CEEAMA *Live Wire*

E-NEWSLETTER

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Topic for January 2026

ELECTRICITY IN DATA CENTRES

"Inside: This month's hot topic and smart reads..
NEW YEAR'S FIRST QUIZ AWAITS YOU..!!

Electrical Consultants Newsletter
Volume No. 4 Issue #55
January 2026

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Chief Editor - CEEAMA LIVEWIRE

From the Editors Desk,

As we step into 2026, I would like to begin by wishing you, your near and dear ones a very Happy, healthy, safe, Prosperous, and fulfilling New Year 2026. May the days ahead bring you peace, and good health too!

I want to express my sincere appreciation and gratitude to each one of you & your colleagues & friends for supporting LiveWire throughout 2025 with increased readership, appreciation feedbacks and contributing good articles. Encouraging all to do more esp. in sending articles!

The year 2025 has been challenging to all shaped by macroeconomic uncertainty, trade tariffs and an increasingly polarised global landscape. Yet, through it all, our passion for engineering, our perseverance and commitment to our endeavours ensured we stayed the course and continued to move forward with clarity and purpose.

As we step into 2026, we remain mindful of the environment around us while entering the new year with confidence. We believe the year ahead will bring greater stability, renewed momentum and meaningful opportunities to build, innovate and grow together.
Let's see the new year as an opportunity to dream bigger, set new standards, achieve more, perform better and lead with purpose. Let's carry forward the lessons, triumphs and challenges of the past. Therefore, before we hang a new calendar on our walls, let us reflect on the year gone by with a sense of contentment, gratitude and humility – recognising how far we have come and how much further we go.

CEEAMA - Builders and Contributors of a Viksit Bharat
We can see blue skies on our economic horizon, signalling an era of steady growth. Many finance pundits reassure that the ecosystem is positive for many business houses in India.
Domestic growth is set to accelerate, fuelled by benign inflation, the lagged effect of 125bps in rate cuts and Rs. 1Lakh crore in tax relief.
Critical reforms – including GST rationalisation, 100% FDI in insurance, the new labour codes and private sector entry into nuclear energy – will support India's growth aspirations.
Thus, we should begin 2026 with confidence and enthusiasm. Once again, wish you and your loved ones a Happy New Year. The best, truly, is yet to come.
Thank you once again to our CEEAMA GC members too for everything they do passionately.
Finally, read something very nice:
2025: Thank you for showing me I could Win and lose, fail and succeed, cry and laugh and still not break!
2026: I'm ready for all the new experiences, miracles, & blessings. I'm grateful for all the good that's on the way!

Happy Makar Sankranti, and Happy Republic Day!!!

Subhash L. Bahulekar
Chief Editor – CEEAMA

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From the President's desk:

Dear Friends,

Wishing you all a very happy and prosperous new year 2026. As we step into a new year, may it bring renewed hope, good health, and fresh opportunities for growth and harmony. Let us move forward together with positivity, compassion, and a shared commitment to building a brighter future for all.

There are several opportunities to look for in 2026 and beyond.

The power grid will increasingly be controlled by software layers with AI-driven protection, digital twins, and cloud-based energy management making power engineering as much about algorithms as about conductors. The grid is also expected to move from Centralized Reliability to Distributed Resilience; meaning instead of preventing every fault, future grids will expect failures and self-heal using microgrids, islanding, and autonomous reconfiguration will be in place. Year 2026 and beyond will also see that energy storage will be treated as a grid asset, not backup. Batteries, supercapacitors, and hybrid storage will actively regulate frequency, voltage and congestion, thus becoming integral grid components. As an out of the box thought, I came across a reference that indicated "Power flow studies in future will include carbon flow alongside real and reactive power, enabling carbon-aware dispatch and protection decisions." The future is exciting as well as getting increasingly complicated.

There are a few initiatives at CEEAMA that we are exploring to make CEEAMA exciting as well. There have been several additions in the Life Fellow Members (LFMs) in the recent past which augurs well for CEEAMA. The onus is now on providing opportunities to meet and discuss prevailing and new opportunities in the industry. The CEEAMA website is undergoing changes and we should be having a all-new-look website hopefully by April 2026. Industrial visits and seminars would continue as before and we would be exploring opportunities to hold technical sessions outside our regular areas.

We at CEEAMA are reminded that this is a time to rise with renewed energy, and to aim higher just as kites soar toward clearer skies. May this New Year, guided by the spirit of Makar Sankranthi which marks the sun's transition into a new celestial path and the end of winter, inspire us to move forward with hope, gratitude, and the courage to embrace brighter horizons ahead. I wish all your dreams come true in Year 2026!

Republic Day on 26 January stands as a celebration of India's constitutional strength, unity, and progress. Just as the Constitution provides the framework that powers the nation's democratic functioning, electrical engineers design and maintain the systems that energize modern India. The need for adopting NEC 2023 and other standards cannot be emphasized more. The reliability, precision, and innovation inherent in electrical engineering mirror the principles of stability and foresight enshrined in the Constitution.

In addition to this, I earnestly request you to please share your experience by using the LiveWire platform. Every day we come across many professional challenges. Documenting them helps in honing our reporting skills as well as help the fraternity to learn from your experience. I am sure people will benefit by shared learning. I also request our Associate Members to kindly indicate whether we can have a factory visit conducted at your premises. We could decide based on mutually convenient dates and plan logistics accordingly.

Enjoy Makar Sankrant and celebrate the Republic Day with verve.

Mr. Chidambar Joshi
Hon. President
CEEAMA

From the Secretary's desk:

Dear Esteemeed Members,

As we step into 2026, I extend my warm wishes to you and your families for a year filled with good health, professional fulfilment, and continued success. The beginning of a new year offers us a moment to reflect on our journey so far and to renew our commitment to excellence, ethics, and innovation in the field of electrical engineering consultancy.

The year ahead presents significant opportunities and responsibilities. Rapid advancements in energy efficiency, renewable integration, digital substations, EV infrastructure, smart buildings, and evolving statutory requirements demand that consulting electrical engineers remain vigilant, updated, and proactive. As professionals entrusted with safety, reliability, and sustainability, our role has never been more critical.

