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WHITE PAPER

The Quest for Sustainability in the Modern Data Center

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Introduction

Sustainability is a word that's gotten a lot of use over the last decade, especially for environments like data centers that are highly dependent on electrical power for every aspect of operations. According to some estimates, data centers consume 220-320 TWh of power on an annual basis and account for over 100,000 MW of capacity. It seems obvious that reducing power consumption should be the primary target for sustainability in the data center; however, there are many factors in a complex system like a data center that affect power consumption, sustainability, and overall efficiency.

This is especially true given the fact that most power consumed by infrastructure hardware is exhausted in the form of heat that you need to pay for again, via heat rejection technologies, which use even more energy. This challenge is compounded by the other factors that come into play in the modern data center, such as backup power requirements, operational SLAs, staffing, operating budget, hardware lifecycle, physical environment limitations, and legal compliance, not to mention the flexibility required to adapt to a continuously changing and evolving infrastructure while continuing to support legacy hardware that seems to hang around forever.

Data center design has been continuously evolving for over six decades, with perhaps the greatest changes happening over the last 20 years. In that time, much of business computing migrated from big-iron systems like mainframes and mini-computers to embrace the economy and modularity of the x86 platform that is still favored today. While this has commoditized a number of infrastructure components, the continued and rapid evolution of server, networking, and storage technology adds substantial complexity to the challenges of data center design, operation, and efficiency.

However, despite this complexity, a growing number of "green" data centers have emerged, so-called due to their larger budgets and continued emphasis on sustainability initiatives. It's these data centers that serve as illustrative examples for the rest of the data center industry—not only highlighting the benefits of prioritizing sustainability in daily operations, but also paving a roadmap for other data centers to simplify the intricacies of sustainable technology and ultimately pursue their own "green journey."

To get a pulse on the pulse of today's sustainability movement, we conducted in-depth and candid interviews with a dozen carefully selected data center operators regarding their approach to sustainability. We've agreed to keep their identities and companies confidential, allowing us to obtain extremely candid interviews spanning a broad range of IT environments that included higher education, healthcare, publishing, large enterprise, colocation, hybrid cloud and data center hosting facilities. As we were conducting these interviews, we were pleased to note that everyone we spoke with had made efforts to promote sustainability in some way, shape or form, though we found that the degree of attention to sustainability varied substantially based on the size of the operator, its culture, and, ultimately, the support and funding made available for green initiatives.

In compiling the results of these interviews, we were able to identify **eight key categories** where green initiatives are occurring within data centers of nearly every size.

#1 *Our interviews showed that heat management remains a primary factor contributing to data center ROI and efficiency.*

In the case of computing systems, power consumption directly translates into heat output, which makes cooling a primary concern for data center operators.

- Most operators focus on efficient placement of racks and components based on total heat generation and their proximity to cooling resources. For those with raised-floor environments, this may involve switching to higher throughput static floor tiles, or to power-enhanced ones.

- Most agree that adopting the use of blanking panels in rack is a key method for minimizing hot spots. While this may seem like a minor issue, filling any open gaps in a full rack makes a major contribution to ensuring proper airflow. Several observed that OEM blanking panels can be costly; fortunately, there are several 3rd party vendors who offer inexpensive, snap-in plastic panels that will work just as well.

- Some respondents are adopting green options for sourcing cooling water and managing condensate output. This is a larger issue for operations in hot/dry environments, but clean water availability remains a growing concern worldwide and is good for the environment.

- There were a few who considered raising overall machine room temperatures as high as 90°F to reduce equipment cooling requirements. This has been demonstrated in Google's data center in Belgium; however, this approach was typically deemed too risky without an in-depth assessment from all the involved hardware vendors being utilized.

- Some have found it necessary to adopt hot-aisle containment to isolate high density racks. This premise—especially when combined with additional in-row cooling—has proven very successful for retro-fitting existing facilities to adapt to high-density computing pods.

