Making Green IT a Reality

Customer Perspectives on the Impact of Storage Vendor Decisions on Power, Cooling, & Space in Enterprise Data Centers

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Simplifying Data Management

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Oliver Wyman, a global strategy consultancy, was engaged by Network Appliance to determine the implications of storage decisions on power, cooling, and space within data center environments. The findings included in this study are Oliver Wyman's, based exclusively on interviews with storage and facility managers and IT executives from large enterprises across various industries and geographies.

■ "Green IT" – The Opportunity Available

"Green IT" is a popular concept today, as data centers worldwide face rising costs for power, cooling, and space and companies strive to meet public demand for improved environmental stewardship. Many IT organizations, however, are just starting to understand the influence that their IT purchase decisions have on data center power, cooling, and space consumption. This paper explores that link, with a particular emphasis on the impact of storage solutions.

Many IT executives are quick to acknowledge the importance of utility costs to their bottom line. Participants in this study estimated that power, cooling, and space costs account for 10–30% of their total IT budget. Interestingly, however, only a few leading-edge companies have formally incorporated facilities considerations into their vendor selection processes. Most companies are just starting to understand the link between their vendor decisions and their power, cooling, and space-related costs.

Utility costs can account for as much as 30% of the total IT budget

"Two years ago, if you were to ask me what level of influence power had on my storage decisions, I would have said it has no bearing, but today it is HIGH."

These costs can be best characterized by three primary pain points: data center space, power capacity, and heating/cooling requirements. First, because of the rapid increases in computing and storage requirements, many data centers are running out of space, both in terms of square feet and rack units. Most facilities managers report they try to delay expanding their data centers as long as possible in order to save costs. This leads to companies deploying denser drives and more highly utilized systems, which, in turn, leads to higher power consumption per square foot. Many companies are finding power capacity to be their primary concern. Others are struggling with how to manage heat dissipation, captured in BTU/hr, as they struggle to keep data centers cool.

Storage is a major contributor to the problems data center managers are experiencing. This study found that there are real and measurable differences across storage vendor platforms on the critical power, cooling, and space metrics. This study found that environments that have deployed NetApp storage solutions tend to have higher system efficiencies than those that have deployed EMC or HP storage solutions.[1]

Storage is the fastest growing driver of data center utility costs, and the storage vendor chosen can drive 50% savings in power, cooling, & space reauirements

According to the data center managers interviewed for this study, the primary drivers of power, cooling, and space in enterprise storage systems have little to do with disk drive technology differences and everything to do with product feature differences provided by storage vendors. Data from customer deployments shows that NetApp solutions require less storage per usable

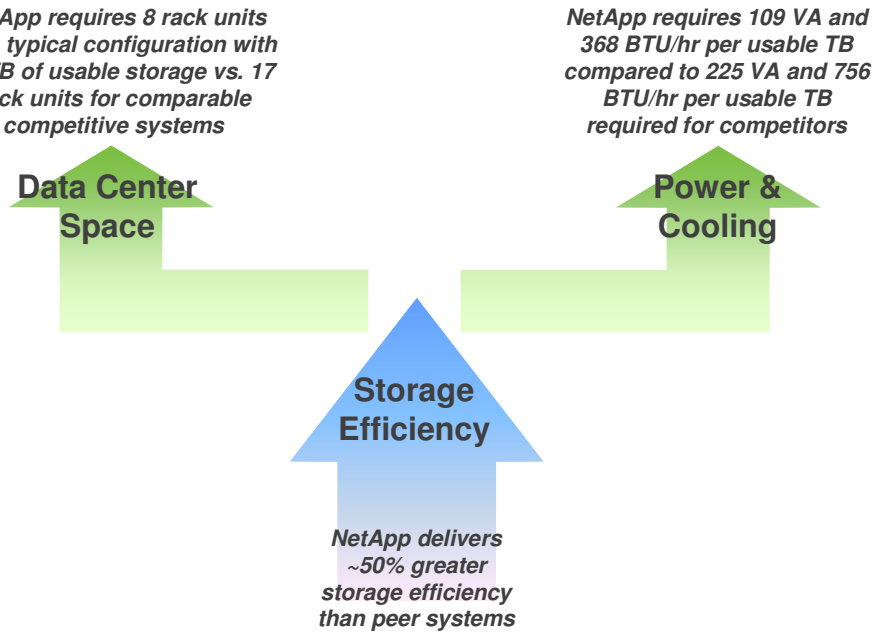
[1] This is consistent with previous Oliver Wyman Total Cost Studies conducted in 2006-2007. Based on typical configurations and policies, the total cost studies found that NetApp deployments have up to a 50% advantage in storage efficiency in the primary environment over comparable competitor systems across seven different application areas.

