



Energy Efficiency in Digital Infrastructure:

Why It Matters, Why It's Hard, and How to Get It Right

Data center energy consumption is rising sharply, driven by surging demand for cloud computing and AI workloads. At the same time, energy costs are climbing, sustainability regulations are tightening, and the scrutiny of enterprise carbon footprints has never been more intense. For data center operators, energy efficiency has shifted from a nice-to-have initiative to a business-critical imperative.

Yet, despite widespread awareness of the challenge, global average Power Usage Effectiveness (PUE), the primary metric for data center energy efficiency, has plateaued. Many operators struggle to translate sustainability goals into measurable operational improvements. The gap between intent and execution is real, and it is costly.

This paper draws on Uptime Institute's extensive expertise in the field, Uptime Intelligence research, global survey data, and hands-on consulting in management and operations to examine three core questions: Why does energy efficiency matter now more than ever? Why is it so difficult to achieve? And what principles and practices have been proven to drive lasting improvement?



THREE PRIORITIES FOR DATA CENTER ENERGY EFFICIENCY

Efficiency is now a
business-critical requirement

The biggest barrier is execution,
not awareness

IT efficiency offers the greatest
opportunity



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1. The Imperative for Energy Efficiency

The Rising Cost and Scrutiny of Data Center Energy

As demand for digital services accelerates, particularly for AI infrastructure, the energy footprint of the data center sector continues to grow. Grid infrastructure upgrades have increased energy costs over the last two years, and recent commodity price volatility has compounded those pressures further. Results from the Uptime Institute Intelligence Spending and Supply Chain survey show 42% of enterprise and colocation data center owner and operators cited per-kWh energy cost as the area of greatest unit cost increase over the past 12 months – the highest response category for both groups ([see Enterprise and colo spending strategies vary for 2026](#)).

This cost trajectory has reshaped customer expectations as well. Enterprise IT clients increasingly ask colocation providers to justify their power management practices and demonstrate efficiency improvements. Meanwhile, many colocation providers (64%) expect to raise their power prices in the coming years, with most anticipating increases of 6–10%.



of colocation providers expect to raise power prices



of enterprise operators cite power cost as top expense driver



expect new sustainability regulations within 5 years

Source: Uptime Intelligence Sustainability and Climate Change Survey, 2025-2026; Uptime Intelligence Capacity Trends and Cloud Survey 2024.

Regulatory Pressure Is Growing and Spreading Globally

Regulations requiring data center efficiency improvements are no longer a distant concern. According to Uptime Institute's 2026 Sustainability and Climate Change Survey of 369 data center owners and operators, 25% report sustainability regulations are currently affecting their operations, while another 53% expect to be subject to new requirements within the next five years. Only 22% anticipate no regulatory impact.

In many markets, this regulation is translated into explicit PUE mandates. China, France, Germany, the Netherlands, and Singapore have all implemented or proposed PUE limits, with requirements varying by facility type and age. Germany, for example, mandates new facilities achieve a PUE of 1.2, while existing facilities must reach 1.5 by July 2030. Singapore reduced its PUE limit for new facilities from 1.3 to 1.25 in January 2026.

Disclosure requirements are emerging alongside performance mandates as demonstrated in two recent examples:

- The European Union's Energy Efficiency Directive (EED) requires data centers to publicly report detailed sustainability metrics including PUE, Water Usage Effectiveness (WUE), renewable energy fractions, and waste heat reuse readiness.
- Malaysia's proposed five star rating system will use facility specific benchmark PUEs to measure and compare performance, with higher stars indicating superior quality and compliance with sector specific standards.

These requirements will make operational efficiency visible in ways that create both reputational and competitive consequences for operators who fall behind.



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Key Regulatory Insight

Regulations are spreading globally and increasingly specify mandatory PUE limits, not just reporting requirements. Operators who fall short of compliance thresholds face real financial and operational risk.

The AI Factor: Capacity Growth Creates a Sustainability Tension

The rapid expansion of AI infrastructure has introduced a new complication. AI training and inference workloads require dense compute configurations that consume far more power per rack than traditional IT equipment. As operators rush to build or upgrade capacity to support AI demand, some are finding that their sustainability commitments are under pressure.

Uptime Institute's Sustainability and Climate Change Survey, run from Q4 2025 to Q1 2026, found 31% of organizations with net-zero emissions goals have modified or extended those goals due to AI expansion plans. While 42% reported no modification, another 27% were uncertain.

