Piping, electrical and communication cable and wireway layouts should be planned to ensure that airflow is not restricted across IT cabinets, under raised floors or above dropped ceilings. Grouping equipment with similar heat load densities and environmental requirements allows for cooling systems to control to the least energy-intensive setpoint for each location.

Hot aisle/cold aisle rack orientation combined with aisle isolation measures reduces the necessary fan power to cool the IT equipment and once mixing of hot and cool air streams is eliminated, allows a higher supply air temperature setpoint. This in turn provides the opportunity to operate the cooling systems more efficiently. Overhead air delivery tends to reduce temperature stratification in the cold aisles compared to under floor air delivery.

Cooling System Opportunities

The program should be based upon the latest environmental conditions recommended by the American Society of Heating, Refrigeration and Air-Conditioning Engineers (ASHRAE) for IT equipment intake air. These recommended ranges of air temperature, moisture level and temperature rate of change are intended to guide operators on energy efficient data center environmental control while maintaining high reliability. Designing for the upper end of the recommended range will result in more energy efficient systems. Even better energy performance may be possible by consulting the manufacturer’s specifications for the IT equipment planned to be utilized. Centralized rather than traditional in room air delivery systems generally provide more energy efficiency opportunities. A centralized air-handling system uses larger motors and fans which are generally more efficient.

Through the use of variable frequency drives, a central air handling system is well suited for variable air volume operation to take advantage of variable IT loads. Redundant fan capacity can be used at lower fan speeds to increase fan system efficiency further.

Air management for data centers with air cooled IT equipment is important.

Designers should design for free cooling opportunities such as air and/or water economizers. Designing for higher data center air temperatures and relaxing humidity requirements increases the number of hours of available free cooling.

In-row or in-rack cooling technologies (“liquid cooling”), capturing waste heat closer to the source, are other strategies to improve efficiency by allowing for more efficient heat rejection to the outside air.

Chilled water plants should operate at the highest allowable chilled water temperature to maximize chiller efficiency. Variable speed driven chilled water plant equipment (pumps, chillers, cooling towers) allows the plant to be programmed to maximize energy efficiency as internal load and ambient conditions change.

Premium efficiency motors in all components should be requested.

Use of waste heat

There are several data centers which use co-generation systems that simultaneously produce on-site electricity for powering the data center and waste heat to operate absorption or adsorption chillers. Backup diesel generators include engine block heaters which require a significant amount of power. Data center waste heat can be used as an alternative source of engine block heat or for preheating ventilation air or domestic hot water for other parts of the building. A nearby district heating water main could be preheated with datacenter waste heat via heat exchanger.

Monitoring

The building monitoring system should include sufficient metering to provide data to continuously calculate PUE and other key energy efficiency metrics described in this guide's Appendix. Efficiency requirements should be specified for IT, mechanical and electrical equipment at initial load, first upgrade, and final upgrade. See Energy Efficiency Performance table for suggested numbers.

Energy Efficiency Performance

To assist the owners and designers of new data centers to set goals for efficiency of energy use in the data center, the results of a data center benchmarking study carried out by Lawrence Berkeley National Laboratory are reflected in the LBNL's Self-Benchmarking Guide for Data Centers: http://hightech.lbl.gov/benchmarking-guides/data.html.

- *The data center design team should be selected based on their experience with accurately modeling annual energy consumption of a data center which may require custom simulation tools and a high level of technical expertise.*

Once a data center's annual energy use is determined, an energy rate schedule, accounting for peak demand charges, can be applied. Separate model runs may be required to account for escalation in energy costs or significant changes in IT equipment heat loads from year-to-year.

Owners with their design team should complete the following table as much as possible and provide it to the designers and energy modelers. Different phases of data center build out should be identified in this table.