TB, reducing the number of hard disk drives and enclosures required. As Figure 1 shows, these benefits directly impact power, cooling, and space metrics:

- NetApp systems require half as many rack units per usable TB as competitors.
- NetApp systems consume 109 VA of power per usable TB and dissipate 368 BTU/hr of heat per usable TB compared to 225 VA and 756 BTU/hr for competitors.

As one study participant said, *"Drive space is like money. You can't get enough of it."*

Figure 1 – Storage Efficiency Drives Power, Cooling, and Space Savings



Study Approach and Methodology

NetApp engaged Oliver Wyman to conduct primary research with storage and facility managers and IT executives at large enterprises and leading-edge companies to determine issues around power, cooling, and space. NetApp commissioned this research with the belief that its storage solutions provide a power consumption and space advantage over key competitors. However, Oliver Wyman had complete autonomy over the research, data analysis, and results.

Participants in this study were recruited by Oliver Wyman for 60-minute structured interviews and were targeted to provide diversity on a number of dimensions, including:

- ***Industry.*** This study primarily focused on healthcare, technology, and financial services companies, but included data from a range of other industries as well.
- ***Company size***. Study participants varied both by the number of employees (up to 80,000) and by the amount of data stored (up to 2 PB) in the data centers.
- ***Data center location.*** This study incorporates data from urban and more remote locations in the U.S., Europe, and Asia.
- ***Primary storage vendor.*** Study participants relied on one or more of the following storage systems: NetApp FAS, EMC CLARiiON, or HP EVA.
- ***Degree of sophistication in managing power, cooling, and space concerns.*** Study participants included both early adopters of advanced power, cooling, and space management techniques and more typical data center environments.

In these interviews, study participants provided Oliver Wyman with perspectives on how their organizations manage power, cooling, and space issues and shared detailed data on power consumption, heat dissipation, and space requirements of the systems they deployed.

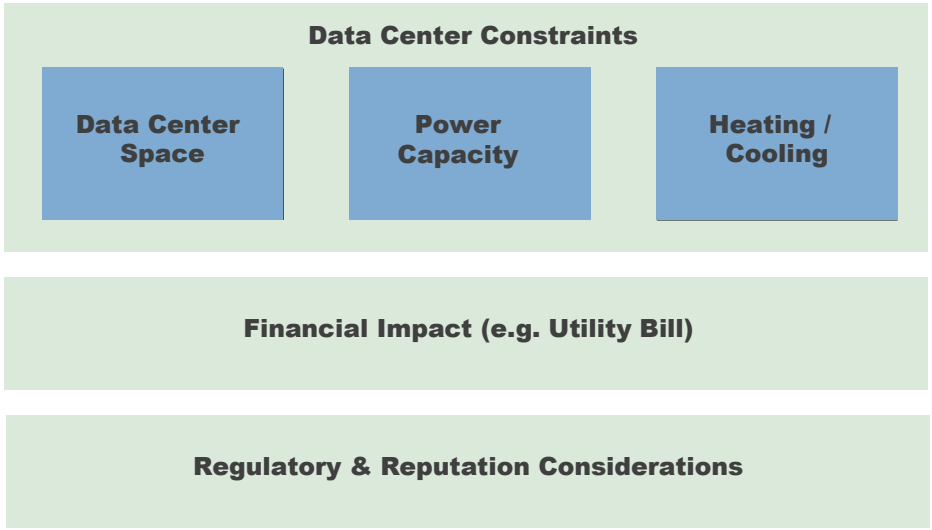
■ Differences in "Green IT" Priorities by Environment

