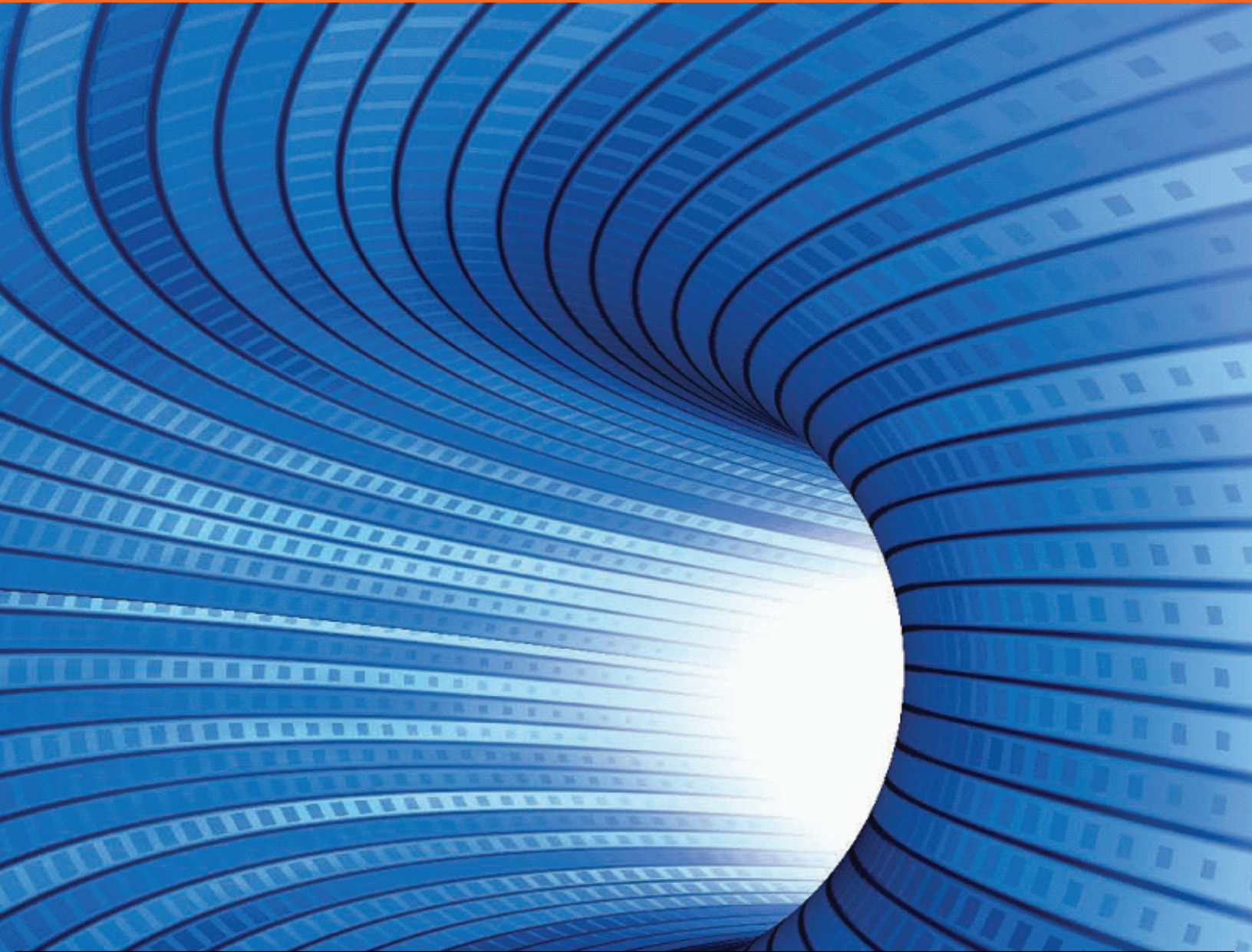


Phase 2: Power and Cooling for Data Centers



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Seeking greater insight through innovative leadership

This report reflects research and feedback from both the High Performance Computing (HPC) and enterprise/telecommunications community, including data centers and vendors, regarding the comprehensive survey conducted in 2009. The final conclusions and recommendations contained herein represent the views of the authors and should not be interpreted as facts, endorsements or official policy, either expressed or implied, by Avetec or IDC.