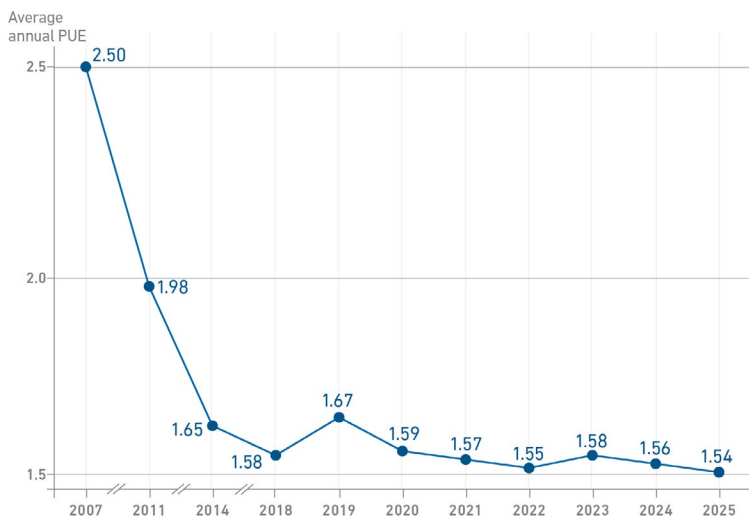
This tension makes efficiency even more critical. Operators who can extract more compute work per watt, through IT equipment efficiency, better utilization, and optimized facility operations, will be better positioned to absorb AI-driven load growth without proportional increases in energy consumption or carbon emissions.

2. Why Driving Efficiency Is So Difficult

PUE Has Plateaued and the Data Shows Why

Global average PUE has improved insignificantly from 2.50 in 2007 to approximately 1.54, according to Uptime Institute's 15th Annual Global Data Center Survey 2025. However, despite more than two decades of industry focus on efficiency, progress has largely stalled over the past several years.

This plateau reflects more than a technical ceiling; it highlights a persistent gap in operational prioritization. Data from Uptime's Management and Operations (M&O) assessment program reveals that efficiency behaviors are consistently under-practiced¹. In M&O assessments across data centers globally, peak energy management processes in computer rooms scored an average of only 46% on proactive behaviors, well below the 80% threshold considered effective. Electrical distribution peak energy efficiency management was similarly weak, averaging 51% on proactive behaviors. The pattern extends to how operators approach efficiency



Source: Uptime Intelligence Global Data Center Survey 2025.

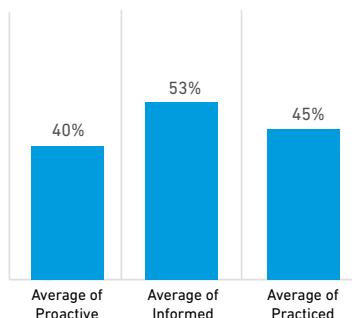
¹ Behaviors are assessed against the principles of proactive, informed, and practiced to highlight the exact area of improvement. To be fully effectively, the behavior must meet the requirement for each principle. Uptime Institute considers 80% a good score.



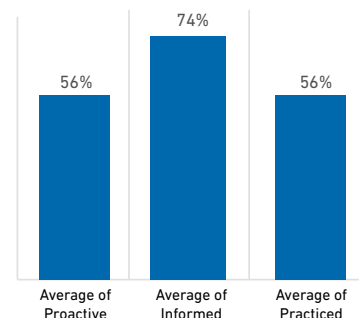
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upgrades and improvements in their data centers. Emerging technologies evaluation averaged only 40% on proactive behaviors. Facility improvement initiatives that explicitly incorporate energy efficiency goals scored only 56% on the practiced behavior. This is shown in the figure to the right. These scores suggest when capex budgets are available and improvement projects are underway, efficiency considerations are often secondary and not an integrated approach.

Emerging Technologies Evaluation Process



Facility Improvement Initiatives Include Consideration of Energy Efficiency Goals



Source: Uptime M&O 2.0 Delivery Data.