Through conversations with storage and facilities managers, this study uncovered three types of drivers behind the increased emphasis on green IT in data centers:

- **Data Center Constraints** – Many facilities managers are dealing with fundamental constraints on rack space, power capacity, and/or heating and cooling capacity.
- **Financial Impact** – While some organizations can manage the physical constraints from rapid growth in storage requirements, they are trying to minimize the cost burden, and utility costs are a major pain point for many organizations today.
- **Regulatory and Reputation Considerations** – Environmental concerns and issues around a "green" brand image also lead to change in data centers.

Through the customer conversations, these drivers affected data centers in different capacities depending on unique attributes such as geographic location, age, and technological advancements.

Figure 2 – Primary Drivers Behind Data Center Action



Data Center Constraints

A significant number of companies specified data center space as their primary pain point. Study participants identified that storage requirements are growing at accelerated rates within their data centers – some are experiencing 50% or higher data growth year over year. To accommodate this demand for storage space, the majority of companies are replacing older, bulkier equipment with smaller, denser equipment. As one study participant said, *"We go through a 20% tech refresh every year to ensure that we are always using the most efficient storage systems out there."*

Some data centers have also been able to save tremendous amounts of floor space by utilizing virtualization technology. A large European data center recently converted a significant portion of its physical server environment to virtual, reducing its server requirements for those applications from 250 servers to 18.

For the companies that have alleviated space issues, power capacity has become top of mind. While switching to denser systems creates more floor space, each one requires more power and gives off more heat per unit of space. *"We have consolidated a significant number of our IT systems but last year that led to a power increase of 25%."* This study found these claims to be typical for larger data centers with mature UPS systems that have consolidated through denser servers (i.e., blades) and storage systems to achieve higher utilization and capacity. *"With the advent of higher processing and denser storage, space is no longer a problem – power capacity is the problem."*

Customers who had reached the maximum power capacity of their data centers discussed the options of either upgrading the UPS or expanding to a new data center. One study participant explained that upgrading a UPS can cost anywhere from $500,000 to $700,000, whereas expanding into a new data center can cost several millions of dollars and take multiple years to deploy.

To alleviate the power capacity stress, facilities managers are using clever strategies to reduce the power needed for cooling equipment. Among the study participants, the best-in-class data centers are able to achieve an input power-to-cooling ratio of 1:0.6.[2] Data centers that have implemented techniques such as the hot aisle/cool aisle but have not quite modeled their airflow efficiency or utilized natural ventilation tend to achieve a ratio closer to 1:1. Additionally, data centers that are either over provisioned due to high growth projections, have consolidated through denser server units (i.e., blades) and storage devices, or are using outdated cooling techniques can have a ratio as high as 1:2. *"HVAC is an issue because the units were sized for previous generations and now [storage] equipment has become denser and is dissipating far more heat than before."*

Financial Impact

The increase in power consumption is carving a bigger chunk out of IT budgets and therefore attracting lots of attention. *"We have a massive plant but are paying out the nose for our [electricity] bills because of our location."* This study found that this driver was more painful for data centers located in densely populated urban areas where utility costs are as high as $0.15/kWh, 3x the amount of some of the data centers in remote locations. Several companies have moved secondary storage facilities to remote areas, not only because of data security policies in the post-9/11 environment, but also because utility costs are significantly less.

[2] The input power-to-cooling ratio highlights how efficiently a data center is able to cool the heat dissipated from server and storage systems. It is calculated based on the amount of power required for the IT systems compared to the power required for the cooling infrastructure in the data center.

Furthermore, some of the leading-edge companies have located in areas where power is abundant and cheap.

