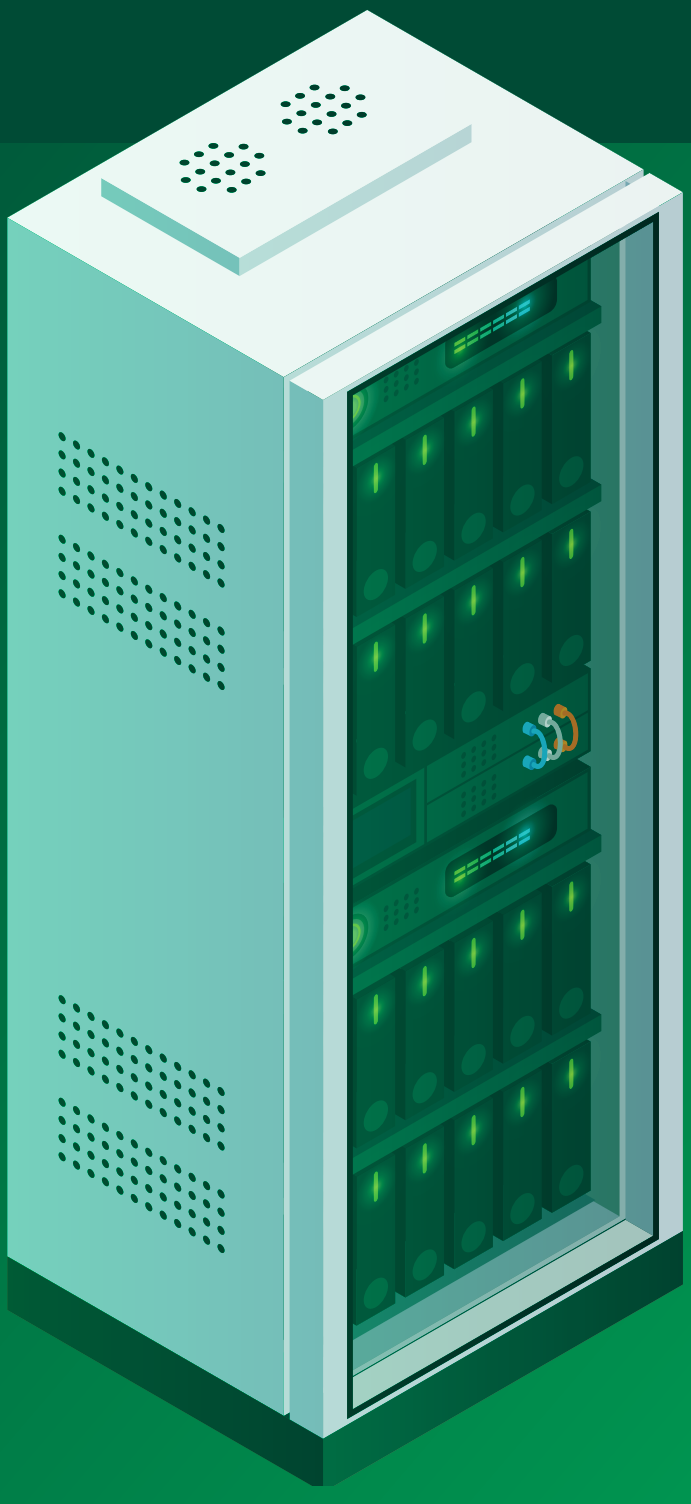
DATA CENTER OPERATIONS INDEX

A Global Benchmark for Data Center Operations



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CBRE

A Global Benchmark

The world of data centers is evolving rapidly. Over the last decade, our reliance upon on-demand technologies has changed the way that technology must be deployed. With digital infrastructure booming, it's critical to stay ahead of what's next for the data center itself. At its core, the data center is the successful meeting of the physical facility, technology, and a sound operational strategy with common goals—maximum uptime, reliability and sustainability with a fully optimized total cost of ownership (TCO).

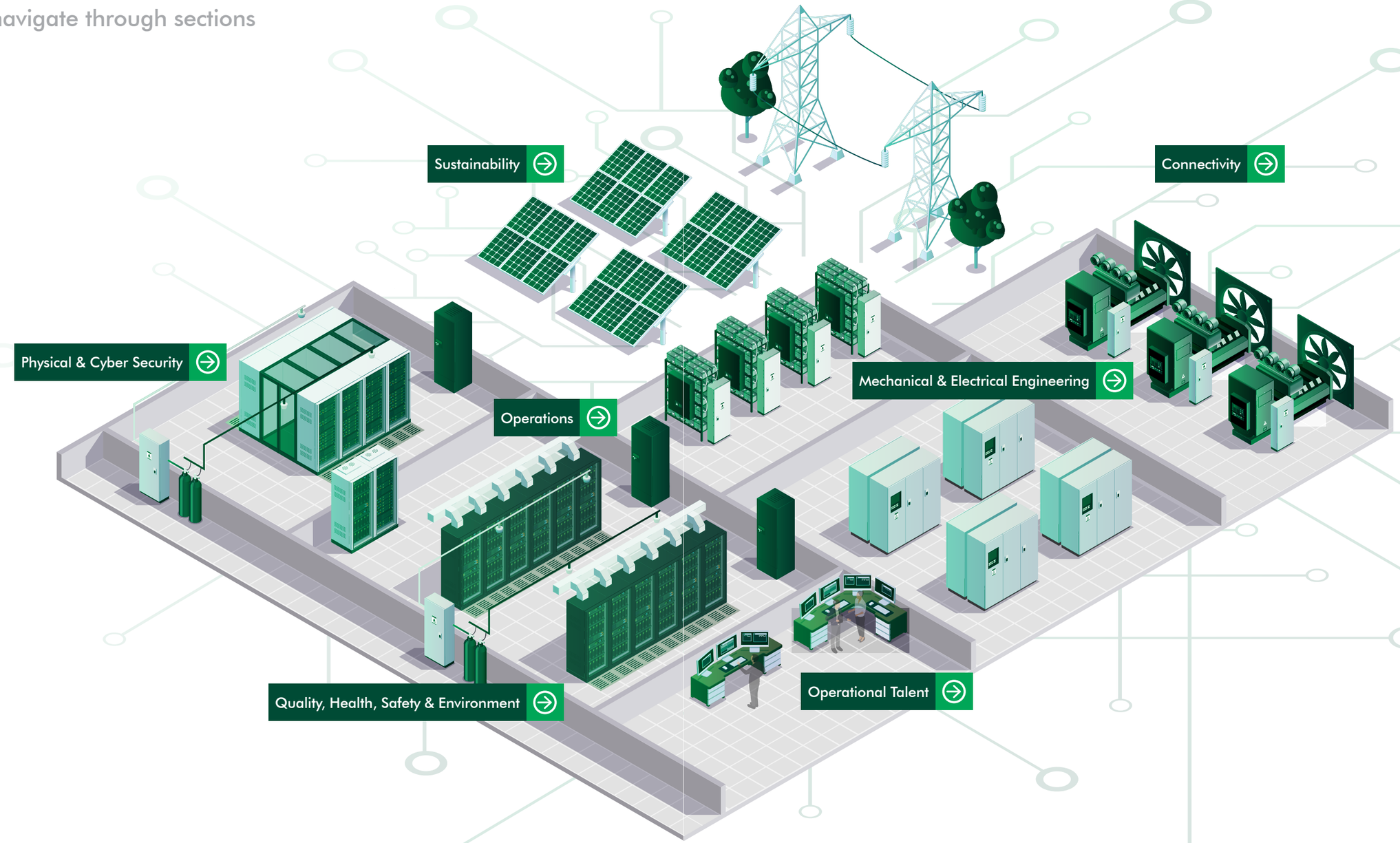
While the data center industry does not have a globally standardized operational model, customer expectations are rapidly becoming consolidated into a single view. For business, facilities and technology leaders, a clear, benchmarked view of the digital infrastructure that underpins the business is vital.

