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A Roadmap to Data Center Greening

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OVERVIEW

Greening our world has become an imperative as we learn more about the existing and anticipated effects of global warming. The preponderance of scientists who work in the area of climate studies have concluded that our modern civilization is creating greenhouse gases that are causing global warming and that we must act relatively quickly to avoid catastrophe. Data centers use between 1.5 and 2% of the world's electricity and much of it is wasted. It is predicted that at the current rate of use greenhouses gases that are created by producing the energy required by data centers will exceed that created by all the jet liners in the world in the year 2020.

This paper presents a Roadmap for reducing energy use in the data center, controlling the use of materials, and disposing of electronic equipment. Much of the content of this paper applies not only to large data centers but also to data centers of small businesses (anything from a server farm to a small room with several servers). Departments of a company other than the data center may find specific areas of this paper applicable to them too.

This paper might have been entitled "A Roadmap to Reducing Energy Costs in the Data Center" because many of the major changes required to green a data center also provide significant cost reduction in its operation. In fact, greening actions that coincidentally result in the reducing of data center energy costs constitute the majority of this paper. Many of the same actions need to be taken whether the data center's objective is to reduce costs or to support greening. The only situation in which greening is inconsistent with reducing costs is where the ROI on a greening activity does not meet company guidelines. Thus the profit motive is fortuitously a major driver of data center greening.

If the ROI of a particular greening activity is not currently in conformance with company's ROI guidelines, it may be soon enough. In the near future today's high energy costs may seem inexpensive according to many experts. The population of the world is growing rapidly and the developing nations are demanding much more energy per capita. (The population of the world is expected to grow about 50% by mid-century.) Oil is a big part of the world's energy supply (more than a third) and the output of oil may have peaked. Natural gas reserves are greater than that for oil but natural gas is much harder to distribute and prices are rising along with oil. (Note that the U.S. has only 4% of the world's natural gas reserve.) Coal, while plentiful, is a "dirty" fuel whose future use depends in part on finding economic methods of cleaning it up. Recent reports have indicated that cleaning up the use of coal for electrical power generation may be more difficult than first thought.

"Alternative" green energy sources are approaching being cost effective but to date have not shown that they can carry a large portion of the required load. There are a limited number of geographic areas where solar or wind power can now be competitive with conventional power. Unless there is a major energy supply breakthrough, it would seem energy costs will be

increasing for the long term. Justification of the expenditure to reduce energy usage in the data center should become easier over time.

Forty tons of e-waste (broken or unwanted electrical or electronic equipment) is generated each year with only 20% being disposed of properly. Data centers must find ways to discard their e-waste in an ecologically sound way. Also they should reduce the use of expendables, purchase green products, and have employees engage in green activities. Some of these actions are not unique to the data center but should be done on a company wide basis.

This paper provides some background of what is causing the recent escalation of interest in data center greening and a Roadmap intended to provide greening guidance to the IT executive. Organizations are being driven to greening by a combination of community pressure, economic demands, shareholder actions, lack of utility power, and pending or existing laws and regulations. Community pressure emanates from the company's customers, neighbors, professional organizations, green organizations, and other aspects of society. Economic pressures are the usual "reduce the costs" edicts from corporate management. Increasingly shareholders are putting pressure on companies to institute green policies. In some geographic areas local power utilities have restricted data center expansion because of insufficient available power. Laws and regulations have been passed by both a number of towns, cities, states, and the federal government that require or encourage specific greening activities. And everyone anticipates future laws and regulations that will be both stricter and more pervasive.

The handwriting is on the wall – **green now!** A recent survey of data center managers taken by AFCOM (an association of data center managers) indicated that 88.5% of them described energy consumption as a serious or very serious concern as compared to only 36.1% five years ago.

A Roadmap for data center greening is provided in this paper. This Roadmap covers the most significant actions Information Technology (IT) can take. In attempting this broad coverage it is not possible (or desirable) to go into sufficient depth in this paper for IT to implement a greening plan without performing further research.

The contents of this paper have been derived from both the professional experience and knowledge of the author and a review of the existing literature.

The remainder of this paper is organized into the following sections:

- What is Driving the Greening of IT?
- The Roadmap
- Roadblocks to the Roadmap
- Future Technological Improvements
- Conclusions

WHAT IS DRIVING THE GREENING OF IT?

Some companies will green out of a sense of social responsibility but most companies are driven more by the desire to reduce costs. This is not as bad an omen as it might seem because much of greening does reduce costs. Some companies see a PR advantage in being able to advertise they are green and thus will green even if the economics don't exactly work out. There is an economic incentive to having good PR but it is difficult to quantify.

Customers are influenced in their purchasing decisions by the stated green policy and actions of a company. Notice how many advertisements now include some reference to a company's green posture. On the bottom of Apple's webpage there is a list of key corporate components with the standard fare of items except for one called "Environment". Here Apple notes all of the things they have done to support environmental improvement. This indicates that Apple sees their green image as an important component of their corporate image. A recent article in MIT Sloan Management Review concluded that consumers are willing to pay a little more for products produced by an ethical company than they would for the same product from an unethical company.

Many companies are feeling pressure from their neighbors to "go green". The data center is usually a big part of a company's "greening problem" resulting in pressure to green IT. There have been many instances where the disposal of materials (including electronic items from the data center) has fouled local dump sites. Local utility companies may run low on available power and need to have major users restrict their power needs to avoid brown outs. Some communities have started local greening efforts and are asking that all local residents and businesses do their part. As previously stated, any department of a company that has computers and other electronic equipment can apply much of what is contained in this paper. The data center might take the lead in bringing these other departments into the fold.

Professional organizations often conduct seminars and conferences to both encourage data center greening and to help define what needs to be done. These seminars and conferences stimulate data center managers, alert them to the possibilities, and helps IT formulate the rationale for greening. These same organizations also produce important paper and articles on the subject.