Regulatory and Reputation Considerations

Rapid data growth has also caught the attention of public interest groups and government organizations, which see these data center trends as potentially large environmental hazards. In Europe, this attention has turned into regulatory action. One customer mentioned a levy that the UK government adds to the data center utility bill for every MW of electricity consumed. Other customers in the U.S. and different European countries have suggested that they also face the pressure of being "good citizens" and note regulatory efforts as being a factor in the push towards green IT. The hype around the importance of eco-friendly IT has made it such a trendy topic that some study participants suggested, "*Green is the new black*" in the IT industry. Another study participant noted, *"It must be green and must be energy efficient or we won't play."*

Although different types of companies have been afflicted by these pain points to varying degrees, the simple solution is to reduce storage requirements. Higher storage efficiencies allow companies to extend data center longevity, alleviate power and cooling issues, and reduce operational expenses (i.e., the utility bill). Storage and facilities managers have an opportunity to address these data center constraints and the resulting financial impact by choosing the most efficient vendor system. The following section focuses on these vendor differences.

■ Drivers of Power, Cooling, & Space Differences by Storage Environment

A. Storage Efficiency

The main driver of power, cooling, and space differences among vendor systems is storage efficiency. Customers who are able to reduce the amount of raw storage needed for each effective or "usable" TB will see a direct savings in space and power consumption. Study participants suggested that NetApp environments are able to provide greater storage efficiencies compared to EMC CLARiiON and HP EVA environments[3] because of the product and system features available with NetApp Data ONTAP® 7G. As one customer explained, *"We prioritize the one vendor that provides advantages we can use and count. We also looked at HP and EMC, but NetApp product features give us the results we need."* The main features that NetApp customers are able to leverage include the Snapshot™ feature and FlexVol®, the capability to thin provision by growing and shrinking volume sizes on demand, as shown in Table 1.

Table 1 – NetApp Product Feature Advantages

Primary NetApp features providing benefits factored into the study

Capability	Benefits	Customer Examples
Snapshot	20% storage overhead compared to 100% for full copies or BCV	*"Snapshot copies have been widely proven as functional equivalents to full copies. It is a reliable technology for creating local copies for recovery purposes."*
Thin Provisioning (FlexVol)	20% - 33% savings by growing and shrinking volume sizes on demand	*"Thin provisioning has helped us a great deal because we can eliminate 20% of the storage we need to buy."*
RAID 6 Implementation (RAID-DP™)	14% - 17% overhead compared to 100% for RAID 1	*"RAID-DP provides as good protection as mirroring."*

Additional features providing environment-specific benefits (not factored into study)

Capability	Benefits	Customer Examples
Multi-protocol (Unified Storage) & FC/SATA Drives	2-3x savings if running multiple protocols with low util rates; up to 50% savings with SATA instead of FC	*"NetApp provides us the flexibility to combine FC and SATA in one box. We can easily migrate lower tiered storage to lower spindle disks and don't have to worry about power as much."*
Multiple Writeable Snapshot Copies (FlexClone®)	Up to 66% savings if creating five copies of original data compared to BCV or full copies	*"It allows us to create clones without additional storage across all environments. On average, it saves us 22% additional overhead."*
Deduplication	10% - 80% space savings depending on data set	*"For our unstructured data, [NetApp] deduplication has led to 80% storage savings. Instead of requiring 10 TB of data, we only need 2 TB."*

[3] Customers suggested that EMC CLARiiON and HP EVA systems were identical in their requirements for raw TB needed for each usable TB, and are therefore grouped together as "competitors" in the rest of this paper when showing power, cooling, and space differences.

As a result of the NetApp Snapshot functionality, customers suggest that NetApp environments require less raw storage than competitors' environments when implementing local data protection policies. EMC and HP customers typically use full live copies for recovery purposes[4], which inherently leads to 2x storage overhead. One study participant who is running a NetApp and EMC environment explained, *"A lot of things NetApp does are available on other vendor systems, but it is complicated so we do not implement SnapView on EMC. NetApp is much easier and more efficient."* Another NetApp customer said, *"We can do multiple Snapshot copies of the volume and only require an additional 10-20% overhead. In our previous environment, we would never have been able to do this because of mirrored data."*