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

Table 1: IT Equipment Types, Quantities and Load Densities

Design Goal Setting during programming phase

As discussed in the previous sections there are several factors, other than selecting efficient equipment, which determine a data center's energy efficiency. Thus, the key to achieving an energy efficient design is to establish quantitative energy efficiency goals. The energy efficiency metrics listed in this guide's Appendix attempt to provide objective criteria for evaluating data center energy efficiency. The overall data center performance metric of PUE provides a high level measure of a data center's electrical and mechanical infrastructure efficiency. This metric, however, does not measure the relative efficiency of the IT equipment, only the IT equipment energy relative to the infrastructure efficiency supporting it. Several organizations are working on developing overall data center efficiency metrics with a protocol to account for the useful work produced by a data center per unit of energy or power. Among some examples are the Data Center Productivity (DCP) and Data Center Energy Productivity (DCeP) metrics considered by The Green Grid.

- Owners and design team should consider defining data center productivity metrics whenever possible to establish overall data center energy efficiency criteria. Appendix includes such targets for the team conformance.

- Team should initiate the Project Basis of Design document during programming. It is a live document and will be updated during different phases of design and delivery of the project.

General Bibliography

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- *High Performance Data Centers – A Design Guidelines Sourcebook*. Pacific Gas and Electric, 2006. http://hightech.lbl.gov/documents/data_centers/06_datacenters-pge.pdf

- *Quantitative Efficiency Analysis of Power Distribution Configurations for Data Centers,* The Green Grid White Paper #16, 2008
http://www.thegreengrid.org/~/media/WhitePapers/White_Paper_16_-_Quantitative_Efficiency_Analysis_30DEC08.ashx?lang=en

- *Self-Benchmarking Guide for High-Tech Buildings: Data Centers,* E.O. Lawrence Berkeley National Laboratory
http://hightech.lbl.gov/benchmarking-guides/data.html

- *Thermal Guidelines for Data Processing Environments,* 2nd Edition, ASHRAE Datacom Series 1, 2009.

Resources

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

- Critical Facilities Roundtablehttp://www.cfroundtable.org/

- Energy Star Data Center Energy Efficiency Initiatives
http://www.energystar.gov/index.cfm?c=prod_development.server_efficiency#rating_dcdp

- Federal Renewable Production and Consumption Requirements
http://www1.eere.energy.gov/femp/technologies/renewable_requirements.html

- The Green Grid
http://www.thegreengrid.org/home
http://www.thegreengrid.org/Global/Content/Tools/DataCenterMaturityModel.aspx

  The Green Grid Free-Cooling Tool
  http://cooling.thegreengrid.org/namerica/WEB_APP/calc_index.html

- Lawrence Berkeley Lab: High Performance Buildings for High Tech Industries
http://hightech.lbl.gov/htindex.html

  Proposed LEED™ Criteria for Data Centers
  http://hightech.lbl.gov/dc-epc.html

- Pacific Gas & Electric: High Technology Facilities
http://www.pge.com/hightech/

- Silicon Valley Leadership Group: Data Center Efficiency Project
  http://svlg.net/campaigns/datacenter/

- US Department of Energy: "Save Energy Now" Program
  http://www1.eere.energy.gov/industry/saveenergynow/partnering_data_centers.html

- United States Green Building Council (USGBC); Leadership in Energy and Environmental Design (LEED™) Green Building Certification Program
  http://www.usgbc.org/DisplayPage.aspx?CategoryID=19

- The Uptime Institute
  http://www.uptimeinstitute.org/

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Appendix A. Owner's Energy Efficiency Data Center Project Performance Targets Template

These energy efficiency project requirements are intended to form the basis from which all design, construction and operational decisions are made. The energy efficiency performance requirements of the overall facility, systems and equipment needs to be established as part of the owner's project requirements to the design team. Benchmark and suggested good and better energy efficient metric values are listed in LBNL's Self-Benchmarking Guide for Data Centers: http://hightech.lbl.gov/benchmarking-guides/data.html.

High Efficiency Data Center Project

Owner's Energy Efficient Data Center Project Performance Targets

Project Description

<***Agency Name***> is building a <***area***> square-foot data center at <***location***> <with the capability of another <***area***> square-feet of future expansion>. This will be a 24/7 facility designed to accommodate <***estimated IT load*** >kW in addition to lighting loads, mechanical loads, and any other miscellaneous office plug loads.