As the global leader in data center operations, CBRE provides a meaningful global benchmark for the operation of data centers, the foundation of the world's digital business infrastructure. These insights, at global scale, provide unparalleled visibility into operations across regions, data center types and operational models. In this report, we'll share a clear picture of how today's data centers operate, what trends will play an increased role in the operational and procurement strategies that keep them online and how you as a data center owner, operator or occupier can meet the market through operational excellence.

Core Operational Factors

A Multi-Disciplinary Operational Benchmark

Click to navigate through sections



State of Data Center Operations

Universal* Themes

The data center market continues to rapidly evolve, both in terms of complexity and criticality to local and global economies. Traditional brick-and-mortar businesses have moved at an accelerated pace to adopt a more complete digital strategy as a response to COVID-19. Restrictions and increased remote working, e-commerce and Internet of Things (IoT) deployments are driving increasing workloads to data centers, placing them more squarely than ever at the heart of everyday life. In parallel, we see the rapid advancements in automation and analytics technologies that are starting to transform the way data centers are operated, helping drive improvements in reliability while simultaneously promising to reduce costs.

Sustainability takes center stage with renewables playing a larger role

An explosion of data center demand in recent years has generated increased awareness of the asset class and its energy consumption. Additional pressure will be placed on operators to create efficiencies through smart investments, energy management and IT strategies. Luckily, sustainable solutions are often good for business, helping both to save on energy costs and advance a widely supported social cause.

Renewable energy availability is also becoming a very real factor in data center energy and sustainability strategies. Many data center operators have begun to claim that they run their data center on 100% renewable energy, enabled through power purchase agreements (PPAs). PPAs allow data centers without easy access to hydropower or other renewable sources to purchase renewable energy at different locations. There are two common ways of doing this:

1. Power purchase agreements (PPAs): Usually used by utility companies, these contracts ensure long-term power delivery and provide funding for the construction of new, renewable generating plants.
2. Renewable energy certificates (RECs): Each REC equates to the generation of 1 MWh of power from a qualified renewable resource, usually wind or solar. This is a common model in the U.S.

PPA contracts suit large data center operators and hyperscalers, as they can afford the required commitment, while RECs are best for smaller data centers not directly serviced by power providers offering PPAs.

The war for operational talent

The demand for a talented data center operations workforce has far outpaced the supply of talent in the market. With an aging workforce in many enterprise locations and technology advancements on the data center floor outpacing the upskilling of existing labor, the global data center workforce is facing a talent shortage that will continue to increase. Historical data center development and site selection has focused on energy costs and network adjacency, but a development boom and the future growth of Edge will create staffing challenges in the market simultaneously creating talent demand in lower-tier markets and the urban cores. Staffing and up-skilling will be major focus areas for operational strategies. Global industry groups like the iMasons have launched large-scale educational initiatives to develop a labor force that can meet this demand.

Assessing existing facilities for an automated future

Aging facilities located predominantly in North America and Europe will assess their ability to adapt to new efficiency requirements and operational standards as automation becomes the norm and demand for capacity continues to grow.

Supply chain put to the test

Widespread retrofitting of existing facilities to meet growing demand, happening simultaneously with increased new development, will place never-before-seen levels of pressure on the data center supply chain. In a post-pandemic world, operational success and maintenance strategies will benefit from global supply chain access, intentional maintenance planning and access to sophisticated project expertise to avoid project delays in existing sites and bring new sites online on time.

The data center as a single system

Applications that are dependent upon Edge will drive an increased interaction between the data center physical infrastructure and the technology layer that inhabits it. For economic reasons, Edge facilities will be low-tier redundancy and therefore have an increased likelihood of failure. Applications at the Edge will be designed to failover and move the workload to another local Edge site without loss of service, just as we see today with the mobile network operators. This will create the idea of the data center as a single system from an Edge perspective. Additionally, we will see the rise of technology to control the application and CPU loads based on external conditions, such as increased external temperatures. This type of technology is present in some cloud providers' core architecture, but Edge will see this technology become more mainstream in both Edge and other data center environments.

Global connectivity

The increased demand for compute capacity at a global level has driven a surge in the need for connectivity. Spend on subsea cables has accelerated with multiple parties joining forces to accelerate the development and reduce their costs. The need to shift workloads from one place to be processed to another with cheaper, greener energy is becoming more apparent. The world isn't fully connected yet, with perhaps only 50% of the world having internet connectivity. For example, 745 million people in China have internet access, but the country has a total population of 2 billion people. There will be a pushback from Edge as the telecommunications companies reclaim revenue for their investments in network connectivity that powers the content delivery.

* Did You Know: DC's Are Headed to Space

Japanese IT service and consulting company, NTT DATA Corporation, and Japanese satellite communication company, SKY Perfect JSAT Group, announced that they are partnering to launch and operate a data center in space in 2026.

SOURCE: Moss, Sebastian. "NTT and SKY Perfect JSAT to Launch 'Space Data Center' in 2025." DCD, 19 May 2021

State of Data Center Operations

Regional Operations Trends

North America

Early enterprise adopters face early obsolescence.