The Organizational Barriers

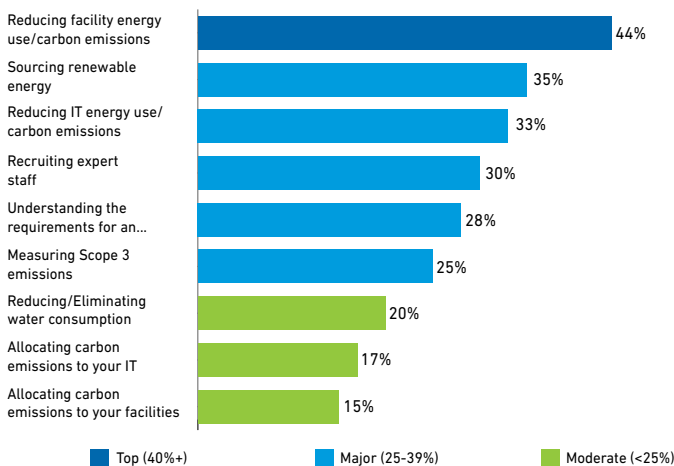
Efficiency is not merely a technical challenge, it is an organizational one as well. An effective sustainability strategy requires cross-functional collaboration between facilities engineering, IT operations, procurement, finance, and executive leadership. Any meaningful change to operating parameters, control setpoints, equipment configurations, or maintenance schedules requires agreement from multiple teams whose priorities often diverge.

Operations teams are typically evaluated on reliability, uptime, and incident avoidance. From this perspective, changes that could theoretically introduce risk, such as raising temperature setpoints, optimizing cooling system efficiency through equipment shut down, or shifting to more efficient UPS operating modes, may appear as challenges rather than opportunities. Sustainability teams may have the mandate to drive improvements but often lack the authority or budget to override operational conservatism.

This conflict is compounded by the complexity of large, multi-stakeholder operating environments. Uptime Intelligence research shows that changing any one parameter, process, or criterion in an operating data center requires agreement from all affected parties. Changes are inherently incremental and must be sequenced carefully to avoid disrupting reliability and performance commitments. In practice, this means efficiency improvements may take months to years to fully implement.

Survey data reinforces these findings. Uptime Institute's 2026 Sustainability and Climate Change Survey asked data center professionals to identify their greatest sustainability challenges over the next three to five years (see figure above). Reducing facility energy use and carbon emissions topped the list at 44%, followed by sourcing renewable energy (35%) and reducing IT energy use (33%). These findings reflect not a lack of awareness but a recognition that execution is genuinely hard.

Greatest challenges to achieving sustainability goals over the next 3-5 years (n=389, respondents chose up to 3)



Source: Uptime Sustainability and Climate Change Survey, 2026.



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The IT Efficiency Gap

One of the most significant challenges in data center efficiency is the persistent disconnect between IT and facilities teams. In most organizations, energy efficiency is treated as a facilities problem. PUE is measured, reported, and discussed primarily in the context of cooling, power distribution, and infrastructure overhead. However, this discrepancy misses the larger opportunity.

IT infrastructure consumes more than 50% of data center energy at a PUE of 2.0. At more efficient PUE levels of 1.1 to 1.3, increasingly common in hyperscale and modern colocation facilities, IT equipment accounts for 73% to 91% of total energy use. Improving IT efficiency is therefore the highest impact lever available to operators, yet it receives far less attention than facility-side improvements.

According to Uptime Intelligence research, doubling IT equipment utilization, a goal that is often technically feasible, can reduce energy consumption by approximately 45%. By contrast, a 20% improvement in PUE (from 1.5 to 1.4) reduces total energy consumption by only about 7%. Improving IT utilization also reduces cooling load and water use, while a PUE improvement affects only cooling systems.

The IT Efficiency Multiplier

Doubling IT equipment utilization: ~45% energy reduction

Improving PUE from 1.5 to 1.4: ~7% energy reduction

IT efficiency also reduces cooling load, floor space, and water use — PUE improvement does not.

Source: Uptime Intelligence (2022), "Reducing the Energy Footprint."

Despite significant opportunities, IT efficiency improvements require collaboration between IT operations, facilities engineering, and sustainability teams that is rarely structured or incentivized. Hardware procurement cycles, workload management practices, and server utilization decisions are made by IT teams who may have little visibility or accountability for the facility-level energy consequences of those decisions.

3. A Strategic Framework for Overcoming the Challenges

There is no single solution to the efficiency challenge. Uptime's global experience working with data center operators has informed a practical operational framework to address these complexities. Drawing on its M&O assessments, energy advisory, sustainability assessment, and intelligence research, Uptime Institute has identified a consistent set of principles and practices that distinguish organizations that achieve sustained efficiency progress from those that do not.