There are a number of green organizations that advocate greening and provide materials that can support the greening efforts of the data center. Some of these organizations are:

- [CERES](#) - a partnership of corporations, investors, and environmentalists that advocates the improvement of our environment by supporting companies working to improve their environmental and social performance.
- [Climate Leaders](#) – an industry-government (EPA) partnership that works with companies to develop long-term comprehensive climate strategies.

- [The Green Grid](#) – an organization of data processing manufacturers and suppliers that seek to define and propagate the best energy-efficiency practices in data center operations, construction, and design. They are working on industry metrics which are very important.
- [Climate Savers Computing Initiative](#) – a group of eco-conscious consumer, business, and conservation organizations whose goal is to promote development, deployment, and adoption of smart technologies that can both improve the efficiency of a computer’s power delivery and reduce the energy consumed when the computer is in an inactive state.
- [The U.S. Green Building Council](#) – an organization working to encourage the creation of green buildings. It has produced a rating system for buildings and related items. It is called - Leadership in Energy and Environmental Design (LEED). A number of states, counties, cities and towns have enacted legislation that encourages LEED’S certification in new commercial construction. A LEED’S certification can be required for public buildings. Many of the LEED standards can be applied to data centers. LEED is scheduled to produce data center certification standards in 2009.

Much of our society today encourages greening. Whether it is at a cocktail party, reading the Sunday paper, or looking at a billboard on the way to a ballgame you hear others talk about it, see advertisements encouraging it, and observe actual acts of greening. It is becoming important and not just as an afterthought. This societal awareness helps us to remember not to put greening on a back burner and to sensitize corporate management to the issues.

There are also the economic pressures on IT to reduce costs. Companies are seeing their electric bills increase significantly. Those companies that can attribute electric costs by areas know that much of the increase has come from the data center and its increasing power needs. (Those companies that cannot measure data center electric usage directly can assume that the data center represents a significant part of their electric bill. A company should strive to be able to measure data center electric usage so they can understand the magnitude of the problem and measure the effect of the improvements made.) Energy bills represent about 50% of the IT budget in many situations. In the recent past, energy bills typically represented about 10% of the IT budget.

Many greening efforts have a very favorable ROI. In fact many have little or no onetime costs associated with them. Greening can be an integral part of corporate cost reduction. As a side note, it is not only important to calculate the ROI for greening activities but a company should also factor in “greenness” into its ROI calculations for all its projects. For example, if a company is calculating the ROI of purchasing a new machine, the energy savings (or costs) relative to the machine it is replacing should be considered in the ROI calculation.

There have been an increasing number of shareholder suits seeking to obtain information on company’s climate-change risk. The SEC has been petitioned to force companies to disclose

additional information about how global warming may reduce their profits. The Free Enterprise Action Fund sues companies for not performing their duty to shareholders to get greener.

Some data centers find that they cannot expand their operation for lack of power to run additional equipment. Utilities, often in large cities, are informing customers that they are at capacity and will not get more power for significant periods of time. This could impact a business' ability to grow and thus become a serious concern for the company. Some utilities are encouraging data centers to reduce energy consumption by offering rebates for increased efficiency. Data centers can benefit from these rebates and at the same time reduce their energy bill and probably their floor space requirements.

Three states (California, Hawaii, and New Jersey) have laws ([Green Card Congress](#)) that require the significant reduction of the emission of greenhouse gases as of the writing of this paper. Several other states are considering such a law and a number of states have set voluntary goals. It will be difficult to meet these new standards without major users of electricity reducing their usage and we can expect some combination of incentives and regulations to be forthcoming. It is hoped by many environmentalists that a new administration in Washington will produce the federal equivalent of such a law.

In the Northeast there is a Regional Greenhouse Gas Initiative ([RGGI](#)) which will require emissions reduction and set up a multistate cap on emissions and trade system for power plants in the Northeast. This initiative will also create pressure on users to reduce electrical usage.

Much of the large amount of energy used in a typical data center is "wasted". The EPA ([EPA Newsroom](#)) found that data centers used about 60 billion kilowatt-hours in 2006, roughly 1.5% of U.S. consumption. The EPA also said the U.S. data centers could save about \$4 billion annually by increasing energy efficiency. Much of existing computer equipment, cooling systems, and associated systems used are energy inefficient. They aren't using mechanisms to manage the cooling systems and power usage of electronic equipment. Servers are running at 10 or 15% utilization. Unneeded and redundant data is often stored on discs. Lights are left on all the time. No attempt has been made in many cases to reduce energy usage. Gartner estimates that from 30% to 60% of the energy used in data centers is wasted.

An example of how computer suppliers are rising to this challenge is the recent announcement by IBM of the new [iDataPlex](#) computer for Internet companies. IBM claims this computer uses

40% less power than standard servers and requires about half the space. It is efficiently water cooled reducing the air conditioning load in the data center. Other computer makers have either announced or plan to announce somewhat similar products.

Small businesses should not ignore the cost saving that accrue from greening and contribute to environmental improvement. Many of the items in the Roadmap can be applied to smaller businesses too, but some may be overkill for them. Each small business should consider the Roadmap and decide what items make sense for their situation. They too may eventually be force into action by economics or future laws/regulations.

THE ROADMAP

The Roadmap section of this white paper is written as a standalone document and in part is redundant with other parts of this article. It starts on the following page.

THE ROADMAP

INTRODUCTION AND PURPOSE

The Roadmap is a generalized suggestive plan of ways for an IT department to green its data center. As a generalized document it is broad and comprehensive and needs to be reviewed and adapted to individual situations. Each organization must craft a specific, detailed implementation plan. Available greening mechanisms and the laws and regulations in effect are changing rapidly and it behooves organizations to make certain that they are considering the most current information.

