A WHITE PAPER BY ITCENTRIX

Power Shift to Green Storage

Establishing a long term eco-sustainable storage strategy

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Executive Summary

Introduction

This paper investigates the practical requirement of setting in place a green strategy for storage as part of a wider context of a green IT strategy. The paper argues that "light green" strategies that reduce carbon have to be coupled with "dark green" strategies that save money. It further argues that these strategies should be implemented as a matter of urgency; failing to act is likely to damage the reputation of IT and inhibit the ability of IT to drive change.

From a business perspective, the debate about global warming has ended. Whatever the merits of the debate, there is a business consensus that the world community is moving toward mandating the reduction of carbon emissions. There is very likely to be legislation that will mandate action to be taken by the business community – in short, we've been warned. Establishing a carbon-neutral strategy has started in earnest for many businesses, especially in Europe and Japan; Sun Microsystems is a good example of a US company with a rapidly developing green strategy. Sun has made significant contributions in the development of green technologies. The development of containers within the Solaris operating system allows a large number of underutilized physical servers to be consolidated into a smaller number of more highly utilized virtualized servers; this reduces the cost of computing and lowers energy costs. Sun has developed highly energy efficient modular and portable data center called the Sun MD. Sun has introduced telecommuting for half of its staff and has achieved very significant energy and budget savings. Sun is developing an end-to-end "emission neutral" strategy, and believes that US businesses that supply internationally will need to be able to demonstrate compliance with carbon neutrality in the next few years.

Power Trends Summary

From one perspective, the IT trends are moving in the right direction; the energy used per terabyte is decreasing by 30% per year, and the energy used per MIP is decreasing by 20% per year. However, the elastic nature of IT is such that even with flat IT budgets, the overall energy consumed is growing by 18% per year. Even more significant, IT equipment is becoming denser, and the energy density (watts/sq. ft.) is growing by more than 20% per year, leading to higher data center costs for providing power and cooling to IT equipment. All figures in this section come from Wikibon.org.

The trend of improved energy efficiency has not been factored into the design of most data centers. A recent survey found that that 90% of data centers were planning to upgrade their power and cooling systems in the next 30 months. Many organizations are facing very high CAPEX costs connected with these upgrades; indeed, many face the prospect of building and moving to new data centers with very visible and unexpected CAPEX costs.

The total power consumption of data centers has doubled between 2000 and 2006 and is now about 1.5% of the total US power consumption. It is expected to grow from 1.5% to 3% by 2012 and be equivalent to the total power consumption of airlines. If you include IT outside the data center, and the power consumed in manufacture and disposal, the total power consumption is closer to 6% of the total consumed in the US, on a par with automobiles. At this level, governmental regulation is very likely.

The price of electricity has been rising 4% per year, and with oil well over $100 a barrel nobody expects the power budget to moderate in the future. Google has shown that data center facilities costs now exceed equipment purchase costs.

The average efficiency of servers is about 6%, and the average utilization of storage less than 25%.

The normal business expectation is that the business departments using the space and energy resources will pay for it and will adjust spend and improve efficiency accordingly. However, fewer than 5% of IT departments have a budget line item for power. Facilities departments continue to struggle to plan data centers without input from IT, and IT fails to include the total cost of facilities in business cases. Executive action is required.

Executive Action Items

ITCentrix recommends the following eight actions items that will bring about effective "light green" and "dark green" strategies for storage in particular and IT in general. These actions should be employed in conjunction with each other; the results are multiplicative:

- **IT Action Items**
  1. Centralize and virtualize storage, networking, and server environments; monitor and raise storage and server utilization (e.g., software enabling thin provisioning, virtualization, and deduplication) and eliminate unnecessary equipment from the data center.
  2. Use disk spin-down and/or tape to reduce the energy footprint of data that is rarely accessed (90% of data that is not accessed for 90 days is never accessed again), and monitor and dynamically turn off equipment that is not required.
  3. Use classification technology to actively delete data, especially from disk.
  4. Understand the contribution that IT applications are making to carbon reduction within and outside the business, and create and publicize the net carbon footprint of IT now and projected forward (as part of or in advance of an overall corporate green strategy).
- **Facilities Action Items**
  1. Take budget ownership of all IT facilities costs for storage and other IT equipment and include them as line items in all business cases.
  2. Plan future data centers together with facilities management in line with the power and cooling projections of storage, networking, and server technologies; plan to use water cooling for servers and/or mixed computing technologies with different heat densities in racks.
  3. Aggressively use hot and cold aisles together with heat monitoring to minimize cooling and air movement and raise data center temperatures.
  4. Use outside air wherever possible to reduce the cost of cooling, and where possible site (or outsource to) data centers to optimize green/low cost power and air cooling.

Summary of Key Metrics

There are three key metrics that should be employed to monitor progress during the early phase of establishing a green storage and IT strategy:

1. The utilization of storage and server equipment in the data center from current levels of 6% for servers and a low 20s% for storage (2010 objective should be >50% for servers and >75% for storage)
2. Data center efficiency (DCE), measured as “power consumed by IT equipment/ total power consumed by data center” (Currently DCE metrics range between 33% [poor] and 60% [good], with an average of about 50%. The 2010 objective should be >55% for the data center.)
3. On target to achieve a reduction of (approximately) 50% in data center power consumption by 2012

Case Study Summary

The case study in this white paper looks at a data center where Solaris is the main operating system and there are more than 100 servers, each running a single system with a combination of directly attached storage (DAS) and small SANs. Many of the applications are mission critical and I/O intensive. Management determined that storage and server utilizations are low. The data center is running out of power and cooling, and there is a long waiting period for additional power to be brought online. Optimizing power is a high priority, and IT management has decided to consolidate and virtualize the IT environment.

Solaris Containers have been chosen as the server virtualization platform, with the objective of reducing the number of servers and increasing server utilization. The number of servers has been reduced from 100 servers to 18 larger UNIX servers. Management must now decide the best storage platform for centralizing the DAS and small arrays.