Principle 1: Recognize That Operations Matter as Much as Design

Good facility design establishes a theoretical efficiency ceiling, however, how a data center is operated determines the energy and environmental performance that is achieved in practice. Uptime's experience suggest that operations-phase decisions affect all five major environmental impact categories: greenhouse gas emissions, energy, water, waste, and biodiversity. The relative impact of operations on energy and emissions is comparable to, and in some cases greater than, the impact of the original design.

This insight has a practical implication: operators cannot rely on design-phase efficiency gains to carry them through the operating life of a facility. Temperature setpoints drift. Cooling systems lose efficiency as they age.



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Equipment configurations change. Workloads shift. Without active, ongoing operational management, even a well-designed facility will underperform against its efficiency potential.

Incorporating sustainability best practices into standard operating procedures and treating them as core operational requirements rather than optional enhancements is a foundational step toward realizing the full efficiency potential of a facility.

Principle 2: Build Cross-Functional Alignment and Dedicated Governance

Uptime consistently finds that organizations that make meaningful progress on efficiency have several structural characteristics in common: dedicated sustainability staff, clear organizational ownership of efficiency goals, and a formal plan with milestones and accountability.

Many operators have set sustainability goals without implementing the mechanisms needed to achieve them. Setting a net-zero target or a PUE improvement goal is not equivalent to having a plan. A credible plan requires identified conservation projects, allocated funding, defined timelines, and the active engagement of financial and executive leadership.

The governance structure matters too. Sustainability and operations teams must be aligned, not competing, in their use of available budgets. Reliability and resiliency requirements often dominate capital allocation discussions, leaving efficiency initiatives underfunded. The sustainability team should work with finance and business leadership to secure the resources needed to execute the efficiency roadmap, rather than treating efficiency as a residual priority after operational needs are met.

Uptime's comprehensive sustainability framework covers ten dimensions: sustainability strategy, organizational alignment, facilities energy use, IT systems energy use, water management, circular economy, greenhouse gas reductions, third-party service provider sustainability, IT client sustainability, and site location and design. Organizations that build governance structures covering all ten dimensions, rather than focusing narrowly on PUE or renewable energy, achieve more robust and sustainable efficiency outcomes.

Principle 3: Embed Efficiency into Every Improvement Cycle

One of the most common causes of efficiency shortfalls is treating energy performance as a standalone sustainability initiative, rather than integrating it into the facility's routine upgrade and improvement cycles. In practice, the most cost-effective efficiency gains come from integrating energy performance criteria into every decision, including hardware refreshes, cooling system upgrades, capacity expansions, and maintenance planning.

Uptime recommends operators evaluate energy efficiency implications as a standard component of every capital project and technology evaluation. Emerging technologies should be assessed not only on performance and reliability grounds, but on their efficiency profile relative to the incumbent systems they replace. Facility improvement initiatives should explicitly document energy efficiency goals alongside reliability and capacity objectives.

Failing to make this integration routine means that opportunities to capture efficiency gains at the moment when equipment is replaced, spaces are reconfigured, or systems are redesigned are systematically missed. Retrofitting efficiency improvements after the fact is invariably more expensive and operationally disruptive than capturing them in the original change.

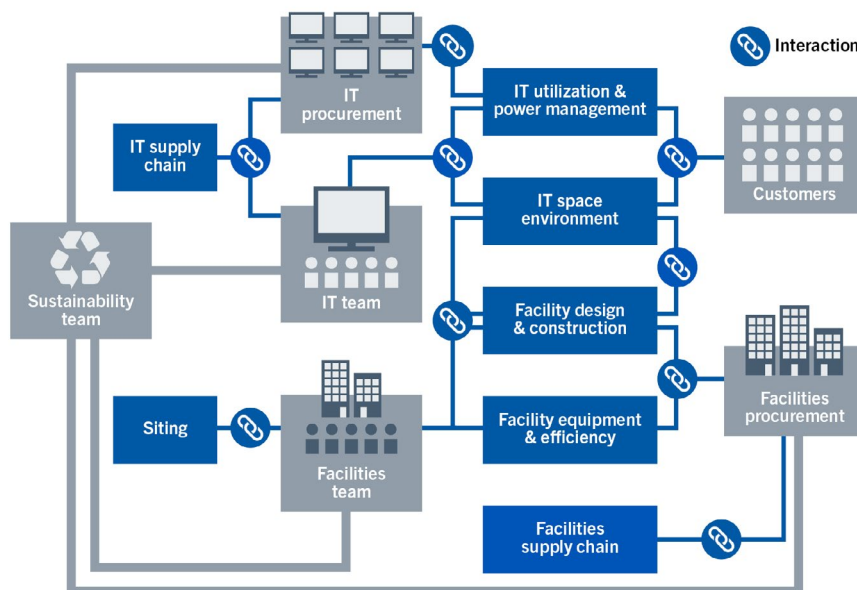


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Principle 4: Elevate IT Efficiency as a Priority