#2 *Data center operators are looking to align with evolving best practices.*

Most acknowledged the growing importance of Environmental, Social, and Governance (ESG) criteria to potential stockholders. ESG is a set of standards for a company's behavior used by socially conscious investors to screen potential investments. From a compliance standpoint, there are continual improvements in construction methods and materials, as well as mechanical, electrical, and plumbing systems. Keeping current with best practices along with all the other technology factors in the data center is always a challenge, though many look to trade organizations and independent rating systems for guidance, such as:

LEED (Leadership in Energy and Environmental Design) Certification – the primary green building rating system in the world and focuses on providing a framework for healthy, highly efficient, and cost-saving green buildings.

ASHRAE TC9.9 – the current "Data Center Power Equipment Thermal Guidelines and Best Practices" specifications from the American Society of Heating, Refrigerating and Air-conditioning Engineers.

Energy Star for Data Centers – focuses on a given data center's PUE (Power Usage Effectiveness) and overall energy performance relative to its peers.

DEEP (Data center Efficiency Evolution Program) – introduced in March of 2022, this framework for assessment is specific to data centers and takes a holistic approach to sustainability addressing the reduction of carbon emissions, water usage and e-waste.

#3 *Many operators are exploring alternatives for energy sources and UPS technologies as they become available.*

Depending on a facility's location, there are a growing number of sources for renewable power, as well as options for operators to supplement their energy sources through the installation of self-owned solar and wind generation facilities.

- Whenever possible, operators are looking to contract with utility providers that support renewable energy; e.g. solar, geothermal, hydroelectric, and wind-driven generation.

- A number have undertaken battery room upgrades to utilize more efficient and resilient valve regulated lead–acid (VRLA), thin plate pure lead (TTPL), or lithium-Ion battery technology to replace traditional lead-acid, wet-cell technology. While in theory these new options are a substantial improvement, there are a lot of variables in manufacture and utilization that affect battery life, so the real-world ROI and lifecycles of these newer offerings are still being determined.

- The availability of improved battery technology also enables an upgrade to more intelligent, UPS-based cycling/recharging technologies that can result in more energy-efficient charging and greater battery life.

#4 *Energy efficiency is widely considered to be table stakes when updating infrastructure components.*

For this study we covered a broad range of data center environments, from IT departments that specify all components of data center infrastructure to colocation providers who primarily offer hosting space and services. Our interviews revealed that energy conservation remains a universal concern for IT infrastructure decisions as well as supporting services like lighting and environmental controls.

- Most IT buyers now include energy efficiency as part of the formula when making purchasing decisions for updating servers, networking, and storage infrastructure. Fortunately, the majority of enterprise hardware vendors have also been factoring in energy efficiency and heat generation in their product roadmaps with increasingly optimized power supplies, as well as liquid-based cooling options for extremely high-density installations.

- Many operators of green data centers have chosen to update lighting with LEDs, dimmers, and automatic switching to reduce overhead lighting costs. There are a number of options for converting existing fluorescent fixtures to LED based on fixture type, tube size, operating voltage, and ballast, but a well-planned LED conversion can ultimately provide anywhere from 25 to 80% energy savings, as well as substantially improved light quality and lifecycle.

- We were pleased to see that there is a growing trend among operators to reduce the e-waste of decommissioned hardware through donation, refurbishment, or approved recycling. While many of the first-tier enterprise hardware vendors have had recycling programs in place for over a decade, a 2020 study showed that over 80% of discarded electronic equipment is not collected or managed in a responsible manner. Much of this can be attributed to consumer products, but e-waste still represents a substantial source of pollution, so following proper disposal guidelines provides operators with yet another opportunity to improve sustainability.