General Energy Efficiency:

The Project shall:

1. Comply with federal, state, and local energy efficiency standards, renewable energy and carbon reduction goals.
2. Achieve LEED <***Platinum***>level via implementation of data center Environmental Performance Criteria posted at http://hightech.lbl.gov/dc-epc.html.
3. Utilize high-efficiency systems throughout to achieve an annual average Power Utilization Effectiveness (PUE) as identified in Energy Efficiency Performance Table *target* or less. This PUE will be defined on an annual basis and not a design day temperature.
4. Have a<***modular***>< ***centralized***> approach to the design while allow for future data center expansion and load density growth.
5. ASHRAE 90.1-Latest version reduction of <***30%***> or more for energy cost of regulated loads using Appendix G Performance Rating Method
6. ASHRAE 90.1- Latest version reduction of <***30%***> or more for energy cost of total loads, including non-regulated (process) loads, using Appendix G Performance Rating Method. Refer to DOE publication "Recommendation For Incorporating Data Center Specific Sustainability Best Practices into EO13514 Implementation".
7. < ***Involve at least three options with different system design approaches with Life Cycle Analysis comparison during the conceptual and schematic design phases .***>
8. Require equipment with efficiencies exceeding Energy Star minimum efficiencies by at least <***percent***>. This requirement applies to both the component and system levels.

HVAC

1. Envelope requirements: <***as needed to meet LEED energy performance***>
2. <***CFD modeling required to determine airflows and temperatures in data center space***>
3. Provide zoning of equipment with similar environmental air requirements <Different IT equipment may have different intake air requirements. The different criteria should be mentioned and provide zoning as needed.>
4. Implement free cooling using <***air-side economizer***>*<and><or>*<***water-side economizer***>*.*

Electrical

1. Electrical distribution requirements to PDU or power supply – <***Volt***><***AC***><***DC***>
2. Comply with IES requirements, reduce lighting power over latest version of ASHRAE 90.1by <***30%***> or more. Peak lighting density shall not exceed <0.7> W/sf
3. Recommended baseline for electrical distribution equipment at 75% load factor is 99% for distribution transformer, 95% for UPS, and 99% for PDU. Overall data center energy use efficiency and target PUE should be considered while selecting electrical systems.

Controls and Monitoring

Recommended Good practice:

1. Real time monitoring of power PUE and monitoring of annual average energy PUE
2. BMS requirements: Open protocol, remote access, trending of all points, including all points required to calculate energy efficiency metric values. All measured values shall be continuously trended and data archived for a minimum of one year to obtain annual energy totals
3. BMS should monitor and control environmental parameters such as air intake temperature, relative humidity, cooling liquid temperature, static pressure, and pump/fan VFDs
4. Provide all power metering necessary to continuously measure all energy efficiency metric values described in these requirements.
5. Metering requirements – <***Define level of metering, UPS vs. PDU, vs. PSU report to BMS***>
6. BAS/BMS requirements – access and trending of all measured and metered systems to confirm all efficiency values described in these requirements
7. Lighting control

Recommended Better practice in addition to the above list:

1. Monitor and manage CPU utilization

Energy Efficiency Performance Table

Energy efficiency metrics and benchmarks can be used to track the performance of and identify potential opportunities to reduce energy use in data centers. Several of these are listed in the data center benchmarking study carried out by Lawrence Berkeley National Laboratories. The data from this survey and further description of these metrics can be found under LBNL's Self-Benchmarking Guide for

Data Centers: http://hightech.lbl.gov/benchmarking-guides/data.html. After designers/bidders create and run models for the data center, they should compare their targets with those in the energy efficiency performance table below to confirm that the design is on track for meeting the owner's energy efficiency goals. Exceptions should be noted.

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

Table Notes:

1- Numbers are compatible with the levels 1, 2, 3, and 5 of Maturity Model published by The Green Grid. Refer to: http://www.thegreengrid.org/Global/Content/Tools/DataCenterMaturityModel.aspx