The Roadmap is divided into the following sections:

- INITIAL STEPS IN GREENING OF THE DATA CENTER
- PLANNING THE REDUCTION OF ENERGY USE IN EXISTING DATA CENTERS
- PLANNING THE CREATION OF A NEW GREENER DATA CENTER
- PLANNING THE REDUCTION AND ECOLOGICALLY SOUND MANAGEMENT OF DATA CENTER MATERIALS
- OTHER GREENING ACTIVITIES

Parts of this Roadmap section may be redundant with the earlier sections of this paper because this section was written to be a standalone document.

Section 1 INITIAL STEPS IN THE GREENING OF THE DATA CENTER

A suggested approach to initiating the greening process is for Information Technology (IT) managers to form an ad hoc committee representing the various IT departments involved in or effected by a greening effort and the Facilities department. It should be made clear to the committee members that this effort is important to IT, Facilities management, the company, and the community. The committee members must commit both themselves and their departments to this effort. If the company has an on-going greening effort, a representative of that group should be invited to participate. Once the initial greening is completed, the ad hoc committee should be disbanded and each organization in IT and Facilities charged with maintaining and improving on the greening work done as part of their every day responsibilities. IT and Facilities management should require periodic reports on the progress of greening for each organization.

If the cost of the data center's energy usage is in the Facilities department budget it should be moved to the data center budget. It is important that costs be allocated to the cost center that controls its usage. This will give the data center additional incentive to reduce energy usage.

McKinsey & Co. and the Uptime Institute in a recent report ([DICE](#)) advocated an alternative approach to creating an ad hoc committee. They recommended the creation of an "energy czar" with significant authority to direct the greening of the data center. This has the advantages of focus and of having a strong in-house advocate. But this structure may require a lot of negotiating between operational managers who may perceive their turf as being invaded.

The committee is well advised to: read the current literature, speak to other IT shops to find out what their experience is on greening, and contact organizations that work in the greening area for updates as to their efforts. Some of these organizations are:

- [CERES](#) - a partnership of corporations, investors, and environmentalists that advocates the improvement of our environment by supporting companies working to improve their environmental and social performance.
- [Climate Leaders](#) – an industry-government (EPA) partnership that works with companies to develop long-term comprehensive climate strategies.
- [The Green Grid](#) – an organization of data processing manufacturers and suppliers that seek to define and propagate the best energy-efficiency practices in data center operations, construction, and design. They are working on industry metrics which are very important.
- [Climate Savers Computing Initiative](#) – a group of eco-conscious consumer, business and conservation organizations whose goal is to promote development, deployment and adoption of smart technologies that can both improve the efficiency of a computer's power delivery and reduce the energy consumed when the computer is in an inactive state.
- [The U.S. Green Building Council](#) – an organization working to encourage the creation of green buildings. It has produced a rating system for buildings and related items. It is called - Leadership in Energy and Environmental Design (LEED). A number of states, counties, cities and towns have enacted legislation that encourages LEEDS certification in new commercial construction and requires it for public buildings. Many of the LEED standards can be applied to data centers. LEED is scheduled to produce data center certification standards in 2009.

The committee should gain a general understanding of what is possible and what activities have proved to be successful in other similar organizations. Greening activities that seem as though they may be beneficial to the organization should be documented for further investigation. (An extensive list of possible greening activities are enumerated in the next two sections.)

Once this knowledge has been acquired, IT managers should discuss the subject of greening with the senior managers of their company and determine the company's current stance on greening. Does the company espouse greening and what is the company's requirement for ROI on greening projects? Does greening have a non-economic public relations value to the company?

IT management should also make certain that they have a good understanding of any changes expected in their company's business that could affect the IT operation and hence the greening effort. At the same time IT management should make senior management aware of the economic and societal potential that IT greening has and ask for funds to prepare a detailed greening plan.

Section 2 PLANNING THE REDUCTION OF ENERGY USE IN EXISTING DATA CENTERS

Assuming approval of the planning effort, the committee should consider who will create the plan -- internal staff members or consultants experienced in the greening of data centers. The goal of the plan should be to define the actions to be taken, to detail the potential energy savings (and their economic effect) that would accrue to these actions individually and in concert, and to plan to affect these changes. The plan should also include the non-energy saving related greening activities that can be taken. Detailed implementation schedule and cost benefits analyses are an important part of the plan.

The plan should include:

- An analysis of current power usage identifying the largest hogs. Consider planned changes to the data center.
- Data center current energy usage growth requirements for several years based on acquiring equipment needed to fulfill the company's plans. These should be fairly specific but also indicate a range that allows for the unknown.
- Goals that push the envelope and are consistent with the goals of the company.
- External drivers such as regulation and laws. Also consider incentives from utilities and governmental organizations.
- A detailed implementation plan that selects appropriate initiatives from those enumerated in the following sections of the Roadmap and their projected impact on the energy growth requirements. The ROI of the initiatives may be a key here.
- Anticipated economic and societal advantages to the plan.
- A methodology to monitor the effects of the actions taken.
- Changes in organizational responsibility that will perpetuate the greening program after the initial plan is completed.
- A recommendation for the next steps.

Unless there are internal candidates with greening experience and knowledge, qualified consultants should be considered. If you decide to use consultants, have some of your staff work closely with them both to insure the quality of the work and to pick up greening knowledge. Note: to successfully create such a plan, much information about the data center's energy utilization, equipment, applications, cooling systems and general characteristics and future plans of the data center and any backup facilities need to be known.