Given the outsized impact of IT equipment efficiency relative to facility-side improvements, operators must make IT efficiency a high priority in their sustainability programs, not a secondary concern relegated to IT teams operating in isolation.

This requires breaking down the organizational silos that typically separate IT and facilities functions. IT procurement teams need to incorporate energy efficiency criteria, including performance per watt benchmarks and capability assessments, into hardware selection decisions. Workload management teams need to understand the energy implications of utilization rates and should actively work to consolidate underutilized servers and maximize resource efficiency.



Source: Uptime Intelligence, 2021.

Key IT efficiency measures include: deploying workload management and power-aware placement software; enabling power management functions on servers that default to performance-optimized modes; setting IT equipment utilization improvement goals and tracking them with the same rigor applied to performance and availability metrics; and aligning hardware refresh cycles to retire energy-inefficient equipment on an accelerated basis where economically justified.

Uptime Institute's 2022 report, "IT Efficiency: The Critical Core of Digital Sustainability," provides detailed guidance on IT efficiency metrics, governance structures, and improvement strategies. The report emphasizes the importance of structured collaboration between IT, operations, and facilities engineering teams, and the need for data center operations to establish IT efficiency as an explicit and measured operational priority.

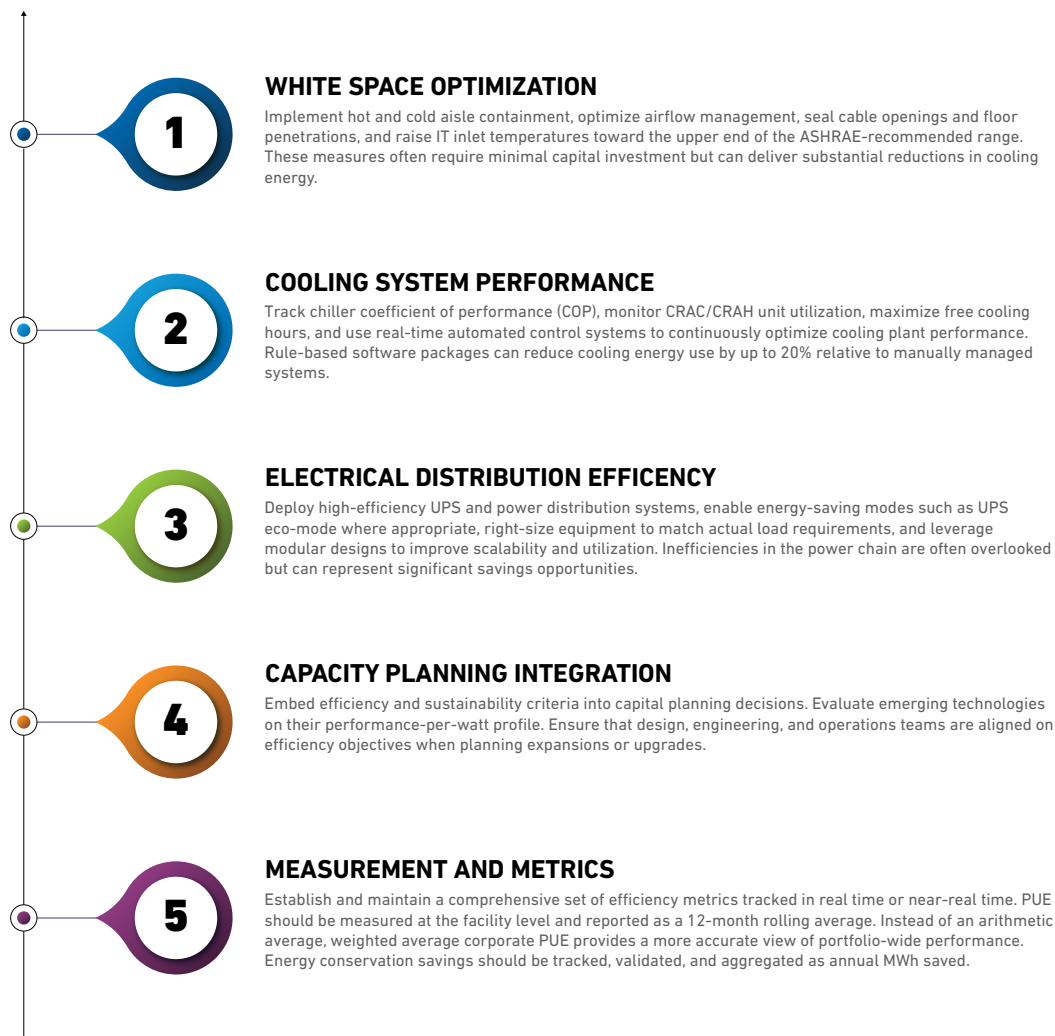
Principle 5: Pursue Facility-Side Efficiency with Discipline and Rigor