The storage requirement was specified as 118 TB storage, 96 FC ports, and 368 initial drives. The proposal from Sun was for 76 terabytes, with software for virtualization, thin provisioning, virtual copying, and a single management console. Overall, the new configuration reduced power, cooling, and space costs to one-third of the previous budget. IT management looked at the requirements of two leading competitors. Competitor A would have required 144% more budget for power, cooling, and space than the Sun storage proposal, and Competitor B would have required 57% more.

One significant goal of the project was to increase the efficiency of the data center. This was done by rearranging the data center into hot and cold aisles, installing monitoring equipment, and using external air for cooling. As a result, half of the chillers could be turned off; this together with some power savings improved the data center efficiency (power delivered to IT equipment/total power delivered to data center) from 44% (poor) to 64% (good).

As a result of combining consolidation, storage virtualization, and server virtualization and improving the data center facilities, the combined savings in power (shown in Figure 9 in the body of the white paper) was $1.2 million over a five-year period.

The environmental saving for storage was 100 tons of carbon dioxide (CO_2) per year and 1 million KVA hours over five years. For server and storage combined, the savings were 1,755 tons of CO_2 over 3.5 million KVA hours over five years.

Summary of Conclusions

The case study shows that by focusing on improving the utilization of storage and servers, and bringing best practices to data center facilities, great improvements can be made to the data center environmentals. There has been a reduced cost of power, the data center has required significantly fewer staff and has become more available, and it is easier to introduce change. Senior management is now focusing on putting together an application portfolio that will monitor energy and emissions saved by IT as part of an overall green IT strategy.

One of the consistent findings of ITCentrix in interviewing organizations is that a strong green IT strategy helps with buy-in to change from stakeholders in the organization at every level. Employees, customers, and partners all want to know that their organization is doing the right thing. Being green helps to save green.

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Power Trends in Storage and IT

The environmental and energy issues facing IT today have been, to a large extent, unexpected. The ECL technologies that were employed in mainframes until the 1990s generated a lot of heat in a small space, which was known as a high heat loading. But with the advent of high-end CMOS technologies, power and cooling were no longer seen as significant problems for IT. Space was at a premium, and technologies such as rack-mounted servers, rack-mounted storage, and server blades helped to consolidate and save space.

A number of studies have shown that IT equipment consumes about 50% of the energy in a data center. Storage and servers consume the majority of the power used by equipment, as is shown in Figure 1 below.

Servers:	30%
Storage:	***15%***
Other IT Equipment	10%
Cooling:	24%
Air Movement:	10%
UPS & Power Distribution	8%
Lighting:	3%

IT equipment directly consumes 55% of the data center 's energy budget

Source: Wikibon.org

Figure 1 – Distribution of Power Usage in the Data Center

Figure 2 below plots the heat load (watts/equipment sq. ft.) for different technologies found in data centers. Steadily, from 1992 to 2008, equipment heat loadings have been rising. The heat load of most technologies, including storage, has been growing at a 20% compound average growth rate (CAGR). The density of equipment such as rack-mounted high-performance communication equipment and 1U (1.75") rack-mounted servers/blades has been increasing recently at 30% CAGR.

The key figure here is 10,000 watts of heat/equipment sq. ft. — about the maximum that can be cooled with air-conditioning alone. Above this figure, other cooling techniques need to be deployed, such as water-cooled cabinets. These special techniques require access to the building’s chilled-water supply or a chiller system, and the costs of designing and implementing cooling increase significantly. That 10K watt milestone is expected to be reached for 1U servers in 2009.

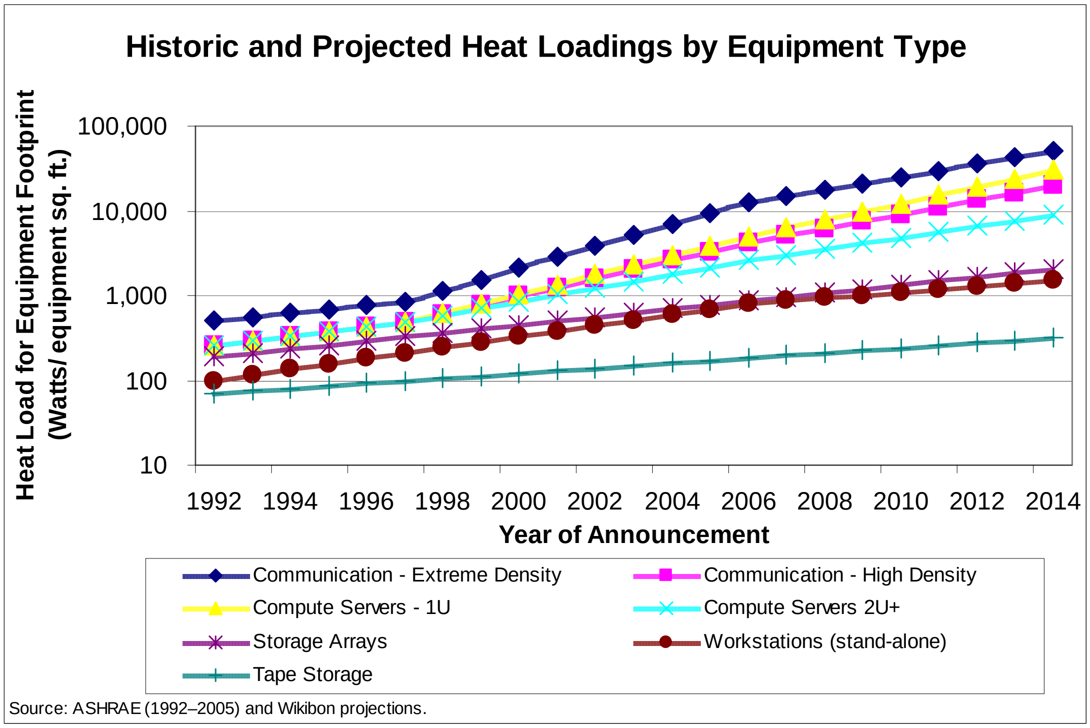

Figure 2 – Historic and Projected Heat Loadings by Equipment Type, 1992–2014 (based on historic data from ASHRAE [1992-2005] and Wikibon.org projections)

The heat loading projections for storage systems are not as aggressive as for servers. Even in 2015, storage systems will probably not exceed 2,000 watts/sq. ft. It is expected that the current 3.5-inch disk forms will migrate to 2.5 inch in the next few years; this will increase heat density to some extent, but not beyond the limits of air-cooling technologies. The heat density for the disk controllers in storage systems will increase faster, but by mixing controllers and disks in the same racks, the overall heat density will remain manageable (although many times higher than today's levels!). One potential solution for data centers will be to mix 1U servers and storage in the same racks, so as to reduce the heat densities of server-only racks.