Our Association will continue to focus on knowledge enhancement, professional development, and collective growth. In the coming months, members can look forward to technical seminars, expert interactions, codes and standards awareness programs, and forums for experience sharing. We also aim to strengthen engagement with regulatory authorities and allied professional bodies to ensure that the voice of consulting electrical engineers is effectively represented.

I encourage all members—senior consultants and young professionals alike—to actively participate in Association activities, contribute technical articles, share case studies, and mentor the next generation of engineers. Your involvement is the true strength of our Association.

Let us move into 2026 with renewed enthusiasm, integrity in practice, and a shared vision of elevating the standards of our profession.

With best wishes for a productive and rewarding year ahead.

Best Regards,

Mr. Ulhas Vajre

Hon. Secretary

CEEAMA

ELECTRICITY IN DATA CENTERS - OVERVIEW

Data centers are the beating heart of our digital world, but they come with an enormous appetite for electricity. Every click, stream, and AI query fuels a global network consuming hundreds of terawatt-hours annually -enough to power entire nations. With hyperscale facilities drawing up to 200 megawatts each, the energy footprint of our cloud-driven future is staggering. As demand surges 5–10% every year and AI workloads threaten to double power needs within five years, the race is on to make data centers smarter, greener, and more efficient.

Today, data centers already consume 448 terawatt-hours annually, accounting for nearly 1.5% of global electricity demand, and this figure is projected to soar to 945 TWh by 2030 as per International Energy Agency (IEA) reported in 2025. A single hyperscale facility can draw up to 200 megawatts, enough to power an entire city. With annual demand growing at 5–10%, and AI workloads expected to double power needs within five years, the challenge is clear: the future must be radically more efficient and sustainable.

Innovations are emerging-liquid cooling slashes energy use by up to 40%, AI-driven optimization trims another 10–15%, and renewable integration is becoming standard, with operators aiming for 100% green energy sourcing. Battery storage systems of 10–50 MWh are being deployed to stabilize intermittent solar and wind power, while waste heat reuse and carbon-neutral strategies redefine sustainability goals.

The next decade will see data centers evolve from energy-hungry giants into intelligent, eco-friendly power hubs. They will not only support the digital economy but also contribute to global energy resilience. The race is to make this vision a reality and the stakes couldn't be higher.

1. **Power Consumption and Efficiency**

   - Energy Demand Trends: How global data center electricity usage is growing with cloud computing and AI.
   - PUE (Power Usage Effectiveness): Strategies to reduce PUE and improve energy efficiency.
   - Server Optimization: Using virtualization and containerization to reduce idle power consumption.
   - Hardware Innovations: Low-power processors, ARM-based servers, and energy-efficient storage

2. **Renewable Energy Integration**

   Renewable energy integration in data centers involves sourcing electricity from clean, sustainable sources like solar, wind, and hydro to reduce carbon emissions and reliance on fossil fuels. Many operators aim for 100%

renewable energy sourcing, often through on-site generation (solar farms, wind turbines) or long-term power purchase agreements (PPAs) with green energy providers.

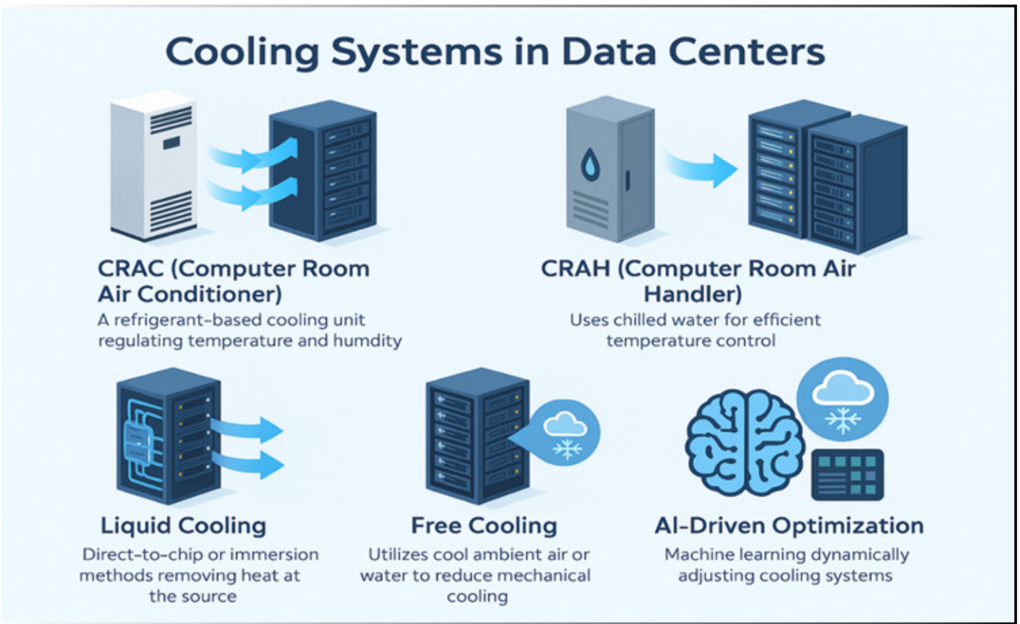
Because renewable sources are intermittent, data centers deploy battery energy storage systems (10–50 MWh) to maintain stability and ensure continuous operations. Some facilities also combine renewables with grid balancing strategies and advanced energy management systems to optimize usage. This approach not only supports sustainability goals but also helps data centers become more resilient and cost-efficient over time.

Batteries and other storage to balance intermittent renewable supply.

3. Cooling Technologies

Data centers rely on advanced cooling systems to maintain optimal temperatures for servers and networking equipment, ensuring performance and reliability. Traditional air-based solutions like CRAC (Computer Room Air Conditioner) and CRAH (Computer Room Air Handler) are widely used. CRAC units use refrigerant-based cooling to regulate temperature and humidity, while CRAH systems utilize chilled water for greater efficiency in large-scale environments.