Data resiliency is also handled differently in NetApp and competitor environments. NetApp customers use RAID-DP (a RAID 6 implementation)[5] with its Data ONTAP 7G operating system, whereas EMC and HP customers typically use RAID 5 to save on the number of disks. NetApp customers also leverage FlexVol with Data ONTAP 7G. According to one study participant, *"The ability to grow and shrink volumes leads to at least a 20% savings in disks."* Customers indicated that FlexVol also allows them to more efficiently manage various end users and accommodate different levels of growth all within one box: *"People are all over the place with what they need and what they ask for so FlexVol is very useful."*

Case Study: Use of NetApp leads to space savings
A Health Care Company's Perspective

For many companies, data center space has become a serious concern due to rapid growth in both primary and backup environments. In addition, many companies have introduced stringent data protection policies, requiring multiple backup copies of the production data for local recovery from application errors, disaster recovery scenarios, or even for archiving, further exacerbating the problem.

A health care company with 0.5 PB of data was experiencing 65% - 100% data growth across different application environments. Needless to say, space was becoming more scarce in their 2,150 sq. ft. facility. But, because of the high cost associated with expanding or adding a facility, the company decided to first optimize what they had. *"Expanding is something we are seriously trying to avoid."*

The company was able to take advantage of the NetApp unified storage architecture and Snapshot feature to help consolidate and protect data as required. *"NetApp products reduced the amount of raw TB that we needed to store. We were able to consolidate storage from our servers and reduce our footprint because NetApp could handle multiple protocols [in one box]."* Additionally, the company retains *"4-5 hourly snapshot copies and 2-3 daily"* for local data protection purposes, leading to further space savings because of minimal overhead required.

In addition to the primary advantages afforded by Snapshot, FlexVol, and RAID-DP, there are multiple other features that customers mentioned that also lead to storage efficiencies. Study participants reported that the NetApp unified storage architecture allows them to run multiple protocols using one system, which can have a very significant impact on space savings. NetApp customers mentioned that they are also able to use SATA drives for lower tier storage within the same system as Fibre Channel drives, leading to lower overall power requirements.[6] Other customers take advantage of the NetApp FlexClone® feature, most widely deployed in test and development environments. Additionally, study participants explained that NetApp has also

[4] This finding is consistent with prior Oliver Wyman research on total cost of different storage solutions in specific application environments. EMC and HP customers have revealed that the best practice for implementing a proper data protection scheme within their primary vendor environment is to create full live copies such as EMC's Business Continuance Volumes (BCV) or clones of the primary data.

[5] RAID-DP (a RAID 6 configuration) provides double parity, using two dedicated parity disks out of fourteen data disks in most customer deployments. Typical RAID 5 configurations use one out of eight disks for parity, according to study participants.

[6] SATA drives typically have greater storage capacity and spin at lower RPMs, which results in less power consumption per drive in comparison to FC drives.

made available its deduplication technology in the latest version of Data ONTAP 7G. Table 1 shows typical benefits from the use of each of these features.

Although these further variations exist in select customer environments, the additional savings are not factored in while deriving power, cooling, and space implications because these features are not uniformly deployed. The results of this paper are based on typical deployment policies for each vendor's solution as captured across the multiple organizations interviewed.

Case Study: Use of FlexVol and FlexClone helps sustain power capacity
A High Tech Company's Perspective

Leading edge companies take a range of approaches to mitigating power, cooling and space issues. Often, the first step is to consolidate their storage environment and move to denser storage as a means of saving space.

However, one high-tech company operating a 72,000 sq. ft. data center with 7.5PB of raw data explained, *"with the advent of denser storage units, space is no longer an issue – it is power capacity."* This data center pulls 14 MW of power off the grid but has issues with getting enough power to different parts of the data center to cover all of the storage appliances deployed.

By upgrading from Data ONTAP 6 to Data ONTAP 7G, the company *"increased utilization from 56% to 80%."* Additionally, it also deployed FlexClone clones *"within six out of nine lines of businesses,"* further increasing utilization within each NetApp box and mitigating the power capacity issues.