One additional change that is likely to impact storage environmentals is flash-based storage based on NAND technology. This is more energy efficient than disk drives, by a factor of 10 or 20 times. However, the cost at the moment is about 20 times more expensive. As NAND costs decrease (they are coming down about 50%/year, versus the industry average of 37%/year for disk), more will be employed to replace the high-performance disks (e.g., 15K FC 146GB drives). However, although NAND storage will become more common and become part of the storage hierarchy, it is very unlikely to replace disk drives within any planning horizon.

Data center managers were once primarily concerned with the size of equipment (i.e., floor-space demands). The emphasis was on finding space; power and cooling needs were less important considerations. Figure 2 above illustrates why the current constraint on data centers is no longer space needs but providing enough power and cooling. In older data centers, equipment has had to be spread out because there was insufficient power distribution capability. If that problem were solved with additional wiring and distribution equipment, there would be insufficient HVAC (heating, ventilation, and air-conditioning) to cool the equipment.

Relative to the cost of equipment, power and heating costs used to be a small percentage of the operational budget. The IT department often never saw the power or HVAC bills; these were included in the building's facilities costs. However, that has changed. Energy for IT is now a highly visible and significant cost. Even more important, the majority of today's data centers are completely unsuitable for the types of equipment that are currently available and forthcoming. The cost of refurbishing or moving data centers is very high and can be career-limiting.

If that were not challenge enough for IT, the world is now very aware of global warming and the need to reduce the carbon footprint. Within the US, this has only recently become an issue. Internationally, there has been for some time very strong governmental and social pressures for businesses to become carbon neutral — to not add to the CO_2 in the atmosphere. This extends not only to the operations of a company but also to the selection of suppliers and partners that will meet the same high standards.

As a result of these political and social pressures, significant legislation is in process, or expected to be raised, to regulate energy efficiency and carbon production. IT is clearly a strong potential contributor to creating in business processes efficiencies that will reduce carbon outputs and energy consumption. An application that schedules a fleet to run 10% more efficiently will improve the environmental impact of energy and carbon significantly. However, if IT fails to reduce its own increasing energy consumption requirements, senior managers and stakeholders will view IT itself as being the problem.

The key environmental business challenges for IT are i) to understand and plan for a new type of data center, ii) to develop an IT plan that is a key component of an organization's ability to deliver an overall green strategy, and iii) to clearly communicate how IT is executing that green strategy successfully.

Eight Ways of Going Green in the Data Center

ITCentrix strongly recommends the following eight actions items that will bring about effective "light green" and "dark green" strategies for storage in particular and IT in general. These actions should be used in conjunction with each other; the results are multiplicative:

- **IT Action Items**

1. Centralize and virtualize storage, networking, and server environments; monitor and raise storage and server utilization (e.g., software enabling thin provisioning, virtualization, and deduplication) and eliminate unnecessary equipment from the data center.

   Servers and storage are often added on an ad-hoc basis to meet project requirements. This practice is changing to the management of mainly virtualized storage and server environments where resources are allocated centrally. The ability to remove IT equipment and especially storage from the data center should be designed into the architecture of the IT infrastructure. Current virtualization best practice can reduce storage removal times from months to days with significant IT and energy savings.

2. Use classification technology to actively delete data, especially from disk.

   Technology has created a mountain of data that is very difficult to delete. The architecture of applications and infrastructures needs to enable most data to be deleted automatically. Automated systems that classify data early in the cycle are likely to be an important component of the solution, as well as aggressive deletion policies within IT.

3. Use disk spin-down and/or tape to reduce the energy footprint of data that is rarely accessed (90% of data that is not accessed for 90 days is never accessed again), and monitor and dynamically turn off equipment that is not required.

   After 90 days, the chances of data being accessed again become minimal. Spinning disk is a very expensive and un-green way of holding data that is never accessed. The use of classification and tiered storage systems (including tape) will allow significant reductions in IT storage and energy costs.

4. Understand the contribution that IT applications are making to carbon reduction within and outside the business, and create and publicize the net carbon footprint of IT now and projected forward (as part of or in advance of an overall corporate green strategy).

   Enabling telecommuting with IT services can, for example, save significant amounts of energy for an organization. These savings should be captured as part of the initial IT business cases. Success in achieving the objectives should be monitored and promoted as part of an overall IT green strategy.

- **Facilities Action Items**

1. Take budget ownership of all IT facilities costs for storage and other IT equipment and include them as line items in all business cases.

   At the moment less than 10% of IT organizations are directly responsible for facilities costs and at best have only an indirect apportionment of facilities costs as a budget line item. Organizations should plan so that IT energy costs are separately monitored, and IT facilities costs are separately accounted for. These should be reflected back to the business as IT budget line items in every project business case.

2. Plan future data centers together with facilities management in line with the power and cooling projections of storage, networking, and server technologies; plan to use water cooling for servers and/or mixed computing technologies with different heat densities in racks.

   The heat density of IT equipment is projected to increase, and it is essential that the planning of the data center anticipates these trends and has sufficient capability to deliver cost-effective power and cooling. Storage is unlikely to require water cooling, but this will increasingly be an option for high-density server equipment. Water cooling is more efficient that air cooling.

3. Aggressively use hot and cold aisles together with heat monitoring to minimize cooling and air movement and raise data center temperatures.

   Mixing hot and cold air reduces the efficiency of the cooling systems. The use of hot and cold aisles or other techniques to minimize air mixing is strongly recommended. The current ASHRAE recommendations specify server temperatures between 20 degrees to 25 degrees Celsius and relative humidity between 40% to 55%. However, ASHRAE is expected to modify its range to 18 degrees to 27 degrees Celsius and a humidity range of 30% to 55%. Increasing the temperature of the data center will significantly reduce costs.