Modern data centers increasingly adopt innovative technologies for higher efficiency and sustainability. Liquid cooling methods, including direct-to-chip and immersion cooling, remove heat at the source, reducing dependence on traditional air conditioning and supporting high-density workloads like AI and HPC. Free cooling leverages naturally cool outside air or water sources to minimize mechanical cooling costs, while AI-driven optimization uses machine learning to dynamically adjust cooling systems based on real-time conditions, cutting energy consumption and operational expenses. These advancements collectively aim to lower power usage effectiveness (PUE) and support greener, cost-effective data center operations.



4. Backup and Reliability

- **Grid Power Supply**

  Primary source of electricity for the data center, delivered through transformers for voltage regulation.
- **Transformer**

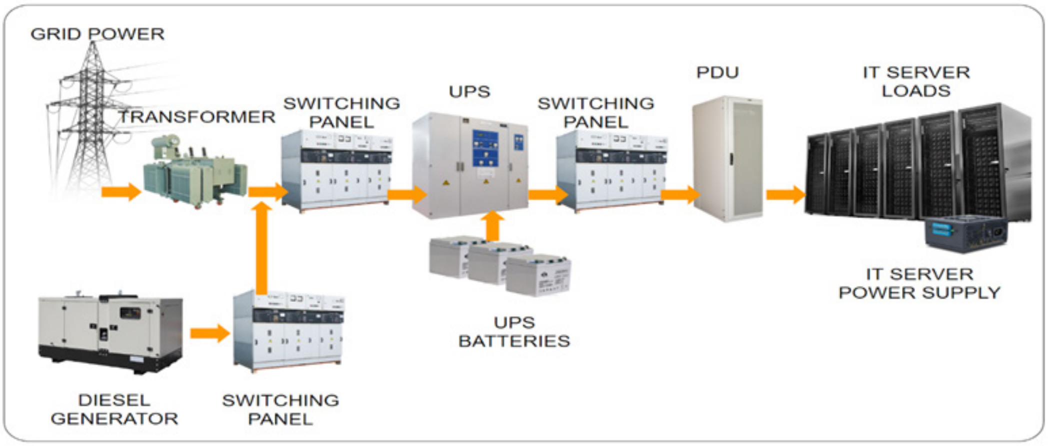
  Converts high-voltage grid power to usable levels for IT equipment and backup systems.
- **Switching Panels**

  Direct and manage power flow between grid, UPS, and generator systems for seamless transitions.
- **UPS (Uninterruptible Power Supply) & Batteries**

Provides immediate backup power during outages using UPS batteries, ensuring zero downtime for critical servers.

Short-term power source to keep systems running until generators start.

- **Diesel Generator**



Long-term backup power solution activated during extended grid failures.

- **PDU (Power Distribution Unit)**

Distributes conditioned power from UPS or generator to IT server loads.

- **IT Server Loads**

Critical computing infrastructure that requires continuous, reliable power for operations.

5. **Sustainability and Carbon Reduction**

- **Carbon-Neutral Goals**

Companies aim for zero emissions in data center operations by using renewable energy, improving efficiency, and offsetting carbon remaining through credits or removal initiatives. Many organizations also invest in carbon capture technologies and set strict timelines to achieve net-zero targets by 2030 or earlier.

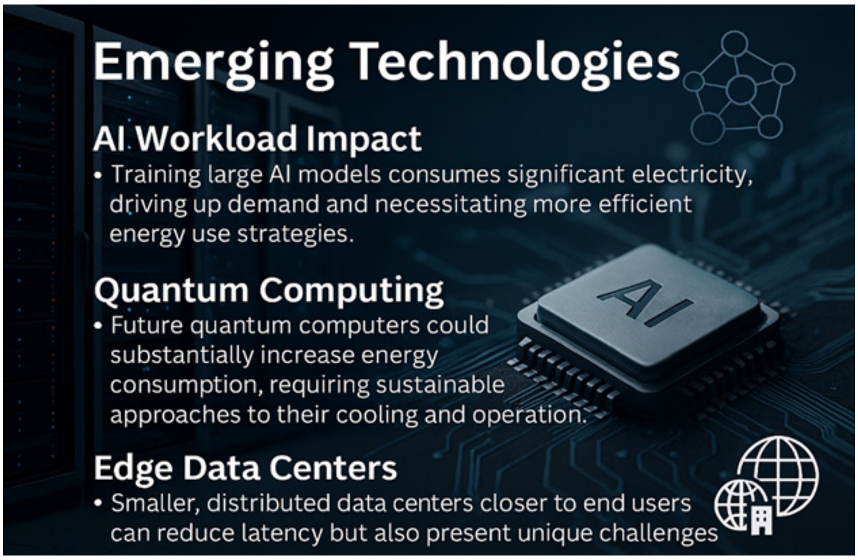
- **Heat Reuse**

Modern data centers capture waste heat from servers and repurpose it for district heating, reducing energy waste and replacing traditional fossil-fuel heating systems. This approach not only lowers emissions but also creates a secondary revenue stream for operators.

- **Lifecycle Analysis**

  Sustainability includes assessing the entire hardware lifecycle—manufacturing, usage, and disposal—while promoting recycling, refurbishment, and circular economy practices. Companies also track embodied carbon in equipment and adopt eco-friendly materials to minimize environmental impact.

6. Emerging Technologies



- **AI Workload Impact**

  Training large AI models requires enormous computational power, which significantly increases electricity demand in data centers. High-performance GPUs and TPUs consume vast energy, making AI one of the fastest-growing contributors to data center energy usage. Companies are exploring energy-efficient chips and renewable-powered AI clusters to mitigate this impact.

- **Quantum Computing**

  Quantum computing promises revolutionary processing capabilities, but its future energy footprint is uncertain. While quantum systems may solve problems faster, maintaining quantum states requires ultra-low temperatures and specialized cooling, which could lead to high energy consumption unless optimized for sustainability.