The United States was the epicenter of early enterprise data center development, with many large, costly and (by today's standards) inefficient sites being built in the 1980s and 1990s. These aging facilities, many of which did not benefit from additional investment during and after the dot com bubble burst, are large areas of exposure for many enterprises who must decide whether to decommission or retrofit for a more efficient future.

Artificial intelligence and machine learning advancements drive compute power demand.

The United States, already the home of the cloud and the force behind the hyperscale boom, is the epicenter of innovation in the areas of artificial intelligence and machine learning. This booming technology sector drives compute power and density needs in the region, forcing data centers to meet this growing demand. As autonomous vehicles and other IoT technologies continue to advance and enter the market, facilities in the United States will set the global standard for reliable operations.

Asia Pacific

First gen connectivity and modern design fit for the future.

For decades the APAC region did not benefit from the same historical "copper in the ground" telecommunications infrastructure that other regions have. This infrastructure was the foundation of early internet-based services and the data center market at large. While this may have created a lack of connectivity in decades gone by, exploding investment in advanced digital infrastructure is bringing online the most sophisticated and largest network of data centers in the world.

Similarly, new development means that newer facilities are designed with automation and next generation operations in mind.

Geographic diversity impedes scaled efficiencies.

Vast distances between major markets and diverse business environments create a barrier for data center development, staffing and operational consistency in Asia. Cross-border operations strategies have created huge value through regional efficiencies in both Europe and North America. Many Asia-based players have found success by aligning disparate operating mindsets through global operator partnerships.

Europe

Data sovereignty, higher cost of land and energy innovation result in smaller, more efficient data centers.

The European data center market has not experienced the same critical mass that the U.S. has and as Asia will. Higher cost of land and energy have resulted in data centers across the region built smaller but much more efficient.

European data centers are often smaller in both size and megawatt (MW) capacity and housed in multiple-level buildings, which is far less common in both North America and Asia Pacific. This has also led to European data centers regularly using dry coolers rather than the innovative cooling technologies more commonly found in North America.

Sustainability and carbon taxation drive design innovations.

Europe is home to the world's most rigorous sustainability standards and carbon taxation programs. These economic realities have driven data center design in the region to be the most advanced in the areas of sustainable design, efficient energy consumption and many other areas impacting the environment.

Latin America

New demands in the region bring higher investment.

Record protection and increased internet use, demand has greatly increased in the Latin American data center market. High investment in the market is driven by increased co-location demands from the world's largest technology companies. New service providers are investing to build hyperscale facilities and more efficient data centers with connectivity in Mexico, Colombia, Chile and Brazil. With this increased demand comes an increased need for talent, which currently needs to be transferred from areas of the world to supplement shortages.

Aging facilities leave questions for owners and operators.

Following the U.S., which was the epicenter of the first wave of large data centers, the second wave were built in the Latin America region in the 1990s and early 2000s. The owners and operators of these aging data centers will quickly need to decide next steps to keep up with today's more efficient and flexible facilities. Newer facilities are being built with a modular design and energy efficiencies to compensate for the utility and predictability limitations.

Africa

Population growth puts pressures on DC facility and operational skill requirements.

By 2030, 20% of the world's population will live in Africa, with more than half of that populating to cities by 2040, driving demand for connectivity. A push for data to remain in the continent and a focus on economic diversification drive the need for more facilities across Africa. The continent's unstable infrastructure has resulted in robust power solutions with generators as the primary supply or alternate gas or renewable power plants. The skills required to manage these facilities will require additional emphasis on power management and, more broadly, a focus on training and talent development in a region where digital infrastructure careers have been limited in the past.

DC sees a trend of new purpose-built & efficient facilities.

Africa is one of the last untapped data center markets. The region's strategies to address the continent's power infrastructure concerns have given rise to new, purpose-built facilities with global efficiency and resilience specifications. This means that from the outset, Africa will be positioned well to attract the incoming hyperscalers. This development complements new subsea fiber infrastructure projects coming online between 2021-2023 with ACE, Equiano and 2Africa creating a North, East, South and West technology hub structure, which will form the basis of the Africa digital ecosystem.

Benchmarking Your Data Center

Mechanical & Electrical Engineering Design

It's crucial at the early stages of design for users to consider designing for operability, reliability and TCO of the data center through its entire lifecycle and not just the initial capital outlay.

The mechanical and electrical (M&E) infrastructure is the foundation of all data centers. If the foundations are sound and fit for purpose, the data center's value proposition in the marketplace is attractive. Over the course of the decade, significant change to the mechanical and electrical infrastructure designs for data centers have been driven by several factors:

1. **New, more efficient technologies**
2. **Improvements to IT hardware resilience**
3. **Green energy and energy conversation initiatives**
4. **Cloud technology (mirror sites) allowing for reduction in physical resilience on site**

Network architecture and application design should also be considered when designing the M&E engineering. Building resiliency into the network or application layer could be considerably more cost efficient than building this into the physical M&E infrastructure. There are further benefits when considering speed to market, supply chain constraints and lead times for equipment such as generators.

Utility grid availability should also be considered as this, along with network and application design, can help to remove the need for standby generators completely and significantly improve the overall total cost of ownership (TCO) of the data center.

M&E design continued on the next page

Benchmarking Your Data Center

Mechanical & Electrical Engineering Design

Enterprise

Enterprise data centers are often not located in dedicated buildings or environments; as a result, the mechanical and electrical design is often compromised to serve both data center and other areas of the facility and is therefore difficult to monitor and optimize. Many enterprise data centers are now between 10 and 25 years of age, sharing the mechanical and engineering plant with other parts of the building or campus, making segregation difficult and resulting in maintenance and monitoring challenges. With age also comes the challenge of density; many enterprise data centers cannot provision the density that today's enterprise technologies demand. As a result, the enterprise data center will often suffer from stranded capacity.

Co-location

Co-location data center facilities can present some of the same challenges as a traditional enterprise data center in that it can be hard to accurately monitor the performance a tenant is receiving. Multi-tenant co-location facilities—unless the end customer organization has secured a large portion of the co-location facility—have high levels of shared infrastructure. As a shared facility, the design of the critical systems is important so that the organization is aware of the concurrent maintenance of key features of the data center; this can be a challenge to monitor as many co-location facilities do not have a standardized setup—though some operators claim otherwise.