4. Use outside air wherever possible to reduce the cost of cooling, and where possible site (or outsource to) data centers to optimize green/low cost power and air cooling.

   Using outside air to cool the data center very significantly reduces facilities energy costs, especially if the temperature of the data center has been raised as discussed above. With simple changes and planning, data centers can be cooled with outside air from between 2,000 and 6,500 hours/year, depending on the location of the data center and the temperature of the data center.

Case Study

The environment before consolidation and virtualization was a collection of servers and storage that increased ad hoc as the applications had been added and grown.

This case study is designed to examine the impact of Sun technologies on environmentals and to compare the environmental requirements against the base and with those of two leading competing storage solutions. The Sun technologies include virtualization and thin provisioning, together with supporting software. ITCentrix has written other papers analyzing the IT and business benefits of Sun technology other than environmentals, so this paper will focus primarily on the environmental impact of these technologies.

The case study also looks at the potential benefit of improving the efficiency of data center facilities. Finally, the paper looks at the impact of including server consolidation and virtualization on power and space requirements.

Case Study—Server and Storage Virtualization

The environment in this case study is a typical high-end I/O intensive set of interlocking UNIX applications found in a large financial services company. Some of the applications are tier 1 (business critical), but the majority are tier 2 applications (business important) and though important have lower recovery-point objectives (RPO) and recovery-time objective (RTO) requirements than the business-critical tier 1 applications. The 100+ UNIX servers were a combination of Sun servers and Intel architecture servers from a number of vendors, mainly running the Sun Solaris operating system. The applications are mainly database and I/O intensive and provide support for employees as well as applications directly accessed by customers and partners.

The storage environment is very varied, with some servers having directly attached storage and most servers being attached to small SANs and a variety of different storage systems.

Case Study—Assumptions

The environment in this case study is a typical high-end UNIX I/O intensive set of interlocking and standalone solutions. The key assumptions are as follows:

- A similar type of disk storage behind the controller is required by all vendors.
- The benefit of Sun virtualization was a 20% reduction in the number of drives required, with no reduction in controller or fibre channel specification. (The "Case Study—Storage Functional Differences" and the "Case Study—Calculations of Reduced Disk Benefits" sections below give more details.)
- The benefit of thin provisioning was a further 20% reduction in the number of drives required, with no reduction in controller or fibre channel specification. (The "Case Study—Storage Functional Differences" and the "Case Study—Calculations of Reduced Disk Benefits" sections below give more details.)
- Cost of power ($ per kVA per hour) = $0.12, increasing 4%/year
- Cost of space ($ per square foot per year) = $150
- Overhead from power distribution (UPS, etc.) = 50.0%
- Additional power overhead from thermal cooling = 50.0%
- Multiplier to calculate actual space used from equipment dimensions = 2
- Storage management software employed was as follows:
    - Universal Volume Manager software
    - Tiered Storage Manager software
    - ShadowImage® software
    - Thin Provisioning software
    - No partitioning software was used in any of the solutions compared.

Case Study—Storage Environment

The situation at the start of the project was a mixture of many different storage systems and direct storage attached to about 100 servers.

The original specification for storage was for 118 terabytes of storage with 368 drives with a mixture of drives types (126 146GB drives, 182 300GB drives, and 60 750GB drives). The competitive storage solutions A and B were configured traditionally, using high-end controllers, as the high I/O rates dictated the highest-performing controller. The requirement for a single storage operating environment for all the interlocking applications meant that sufficient controllers were configured to meet the workload, and sufficient disk frames to house all the different types of disk were configured. The number of actual drives required for competitor A was 295 (i.e., 95 terabytes), and the number of drives for competitor B was 398 (i.e., 118 terabytes).

The third configuration assumed a reduced number of physical drives (236 drives, 76 terabytes) on the Sun StoreTek 990V configuration attributed to virtualization and thin provisioning of internal storage.

Case Study—Results

Environmental metrics revolve around the physical and energy characteristics of the IT equipment. These include:

- Total combined cost of power, cooling, and space
- Cost of power and cooling
- Heat loading (watts/equipment sq. ft.)
- Space (height, width, depth), with service area assumed to be the same as equipment space
- Floor loading (weight/[width × depth])

The relative importance of these metrics will depend on an organization's specific data center constraints. Minimizing power, cooling, and space costs is important for most customers who have these as budget line items. Figure 3 below depicts the five-year power and space costs for each configuration.

- The Sun solution costs are approximately one-third of the previous budget for power, cooling, and space.

- Competitor A has to budget 144% more for power, cooling, and space than the Sun StorageTek 9990V employing virtualization and thin provisioning; Competitor B has to budget 57% more.