- **Edge Data Centers**

  Edge data centers are smaller, distributed facilities located closer to end-users to reduce latency. While individually they consume less power than hyperscale centers, their growing numbers increase overall energy demand. Efficient design and renewable integration are key to minimizing their environmental impact.

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Integrated System Testing & Commissioning - Proving Data Center Reliability Before Go-Live

As the dependance on internet-based operations in all fields and importance of data storage and availability is increasing, 'Reliability of data center operations" has become extremely important. Availability mainly depends on availability of continuous and reliable electrical energy at last mile server racks. With AI data centers energy requirements have started crossing even 20MW. Most of the energy that goes in server racks, ultimately gets converted into heat – so HVAC systems also become very critical which help in removing this heat. Tier wise data center requirements are as below. FAT (Factory acceptance test) and SAT (Site acceptance test) are normally carried out in projects, however they do not ensure critical integrated behavior of the entire system which is prime necessity for safety and maximum up time. Following table gives up time requirements of data centers based on their "Tier based" classification. One can observe that similar requirements are now cropping up with other projects. This article attempts to explain the systematic methodology followed by data center projects to meet their operational requirements.

Tier-wise Data Center Classification – Summary

Tier Level	Key Requirements	Typical Use
Tier I – Basic Capacity	• Single power and cooling path • No redundancy (N) • Planned maintenance requires complete shutdown • Basic monitoring and protection • No Fault tolerance – Availability – 99.671%	Small offices, startups, non-critical IT systems
Tier II – Redundant Capacity Components	• Single distribution path for power & cooling • Redundant components (N+1) such as UPS, chillers, generators • Partial shutdown needed for maintenance • No Fault tolerance – Availability – 99.741%	SMEs, departmental servers, test & development environments
Tier III – Concurrently Maintainable	• Multiple power and cooling paths (one active) • N+1 redundancy with dual distribution • Maintenance without IT downtime • Controlled switching and isolation • Limited Fault tolerance – Availability – 99.982%	Banks, telecom operators, enterprise & colocation data centers
Tier IV – Fault Tolerant	• Multiple active power and cooling paths • 2N or 2N+1 redundancy • Compartmentalization and fault isolation • No impact from single failure or maintenance • Full Fault tollarance – availability 99.995%	Hyperscale cloud providers, financial exchanges, mission-critical infrastructure

In modern data centers, reliability is not achieved by design intent alone — it is achieved by proof. **Integrated System Testing (IST),** supported by structured Commissioning and disciplined script writing, provides that proof. For electrical consultants, IST is the final opportunity to validate that a facility will behave correctly when subjected to real-world failures — electrical, mechanical, control-related, or human-induced. Following information covers the exact requirements of IST and Script.

Commissioning vs. Integrated System Testing

Commissioning verifies that individual systems perform as specified. Switchgear, transformers, generators, UPS systems, chillers, CRAH (Computer room air handler) units, and control panels are tested largely in isolation or in limited combinations.

Integrated System Testing (IST) validates the *facility as a whole*. It intentionally introduces disturbances and failures to confirm that all systems — electrical, HVAC, and controls — operate together without compromising working and safety IT load.

In simple terms:

- **Commissioning confirms equipment readiness**
- **IST confirms facility serviceability**

A data center may be fully commissioned and still fail catastrophically if integrated behavior is not tested.

Electrical Systems Covered Under IST

From an electrical perspective, IST evaluates the complete power chain under dynamic conditions. Typical systems include:

- Dual utility incomers and substations
- HT/LT switchgear, protection, and interlocks
- Transformers and bus duct systems
- Diesel generators, fuel systems, synchronization, and load sharing
- UPS systems (normal, battery, bypass)
- Static Transfer Switches (STS)
- PDUs, RPPs, and downstream distribution
- Earthing, bonding, and monitoring systems (EPMS/BMS)

While each of these systems may pass standalone commissioning tests, IST exposes how they behave during **fast transfers, sequential failures, recovery events, and operator actions**. Integrated testing is scenario-driven rather than equipment-driven.

Common electrical IST scenarios include:

- **Utility failure**, observing UPS ride-through and generator start time
- **UPS operation on battery**, including discharge and controlled recharge
- **Generator failure under load**, validating N+1 or 2N redundancy
- **Breaker trips and protection operation**, confirming selectivity and fault containment
- **Maintenance isolation**, ensuring redundancy is preserved during planned work
- **Human error simulation**, such as incorrect switching or delayed response

The central objective remains constant:
No single failure — including human error — should interrupt IT load.

HVAC Integration – An Electrical Reliability Issue

Although HVAC systems are traditionally viewed as a mechanical scope, their dependency on electrical power makes them integral to IST.

During integrated testing, HVAC systems are evaluated not only for capacity, but for **response time and restart behavior** following electrical disturbances.

Typical HVAC elements included are:

- Chillers and cooling towers
- Primary and secondary pumping systems
- CRAH / CRAC units serving IT halls
- Control valves, actuators, and BMS logic
- Power failure and restart sequencing

The Importance of IST Script Writing

One of the most critical — and often underestimated — aspects of IST is **script development**.

An IST script is a **structured, time-sequenced procedure** that defines:

- Preconditions and system readiness
- Exact switching or control actions
- Expected system responses
- Acceptance criteria (time, voltage dip, temperature rise)
- Alarm generation and escalation
- Safety precautions and rollback steps

Scripted testing ensures that IST is **safe, repeatable, auditable, and objective**. Without scripts, testing becomes ad hoc and risk-prone, defeating the very purpose of IST.

Typically, a third party with proven experience on complex and large electrical systems is selected for IST script writing and conducting IST. A written document is generated based criticality of the project and complexity of the system in consultation with data center technical team. This written down document lists all anticipated scenarios, their simulation and testing sequence and acceptance criteria – signed by all stake holders. This IST script is used while conducting actual tests.

Case Study: Hidden Dependency Revealed During IST

Project: Tier III Data Center, 20 MW IT Load
Stage: Pre-handover Integrated System Testing

During IST, a planned utility failure was simulated while the facility was operating at approximately 65% IT load.

Electrical systems responded as expected: UPS picked up load instantaneously and generators synchronized within the specified time.