Hyperscale

Typically, modern and at full capacity, the mechanical and electrical engineering design focus with hyperscale data centers must focus on the use of energy. Not only is energy consumption an issue that needs to be monitored, but due to the scale of energy usage, even a small percentage savings in energy can result in huge reductions in CO^2 emissions and costs.

Speed to market is critical when building at scale, with commissioning a critical step that often gets squeezed as it's at the back end of the schedule. Ensuring the data center is performing to the design criteria and operating as intended is critical to the overall risk and TCO profile.

CBRE's patented Romonet validates the building operations against the design intent and continually monitors through its lifecycle providing real-time feedback of performance, energy consumption and cost.

Key Operational Considerations

Mechanical

1. What is the cooling medium within the data center?
2. Can the cooling system be extended or upgraded for additional thermal capacity?
3. Is the cooling system a modular or centralized cooling arrangement?
4. What is the current level of redundancy within the cooling system?
5. Service level agreement risk
6. Is there segregation throughout the mechanical infrastructure?

Electrical

1. What is the redundancy of the incoming utility power system?
2. What is the redundancy of the HV/LV transformers onsite?
3. Are there dedicated and segregated A&B power streams from HV to IT rack?
4. Are the A&B UPS systems segregated?
5. What is the redundancy level of the UPS back-up systems?

Benchmarking Your Data Center

Physical & Cyber Security

Data center security strategies must have access to and protection of data at their core. The proliferation of data center numbers, type and location presents a unique set of challenges to the security sector. Principle among these is how to effectively converge physical and cyber security measures into an operationally integrated framework.

A zero tolerance of downtime means that data center security must be responsive, not reactive.

Leaders in data center management are taking a cross-functional approach to achieving this, with principle risk owners such as IT, HR and FM all included in designing and implementing security solutions, providing security staff & managers with the tools to succeed. A zero tolerance of downtime means that data center security must be responsive, not reactive. As such, security solutions need to be capable of monitoring and predicting threats in a timely manner, supported by escalation measures capable of rapidly scaling to a range of predetermined and unplanned threats. The growth of AI and analytics-based technologies are providing data centers with the tools to respond to and mitigate threats, but they must be underpinned by human interventions and well-informed management decisions.

An exponential rise of cyber-based threats makes managing the risk a top priority. Defeating the cyber adversary requires a fully integrated and constantly evolving defense. The most sophisticated network security infrastructure is only as good as its weakest link, which is typically the people operating and accessing data centers. As such, the investment into network and data protection must be matched by an equivalent investment in operations, training, testing and assurance to minimize human risks, whether deliberate or accidental.

Physical & cyber security continued on the next page

Benchmarking Your Data Center

Physical & Cyber Security

Enterprise

Operating an enterprise data center from the headquarters building of an organization and expecting the main physical and cyber security apparatus to meet the needs of data center security is a considerable risk. An enterprise data center requires distinct security procedures and services to ensure it has sufficient protection, including monitoring and planning for external threats. Of particular importance is ensuring the security personnel are supported by effective and integrated security technology and infrastructure. Staff and suppliers should be vetted and trained on the unique needs of their specific data center.

Co-location

CBRE studies find no common standard of security within co-location data centers, ranging from co-location facilities with excellent practices including well-documented systems and processes and the campuses split into separate zones with multiple layers of perimeter and internal security. When working with a co-location facility, it is vital that procedures are rigorously enforced with regular testing to ensure compliance. Identity checking and the escorting of third parties should be standard practice. Procedures should also be clear and concise as some co-location sites have unnecessarily complicated security processes, which compromises operational efficiency. Some sites offer customer access to certain security features, such as CCTV camera feeds in segregated customer areas, and may offer bespoke access control and key management overlays.

Hyperscale

The nature of hyperscale data centers means that security is of prime importance, and the majority of hyperscale facilities have security services well above those seen in an enterprise or co-location data center. Despite this, perimeter security can be a challenge for some hyperscale service providers, and extra measures for physical and electronic security are regularly required. Convergence of physical and cyber security measures must be at the center of a hyperscale data center's security strategy.

Key Operational Considerations

Leadership & Governance

1. Is there a clear, written physical and cyber security strategy in place, based on assessed and quantified risks to the data center?
2. Are staff aware of their responsibilities and is an organizational structure in place to deliver effective physical and cyber security operations?
3. Is a system of governance and assurance in place to drive a culture of continual improvement?

Physical & Operational Security

1. Are systems in place to continually monitor, preempt and respond to physical and cyber threats?
2. Are guarding operations supported by effectively and proportionately designed physical and electronic security measures?
3. Are security operations supported by effective procedures designed to deliver effective day-to-day asset and data protection requirements and capable of supporting responses to security incidents?

Personnel & Supply Chain Security

1. Is a system of routine personnel and supply chain vetting in place?
2. Are suppliers' contracts supported by SLAs and KPIs that are aligned to the data center's overarching security strategy?
3. Is supplier performance routinely and independently tested through learning-based assessments, driving quality and continual improvement?

Benchmarking Your Data Center

Connectivity

The Internet of Things (IoT) or 5G mobile devices is generating and consuming new data in large volumes.

As companies move to an increasingly digital world, data centers are becoming the cornerstone of digital infrastructure and the availability of cost-effective, resilient connectivity and 'cloud on-ramps' is vital. No matter the type, data centers require robust connectivity from multiple and diverse sources to guarantee connectivity—the focus on digitization means that data volumes are increasing exponentially, and the next generation of applications is going to drive that even further.

The move to a more distributed world, where everybody needs to be able to connect from wherever they are to an increasingly sophisticated range of platforms, means that connectivity has become critical infrastructure for all organizations. Lockdowns have shown many companies that being able to access and rely on flexible bandwidth is essential for maintaining their systems. The move to cloud infrastructure has also brought a new level of importance to connectivity, with cloud on-ramps providing secure, flexible and reliable solutions for application delivery.

The huge growth in new technologies such as the Internet of Things (IoT) or 5G mobile devices is generating and consuming new data in large volumes. Data center fiber connections have to carry volumes of data that were not considered feasible a few years ago, and as requirements increase for distributed network traffic between data centers, cloud services, consumers, devices, corporate offices and home offices, the role of the backbone network that provides inter-connectivity between them all increases in prominence.