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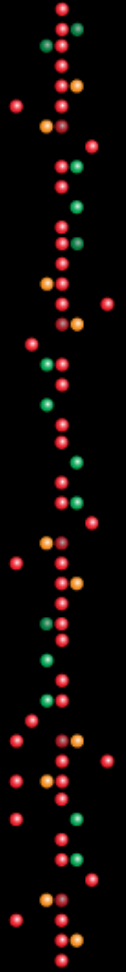


About DICE

Avetec's HPC Research Division - DICE is a geographically distributed test environment that provides independent product and technology testing, validation and consulting services for new and emerging HPC data management solutions. The DICE team works with the HPC community, including vendors, data centers (government and industry) and the research community to evaluate new and emerging products and technology. DICE is the foundation to enhance research computing data and move technology from discovery to deployment.

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KEY NEEDS VALIDATED BY THIS REPORT

1. **High Performance Computing (HPC) is critical to the future of the United States to maintain American competitiveness in science and technology.**
2. **Energy efficiency is critical to the future growth of HPC data centers.**
3. **The United States needs a capability where vendors and data centers can openly test and evaluate emerging power and cooling technologies while protecting intellectual property.**
4. **A strong HPC-community wide (government, industry and academia) partnership needs to be established to research, develop and deploy more energy efficient power and cooling solutions.**
5. **Since federal and state governments are the largest buyers of HPC systems, they must take a leadership role in establishing policies and research directions that will allow for the growth and expanded application of HPC solutions while encouraging innovation in power and cooling solutions.**

Recommendations addressing these needs are listed on pages 5, 6 and 7.

PREFACE:

Avetec, in conjunction with the IDC HPC group, conducted a two-phase study on power and cooling issues, solutions and trends in data centers. The first phase focused on HPC data center sites, HPC hardware manufacturers and cooling manufactures. After analyzing the Phase 1 data, it was clear that the scope of the research needed to include large-scale commercial Enterprise centers as well as resource management software vendors. The inclusion of the information technology (IT) centers is important in that these centers and the HPC centers are beginning to use the same, commodity-based hardware and cooling solutions. In the past, there were a significant number of special purpose processors and manufacturers focused on HPC needs.

Avetec has learned through this two-phase study that both the HPC and IT communities are struggling with power consumption and meeting ever-increasing cooling needs. We trust this survey will spur the creation of best practices to deal with the power and cooling issues. In this report, Avetec felt it was important to communicate to the hardware and cooling manufacturers that a new series of approaches is required in order to meet the growing needs of the community. Finally, we hope the results of the survey will initiate a public policy discussion. If the status quo continues, it appears that our country's reliance on technology to enhance productivity, increase research and discover innovative solutions is at risk. Soon America's power infrastructure will not be able to support the growth in computing to maintain, let alone grow, America's competitiveness in the world-wide community.

POWER AND COOLING STUDY: PHASE 2

The Avetec HPC Research Division, the Data Intensive Computing Environment (DICE Program), was contracted to evaluate data center cooling requirements using conventional air and emerging cooling technologies. This is the second study in a two-phase research project. As part of this study, Avetec subcontracted the IDC HPC group to conduct a worldwide survey of data centers and vendors of HPC products and services.

The Phase 1 study was conducted in the second quarter of 2009 and titled “Power and Cooling Practices and Planning at HPC Data Centers.” This initial, groundbreaking study focused on HPC data center sites, HPC hardware manufacturers and cooling manufacturers. This study revealed interesting findings, but also raised additional questions requiring further research. These were explored in the Phase 2 study.

The Phase 2 study, “Power and Cooling Solutions for Data Centers,” was published and released for public distribution in October 2009. The Phase 2 study, unlike the Phase 1 study, includes both HPC and Enterprise/telecommunications data centers. This approach was taken based on the knowledge that the differences between HPC and Enterprise centers have narrowed as both increasingly use similar commodity-based hardware for compute and storage. The focus of Phase 2 was on current actions, attitudes, approaches, plans and expectations related to energy efficiency and the growing problem of data center power and cooling. Part 1 of this report provides the detailed survey findings from Data Centers and Part 2 from the vendors surveyed for the Phase 2 study.