#5 *Mature and/or well-financed operators are able to invest in intelligent management tools to monitor and automate operational efficiencies.*

For all operators, the process of data center management can be extremely complex, especially for legacy environments that have been modified over years or decades of operation. There are dozens of software platforms available for Data Center Infrastructure Management (DCIM), but effectively using a DCIM usually depends on establishing a dedicated communication framework for connecting the wide range of power and thermal sensors in servers, storage, and networking components, as well as those in power distribution units, computer room air handlers, and other environmental devices.

- Some of our respondents have adopted DCIM technology as a key tool for power management, capacity planning and environmental monitoring. Like so many other IT challenges, you simply can't fix what you can't see, which makes the real-time visibility into the physical environment combined with the historical records offered by a DCIM platform a prerequisite for eventually adopting AI/ML technology for automating common operational tasks and challenges.

- Several respondents cited intelligent sensor placement as a key to providing accurate visibility of operational status and to better identify and predict trouble spots. According to one interviewee, "Temperature monitoring at top, middle, and bottom is required to feel safe increasing the temperature even a degree." However, this can be particularly tricky in rapidly changing environments where new hardware is regularly onboarded, especially so in the case of raised-floor data centers, where changing around floor tiles can have a substantial effect on other systems nearby.

- Greener data centers have utilized dynamic airflow visualization technology to see where heat is generated and how it moves within the data center. Also known as Computational Fluid Dynamics, it's similar to the technology used by automobile and aircraft manufacturers to estimate wind movement and drag on vehicle designs, but it's optimized for tracking the interaction and flow of hot and cool air in a data center that's moving at 0 MPH. Depending on the DCIM product in question, the process is much like the creation of a digital twin. The data center is modeled in a CAD program and rack positioning, heat generation and cooling potential calculations are attached to all racks/devices and coordinated with airflow measurements to get a visualized estimate of the efficiency of a given layout. CFD offers a fascinating look into the invisible world of air movement, but as a simulation rather than a dynamic visualization tool, it's likely more useful as a planning tool rather than a monitoring tool.

#6 *Organizational silos & lack of visibility into energy costs have been found to inhibit sustainable practices.*

The specifics of energy consumption are not commonly shown to IT staff, and according to a number of our interviewees, it's often difficult to separate a data center's energy consumption from the overall costs of the entire facility. It's very common for companies to look at IT energy costs as a necessary evil, simply part of the cost of doing business. It's hard to disagree, given business' continually growing dependence on IT, and as one operator stated, it really doesn't make sense to push energy efficiency to save $20K a year at the risk of crashing a $40B data center.

- We found that disclosure of energy costs is highly variable, ranging from zero IT awareness of energy costs in many enterprises to facility administrators who have full responsibility for infrastructure placement and energy management. "I don't pay the energy bill," one respondent said. "I'd have to spend money to save money on a bill I don't even pay!"

- Many IT-specific administrators don't have either the time or tools to manage energy efficiency. This is extremely common in enterprise environments where the energy efficiency for the IT infrastructure isn't considered to be anywhere near the importance of uninterrupted IT services.

- There's often little visibility of buried costs; e.g., chilled water, generator fuel, and other facility-borne expenses. Again, we found this to be common in smaller data centers where the IT energy costs are folded into the total operational budget.

#7 *Geographical placement leads list of key considerations for new facilities or colocation options.*

Determining the best physical location for a new data center or colo partner is dependent on a number of factors that have changed over the last decade, especially due to the increasing availability of high-bandwidth, low-latency communications around the world. This has left the door open to explore locations as diverse as the US high desert for its solar power potential, or Iceland for its low energy costs and environmentally aided cooling. One of the benefits of the growth of the cloud lies in the fact that data centers have been proven to be capable of existing practically anywhere, with fewer and fewer limitations as technology continues to spread worldwide.

- Many operators are focusing on areas with utilities that offer alternative energy sources. The utility industry is evolving in a number of states to include solar, hydro and wind-based generation options, as well as traditional generation based on natural gas rather than coal.