A basic question that needs to be answered during the planning effort is whether the current data center and any backup facility are adequate in size, quality, security, and "greenability". The adequacy of data center size should be considered with a full understanding of company expansion --or contraction --plans, anticipated changes in computer applications, the nature of new equipment that will be acquired, and the risks of being too big or too small. Mechanisms to reduce floor space requirements include: use of blade servers, virtualization of servers, using multiple function network equipment, elimination of "ghost" servers, and reduction of storage requirements by effective storage management. All of these mechanisms, not only reduce floor space requirements, but are integral to data center greening as noted in the next section.

Another basic question is the appropriateness of the data center location. Many factors enter into this consideration -- security, cost of labor, desirability of being close to the rest of the company, political considerations, location of resident staff, transportation, etc. A major consideration should be the cost of energy and the availability of alternative energy. If the current location is found to be undesirable, the possibility of constructing a truly green data center at a desirable location should be considered. More details on these considerations are provided in Section 3.

If there is no reason to move from the existing data center then a series of greening improvements to the existing data center should be evaluated. For each improvement the ROI should be determined in addition to evaluating the non-economic value to the company and the community. Of course if laws or regulations mandate the improvements the ROI calculation becomes unnecessary.

The following is a compendium of possible greening initiatives for an existing data center and ideas and comments about each of them:

DO THESE TODAY – THEY ARE EASY AND DON'T COST MUCH

Maintain cooling systems - clean fans, change air filters, redirect ventilation ducts, move cables that block air flow, block cable openings in raised floor, and adjust cooling system for optimum efficiency.

☑ **Use PC power saving techniques** – enable power management and turn off equipment when not in use. (Note: this refers to equipment in the data center but also should be affected in non-data center locations.)

☑ **Make staff green sensitive** – there can be immediate improvements by making your staff aware that greening is important and of ways that they can contribute such as: turning off unused lights, turning off their PC's when not in use, and noticing items that could help greening and recommending them to their managers.

☑ **Keep up with industry greening progress** in identifying areas and methods of improvement – there is a continuing stream of new developments in more efficient equipment, systems, and approaches to greening. By keeping yourself up-to-date you can take advantage of these.

☑ **Become aware of pending legislation and regulations** – by being aware of the inevitable laws and regulations that are anticipated you can better evaluate the need to green. Some of these laws and regulation will obviate the need to determine ROI.

☑ **Institute green purchasing policies** – purchase energy efficient products such as Energy Star PC's ([Energy Star 4.0](#) is best), servers, and other equipment, and energy-efficiency lighting. Also use the [EPEAT](#) (Electronic Product Environmental Tool) to evaluate the materials used and energy consumed in PC's, laptops and monitors. EPEAT will cover more products in the future. Green Grid plans to produce metrics for evaluating equipment efficiency. (Note: the U.S. government now requires its agencies to purchase EPEAT qualified equipment for 95% of their acquisitions.) The EPA is working on new energy-efficiency specifications for enterprise servers. Dell has just announced that they will reduce energy consumption ([PC Advisor](#)) of their notebooks and desktops by up to 25% over the next two years.

☑ **Turn up the thermostat in the data center** – most data centers are colder than they need to be. Check with your equipment manufacturers but temperatures of 78 degrees F. is usually acceptable. Remember to watch out for hot spots. (HP and IBM and other suppliers have thermal mapping tools to determine hot and cold spots.)

☑ **Get an energy-efficiency assessment** – vendors such as EYP Mission Critical, Syska and APC offer these services.

☑ **Replace CRT screens with LCD's.**

☑ **Work with local power supplier to identify areas of improved efficiency** – often local power companies can provide assistance in identifying ways to improve power utilization.

DO THESE SOON – THEY ARE NOT EASY BUT MAY HAVE SIGNIFICANT RESULTS AND A FAVORABLE ROI

- ☑ **Make certain you can measure electric usage of the data center** so you know both the magnitude of the problem and the results of greening. If you can't measure it, you can't manage it. There are electric metering systems made that can be connected to your electrical system that report your usage to a central station which records and reports on your usage. Metering can be on major portions of the data center or on a single piece of equipment. You may need a knowledgeable electrician or consultant to install these devices. Investigate the possibility that there may be financial support available from your state government to pay for part of this. (NYSERDA does in NY State.) A metric to properly assess the facility efficiency needs to be developed to help manage the energy usage of the data center. Work is being done to provide this metric. The Green Grid has developed a measure called Power Usage Effectiveness ([PUE](#)) which measures infrastructure efficiency but not total facility efficiency. McKinsey & Co. and the Uptime Institute in a recent report recommend that companies adopt a new metric called Corporate Average Data Efficiency ([CADE](#)). It takes into consideration such items as: CPU utilization, IT load, facilities capacity, and the total energy consumed by the data center. CADE will give companies the ability to evaluate their progress toward the reduction of energy usage with a single metric. (Note - CADE is still incomplete.)

- ☑ **Use advanced cooling techniques** - use of rack-based or row-based cooling systems to augment the room's basic AC system can be an energy saver but needs to be carefully planned. IBM produces a Rear Door Heat eXchanger that uses cooled water to remove heat from the backs of computer systems. Use hot/cold aisle configurations. According to Gartner, by 2010 about half of the Forbes Global 2000 companies will have energy costs greater than hardware costs. ([BusinessWeek](#))

- ☑ **Use advanced chillers** – chillers are power hogs. For large scale systems look for bearingless designs (soon to be available); for smaller scale systems look for chillers such as Liebert's Digital Scroll or IBM's Cool Battery. New chillers can be as much as 50% more efficient.

- ☑ **Get a server tacking system** - get rid of the "ghost" servers (servers that are power up but are not running any applications) that many data center have without knowing it because of poor record keeping. Knowing what your servers are doing is an important step in reducing their energy consumption – see the next bullet.