KEY FINDINGS VALIDATED BY THIS REPORT

1. As the United States' (U.S.) economy shifts from paper to digital electronic information, data centers, including High Performance Computing (HPC), enterprise and telecommunication are critical resources for competing in a world economy.
2. The U.S. data center industry is in the middle of a growth period that is being stimulated by the move to more sharing of information and data across high speed networks.
3. The Environmental Protection Agency (EPA) report to Congress in August 2007 identified the following major concerns:
 - a. During the five years between 2002 and 2007, the demand for computer resources has led to a significant growth in the number of data centers.
 - b. There is significant potential for improvements in data center energy efficiency. The use of existing technologies can reduce typical usage by 25 percent or more even in existing centers.
 - c. The increased power requirements have led to a situation in which new data centers are being built primarily to increase power capacity or exploit lower local power costs, not because the current centers are running out of floor space.
4. A strong community-wide (government, industry and academia) partnership needs to be established to research, develop and deploy more energy efficient power and cooling solutions. There is also a need for industry-wide standards and metrics to monitor and report utilization as well as energy efficiency.

POWER AND COOLING STUDY: PHASE 2

5. The IT community needs incentives to accelerate innovation and emerging solutions in energy-efficient technologies and practices.
6. The IT community needs more insight and accountability for the total cost of ownership (TCO) to include power and cooling usage.
7. The U.S. needs a capability where vendors and data centers can openly test and evaluate emerging power and cooling technologies while protecting intellectual property.
8. The U.S. would benefit from an independent, third party evaluation and validation source for data center energy efficiency. The DICE program, an independent test and evaluation center serving the entire HPC and IT community, is ready to offer this service. This requirement is reinforced in a report by The Department of Energy (DOE) stating that the industry needs an independent, third-party testing body to conduct performance validation of vendor performance claims and results (DOE Recovery Act: Energy Efficient Information and Communication Technology Funding Opportunity Announcement Number: DE-FOA-0000107 CFDA Number: 81.086, date 06/02/2009). This report calls for a proposal that will make improvements in the energy efficiencies of data centers.

CONCLUSIONS & RECOMMENDATIONS

Avetec believes both the HPC and enterprise community are at a crossroads and that power and cooling has become a significant factor in the current operation and upgrade/expansion decisions being made by data center administrators. In the Phase 2 survey, as in the Phase 1 study, all other issues facing data center administrators were treated as constants and set aside so the focus was squarely on how power and cooling issues were being addressed.

Avetec believes that the explosive growth in the number and size of data centers is creating an unsustainable demand for power requirements. The 2009 EPA Report to Congress forecast indicated that unless energy efficiency improvement trends are not accelerated, energy consumption by data centers could nearly double again in five years. By 2011, the energy consumption could reach 100 billion kilowatt hours (kWhs). This rate of increase could require building two additional power plants per year in order to provide the required power.

Future data centers will require as much power as a small to mid-sized city and stimulate greater public policy and environmental concerns. In the HPC domain, the next generation of multi-petaflop systems will each add the equivalent of a small city to the power grid when they are brought online, with some potentially consuming as much as 100 Megawatts. Buyers and vendors alike will feel the impact and should be proactive on this growing issue. Federal government research should be supported and public policy should be fashioned today to support the development of more power- and cooling-efficient data centers, servers and related technologies in the private sector.

Finally, Avetec believes that with the key finding from the Phase 2 study that “most data centers lack a strong internal mandate from their management to improve energy efficiency,” the U.S. will soon be in a crisis mode to improve and/or reduce the power required to operate current data centers. The Phase 2 study also found that energy cost is viewed by many simply as the “price of doing business” and is therefore not considered a limiting factor. If this community-wide view continues to be prevalent, then the community may well find itself in a rationing mode for power. (Some rationing is already starting to take place.)

RECOMMENDATIONS FOR THE COMMUNITY

As a result of the Phase 1 and Phase 2 surveys as well as other research, Avetec provides the following recommendations for government policy makers, data centers and vendors.

1. Recommendations for Government Policy Makers

Avetec believes that the federal government should be very proactive in developing and funding a list of data center energy efficiency goals and initiatives. The U.S. economy and national security are dependent on a resilient and innovative IT community. The IT community is key to the Information Age and will continue to fulfill this role in the foreseeable future. The following recommendations are provided for consideration.