- Whenever possible, companies are locating where cooler, environmental free air is an option for economizer-based heat reduction. While it's possible to use free air directly, it's more often used indirectly to avoid the introduction of excess humidity and contaminants into the machine room. One of our respondents described their relatively unique use of the "thermal wheel," a rotary heat exchanger technology that leverages cool outside air in place of a chiller.

- Some larger data center operators recommended adopting a "good neighbor" policy that focuses on and includes the needs of the local community. This is an excellent philosophy for any business venture and goes hand-in-glove with the core goal of sustainability: maintaining an ecological balance.

> ***Working hand-in-hand with a local community is an excellent philosophy for any business venture and aligns with the core goal of sustainability: maintaining an ecological balance.***

#8 *Budget-restrained enterprises are exploring alternatives to increasing on-site facility growth.*

Depending on the specific nature of IT production, there are times when it just makes sense to build out additional data center space. However, in our current IT environment, there are few options that can possibly offset the need to build. Given the increasing power demands of some hardware platforms the issue may be more about heat and power management rather than a lack of square footage, but regardless of the specifics there are certainly other ways to extend your production capabilities.

- Some respondents leverage resource monitoring tools to ensure applications are efficiently placed on existing infrastructure. The movement toward providing self-service infrastructure options for developer usage leaves the potential for trapped capacity and underutilization. There are plenty of options available for visualizing and monitoring resource allocation, so an intelligent first step in any expansion project should be an assessment of your existing efficiency.

- There's growing adoption of hybrid cloud utilization for applications that can be placed in the cloud. While the cloud isn't perfect for every application, it should be considered as a possible option for a broad range of non-critical production workloads; provided that your business doesn't have compliance issues that prevent it. One of our respondents mentioned that they were able to migrate the majority of their x86 production to the cloud, which accounted for about 70% of their workload.

- Greener data centers have adopted the use of colo facilities for redundancy or for infrastructure that may be too power dense for existing facilities. Latency can be a problem depending on the nature of the application and the location of its data. But something as simple as insuring a high-performance and extremely hot AI cluster and its data storage are hosted in close proximity within the same facility can minimize any functional latency.

As we reviewed the overall results of our interviews, it was obvious that heat management remains the major data center challenge, which was true even when a typical data center rack consumed less than 5 kW of power. Today, it's not uncommon to find rack configurations that fall in the 20-kW range, not to mention high performance analytics or AI-optimized systems that can exceed 50 kW per rack. To put that in perspective, a single 50-kW rack translates to about 170,000 BTU/hour in heat generation, or more than enough to heat a 3,500 ft2 home. This has been the case for the last two decades: as hardware becomes more powerful and even more energy efficient, the actual physical space it takes up continues to shrink. We've seen this result in raised-floor data centers with some racks that are only partially full because the power consumption is too high to keep cool.

> ***Simply adding sustainability to your thought process when making IT decisions can result in financial, ecological, and social benefits that will continue to pay back in the future.***

Some of these observations, like the use of blanking panels to fill out rack spaces, or even equipment retirement, seem to be pretty minor, but even small efficiencies can have a substantial impact on energy consumption and long-term sustainability. These types of optimizations are often the real key to sustainability when applied at scale, even though it may be hard to see immediate results. Sustainability is a philosophy as well as a goal, and even though environmental concerns have become a political football over the years, simply adding sustainability to your thought process when making IT decisions can result in financial, ecological, and social benefits that will continue to pay back in the future.

Further recommendations to promote sustainability in data center operations:

- Make sustainability a factor in the IT decision-making process and get C-suite buy-in
- Devote a small percentage of annual budget to evaluate ongoing energy conservation
- Work with local utilities to explore current and future green energy options
- Consider liquid-based cooling options for high-energy-consuming racks
- Minimize use of freshwater for cooling; utilize recycled water whenever possible
- Ensure obsolete infrastructure components are either repurposed or properly recycled
- Use blanking panels for a simple and effective way to improve efficiency