However, within 6–8 minutes, localized temperature rise was observed in one IT zone.

Root Cause Identified:
One CRAH unit serving a high-density server rack row was powered through a distribution board that was inadvertently connected to a non-redundant UPS output. During the test, the CRAH experienced a delayed restart, despite upstream redundancy being available.

Outcome:

- No outage occurred during IST
- Design documentation was corrected
- Electrical distribution was reconfigured
- Control logic was modified and re-tested

Key Lesson:
The issue was invisible during commissioning and would likely have caused an outage during a real utility failure. IST exposed a *hidden electrical–HVAC dependency* before go-live.

Applicability of this systematic approach in other projects.

In India recent years have seen critical projects like Metro rail lines, Semiconductor manufacturing, complex chemical industries with huge running electrical loads (In excess of 100MW), Complex microgrids created by industries to optimize cost of electrical energy - all these along with data centers deserve such IST based testing – post proper designs to ensure electrical safety and maximum uptime.

We as electrical design consultants can help client post appreciating the project complexity by recommending such systematic testing and commissioning to ensure reliable operation of the project with maximum up time. Typically, about 2% of project costs are allocated for such IST and C services.

Contributed By

Mr. Narendra Duvedi


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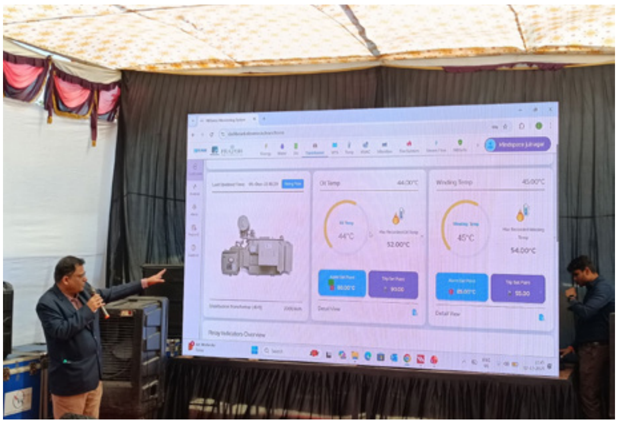
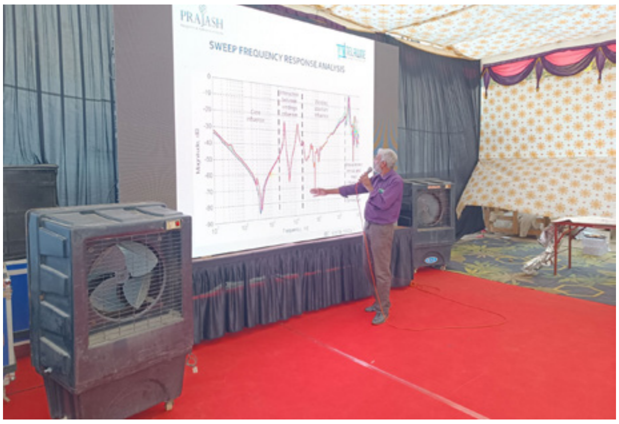
Comparison Table
Parameter
Separate VCB + Transformer + LT Panel
CSS / Skid Solution
Installation Time
Long – civil work, cable routing, individual testing
Very short – factory integrated, plug-and-play
Space Requirement
Large; needs a full substation room
Very compact; typically 30-60% less area
Civil Work
High (substation building, trenches, foundations)
Minimal (simple pad/foundation)
Safety
Depends on site design; higher exposure risk
Very high – enclosed, touch-proof, IEC/IS certified
Aesthetics / Footprint
Bulky, building required
Neat, outdoor-friendly, compact
Reliability
Good but depends on installation workmanship
Very high – factory tested and integrated
Cost
Lower equipment cost but higher civil + installation cost
Higher equipment price but lower total project cost




PRAJASH
SWEEP FREQUENCY RESPONSE ANALYSIS

Lighting Controls: A Key Strategy to Reduce Carbon Footprint in Data Centers

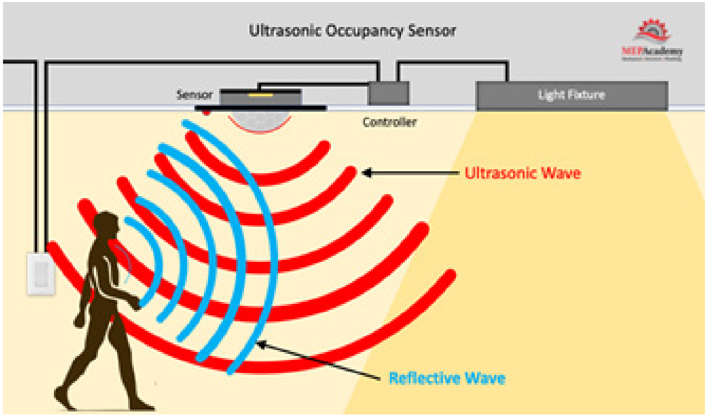
Data centers are among the most energy-intensive facilities, consuming vast amounts of electricity to power servers, cooling systems, and auxiliary infrastructure. While much attention is given to optimizing IT equipment and cooling efficiency, lighting is often overlooked as a contributor to energy consumption and carbon emissions. Implementing advanced lighting controls can significantly reduce the carbon footprint of data centers.

Why Lighting Controls Matter

Although lighting accounts for a smaller portion of total energy use compared to servers and cooling, it still represents a measurable load, especially in large facilities operating 24/7. Traditional lighting systems often run continuously, even in unoccupied areas, leading to unnecessary energy waste. By adopting intelligent lighting controls, data centers can minimize this waste without compromising safety or operational requirements.