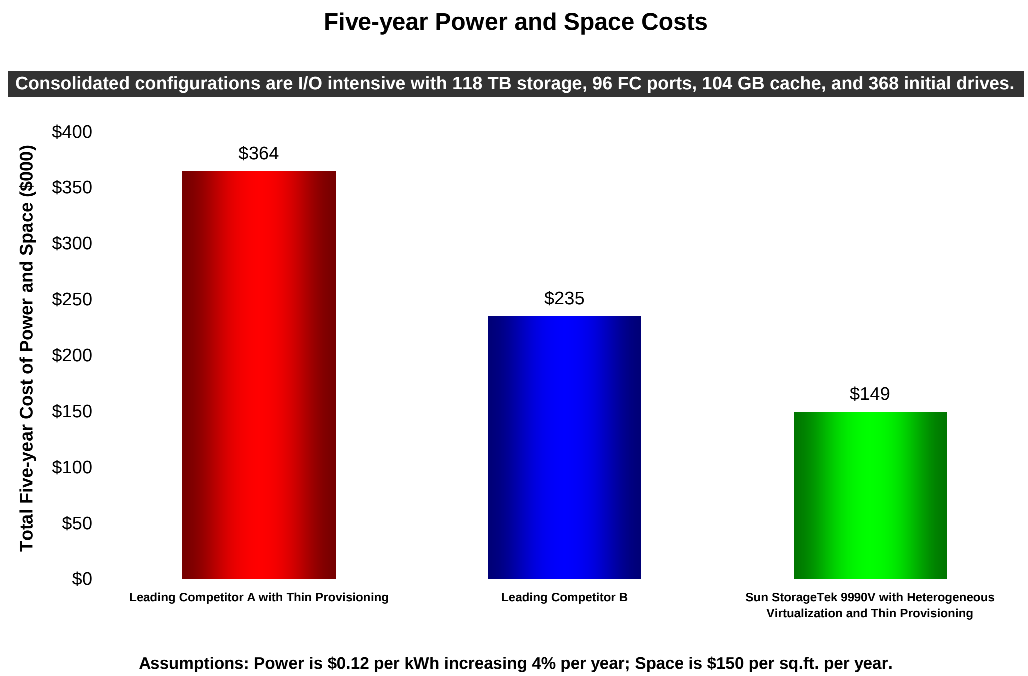

Figure 3 – Comparative Five-year Power and Space Costs

For some organizations, space is less of an issue. Figure 4 below depicts only the five-year power costs for each configuration.

- The Sun solution costs are approximately one-third of the previous budget for power.
- Competitor A has to budget 168% more for power and cooling than the Sun StorageTek 9990V employing virtualization and thin provisioning; Competitor B has to budget 57% more.

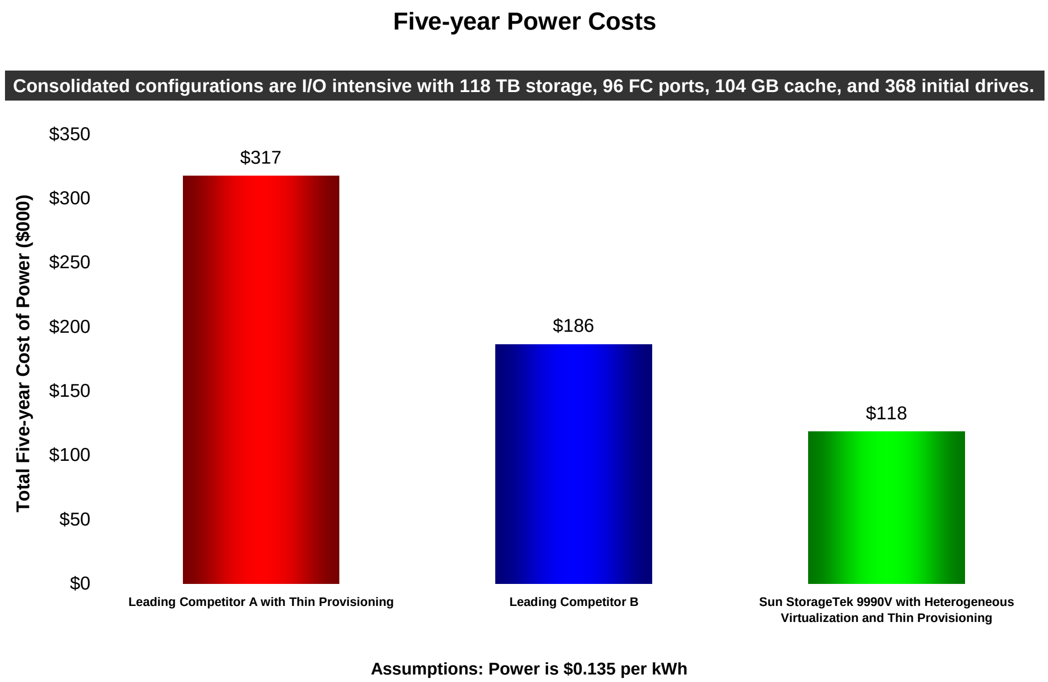

Figure 4 – Comparative Five-year Power Costs

Heat removal is the most complex aspect of data center design and is difficult to retrofit. The following section will focus on heat loading (watts/sq. ft) as the primary metric analyzed. Figure 5 below depicts the heat loading for each configuration.

- The heat loading of the Sun solution is 40% of the current situation.
- Competitor A has 66% more heat loading than the Sun StorageTek 9990V employing virtualization and thin provisioning; Competitor B has about the same.

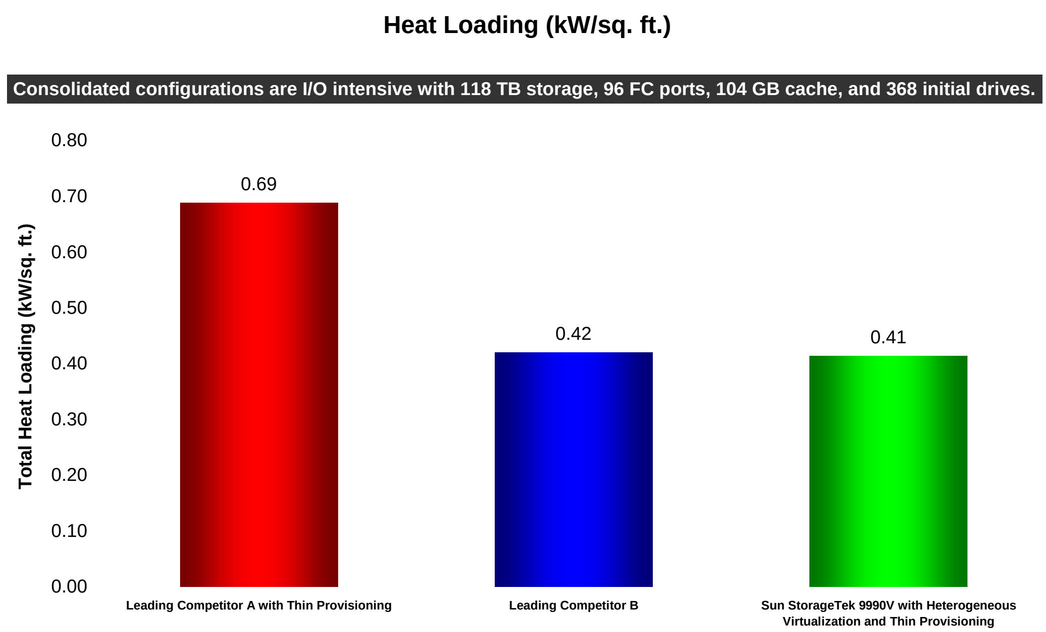

Figure 5 – Comparative Heat Loading

For some organizations in major corporations, space is expensive and important. Figure 6 below depicts the space requirement for each configuration.