The 3 pillars of connectivity:

1. **Metropolitan Fiber**
   Last-mile fiber networks connecting the site
2. **Long-Haul Fiber**
   Network that connects the site to the world
3. **Interconnection**
   Regional connection hubs where long-haul and metro networks meet to create the service-point edge

Connectivity continued on the next page

Benchmarking Your Data Center

Connectivity

Enterprise

On-site enterprise data centers can pose the business a series of risks and compromises with respect to connectivity. Sharing the facilities and connectivity with the main organization makes bandwidth a critical resource. Providing additional network connectivity can be complex and costly to install, depending on the location. CBRE recommends that best practice is to use at least two different routes to the data center and multiple vendors to ensure resiliency. Organizations with significant technology requirements will frequently use dark fiber to provide interconnections between their data centers, but this can be very expensive. Rarely do cloud on-ramp providers surface in an enterprise data center, although secure low latency connections from enterprise data centers into public cloud providers is becoming more and more popular.

Co-location

Co-location facilities can typically connect their customers to a wide range of leading Tier-1 network service providers with a simple fiber cross-connect. For companies with "cloud-first" hybrid cloud strategies, it can be advantageous to look for a co-location provider that can deliver either a cloud on-ramp or direct connection to the main hyperscale cloud services. CBRE recommends validating the selected network service providers' pathways, pricing and capabilities.

Hyperscale

Due to their scale, hyperscale data center providers typically have strong and varied Tier 1 network service providers connected. Adding additional Tier 1 connectivity is rarely a challenge with hyperscale locations and providers.

Key Operational Considerations

On-Site Presence

1. Are the right network service providers available in the data center? If not, how can you get them to the site and what are the potential costs?
2. Can you get dark fiber for mission-critical services?
3. Can your providers offer you the right value-add services?
4. Can you increase capacity easily and without digging in new cables?
5. What is the market pricing for the services needed?

Diversity / Resillience

1. Do you have an ingress and egress site communication systems plan that maximizes network resiliency?
2. Are your selected providers using their own network or someone else's?
3. Are the network fiber routes into and across the site taking diverse paths?
4. Have you validated the actual routes being taken by your provider's fibers to ensure there are no single points of failure?

Cloud On-Ramp Availability

1. Who can offer you direct connectivity to the cloud services you rely on?
2. How flexible are their services and pricing models?
3. What are the limits if you need to increase capacity?
4. Are there better routes available?

Benchmarking Your Data Center

Operations

A data center can only deliver services in line with the design and build intent if it is well managed and maintained regardless of the Tier rating.

Whether a facility is managed through a traditional shift coverage pattern, fully automated with remote monitoring or somewhere in the middle, it is vital to ensure that the processes and procedures being adopted (whether by people or codified into automation scripts) are complete, fit for purpose and will deliver the expected outcomes.

Inevitably, despite the best operations model, design and supply chain, things can go awry. It is crucial that your operations teams are well-drilled in failure scenarios and implement learnings from root cause analysis as part of the continuous improvement mindset.

Where facilities have significant human participation in the delivery of service it then becomes important to establish the competence, confidence and self-awareness of those individuals, which includes a comprehensive review of training programs supported by a continuous improvement culture with regular reviews of capabilities.

Organizations must ensure that the operational procedures and processes of a data center provider fit the needs of the business, whether it is an on-site enterprise data center operated by an outsourced service provider, co-location facility or hyperscale provider. When assessing the operations, organizations must be sure of service levels, staffing procedures, monitoring and methods of managing visitors to the data center. Enterprise, co-location and hyperscale all carry some level of operational risk if there is not a good awareness and monitoring of operations. Monitoring tools provide organizations with insight, but it is vital to ensure that the monitoring is of a standard that provides data the business requires to truly understand its data center operations.

Supply chains play a key part in operations, especially within warranty periods while OEMs are supporting. Ensuring that you have the right partners supporting the data center is crucial along with ensuring call-out SLAs are aligned to the business needs. Managing the performance and capabilities of your critical supply chain should be an ongoing exercise, along with creating a culture of continuous improvement.

Operationalizing your maintenance strategy

Integrating your maintenance strategy into your day-to-day operational approach will provide an added layer of reliability and cost-savings to your data center but can also introduce areas of risk. Key risks to consider and mitigate include:

1. Resilience Risk –
   The performance of the data center under component, system or utility failure
2. Redundancy Risk –
   Redundancy is typically required for power supplies and cooling components as they are crucial for maintaining system health, accessibility, and reliability
3. Service Level Agreement Risk –
   A data center SLA is a service level agreement that covers all the key infrastructure elements and service metrics like power, temperature, and network availability
4. Site Constraint Risk –
   Data centers are normally aligned to industry standards for secure environments, which bring significant challenges when delivering a project such as when and how deliveries can be made and who has authorization to be on-site

Click to read more and discover risk mitigation strategies in CBRE's article **Lessons from a Live Data Center**

Operations continued on the next page

Benchmarking Your Data Center

Operations

Enterprise

Enterprise data centers can benefit from dedicated operational staff providing high levels of performance but can also suffer from sharing stretched resources with split responsibilities. In HQ buildings, DC operations can be compromised by sharing infrastructure with the general building services. In outsource arrangements, careful management of OLAs and SLAs is required to ensure service continuity, efficiency and cost effectiveness.

Co-location

While operational responsibility remains with the co-location provider, customers need to ensure that processes and procedures are fit for their purposes. The use of smart hands and other remote services requires clear routes for service requests, escalation and monitoring. Access to monitoring systems can provide transparency but is available only in some providers. Reporting and compliance with OLAs and SLAs are increasingly important factors for many enterprise users of co-location data centers.

Hyperscale

By and large, sites owned and operated by hyperscale providers are relatively new facilities with modern plant and control systems combined with highly standardized operational models designed to meet the precise needs of the hyperscale provider. There are benefits of having standardized designs to build at speed and scale and leverage learning across the portfolio of sites.

Key Operational Considerations

Services

1. Are your service level targets aligned to your customers' needs and your design standards?
2. Are your Standard Operating Procedures (SOP), Maintenance Operating Procedures (MOP) and Emergency Operating Procedures (EOP) up to date?
3. Have you considered doing disaster test drills on your EOP and continually updating them through lessons learned?
4. Is your approach to risk management, maintenanceand vendor/subcontractor management aligned holistically with your approach to reliability and your TCO modelling (e.g., maintain vs. run to fail)?

Staffing

Jump to: Operational Talent Section

Monitoring

1. Are you monitoring your facility at the correct level to capture data points that drive informed decisions? Does your monitoring allow for a proactive approach vs. incident response?
2. Are your escalation procedures aligned to your customers' needs and tested as part of your EOP drills?