- ☑ **Virtualize your servers** – users that have "virtualized" servers have found reductions of the number of active servers in the range of 10 to 1. Some claim even higher reductions. Reduction of servers potentially reduces floor space requirement, cooling needs, electrical power

requirements, hardware costs, and software costs. It can also make disaster recovery and other environments easier to set up and less costly. Many have found virtualization has an ROI that easily justifies the effort. Some claim ROI's of as short as 6 months. Note: not all applications are suitable for virtualization, so be careful. VMware, XenSource, HP, Microsoft, IBM and others provide server virtualization packages.

- ☑ **Obtain advanced power management systems** - these turn off servers and other equipment when not in use. PC management tools (made by Verdiem, 1E and others) can control your whole network of PC's and reduce energy usage significantly.

- ☑ **Use multifunction devices** - devices that perform multiple functions (i.e. a single box that is a router, firewall, Wi-Fi access point and voice gateway) use less energy, take less floor space and require less cooling. Further, they cost less than buying multiple devices. These types of devices are in production by major manufacturers such as Cisco and Juniper Networks.

- ☑ **Streamline file storage, data warehousing and backup functions** – according to Sun Microsystems only about 30% of existing storage space is used well. Deduplication of data can reduce requirements significantly. Savings in storage requirements can be up to 95% with important savings in energy. Turning off some of the spinning archives is also a help in reducing power and cooling requirements. Storage virtualization can also reduce the number of spindles required and thus the power needs.

- ☑ **Desktop Virtualization** – desktop virtualization reduces overall energy use considerably. The added load on servers is relatively small, while the cumulative reduction of desktop use of energy is great, netting substantial saving of energy. The ROI on this approach will depend on the individual situations. This is a newer technology that is emerging rapidly.

- ☑ **Upgrade disk technology** – consider replacing older, smaller drives with newer, larger drives that are more energy efficient per unit of storage.

- ☑ **Move data from disc to tape** – many data centers retain data on disk whose usage is unlikely and if needed can have a reasonable delay. Such data can be transferred to tape reducing the number of drives needed and thus reducing energy usage. It will take some effort to review your current storage profile to determine what data can be shifted from disc to tape.

- ☑ **Optimize software** – making software multi-threaded can take advantage of multicore processors and both improve performance and reduce the amount of energy required to do a unit of work. This can be a laborious task and may only make sense for large programs that will be used for a long time.

- ☑ **Use Software as a Service** – obviously by using SAAS you reduce your energy usage. But be sure that the service meets your application, security, and availability requirements.

☑ **Investigate retrofitting your facility** to some LEED's standards – it may be possible to improve your building's energy efficiency by applying some parts of the LEED's standards.

LONGER TERM CONSIDERATIONS

- ☑ **Optimize location of data center** – energy costs are a major consideration in the location of a new data center. Some companies are considering moving their data centers to more cost effective locations – for example, Iceland has an unusual combination of inexpensive land, low-cost energy and cool climate that can significantly reduce cooling costs. The U.S. northwest has attracted some new data centers (i.e. Google in Oregon). See the Section 3 below on creating new, greener data centers.
- ☑ **Acquire the latest UPS** – newer UPS designs have improved efficiency by as much as 70%. Look carefully at the ROI on this.
- ☑ **Use an alternate energy supply** – building an alternative energy capability often does not provide an adequate ROI but may have significant value to the community and thus be worth doing. But the cost of wind and solar are becoming more competitive as they become less expensive and utility-supplied power prices increase. Where available, geothermal energy can be very inexpensive. Google is making a major effort to make renewable energy cheaper than coal derived energy. Keep an eye on the comparative costs. Consider collocation with a source of renewable energy generation.

You should review the above steps and seriously consider the steps enumerated in *“Do These Today - They are easy and Don't Cost Much”*. You need to analyze more carefully the steps suggested in *“Do These Soon - They are Not Easy but May Have Significant Results and a Favorable ROI”*. Some of these could provide major energy reduction. The steps in *“Longer Term Considerations”* need to be carefully analyzed and acted upon after confirming their ROI and relevance to your individual situation.

Section 3 PLANNING THE CREATION OF A NEW GREENER DATA CENTER

If it is determined that the existing data center location is no longer adequate, then a new location needs to be found and a new, greener design instituted. If you are going to move to an empty existing data center, use as many of the ideas in Section 2 of this paper as you can. If you are going to build a new data center, there are five basic things to do in coordination with the Facilities department:

- Select the location
- Design the building
- Build the building
- Equip the building
- Hire/move personnel

Note that the cost of building a green data center is in the order of \$1,000 a square foot. ([Data Center Knowledge](#)) This cost will vary depending on location and the eventual design. For example, Google is spending almost \$3000 a square foot for its new data center in North Carolina.

SELECTING THE LOCATION

The selection of the location of a new data center will involve understanding many factors related to your situation. You will need to plan this move very carefully and in great detail. It may be advisable to engage consultants with experience in moving and greening data centers. If you haven't moved a data center before, do not underestimate the difficulty and potential for problems. The following are the considerations you need to take in this endeavor:

Is there a need for the data center to be close to any part of the company or to any other location? Is there a desire for geographic dispersion of sites? (A remote data center may be able to act as a backup site for other functions of the business.) What is the business continuity plan for the company and how does it relate to the location of the data center (or should it be changed as part of this process)? Can you move to a distant location that has energy and security advantages? How would you staff a distant location? Is a new location one that would be desirable (or undesirable) to some of your current staff? Are there qualified people already in the area? Do places like Iceland or the Northwest U.S. make any sense? (There are other favorable locations – these are mentioned only as examples.) How are communication capabilities in that area? Is there adequate electrical power in the area? Is the prospective area prone to natural disasters? Are there incentives from the remote location's government organizations to move? What is the taxing rate? If not in the U.S., what is the risk related to currency rates and political stability? How is transportation in the area? All moves are potentially disruptive and a move to a distant location more disruptive than staying close to the existing location. How does your management feel about all of this?