- The space requirement of the Sun solution is 25% less than the current situation.
- Competitor A has to budget 52% more for space than the Sun StorageTek 9990V employing virtualization and thin provisioning; Competitor B has to budget 56% more.

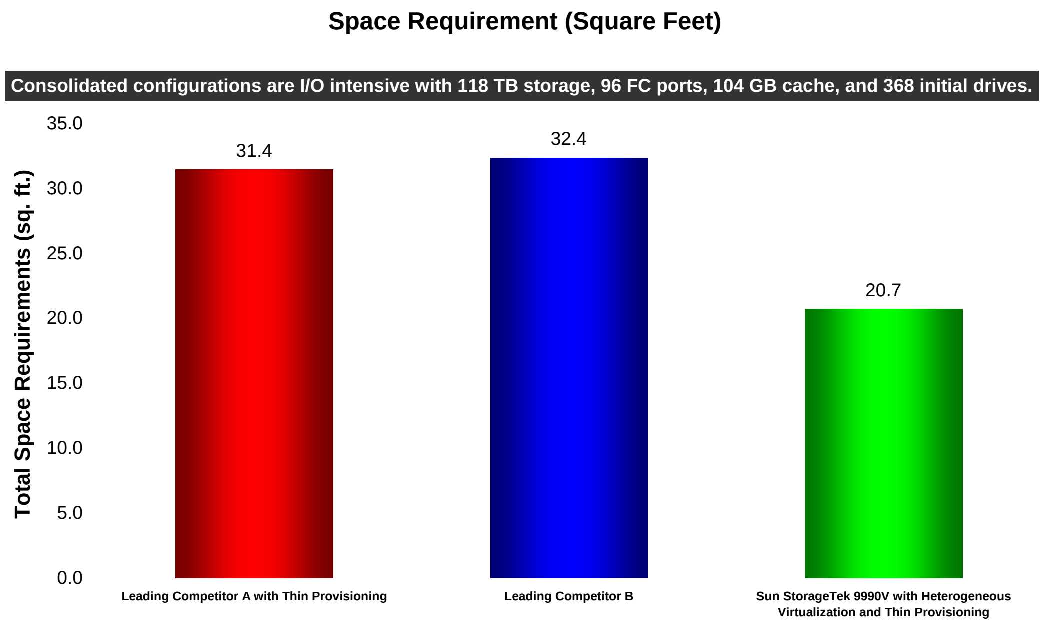

Figure 6 – Comparative Space Requirement

The floor loading metric helps determine where on the floor equipment can be located and whether any special weight distribution equipment is required. For some organizations, especially those in older buildings, floor loading is important. Figure 7 below depicts the floor loading for each configuration.

- Competitor A has a 47% greater floor loading figure than the Sun StorageTek 9990V employing virtualization and thin provisioning; Competitor B's figure is about 1% lower.

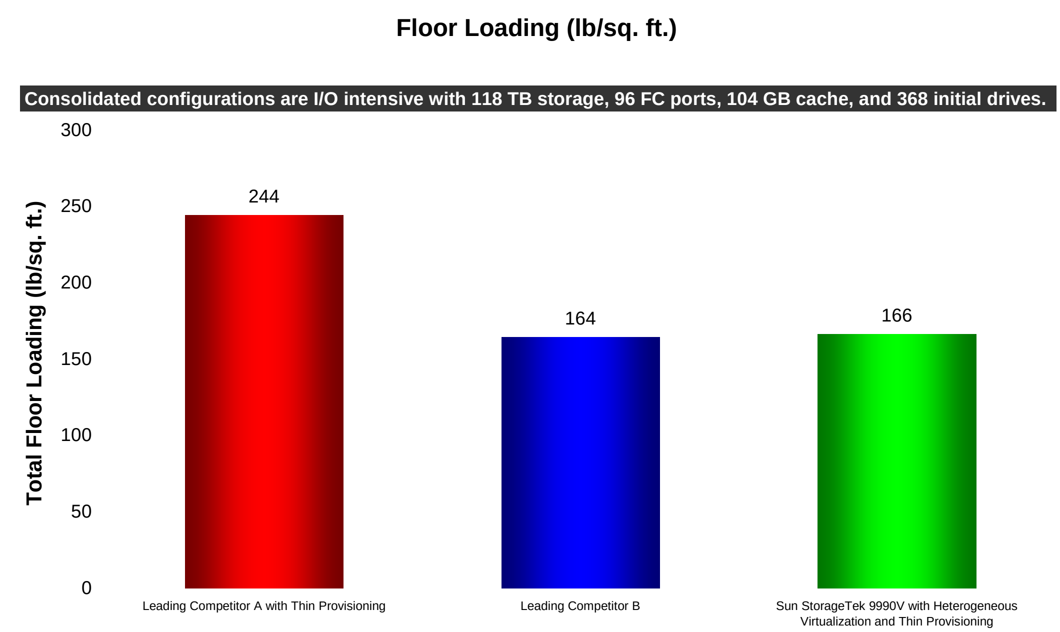

Figure 7 – Comparative Floor Loading

Case Study—Storage Functional Differences

This section examines the key Sun technologies that provided environmental reductions for the different configurations.

The benefit of **external storage** from the point of view of both cost and usage of environmental resources is that disk and I/O activity requiring less function and speed can be placed on the optimal device. Universal Volume Manager and Tiered Storage Manager software facilitate seamless allocation and administrative control both within a controller and between controllers.

Both competing systems from other vendors allow tiered storage management within one controller; however, they do not allow management between systems. The "one-size-fits-all" approach of both competing systems means that every workload has to employ the same high-performance environment, whether it is needed or not.

Consolidation of storage moved all directly attached storage to the SAN, and consolidated a number of small SANs to one overall SAN with two directors.

Virtualization of the internal storage allows separation of the logical volumes from their physical location. This in turn allows complete flexibility as to where volumes are placed, as well as optimization of the space used and the related environmentals. At the same time, the same set of storage management software is applied to all storage, with significant reduction of complexity, savings of administrative time, and improvements in levels of service.