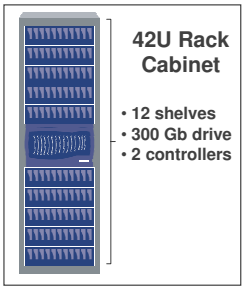
Taking into account the differences between vendor environments for local data protection and thin provisioning, study participants found NetApp solutions to be far more efficient in storage utilization than competitor solutions. Data from customers revealed NetApp environments have a 1.4x overhead capacity requirement due to the additional storage needed for Snapshot copies and the extra disks necessary for RAID protection, whereas competitive environments have a 2.3x overhead capacity requirement for RAID protection and full copies. Table 2 shows that for a typical deployment with 10 TB of effective storage, NetApp customers require 11.2 TB of disk capacity, but competitor environments require approximately 22.9 TB.

Table 2 – Typical Configurations for NetApp vs. EMC CLARiiON and HP EVA
Based on a 10 TB effective storage deployment

	NetApp	Competitors
Storage Hardware	▪ FC disks (300Gb, 15k RPM) ▪ RAID-DP ▪ Snapshot (incremental copy) ▪ FlexVol (Data ONTAP 7G)	▪ FC disks (300Gb, 15k RPM) ▪ RAID 5 ▪ BCV (full copy)
Usable Storage	▪ 10 TB Usable data	▪ 10 TB Usable data
Typical Storage Acquired[1]	▪ 11.2 TB (1.4x for Snapshot and RAID-DP overhead, 20% savings from thin provisioning)	▪ 22.9 TB (2.3x overhead for BCV and RAID 5)

1. Typical storage acquired includes a copy of files protected by either Snapshot copies or snapshot equivalents (BCV) and RAID protection. NetApp Data ONTAP 7G also provides additional savings through FlexVol.

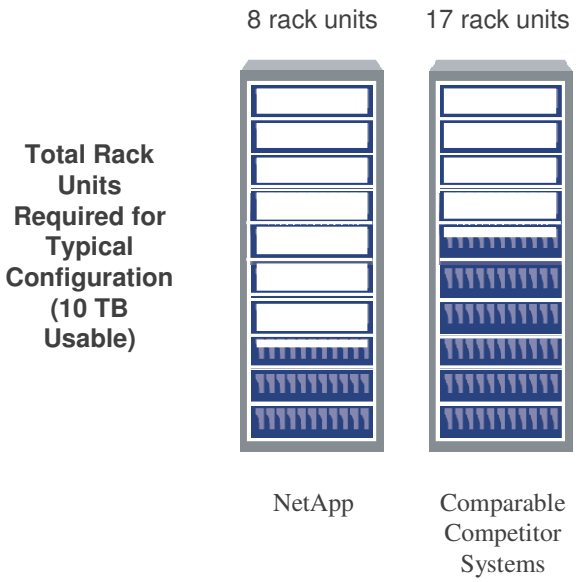
B. Rack Space



According to study participants, the most straightforward metric to capture space required for modular storage is rack units. Within a typical cabinet that contains 42 rack units, customers commonly allocate 12 disk shelves, with the rest of the space required for controllers. For a modular storage device with a fully utilized rack, this can typically amount to approximately 50 raw TB[7].

Through the storage efficiencies captured in the previous section, NetApp customers are able to reduce the rack space required for the same amount of usable storage compared to other vendor environments. Study participant data shows that for a typical configuration described in Table 2 with 10 TB of effective (usable) storage, a NetApp solution requires 8 rack units compared to 17 rack units required for comparable competitor systems.[8] This data is presented in Figure 3.