Key Strategies for Lighting Control

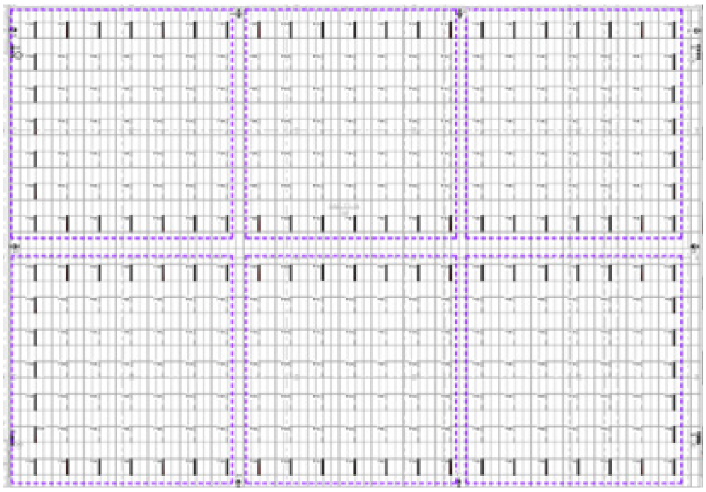
1. **Occupancy Sensors:** Installing motion or presence sensors ensures lights are only active when personnel are present. This is particularly effective in server aisles, maintenance zones, and storage areas.



2. **Daylight Harvesting:** For data centers with windows or skylights, daylight sensors can automatically dim or switch off artificial lighting when natural light is sufficient.

3. **LED Integration:** Combining controls with energy-efficient LED fixtures amplifies savings, as LEDs consume less power and respond well to dimming technologies.

4. **Zoning and Scheduling**: Dividing the facility into zones and programming lighting schedules based on operational patterns reduces unnecessary illumination during off-peak



Environmental and Operational Benefits

Implementing lighting controls can reduce lighting energy consumption by up to 50–70%, translating into lower greenhouse gas emissions and operational costs. This contributes to sustainability goals, helps meet regulatory requirements, and enhances the overall energy efficiency of the data center. Additionally, smart lighting systems can integrate with building management systems (BMS) for real-time monitoring and optimization.

Real Examples

- **Saudi Aramco**: Added motion sensors in 1,927 IT closets. Energy use dropped by **80%**, saving about **2.2 million kWh** and cutting **1,600 tons of CO_2** each year.
- **U.S. Data Center**: Upgraded lighting and controls. Saved **19% of total energy** and reduced emissions by **625 tons of CO_2**.

Conclusion

While servers and cooling dominate energy discussions, lighting controls offer a simple yet impactful way to reduce a data center's carbon footprint. By leveraging occupancy sensors, daylight harvesting, and intelligent scheduling, operators can achieve meaningful energy savings and support global sustainability initiatives.

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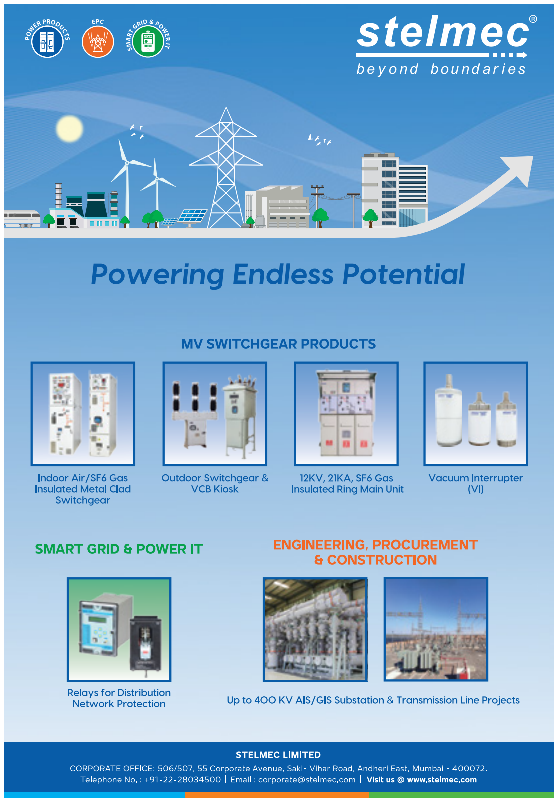
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INTRODUCTION

Data centers form the foundation of today's digital world, hosting the servers, storage, and networking systems that enable continuous online services. Given their critical importance, these facilities rely on resilient and efficient electrical infrastructure to ensure constant availability. As modern computing equipment operates around the clock at extremely high-power densities, effective energy management has emerged as one of the most vital operational challenges.

ELECTRICITY CONSUMED BY THE DATA CENTER WORLDWIDE

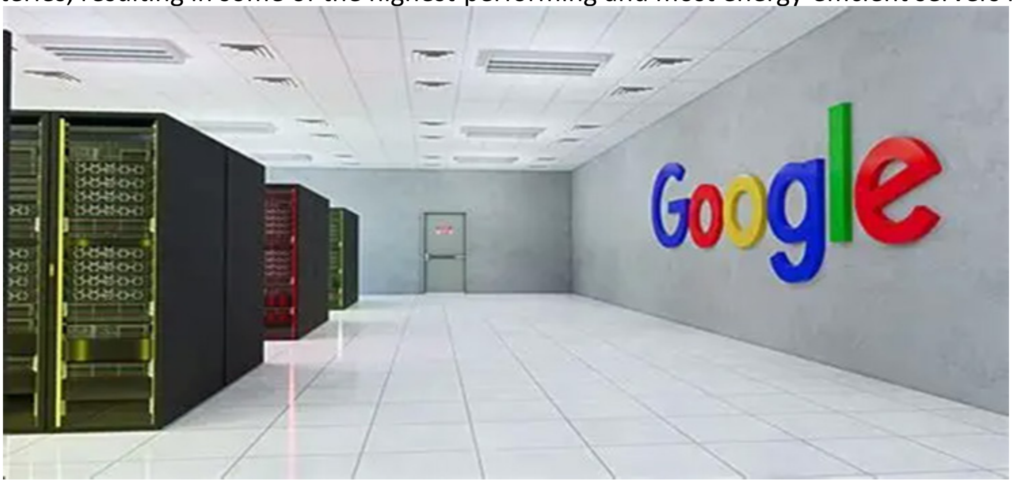
Data centers consume 2% to 3% of the world's electricity, according to the International Energy Agency. In 2023, this infrastructure consumed around 350 TWh, according to the International Energy Agency. This marks a significant increase in previous years.