- a. The federal government needs to consider funding research and development (R&D) efforts in the following technology areas that have the potential as a positive solution that will lead to greater energy efficiencies:
 - Advanced power management in hardware and the use of software energy management optimization.
 - New data storage technologies with higher efficiency.
 - New and novel computing architectures that improve energy efficiency.
 - Select game-changing technologies that will have a major impact on the power usage of data centers. The following are examples:
 - o All-optical networks
 - o Superconducting components
 - o Nano-electronic circuitry
 - o Eliminate voltage conversion steps
 - o Transition to direct current (DC) operation
 - o Research on bio-computer circuit design
- b. Provide tax incentives to develop and/or buy energy efficient equipment, software and testing to validate specifications and energy efficiency. Identify and consider modifying any regulatory barriers to innovation.
- c. Support and encourage industry-wide collaboration, forums and sharing of knowledge on energy-efficient solutions and innovations.
- d. Encourage development of industry-wide standards and practices for energy efficiency. Incentivize meeting or exceeding these standards.
- e. Develop a community-wide database to track power usage and best practices.
- f. Monitor industry progress, trends and issues and report findings to the community.

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- g. Encourage research, training and education in power and cooling through incentives, scholarships and grants, including K-12, college as well as current employee continuing education and research.
- h. Support the development and utilization of an independent test and validation center to validate energy efficiency claims, evaluate proofs of concept of new technology and research technology solutions. Encourage the use of/provide incentives to data centers and vendors for utilizing independent testing and validation.

2. Recommendations for HPC Data Centers

The trends and results identified in the Phase 2 study indicate that data center administrators need to take some proactive steps. The following recommendations are provided:

- Continue the focus on power and cooling with emphasis on efficiency as part of the centers' strategic direction to ensure proactive solutions and management. Make return on efficiency part of management and cost reporting, e.g., include this in a balanced scorecard tool. Include "energy efficiency and environmental responsibility" as a focused priority for the entire organization, e.g., develop goals, objectives and strategies and communicate this as an executive priority throughout the organization.
- Developing metrics is an essential first step in understanding current power usage at a data center and making system power efficiency a rational part of center operations and procurements. Thereafter, consistent tracking, reporting and communicating of these metrics are critical to progress. Metrics should reflect cost as well as energy efficiency ratios for facilities and equipment as well as software efficiency.
- Develop specific targets and a baseline. Thereafter, monitor/track performance and report improvements as well as opportunities for improvement. Incentivize meeting or exceeding targets.
- Develop tools to continuously monitor and improve facilities to ensure they remain energy efficient as they age.
- Improving a site's power and cooling profile is a multi-dimensional process. Each site is unique and improvements need to fit their constraints.
- Proactively work with vendors, researchers and the HPC community to identify and pursue breakthrough power and cooling technologies.
- Request cost information to better understand the full cost implications of power and cooling. Develop and track life-cycle cost (LCC)/ TCO to analyze and track the cost of power and cooling. Be wary of government mandates that either reward or punish utilization, e.g., "sin-tax" for using too much power, rationing measures, etc. In addition to bottom line metrics, executives and leaders could become responsible and accountable for energy usage and efficiency.
- Support collaboration and the development of industry-wide standards and practices for energy efficiency. Publicize reports and findings of performance data and best practices.
- Utilize independent testing and validation to understand the impact on data centers and to support acquisition decisions.

3. Recommendations for Vendors

The trends and results identified in the Phase 2 study also revealed areas of recommendations for consideration by vendors. These include the following:

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- It is critical that vendors have a good understanding of the needs and requirements of data centers, and the metrics that are considered are important to the data centers. The metrics of choice most likely will not be consistent from data center to data center. At this time, the community has not reached consensus on one individual metric or set of metrics to measure and monitor energy efficiency. As suggested in the Essential Guidance section of the DOE report, the “Power Usage Effectiveness (PUE)” metric is being used by many centers. This is an excellent starting point.
- In the near term, the most effective approach in moving to more efficiency in energy usage will be achieved by incremental steps. Working with data centers to achieve these steps is more important than trying to make a grand leap.
- Obtaining the level of improvements required in energy efficiency is a complex systems engineering problem. Vendors need to be a part of a team approach and bring their expertise to help solve the problem.
- Include “energy efficiency and environmental responsibility” as focused priorities for the entire organization, e.g., develop goals, objectives and strategies and communicate this executive priority throughout the organization.
- Lobby for funding and corporate tax incentives to develop energy efficient facilities, equipment and software.
- Support collaboration and the development of industry-wide standards and practices for energy efficiency. Publicize reports and findings of performance data and best practices.
- Utilize independent testing and evaluation to validate performance specifications and support data center (customer) acquisitions.