Visitor Management

Jump to: Security Section

Benchmarking Your Data Center

Quality, Health, Safety & Environment (QHSE) Management

The fifth industrial revolution is placing unprecedented demands on data centers, infrastructure and services, and the demand for capacity, quality, resilience and reliability of service increases with every step forward. Operating a data center in a way that minimizes the impact on the environment and the risk to the people working within it, while ensuring consistent processes to maintain and operate the facilities in a safe, sustainable, and reliable way, is critical to meeting that need.

Robust, effective and efficient QHSE management relies on the holistic management of risks and opportunities through methodical identification, evaluation, mitigation and monitoring.

Advances in technology capability, engineering longevity, material and component evolution are changing the way that sites are managed, requiring fewer people on-site to monitor and intervene and less manual monitoring and intervention. The need for robust, effective and efficient QHSE management has not diminished; if anything, as the on-site human presence becomes reduced, QHSE becomes more critical.

QHSE programs need to be demonstrable to the business and stakeholders outside of the site boundary. Measuring, collating, analyzing and sharing data in ways that demonstrate leading positions and the ability to compare and learn is a key element of continuous improvement. Robust, effective and efficient QHSE management relies on the holistic management of risks and opportunities through methodical identification, evaluation, mitigation and monitoring. This needs to be implemented through robust standards, consistent processes that drive measurable, continuous improvement, and an integrated approach that places equal priority on technology, engineering and people.

QHSE Management continued on the next page

Benchmarking Your Data Center

QHSE Management

Enterprise

Enterprise data centers have the benefit of being under the control of the organization ecosystem, with consistent and integrated approaches to risk and opportunity management, on-site physical support and consistency in the methods used to deliver work.

The critical nature of data centers requires that QHSE arrangements are tailored to the unique risk and operational challenges. Specific attention is needed to assess human factors, behaviors and level of compliance and potentially to implement a more stringent approach to technical design, installation, maintenance, upgrade and decommissioning.

Co-location

Co-location facilities bring the benefit of scale, consistency and flexibility. The approach to QHSE must be flexible enough to deal with necessary variations and expectations but maintain consistency wherever possible, leading with the need for consistent processes and behavioral expectations and providing the basis to mitigate human risk factors.

Risk and opportunity management by its very nature is a collective responsibility at co-location facilities, and providing clear analysis to customers and operators is essential to ensure risks are addressed and opportunities realized.

Hyperscale

Hyperscale sites enable focused and streamlined QHSE due to reduced numbers of stakeholders and potentially a single system for the entire site or portfolio.

QHSE management can be focused on efficiency and standardization based off the client's need and can benefit from scale to reduce associated costs relating to mechanical and electrical, security, operations, sustainability and talent management.

Fewer stakeholders mean fewer "challengers." A focus on continuous improvement, review and benchmarking is essential to maintain the highest standards of QHSE.

Key Operational Considerations

Leadership & Behavior

1. Are the behaviors that are expected of everyone at a site clearly defined, communicated and visibly demonstrated?
2. Are procedures defined, implemented and clearly communicated, along with the consequences for not demonstrating the expected behaviors?

Risk & Opportunity Profiling

1. Have you created a holistic risk profile through methodically identifying, evaluating and defining controls for all risks at the site?
2. Do you methodically review and where beneficial pilot and implement programs and technology that enhance efficiency, safety, consistency or integrity?
3. Do you have a program that regularly reviews the risk and opportunity profiles?
4. Do you regularly test procedures, drills and emergency measures that have been defined as mitigating controls?

Management System

1. Do you have clear, concise and targeted standards that detail the minimum expectations for all high-risk processes?
2. Do you have clear processes that define how tasks need to be completed to ensure that roles and responsibilities are clearly understood?
3. Do you have a regular review process to ensure that you learn from errors, incidents, near-miss events and non-conformances?

Assurance

1. Do you have planned, consistent, documented and auditable assurance processes that verify the compliance with all key legislative requirements and risk controls?

Benchmarking Your Data Center

Sustainability

To benchmark data centers, focus should be on implementation of effective sustainability goals, flexible energy usage and innovation, use of renewable energy sources and reducing water usage.

As data center growth has accelerated during the pandemic, considerations for the most part have focused on growth and not necessarily on sustainability. The servers, storage equipment, backups and power cooling infrastructure in data centers require a lot of energy. The leaders in data center management are focused on the sustainability of data center management, focusing on efficiency gains, artificial intelligence, colder environments, cheaper renewables, flexibility of demand and using waste heat for other requirements.

The first step to consider when benchmarking sustainability is to find out your baseline. Setting science-based targets based on that baseline can support further work in this area. Companies wishing to set science-based targets need to consider the greenhouse gas emissions associated with their internal operations, including their direct emissions (Scope 1) and the emissions related to the energy used for their operation (Scope 2) as defined by the GHG Protocol Corporate Standard. If a company has significant value-chain (Scope 3) emissions (over 40% of total emissions), it is also required to set a Scope 3 target that clearly demonstrates the company is addressing the main sources of value-chain GHG emissions.

Sustainability continued
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Benchmarking Your Data Center

Sustainability

Enterprise

Enterprise data centers vary in their sustainability efforts and are often dependent on the larger enterprise sustainability goals.

Enterprises can benefit from a wider sustainability program that can be used for setting targets and addressing the overall company sustainability goals. However, there can also be complications in terms of shared facilities where complete ownership of the infrastructure does not lie with the data center itself.

To improve efficiency and reduce cost over time, considerations should be taken for energy supply options, energy efficiency measures, water and waste usage.

It is also recommended to benchmark your facility against a co-location option and evaluate which one is more efficient and will best align with your sustainability goals.

Co-location

Many co-location companies are focusing on sustainability, not only to drive down energy usage but also because of the positioning upside of strong sustainability initiatives. With end clients putting more and more focus on the topic, it can create considerable competitive advantage.

For co-location operations, scale brings efficiency and cost reduction. Whether a single- or multi-customer site, the greatest sustainability benefits come with scale and standardization, creating an advantage through standardized processes and systems to manage energy, greenhouse gas emissions, water and waste.

It can be useful to keep up to date with new innovations in the market and benchmark against best practice in the hyperscale environment.

Hyperscale

Hyperscalers are front runners in data center sustainability, utilizing their enormous scale to bring efficiency and cost reduction.

Due to the scale and purchasing power of hyperscalers, they can benefit from Power Purchase Agreements (PPAs) that are usually used by utility companies to ensure long-term power delivery and to provide funding for the construction of new renewable generating plants.