Figure 3 – Space Advantage of NetApp FAS vs. EMC CLARiiON and HP EVA



Study participants suggest that this advantage for NetApp is directly attributable to NetApp product features providing space savings. Respondents claimed that NetApp delivers over 50% greater storage efficiency than competitors through its use of Snapshot, thin provisioning, and RAID-DP. One study participant noted, *"We save a lot of disk space with Snapshot. We use it in every environment: Production email storage, Test and Development, Home Directories, etc."* Another customer said, *"We are handing out more storage space than we physically have."* A third respondent credited thin provisioning (FlexVol) for an increase in utilization rates within

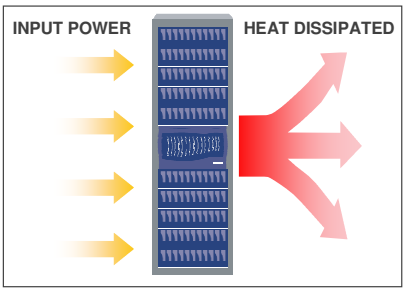
[7] Based on 300 GB drives, 14 drives per disk shelf, and 12 disk shelves per rack cabinet.

[8] Based on 300 GB drives, 14 drives per disk shelf, and 3 rack units required per disk shelf.

his NetApp environment: *"Today we have 60% utilization and without thin provisioning, it would be 40%."*

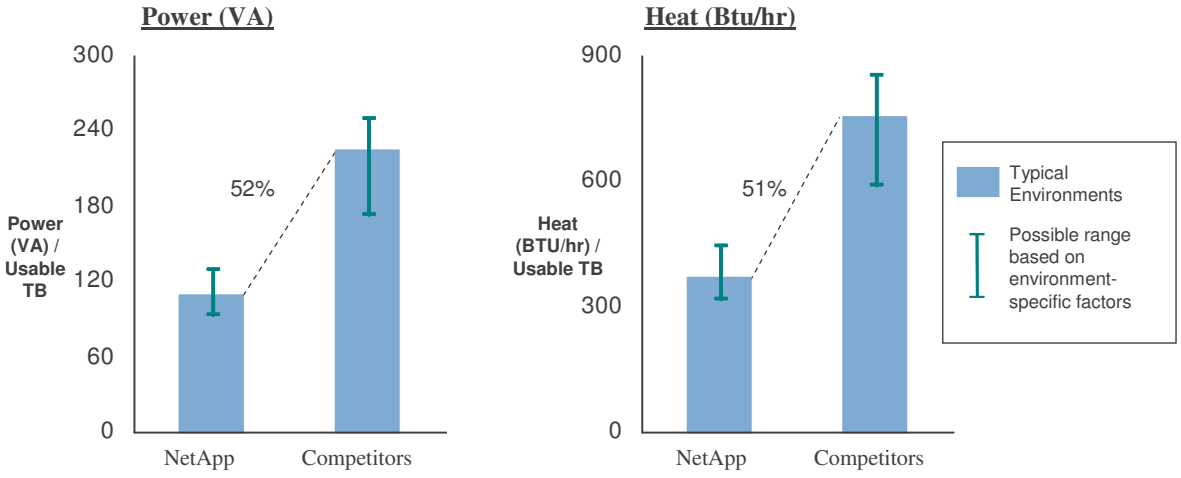
C. Power & Cooling

The most relevant metric for input power required for storage systems as indicated through various vendor data sheets is Volt-Amperes (VA). Study participants mentioned that cooling is best thought of in terms of heat dissipated by the storage appliances, which is tracked based on BTU/hr. Across all study participant environments, the average ratio between input power for storage systems and cooling required to offset the heat dissipation is approximately 1:1.



Customers suggested that since most storage vendors source disk drives from the same set of suppliers, it is not the hardware technologies that lead to power and heat dissipation differences for different vendor systems, but rather the number of disk drives needed for equal amounts of usable storage. Similar to advantages in rack space, NetApp customers mentioned that they are able to achieve higher power and cooling efficiencies because they require fewer disk drives to store the same capacity of usable TB. A study participant for whom power savings was top of mind commented, *"We pick NetApp because of power savings. Other systems do not seem to have the full feature advantages that the comparable NetApp system does."* For a fully utilized rack configuration using FC disk drives with 300 GB storage capacity per drive, study results indicate that NetApp systems require 109 VA and 368 BTU/hr per usable TB compared to 225 VA and 756 BTU/hr per usable TB required for competitors. This data is shown in Figure 4.