Projections for 2025 indicate global data center consumption of between six hundred TWh and 1,050 TWh depending on the scenario.

Global Consumption (2026): Global electricity demand from data centers, AI, and cryptocurrencies is expected to reach up to 1,050 TWh in 2026. This is a substantial portion of global electricity use.

MAJOR PLAYER IN DATA CENTER POWER CONSUMPTION, GOOGLE.

Google is a major force in the data center industry, with substantial energy demand consuming 2.7 million MWh globally in 2011, equal to the output of 650 land-based wind turbines. Despite this scale, the company has made significant strides in efficiency, with its data centers operating at twice the efficiency of typical organizations. By 2019, Google had achieved 61% carbon-free energy across its facilities, a figure that has risen to 67% through targeted sustainability strategies. To further reduce consumption, Google leverages DeepMind's machine learning to optimize energy use, while also designing its own servers since 2001 with advanced power supplies and integrated batteries, resulting in some of the highest-performing and most energy-efficient servers in the sector.



ENERGY CONSUMPTION IS DUE TO THREE FACTORS

- **Servers running non-stop:** Servers, which are the heart of data CENTERs, need to be operational 24/7 to ensure access to stored data. This uninterrupted availability requires constant energy use.
- **Equipment cooling**: To prevent overheating and maintain server performance, cooling systems are crucial. These systems, which often use air-conditioning technology, consume lot of power.
- **Security systems:** Data CENTERs need to be protected from physical and digital intrusion. Security systems, such as surveillance cameras and firewalls, also consume energy.

GRID IMPACT AND REGIONAL CHALLENGES

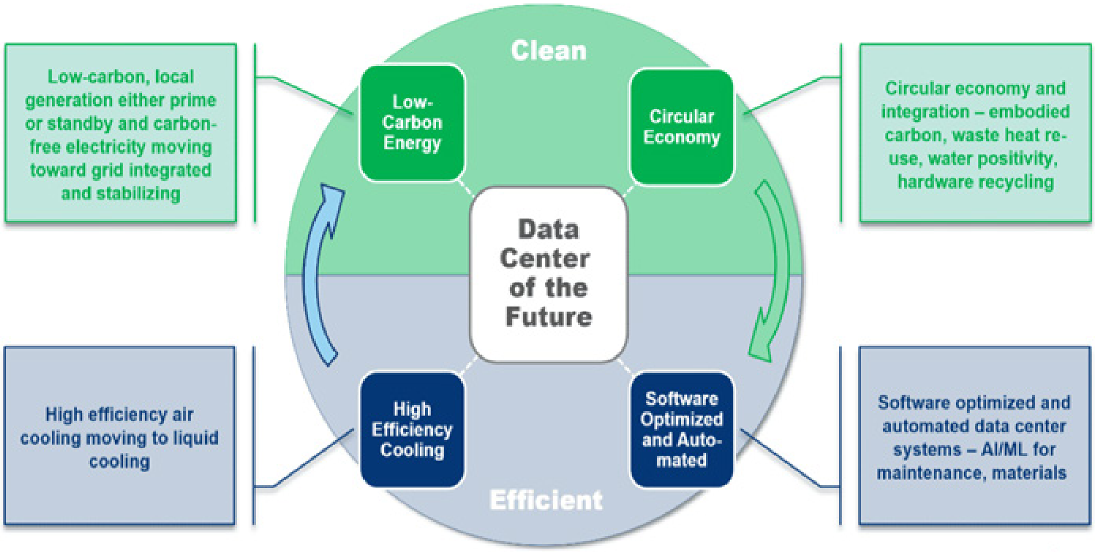
Data centers play a vital role in driving digital growth, yet their heavy clustering in specific regions places significant pressure on local electricity grids.

The key challenges are:

1) Delayed infrastructure projects due to grid capacity limits.
2) Higher electricity prices for surrounding communities.
3) Increased reliance on backup generators and microgrids to ensure resilience during peak demand or outages.
4) Government actions where they restrict new data center developments until grid upgrades completed.

SUNSTAINABILITY OF DATA CENTRE

Data centers use large amount of electricity, which adds to global carbon emissions, but ongoing sustainability efforts are helping to reduce this impact. Many operators are turning to renewable energy sources like wind, solar, and hydro, with major companies such as Google and Microsoft pledging carbonfree or netzero operations. Improvements in efficiency such as AIbased cooling, better server designs, liquid cooling systems, and energy storage are cutting down on wasted power. At the same time, recycling equipment and using ecofriendly building materials are helping to manage e-waste and resource use.



Although challenges remain, including pressure on power grids, high water usage, and stricter regulations, the industry is steadily moving toward greener practices to balance rapid digital growth with environmental responsibility.

TECHNOLOGICAL INNOVATIONS

Technological innovations are transforming data centers into more efficient and sustainable facilities. Artificial Intelligence and machine learning are used to optimize energy consumption, particularly in cooling systems, by predicting temperature changes and adjusting operations in real time. Advanced cooling methods such as liquid cooling, immersion cooling, and freeair cooling are replacing traditional air conditioning to reduce electricity and water use.

At the hardware level, companies design custom servers with highefficiency power supplies and integrated batteries, which minimize energy losses and improve performance. Alongside this, renewable energy integration through solar, wind, and hydro power, supported by onsite storage solutions like batteries and fuel cells, is helping reduce carbon emissions.

Smart power distribution systems and automation further enhance reliability and efficiency, while ecofriendly building designs and wasteheat reuse contribute to greener operations. Together, these innovations are reshaping data centers to meet rising digital demands while reducing their environmental footprint.

CONCLUSION

Data centers drive modern digital innovation but also pose significant sustainability challenges due to their rising electricity use. The path forward is clear; growth must be balanced with efficiency and renewable energy adoption. Without urgent action, data centers could become one of the largest sources of global energy demand and emissions.