Most hyperscale data centers have ambitious sustainability goals that place additional focus and value on automation and innovation as well as continued implementation of energy efficiency plans.

Large hyperscalers can benefit from their scale and position as frontrunners by keeping a continuous focus on innovation as the market evolves

Key Operational Considerations

Sustainability Goals Implemented

1. Do you know your baseline in terms of your current energy usage, carbon emissions, waste and water usage?
2. Do you have sustainability goals and metrics implemented?
3. Are your goals documented and reported in a transparent and measurable way?
4. Have you considered the life cycle aspects of future investments into your data center?
5. Are your goals also evaluated to mitigate potential supply chain issues?

Renewable Energy Usage

1. What renewable options are available from your utility provider in your geographical location?
2. If renewable energy sources are not available what possibilities are there for power purchasing agreements or renewable energy certificates?

Water Usage

1. Do you have a zero-water cooling solution, or do you have a plan for water usage reduction?

Energy Innovation

1. Are you up to date with best practices currently on the market?
2. What tools are you using to forecast, collect and analyze your data?
3. How are you improving the energy efficiency of your plant?

Waste Management

1. How is your waste managed today, and do you have an operational process for waste handling and recycling?
2. Have you implemented any tools for extending the expected lifetime of your equipment?

Benchmarking Your Data Center

Operational Talent

Recruiting, retaining and developing high performing talent is critical to the success of the data center sector; however, advancement could be stalled by serious talent challenges. This is not endemic to a specific point in the DC lifecycle but is a trend that has been identified by organizations working from planning & design through operations across the globe. The data center sector requires people who are not just highly skilled but also have key behavioral attributes, such as high resilience, to operate successfully in high-pressure environments. With up to 70%* of outages in DC's attributed to human error, it is imperative that organizations not only recruit, but properly train, retain and develop their staff to operate successfully.

Traditional associations between inexperience and unplanned downtime have historically created a reluctance to invest in emerging talent, leaving the sector with a mid-level skills gap that needs to be bridged to dampen the impact of the imminent "silver tsunami" of retirements. Organizations need to focus not only on next generation talent but also career transitions from other sectors to meet demand. To that end, more work is needed to improve visibility of the opportunities in the sector alongside demonstrating clear career paths to new and existing employees. Additionally, the sector will benefit from training and educational programs—robust academic routes into careers either directly from school or from related fields. Younger workers can be recruited at a lower cost and trained in the company's specific culture and ways of working. Organizations should also consider focusing on attracting more diverse talent to broaden the talent pool as well as taking advantage of the various government initiatives to try to bridge the gap between schools and workplaces.

These programs will be critical as recruiting from within the industry has not shown to be a sustainable solution for filling near-term talent gaps. The sector is characterized as a high-growth, job-rich and candidate-short market where competition for talent is fierce. Recruitment challenges are exacerbated by the fact that data centers are typically built in either mature, saturated markets where unemployment for technically qualified talent can be as low as 0%. Organizations find themselves aggressively competing over a finite pool of qualified talent within a given geography. In cases where data centers are built in more remote areas with small or nonexistent technical talent bases, talent teams are forced to create enhanced compensation and relocation packages to draw talent from core markets.

In this changing environment, workforce planning and a comprehensive understanding of the talent supply chain are critical. Leaders need a deep understanding of the talent marketplace to put the right planning and core talent strategy in place to ensure they have the skills their workplace needs. While the DC sector continues to grow, organizations will be unable to leverage it without the right talent. To secure their future, companies must look to address the talent crisis now.

Operational Talent continued on the next page

*SOURCE: 70% Of DC Outages Due to Human Error." Uptime Institute

Benchmarking Your Data Center

Operational Talent

New Markets & Remote Locations

Including Nordics, Africa, Australia, Latin America

Currently in markets with limited or no existing data center talent, companies are focusing on identifying parallel sectors in their regions where key skills or behaviors overlap with the ideal data center candidate.

When focusing on career transition, it is important to clearly articulate how the roles you are hiring relate to roles in the sectors you are approaching, emphasizing the many opportunities available in the data center sector. This will be critical to ensuring talent stays in the sector, especially in cases where declining sectors that once provided steady recruiting pools experience a resurgence.

New markets can rapidly become 'hot' and, as with mature markets, a strong focus on employee engagement (including company culture, learning and development, career opportunities, wellness, etc.) will be integral to ensuring high staff retention.

Leveraging global programs originally created for more mature data center markets will be a great tool for quickly scaling, training and educating programs in new and remote markets.

Mature Data Center Markets

Including FLAPD, Singapore, U.S.

In these markets, employers are firmly focused on recruiting, developing talent and, critically, retaining talent who may be frequently approached about opportunities with competitors. A clearly articulated employee value proposition, an internal talent acquisition function and investment in external employer branding strategy has been demonstrated to deliver results. Investment in a diverse, inclusive and engaging candidate experience also delivers results.

In mature markets, candidates will usually have multiple options, so engagement is critical. A strong focus on employee engagement (including company culture, learning and development, career opportunities, wellness, etc.) ensures higher staff retention in highly competitive markets.

Many organizations have been successful building long-term partnerships with academic institutions and supporting data center-related academic courses to create long-term talent pipelines.

Key Operational Considerations

Talent Attraction

1. How do you identify current and future hiring needs, including critical skills gaps?
2. What are the key talent segments that you are targeting, and what are the best methods to communicate with them?
3. What type of market are you recruiting in (mature/immature), and how will this affect your approach?
4. Are your attraction and hiring strategies diverse, equitable and inclusive?
5. How do you successfully onboard new employees?

Talent Retention

1. What is your retention strategy for critical talent given changing candidate priorities (differing by generation)?
2. How do you measure employee engagement and act upon the feedback?
3. Does sufficient operational documentation exist to ensure no loss of knowledge should a critical team member depart?
4. How do you ensure a strong, positive and consistent culture to have a greater chance of retaining top talent?

Talent Management / Development

1. Are there defined career paths for your data center talent?
2. How do you identify critical talent, talent gaps and high performers?
3. What is your approach to mentoring and succession planning?
4. How does your learning and development strategy support your business growth?

Custom Benchmarking Solutions

Benchmarking Your Data Center with CBRE

CBRE offers customized benchmarking assessments through its Data Center Assessment Reporting product (DCAR). Through this process, data center owners, occupiers and investors can gain insights into the specific operational performance of their portfolio, identifying opportunities to create value and drive efficiency.