The great advantage of virtualization, from an environmental point of view, is that storage can be efficiently allocated, higher disk utilization can be achieved, and fewer disks are required to provide the same levels of service. The case study assumes that 20% greater storage utilization can be achieved by using virtualization, which results in reduced storage administration.

Neither competing model offers in-controller virtualization. Therefore, additional virtualization units are required in the network, which adds to the environmentals required. Although out-of-controller virtualization is a viable approach for less-intensive I/O environments, it is not suitable for the very-high-intensity environment described in this case study and was not included in the competing configurations (error recovery with high I/O rates is much quicker and more secure with a single point of control).

The “Case Study—Calculations of Reduced Disk Benefits” section below gives more details on the methodology.

Thin Provisioning is a significant capability of the Sun StorageTek 9990V. This feature allows the disk drives to be logically over-allocated but physically allocates storage only when required. This over-allocation is endemic in almost all data centers. Users ask for more storage “just in case”; storage administrators know that the penalty for allocating too little storage is sudden and severe outages. In the open systems area, the tools required to determine the true utilization of storage are rudimentary. IT departments almost always exceed 30% over-allocation. In addition, as mentioned in the virtualization bullet above, over 30% of disk space in most data centers is not used. Detailed (and time-consuming) studies have shown that overall utilization is rarely over 50% and usually below 40%. This means that virtualization and thin provisioning have the potential to improve utilization by 50-plus percentage points.

The “Case Study—Calculations of Reduced Disk Benefits” section below gives more details on the methodology.

Virtual Ports–Because there are many servers and other devices, Sun’s virtual ports feature significantly reduces the number of real ports required to interface with the storage network. In this case study, the reduction in FC ports has not been explicitly factored in.

Storage Partitions–The ability to partition the storage controller allows resources to be dedicated to specific applications or storage pools without having to dedicate a specific controller. This is important when different workloads would interfere with each other, and leads to better utilization of storage controllers and a reduction in environmentals. In this case study, the reduction in storage controllers due to storage partitions has not been explicitly factored in.

Storage-Specific Architecture–One key characteristic of the Sun StorageTek 9990V architecture and design is the heavy use of specialized logic to provide high-performance storage protocol execution, high-performance switching, and high-performance of advanced functions such as virtualization. The Sun StorageTek 9990V was designed from the ground up as a storage controller.

Competing vendors take the traditional approach — they employ general purpose server and communication technologies and use such for storage controllers. This approach can reduce the cost of the controller components, but at the cost of lower performance and higher environmentals.

Case Study—Calculations of Reduced Disk Benefits

The assumption employed in this case study is that the number of disk drives required is reduced by 20% from virtualization and 20% from thin provisioning, with an overall combined reduction of 36%.

One assumption that underlies reducing the number of drives is that I/Os are not symmetrically distributed across volumes. Therefore, there are some volumes where the utilization cannot be improved, because the I/O throughput would be exceeded, and a majority will be underutilized with I/O throughput in hand. As part of the exercise of introducing virtualization and thin provisioning, a major planning exercise would have to be done to adjust volume placement. Part of that exercise is to establish the design of the thin provisioning pools (up to 32) and the allocation (or over-allocation) of volumes to those pools. One design option is the use of wide striping, which spreads I/Os more evenly across a large number of physical volumes. As part of the exercise, it may well be that the mix of drives will need to be changed across the arrays. The assumption for this paper is that 20% improvement in disk utilization can be achieved from virtualization and 20% from thin provisioning. "Your mileage may vary," and it will take time to achieve the full benefits, but these are reasonable expectations and good implementation objectives.

Case Study—Data Center Facilities Improvement

A key metric for improving data center facilities, as recommended by the Green Grid and Wikibon, is DCE (data center efficiency, or power delivered to IT equipment/total power delivered to data center). In this case study, improvements are made to the implementation of hot and cold aisles, and monitoring equipment is now installed to ensure that "hot spots" are detected and the actual temperatures are known. As a result, the temperatures in both the hot and cold aisles could be raised.

All the uninterruptible power supplies (UPS) and chillers in the data center were connected and working, which significantly reduced the capability of the data center. Due to the rearrangement of the data center, the UPS and chillers not required are now isolated and turned off. The other major change planned is the introduction of outside air to do the majority of the cooling on most days of the year (~4,000 hours/year). The changes required for this included additional filters, an "air switch" to redirect the airflow in the plenums, and monitoring and automation equipment to determine when outside air is suitable.

The overall impact of these changes has been to increase the DCE (power delivered to IT) from 44% (poor) to 64% (good). This changes the total available benefit to less than one-quarter of the original power and space costs over a five-year period, as shown in Figure 8 below.