After determining and prioritizing the answers to the above questions (and others you will come up with) you can make a decision on geographic area. You will need to contact real estate people and work with architects to select the best location. This Roadmap will not attempt to go into the process of acquiring the property.

DESIGNING THE BUILDING

Starting with “a clean sheet of paper” you have the opportunity to build a state of the art green and secure building. (We won’t go into security in this paper but you shouldn’t ignore that in a new structure.) You should engage architects and general contractors with specific experience in building green data centers. Some key points in the design are:

- It is very difficult to estimate how big a data center should be that will serve you for many years. What are your company’s plans for expansion (or contraction)? Both data centers that are too small or too big have obvious problems. How much processing capability do you need now; how much will you need in X years? To what degree will the ever-increasing capacity of equipment (with the same or less floor space required) offset your growth?
- And how much cooling capacity and power do you need now and how much will you need in the coming years? Designing expansion flexibility into your new data center will allow you to size it for today as well as for tomorrow’s needs and still feel comfortable that you will be able to expand to the need X years from now.
- Design to LEED (Leadership in Energy and Environmental Design) standards where possible and reasonable – the LEED standards offer many valuable insights into greening of buildings. Remember that the LEED standards were designed for office buildings and cannot always be reasonably applied to data centers. Never the less, they represent a standard to be strived for. LEED standards cover such things as: sustainability, water efficiency, energy and atmosphere, materials and resources, and indoor environmental quality. They apply to both the equipment and personnel areas of the data center. To date only a small number of data centers have been LEED certified in the U.S. Citigroup has committed that wherever possible its new data centers will be LEED compliant. If your organization is a public one you may be required by your governmental organization to be [LEED’s certified](#). LEED intends to issue a certification standards design specifically for data centers next year

BUILDING THE BUILDING

This Roadmap will not go into any great detail on the “building of the building”. The Facilities department will probably lead this part of the project but IT should remain involved. This will be a demanding effort because IT management will need to continue to run the existing data center and at the same time be at the new site from time to time to insure its proper

construction and outfitting. (This will be particularly difficult if the new site is far away.) It will be critical to have engaged the “right people” as architects and general contractor. Use people that have done it before and check to see if they did it well. All too often new data center run over budget and are late.

EQUIPPING THE BUILDING

Equipping the building requires creating a plan that protects the continuity of processing, improves your energy efficiency, minimizes costs, creates flexibility, takes advantage of newer technology, and insures security and reliability.

- **Design your cooling system carefully** – there are new, more efficient methods of cooling that should be incorporated into new data centers. Use of chilled water will provide a significant efficiency improvement. Rack cooling is also recommended. Smart building technology can include dynamically controlled air/water distribution based on strategically placed heat sensors. Consider the use of an economizer if the outside temperatures in the location are favorable to such a mechanism. The design of a cooling system is not a trivial exercise.
- **Acquire a newer, efficient UPS** – there have been significant advances in UPS equipment efficiency. Make certain to take advantage of these in a new building.
- **Moving or buying processing, network and office equipment/furniture** – do you want to move the equipment/furniture from the existing data center to the new data center? (Is this even possible considering the need for continuity of processing)? Do you want to replace the equipment/furniture in whole or in part with newer, more efficient/greener equipment/furniture? This must be considered carefully from both the financial and operational sides. These decisions could affect the building design since the newer equipment may take less floor space and use less energy. Moving does provide an opportunity to upgrade to more energy efficient equipment and systems that should not be ignored.
- **Testing the new site** – a detailed and comprehensive testing plan must be created and performed prior to the move. This is a critical step and must be planned and performed rigorously.

HIRING/MOVING PERSONNEL

This section deals with an item that is not directly related to greening but is a necessary prerequisite to successfully moving a data center and gaining the greening advantages that accrue to that process. It is dealt with it only in a cursory way herein to alert you to some of the potential pitfalls.

Dealing with people and their sensitivities always has a different dimension than dealing with inanimate objects. It is recommended that personnel be kept informed about the company's plans and how they may affect employees (periodic meetings are recommended). When the staff is not hearing the truth from the company, rumors inevitably arise. Often these rumors are worse than the reality. If people are going to lose their jobs, an incentive plan should be created to encourage the employees to stay until the appropriate time.

Key staff members should be identified and steps taken to insure that they will remain with the company. This would be a particularly bad time to lose key staff members.

Staff that is going to the new data center should receive some compensation if they need to move their residence or suffer other significant inconvenience.

If possible, new hires should be integrated and trained with the old staff before the move to insure continuity.

Work closely with the Human Resources department to make certain that you abide by the relevant laws and company policies.

Section 4 PLANNING THE REDUCTION AND ECOLOGICALLY SOUND MANAGEMENT OF DATA CENTER MATERIALS

There are many areas of the data center where careful use, planning and purchasing can reduce the amount of non-green materials used in the data center and minimize the use of expendables. The following considers a number of areas where such activities can help, but you should always be on the lookout for new products and ideas that can further green your data center.

- **Many equipment manufacturers now claim their products have greener components.** To the extent possible you should attempt to verify their claims before purchasing by reviewing information provided by reliable organizations. (EPEAT and Green Grid may have information.) If information isn't readily available, carefully evaluate the manufacturer's claims before making a selection. Ask about their use of toxic materials and the recyclability of the equipment in addition to its power requirements.
- **Disposal of electronic equipment should be done using techniques that insure proper recycling.** Electronic equipment contains a number of toxic substances. Today only about 20% of discarded electronic equipment is properly disposed of. There are companies that specialize in ecologically-sound equipment disposal. Sometimes the

equipment manufacturer can help in this regard. Nine states require electronic equipment manufacturers to collect and recycle computers and other electronic equipment or pay someone else to do it. Legislation is pending in other states. California prohibits the disposal of e-waste in its landfills. HP collects about 5 million pounds of electronic equipment a month in the U.S. It is estimate that over 800 million PC's worldwide will be replaced in the next 5 years ([Gartner](#)).