The process:

Client requirements for the data centers are captured in an initial client workshop, which can be held on-site or online as necessary. The CBRE team will capture immediate requirements, such as space, power, security and support, but will also gather information about strategic intent in order to gain an understanding of how requirements might evolve over time to accommodate business growth, change initiatives, technology refresh programs or development projects. This also helps take into account the impact of hybrid cloud strategies over time, which can be important in determining not just spatial and power requirements but also changes to connectivity, including dedicated on-ramp services to public cloud providers.

An important aspect of the assessment is that the scoring system can be tuned to reflect client priorities. Certain elements, such as resilience, security or connectivity, can carry different priorities for clients, so the scoring can be weighted to bring out the relative importance of the key factors in the final report. The initial client workshop is also used to understand those priorities and document them for the analysis and reporting phases. For co-location data centers, separate workshops are held with the owners and operators for deep dives into the various categories as outlined on the next page.

The CBRE Custom Benchmarking Process

1 Request for Data

+ Documents
+ Schematics
+ Drawings
+ Certifications
+ Policies
+ Operational Reports

2 Workshops

+ Understanding of client requirements & priorities
+ Deep dives into data provided
+ Sessions for electrical, mechanical, building control & security

3 Site Visits

+ Optional but recommended if possible

4 Analysis

+ Scoring
+ Weighting
+ Benchmarking
+ Risk analysis
+ Report writing

5 Report

+ Presentation of findings & conclusions
+ Highlighting of red-flags

Learn more about your benchmarking considerations

Benchmarking Your Data Center with CBRE

For Occupiers & Enterprises

Most enterprises have constantly changing requirements for data centers, often because of digital transformation agendas, which lead to four distinct challenges with capacity planning:

- Cloud services adoption for significant levels of the IT workload results in a proportion of the workload moving out of the enterprise data center. However, many organizations discover that enterprise cloud computing programs deliver lower migration levels than forecast and at a slower rate than planned.
- Modern IT equipment is getting denser, which results in data centers needing to deliver more power and cooling in a smaller space. Legacy data centers do not provide enough flexibility to adapt to new power densities, which can lead to stranded capacity, such as empty racks that cannot be used due to the lack of adequate power or cooling.
- IT equipment upgrades, moves, additions or decommissioning, leads to a "swiss cheese effect," where pockets of unusable space are left throughout data halls.
- Migrating or moving IT equipment is expensive and a high risk – many mature data centers have poor inventories or asset databases, the systems are complex and interconnected, networks are extremely complicated, and security systems make change highly risky.

For Enterprises in Existing, On-Premises Data Centers

On-premises, single-occupancy data centers were once considered essential and the safest business option. However, today most on-premises data centers are now aging and frequently suffer from legacy mechanical and electrical systems, buildings in need of repair and inflexible spaces that were designed for older, low-density technology. Highly regulated sectors with IT operational resilience demands, such as financial services and pharmaceuticals, remain the mainstay of the on-premises data center requirements. As a result, benchmarking an on-premises data center is valuable for the following reasons:

- Independent assessments of legacy data centers that focus on risk evaluation are used to formulate plans for each data center's long-term future, typically deciding on a maximum lifetime or planning for remediation works.
- Comparison of like-for-like data centers within their estate provides a consolidation plan for closing the least efficient and cost-effective sites.
- Industry and peer benchmarks provide organizations in highly regulated sectors with a standard that matches them with organizations facing the same challenges.

For Co-Location Data Centers

The co-location data center has become a cost-effective, resilient and flexible alternative to operating or owning a data center. As organizations increasingly move towards a hybrid strategy including both cloud and co-location, benchmarking provides the ability to analyze co-location facilities and improve the procurement process with intelligent, data-led analytics.

Benchmarking provides a standard evaluation that allows enterprises to assess the most important physical and operational attributes of the co-location data centers in their selection process—a recommended discipline when changing co-location providers or migrating to co-location from an enterprise on-premises data center.

For Investors

Data centers are a reliable and profitable investment, particularly since the onset of the COVID-19 pandemic. Benchmarking provides valuable insight into the investment process and can be used for any type of investment appraisal:

- Site acquisition
- Platform acquisition
- Sale and (partial) leaseback
- Disposals
- Portfolio valuation

Operational Excellence

CBRE Data Center Solutions

CBRE maximizes data center uptime, placing talent and risk management at the heart of our operational approach.

We develop a deep understanding of your portfolio, applying our global scale, expertise and buying power in the right configuration to make your data center work harder for you.

Our focus is your data center's uptime. Our clients benefit from experience and best practices accumulated by managing ~700 data centers in 45 countries – more than any firm in the world.

CBRE's services stand out where it matters most – best-in-class training and proprietary technology platforms are the foundation of our life cycle data center services. Our team, over 3,800 strong, ensures uptime and delivers peak performance for your customers; with services that range from extensive maintenance, technology operations, consulting and project management to energy optimization and analytics.

What our customers expect from us

- **Uptime** – zero unplanned downtime
- **Safety** – 100% compliance all the time
- **Operational Excellence** – quality & operational excellence
- **Predictability** – use monitoring & analytics to reduce risk & forecast capacity
- **Access to Talent** – consistent supply and retention of quality data center professionals
- **Operating Efficiency** – balance site performance with cost to operate & maintain
- **Supply Chain** – leverage our global buying power to provide resiliency & competitive prices
- **Cost Reduction** – unlock maximum value of data center assets

The Global Leader in Data Center Operations

- **45 Countries**
- **2,175 Data Center Technicians**
- **200+ Data Center Project Managers**
- **~700 Managed Data Centers**
- **99.99968% Uptime**
- **$74B Supply Partnerships**
- **>4M Hours/Year DC Operation**

CBRE's Data Center Services

- **Critical Engineering & Management**
  We maintain the mission critical engineering & infrastructure that is essential for data center business continuity.
- **Supply Chain**
  We have built the most advanced and comprehensive procurement networks to leverage our aggregated spend and deliver significant client savings.
- **Analytics & Monitoring**
  Our automated analytics & monitoring improve the speed & quality of critical decision making for data center operations.
- **Technology Operations**
  Our teams will significantly improve the efficiency of your site management through our deep experience and the use of innovative technology.
- **Energy Optimization**
  We help data centers operators optimize their energy performance through efficient cooling systems and cost-effective energy contracting.
- **Project Services**
  Our dedicated projects division specialize in delivering project services to data center clients globally.

For more information on Data Center Solutions, please visit cbre.com/datacenters or contact:

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