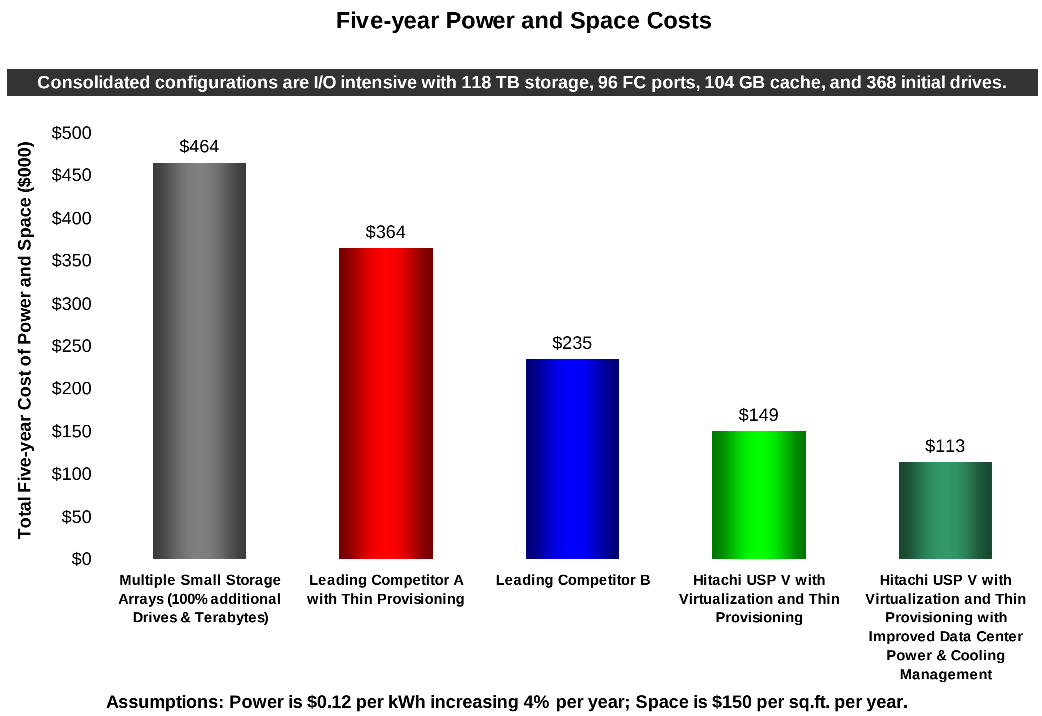

Figure 8 – Five-year Storage Power and Space Costs, Including Data Center Facilities Improvements

Case Study—Server and Storage Consolidation and Virtualization

The final stage in the improvement is to add in the savings from the server virtualization. Wikibon and other commentators have consistently recommended that server and storage virtualizations be combined. Server consolidation means significant changes to the way that storage is assessed and to storage backup and recovery procedures.

The overall savings in power and cooling from the combined project of consolidation, storage and server virtualization, and data center facilities improvement is given in Figure 9 below. The overall five-year savings are $1.2 million, and the overall reduction in power is 75%.

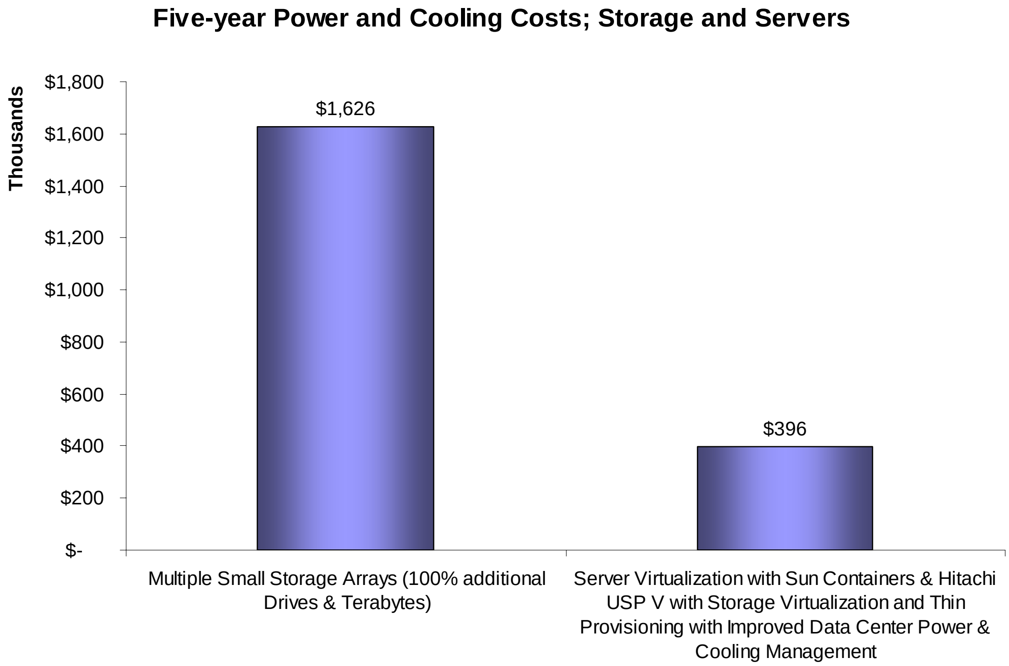

Figure 9 – Five-year Power and Cooling Costs for Storage and Servers with Data Center Facilities improvements

Case Study—Conclusions

This case study demonstrates that very significant savings can be realized from the data center. By combining the virtualizing of servers and storage and improving the data center facilities, the overall reduction in cost of environmentals was 75%. Management is now committed to using the breathing space it has to avoid any reoccurrence of this crisis. It is planning for significantly higher power and cooling loads on the data center in the near future.

The environmental savings for storage are 100 tons of CO_2/year and 1 million KVA hours over five years. The environmental savings for server and storage combined are 1,755 tons of CO_2 over five years and more than 3.5 million KVA hours.

Conclusions and Recommendations

The case study herein demonstrates that by focusing on improving the utilization of storage and servers and bringing best practices into the data center facilities, great improvements can be made to data center environmentals. In addition to the reduced cost of power and space, the data center now requires significantly fewer storage administrative staff members, systems have become more available, and it is easier to introduce change.

Senior management is now focusing on assembling an application portfolio that will monitor energy and emissions saved by IT as part of an overall green IT strategy. In addition it is tackling some of the longer-term issues, such as introducing data classification as a first step to deleting data that is no longer accessed.

One of the consistent findings of ITCentrix when interviewing organizations developing green IT strategies is that a strong IT green strategy helps with buy-in from the organization at every level. Employees, customers, and partners can be persuaded more easily to make changes that will improve the business if those changes are also aimed at improving the organization's green initiatives.

The overall conclusion from this white paper and case study is that IT executives have to take environmental issues seriously. CIOs should give a senior IT executive specific responsibility for introducing an overall green strategy and for liaising with the facilities group. Most important of all, CIOs should take budget responsibility for IT facilities, play a very full part in the planning of these facilities, and ensure that the full cost of IT facilities is factored into business cases and business plans.

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About ITCentrix

ITCentrix is a consultancy that primarily serves the needs of CIOs and technology professionals. Its main emphasis is using tools and analytic modeling techniques to advise clients on increasing company performance through improved resource allocation and better infrastructure management.

The company's products and services have been used at several hundred organizations in North America, Europe, the Asia/Pacific region, and emerging countries to focus investments on returning optimal business value.

In 2007, the company launched the Wikibon project (http://www.wikibon.org), a community of practitioners, consultants, and analysts dedicated to improving technology adoption through the open sharing of business and advisory knowledge.