- **Consider extending the life of equipment by upgrading** it rather than replacing it. But make certain that the upgrade will provide the capabilities that you require.
- **Reduce the use of expendables.** Review the use of paper and ink. Use double-sided printing and narrower margins when possible. Buy recycled paper. Used paper should be recycled. Check printer ink use to make sure the printers are adjusted to use minimal ink consistent with the need. Check with users to determine if they really use the reports that you print for them. Many data centers have found that users never cancel report printing when they stop using reports. Ask users to minimize the unnecessary printing of emails and use emails rather than fax.
- **Use green cleaning products** to clean the floors and furniture.
- **No longer needed cables and cabinets should be disposed** of with a recycler.

Section 5 OTHER GREEN ACTIVITIES

There are a number of other green activities that data center personnel can do. Most of these are things that all employees of the company can and should be encouraged (if not required) to do by the company. The data center might take the lead in these endeavors.

- **Encourage non-data center areas to use some of the same methods** previously mentioned to reduce their carbon footprint in cooperation. This can involve PC's, printers, lighting, paper usage, reducing the number of machines (an example might be the use of a multifunction printer rather than separate printers, fax machines and scanners) and air conditioning.
- **Promote the use of virtual meetings** (video, web, telephone) rather than having people travel. Travel avoidance not only saves fuel, it also saves time and makes people more efficient. Today's video, web, and telephone conference systems have become relatively inexpensive and of improved quality. The cost of travel has increased significantly. Granted there will always be some meetings that need to be done in person, but these can become the exception rather than the rule. There may be initial resistance but over time most employees will appreciate the use of virtual meetings.

- **Have employees telecommute** when possible. With the tools that we have today, telecommuting makes good sense for many employees. Companies have seen increases in productivity through the use of telecommuting. Most employees have positive feelings about telecommuting.
- **Encourage employee car pooling.** Car pooling can significantly reduce energy use and can also become a way that employees build positive relationships with one another. Companies can designate central meeting points and coordinate employees in finding others that live in the same areas and have the same work schedule.
- **Support employee use of public transportation.** A company can both make employees aware of this option and reward them for using it. They can also provide company sponsored transportation from key locations at appropriate times of day. (Such corporate subsidies are now tax deductible.)
- **Encourage employees to live near work.** It is to the companies benefit to have employees live near work and obviously ecologically sound. The company might reward employees that move closer to work.
- **Suggest more basic transportation** such as walking or cycling to the employees. This can also be part of a corporate health program.
- **Have a “suggestion box”** for employees to provide greening ideas.
- **Promote greater recycling** of food containers (soda/water/plastic food packaging) and the recycling of unwanted bulk mail materials.
- **Have meetings with your employees to talk about the importance of greening** and ways for them to contribute to the effort. It is important to have a greening kick off meeting and subsequent greening meetings (or at least mention the greening effort in general meetings). Guest speakers from organizations involved in greening might be influential.
- **Try to get your company’s policy manual modified** to include greening policies that include some of the items mentioned above.

This is the end of the Roadmap. As previously indicated there are many activities and not all of them are appropriate for your company and some may not have the ROI you need. But there are many that will make sense now and others that may make sense in the coming year or two.

The paper continues on the next page with a description of Roadblocks to the Road

ROADBLOCKS TO THE ROADMAP

As in most important endeavors there will be roadblocks that need to be overcome. Some of these roadblocks will be unique to your organization but there are some typical ones that are discussed in this section. With the significance of greening to the future of our civilization and the more mundane but maybe more persuasive importance of reducing data center costs, there are cogent arguments for your company to proceed. But there always will be luddites with arguments against moving ahead.

The most common arguments used to shoot down greening are:

- ✗ **Energy costs are only temporarily high and are likely to go down** – all of the evidence is that energy costs are most likely to go up significantly. Most experts acknowledge that there is and will be a shortage of energy for the foreseeable future. As discussed earlier, oil production may have peaked, coal is dirty and ways need to be found to efficiently clean it up, and gas is hard to distribute. The demand for energy has increased significantly in the developing nations and the developed nations are moving too slowly toward conservation. The chance of energy prices holding or going down is slight.
- ✗ **There are more important things to do, we'll green next year** – there may be cases where there are more important things to do in the immediate future but with the favorable ROI of at least some of the steps it would make sense to outsource the greening if internal staff can't handle it. Or at least get a firm commitment to do it "next year".
- ✗ **There will be improved ways to green in the future so let's wait for them** – sure there will be improved ways to green in the future – just as there will be improve TV's, cars, and cell phones. But at some point you have to move ahead and, at least with items that have a favorable ROI, the time to move is now.
- ✗ **How do we know this greening really works** – there is so much positive literature on the subject that this argument should be easy to overcome. And the organization down the highway (or wherever) has had a major success with greening.
- ✗ **Greening could disrupt our data center and cause instability** – as most of us know, any change to the data center is potentially disruptive and must be done carefully. But we do make changes when they are important and this is important.
- ✗ **We will be moving our facility in the next year or two so why do it now?** – there are many things in the Roadmap that are simple and inexpensive to do and can easily be moved to the new facility. For example, virtualizing your servers would be advisable prior to moving because it will reduce your space and cooling requirements and may change your plans for the new facility. Most of the Roadmap items listed under "Do These Today – They are Easy and Don't Cost Much" should be done in any case.