While IT efficiency offers the greatest leverage, facility-side improvements remain important because they can be implemented relatively quickly and are central to most regulatory frameworks and disclosure requirements.

Uptime recommends a systematic approach to facility efficiency that covers five primary areas:



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Principle 6: Recognize That Sustainability and Operations Are Complementary

A persistent barrier to efficiency progress is the perception sustainability goals conflict with operational requirements. In conversations with data center operators globally, Uptime frequently encounters the view that reliability and efficiency are in conflict — that raising temperatures risks equipment failures, disabling redundant systems creates vulnerability, and sustainability initiatives distract from the primary mission of maintaining continuous operations.

Uptime's experience contradicts this view. Operators who pass Uptime's Management and Operations assessment or Tier Certification of Operational Sustainability (TCOS) certification, demonstrating excellence in operational disciplines, also tend to perform well on sustainability assessments. Good operational practice and good environmental performance are aligned, not opposed.

The reasons are logical. Many energy efficiency measures also improve operational effectiveness. Better airflow management reduces hot spots and the risk of cooling failures. Improved monitoring and metering enable earlier detection of equipment anomalies. Reducing deferred maintenance by controlling energy costs preserves capital for upkeep. Additionally, organizations whose operations budgets are not consumed by



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runaway energy bills have more resources available for other improvements.

Framing sustainability as a complement to, rather than a competitor with, operational excellence is not just rhetorically useful; it is analytically correct. This key framing can help operators gain the internal alignment and organizational support needed to drive efficiency programs forward.

5. Conclusion: From Aspiration to Action

The data center industry is at an inflection point. Energy costs are rising, regulations are multiplying, AI is driving capacity growth, and the scrutiny of enterprise carbon performance has never been more intense. For data center operators, energy efficiency is no longer a discretionary initiative, it is a strategic and operational necessity.

The good news is that the efficiency opportunity is substantial. Most operating data centers have significant headroom for improvement, both on the facility side and, more importantly, on the IT side. The tools, methodologies, and best practices to capture those improvements exist and are proven.

The challenge is execution. Efficiency programs fail not because the technical solutions are unavailable, but because the organizational conditions, such as the alignment, governance, prioritization, and sustained management attention, are not in place. Closing this gap requires treating energy efficiency not as a project but as a discipline: embedded in operating procedures, integrated into every improvement cycle, supported by dedicated resources and governance, and pursued with the same rigor applied to reliability and availability.

Operators who make this transition will be better positioned to manage rising energy costs, achieve compliance with an expanding regulatory landscape, satisfy customer and investor expectations on sustainability performance, and scale their infrastructure efficiently as AI and cloud demand continues to grow.

Those who fail to act risk falling behind, not just on sustainability metrics, but in the financial and competitive performance that efficiency drives.

How Uptime Can Help

Uptime offers a comprehensive portfolio of services to help data center operators build and execute effective energy efficiency programs:

- Management & Operations (M&O) Assessment: Evaluate operational maturity across 106 behavior areas, including energy management processes.
- Uptime Institute Sustainability Assessment: Assess and advise on environmentally sustainable data center operations.
- Sustainability Strategy Gap Analysis: Expert advisory support for developing and executing wholistic sustainability programs.
- Uptime Intelligence Research: Access to Uptime Institute's global survey data, benchmarking reports, and expert analysis on energy, sustainability, and digital infrastructure trends.
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References and Sources

All data and findings cited in this paper are drawn from the following Uptime Institute publications and research:

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