Figure 4 – Relative Advantage of NetApp vs. EMC CLARiiON and HP EVA
Normalized per usable TB



Lessons Learned from Leading Edge Companies

As noted above, this study included perspectives from companies acknowledged by their peers as taking an innovative approach to data center management. These leading edge companies tend to have a more holistic view around IT and storage and are promoting internal change in the way they manage and think about their decisions. The most noticeable transition that customers mentioned was from the very segregated *"IT operates within its own sphere"* viewpoint to a very integrated one: *"Think of [us] as an octopus – each arm is a separate business but all share the same checkbook and data center. We all have to plug our gear into the same box, so it behooves us to work together."* In some of the most successful data centers, these two groups have *"joined at the hip"* when making storage purchasing decisions and deployment techniques. In one company, this interaction is not only encouraged but required: "*IT has to submit power footprint approval forms in addition to a PO to ensure the device chosen can be powered and cooled efficiently."*

As a result of this transition, IT managers have started to look beyond traditional functionality characteristics, what one study participant referred to as "*0 to 60 MPH specs,"* and focus more on *"the miles per gallon specs."* They are considering attributes across various other categories when making storage vendor decisions. Such categories include total cost, performance, form factor, current power consumption and energy efficiency rating, and roadmap with key product features.

Beyond purchasing decisions, data centers have developed strategic deployment techniques to achieve further savings. As facilities managers' understanding of IT equipment becomes more granular, they are able to pinpoint hot spots not only on the data center floor, but within the actual storage boxes. Leading edge companies are utilizing several innovative techniques to maintain power consumption and cooling while increasing storage performance. The foremost include:

- ***Data center footprint design*** becomes more critical as companies switch to denser storage units and space becomes less of a pain point. One facilities manager referred to his footprint design as "white space management." Strategically placing servers and storage units for both power and cooling efficiency purposes is beneficial.

- ***Creative cooling techniques*** can lead to significant power savings. According to one customer, *"Cooling is the single biggest place where the facilities manager can make the most dramatic impact."* Data centers not only implement hot- and cold-aisle airflow, but they take significant measures to keep it as fluid as possible using partitions and minimizing bulky power cords.

- ***"[Managing] energy efficiency*** *is critical for growth mitigation strategy."* Several data centers have moved towards a standardized floor-tile, which makes an appliance refresh easy. Some suggest that leveling the load across the data center floor creates less strain on the

power and cooling systems. *"We were able to drive towards 40% energy efficient gains by changing how we manage power."*

- ***Constant feedback*** is a key component to leading edge companies' success in data center efficiency. Study participants suggested that leading edge companies are evaluating and making use of metrics such as Power Efficiency Rate (kWh / Usable TB) to help them optimize their power usage. Other universal metrics that have been promoted by The Green Grid include the Power Usage Effectiveness (PUE)[9] ratio and the Data Center Infrastructure Efficiency (DCiE) percentage[10]. All of these metrics allow leading edge companies to improve operational efficiency, compare competitive data centers, benchmark improvements, and determine opportunities to repurpose energy for IT equipment[11]. A large utility supplier mentioned that *"If metrics [such as these] become a standard, then we would be able to structure incentive programs for the top data centers."*

Conclusion

According to study participants, measures can be taken to reduce power consumption and heat dissipation and increase space efficiency by picking the storage vendor that provides the lowest number of raw TB for the usable capacity required. Additional savings can be achieved through strategic deployment techniques. This paper revealed that storage vendor decisions do in fact have an impact on data center power, cooling, and space efficiencies. As one senior executive at a leading healthcare company said, *"Two years ago, if you were to ask me what level of influence power had on my storage decisions, I would have said it has no bearing, but today it is high and growing."*

[9] Total Facility Power / IT Equipment Power. IT Equipment Power is defined as the equipment that is used to manage, process, store, or route data within the data center and Total Facility Power is defined as the power dedicated solely to the data center measured at the utility meter.

[10] IT Equipment Power/ Total Facility Power * 100. IT Equipment Power and Total Facility Power are defined above.

[11] For more information about using these metrics, visit The Green Grid at http://www.thegreengrid.org.

Oliver Wyman

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