✗ **We can't afford it now** – the reality is that for the items with a very favorable ROI you probably can't afford not to do them now. Before anyone concludes that you can't afford to green now a comparison should be done between the ROI of other projects and some of the greening items with the most favorable ROI. In any case, many items in the Roadmap cost little or no money – such as turning off lights and PC's.

✗ **Global warming isn't real** – there are two arguments against this. Firstly, it doesn't matter whether global warming is real. Energy costs are very high and will remain so and this results in a favorable ROI on many greening projects – not even mentioning that some Roadmap steps require little or no investment. Secondly, the great majority of scientists are convinced that global warming is real and a major threat to our civilization. There has been so much reported on this – although there are a few scientists that are still holdouts.

✗ **We don't meter the data center so we don't really know how much energy it is using** and we will not be able to measure the savings of greening – unfortunately many data center aren't metered; retrofitting metering can be done without enormous costs in most cases. But even if you don't meter, the data center is using a lot of energy (it can be estimated) and significant savings (along with the associated greening) can be had (and approximated).

You can counter a lot of opposition by citing a study done by [Emerson Network Power](#). In their study they identified the top ten data center opportunities to reduce energy consumption and applied it to a model of a typical 5000 sq. foot data center. The results freed up two-thirds of the floor space, one-third of the UPS capacity, 40% of the precision cooling capacity, and reduce energy consumptions by 50%. The ROI for the steps varied between 3 and 18 months. Since Emerson Network Power sells some of the equipment involve you may wish to take this with “a grain of salt”. But it is still pretty persuasive.

FUTURE TECHNOLOGICAL IMPROVEMENTS

As mentioned earlier there are new capabilities that will further enhance our ability to green data centers. Some of these are:

- **415 volt power distribution systems** – a different UPS design than commonly used in the U.S. today can provide 240 volts (one phase) for equipment more efficiently than today's UPS's which provide 208 volts ([Emerson Network Power](#)). Be careful to be assured that the 240 volts will not detrimentally affect availability of equipment.
- **Better matched power supplies** – today much equipment is powered by power supplies that are highly inefficient (75 to 80%) in part because they are not sized to actual load. Future equipment using digital controls should bring efficiency up to about 90%.

- **Chip level cooling** – to be able to cool at the source of the heat will increase the overall efficiency of the cooling process. Chip level cooling is being developed today.
- **Improved power management** – today’s power management mechanisms will be replaced by more sophisticated and comprehensive system in the near future that will react to changes in temperature, utilization rate, and various levels of state information.
- **Improve capacity management** - time-of-day and seasonal usage can be controlled to reduce usage.

Should you wait for these things to happen? As a general rule you should proceed without them. But if you determine that a particular improved capability that is important to you will be available soon, it might make sense to wait.

CONCLUSIONS

Green – do it now – and do it intelligently – and save your company money – and insure you don’t inhibit your company’s ability to grow - and save our civilization from potential catastrophe. Is there much more to say? How much better payback can you get from an initiative? Whether you believe in global warming or not, greening makes sense. Your management may or may not have altruistic values – it doesn’t matter. They have to at least see the business and PR value.

Don’t try to do it all at once for fear of interfering with other important company initiatives and give greening a “bad name”. Do the easy and quick ones right away. Pick out some big winners of the more difficult ones and create a detailed plan to do them. Measure and report the savings to the company to encourage more support going forward.

Do it right. The chance to complete the greening work will be reduced if greening causes operational problems. So plan it carefully and make sure you have both the people and material resources to accomplish each step uneventfully.

Stay up to date with both the changing laws and regulations and the evolving technologies available to promote greening. This field is advancing quickly and there will be better solutions.

Don’t be talked out of it. There will always be those that will find reasons not to do it now or not at all. There are all the reasons in the world (including saving the world) to do it.

View greening not as a onetime project but as an ongoing part of your responsibility.

Happy Greening!

Author

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As President of Keim Consulting Associates he has been involved in all aspects of business and information systems support. He has consulted to firms such as: The Depository Trust and Clearing Corporation, Furman and Selz, Reuters America, Intralinks, and Global Internet. He has advised in areas such as data center operations, client service, operations, systems development, business management, telecommunications, website development and new business development. He is a member of the Steering Committee of the Westchester Not for Profit Technology Council and has advised a number of Not for Profits (on a volunteer basis).

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Polytechnic University

Center for Emerging Technologies

The Center is a unique partnership between Westchester County and Polytechnic University, a leader in engineering research and education in the Greater New York Area. Based on Poly's education center in Westchester and a small staff of dedicated engineers directing the work of top notch graduate students research assistants supplied by the university, the problems facing the county and regional businesses are researched and solved based by applying cutting edge technologies. Some so new that they are barely out of the lab.

The Center is charged with researching innovative solutions to solve problems identified by the business executives supporting the center and desirous of applying cutting edge technologies to solve their business problems. The research will focused on emerging technologies to produce engineering solutions across all technology fields and industry sectors including healthcare systems, transportation, energy, information technology and services

It is difficult to get unbiased technical advice on very promising but risky emerging technologies. By the time innovative solutions become commercially available the vendors selling these solutions have a vested interest in promoting their version of the technology and it may not necessarily fit the need of the county and its affiliates. The Center provides the necessary research into the appropriate cutting edge technologies, which in many cases has not been commercialized yet, and its suitability to solve certain problems faced by the county. The research reports would guide executives and their staff to pursuing the technology with the appropriate vendors to have it developed and applied. Not only engineering feasibility but the also the economics of the technology would be researched and reported.

The Center holds regular workshops to present its findings and organize research symposia with researchers, vendors and county managers and executives to develop problem sets and guide the research. It makes available the services of research assistants together with engineering supervision to research engineering and technology solutions for companies.

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