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L&T Technology Services


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Operation & Management of Next-Gen DCPI

With rapid advancements in IT—virtualization, cloud, and consolidation—the physical infrastructure often becomes an overlooked foundation. A robust DCPI ensures power, cooling, security, and management systems operate seamlessly to support business-critical applications.

Core Elements of DCPI

DCPI consists of seven elements: **Power, Cooling, Racks & Physical Structure, Security & Fire, Cabling, Management, and Services.**

Each element faces challenges in lifecycle cost, adaptability, availability, manageability, and serviceability.

1. Power

A modern data center integrates seven critical elements of DCPI to ensure reliability and scalability. Power systems, including UPS and distribution units, provide uninterrupted energy flow. Structured cabling overhead ensures organized connectivity, while robust racks house servers securely. Security measures like biometric access and fire suppression systems safeguard infrastructure.

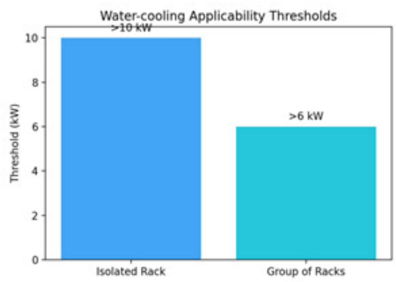
Power systems include UPS, generators, and distribution panels. Modern power systems require modular, standardized designs for adaptability and cost efficiency.

The adjoining image shows two large UPS and power distribution units. These cabinets are designed for uninterrupted power supply, equipped with digital control panels and ventilation for optimal performance.

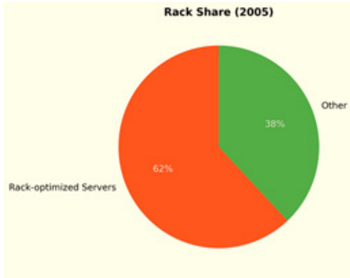
2. Cooling

Cooling systems involve CRAC units, chillers, and airflow management. Advanced cooling solutions maintain optimal temperatures for high-density racks. Modern cooling system requires modular, standardized designs for adaptability and cost efficiency.

Direct water-cooling benefits isolated racks >10kW or groups >6kW but remains niche.



3. Physical Structure & Racks



- Rack standards: IEC 297-3 and EIA 310 foster multi-vendor mechanical compatibility.
- 2005: 62% of servers shipped were rack-optimized—pressuring rack design as integral DCPI.
- Rack systems must be adaptable to change to improve availability and cost-effectiveness.

4. Security & Fire Protection

Security combines 'What you have, know, and are' principles. Fire protection aligns with NFPA 75 standards and AHJ requirements.

Strong Access Controls

- Deploy room and rack-level controls (biometrics, keys, codes, cards).
- Track and audit human activity to reduce downtime from accidents or sabotage.

NFPA 75 & AHJ Alignment

- Use intelligent smoke detection and clean agent total flooding systems as appropriate.
- Note: NFPA 75 (1999 6-4.2.1) allows continued power during gaseous suppression under defined risk considerations. Authority Having Jurisdiction (AHJ) has the final decision on protection systems; review latest NFPA standards.

5. Cabling Best Practices

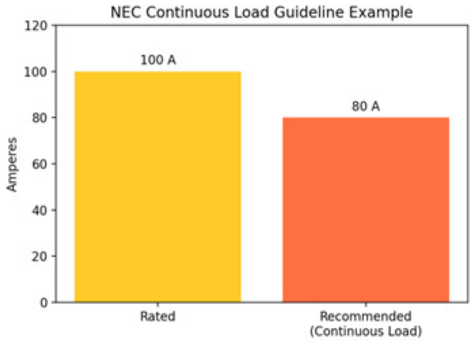
Overhead trays improve flexibility. Maintain bend radius and avoid tight ties.

Overhead vs Underfloor vs In-Rack

Aspect	Overhead	Underfloor	In-Rack
Visibility	High (easy to inspect)	Hidden	Visible within enclosure
Flexibility	High (trays, pre-configured)	Lower (raised floor constraints)	Medium
Cooling Interaction	Does not disrupt plenum	May expose cooling plenum	Neutral
Change Management	Fast to reroute	Risk opening floor	Structured with management panels

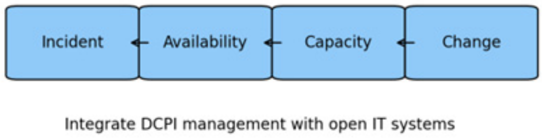
Power Cabling: NEC Continuous Load Rule

- Treat all data center loads as continuous (>3 hours).
- De-rate current by ~20% (e.g. 100 A rated → 80 A recommended) to avoid overheating, arcing, and fire risk.
- Ensure proper copper cross-sectional area (circular mils) and secure terminations.



6. Integrating ITSM with DCPI Management

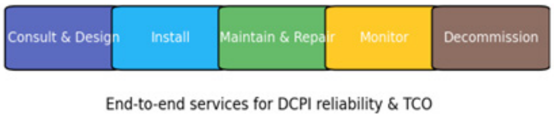
- Incident Management: Restore normal service ASAP per SLA, minimize business impact.
- Availability Management: Compare requirements vs performance; introduce improvements at justified cost.
- Capacity Management: Provide resources at the right time and cost; align to future needs.
- Change Management: Standard methods to implement changes with minimal service impact.



Integrate DCPI management with open IT systems

7. Services

- Categories: Consulting & design; Installation; Maintenance & repair; Monitoring; Decommissioning.
- Human error drives 40–60% of failures; Reduce human-error risk via procedures, training, standardization and integrated service partners mitigate risk.
- Shift from margin-on-service model to predictable maintenance built into modular components.



End-to-end services for DCPI reliability & TCO

- **Traditional vs. Modern DCPI**
  - Traditional: Multi-vendor, customized builds, complex integration, long cycle (~400 days).
  - Modern: Pre-engineered modules, standardized interfaces, integrated management, quicker commissioning.
  - Outcome: Reduced oversizing, improved agility to support consolidation and high-density workloads.

- **Operational Checklists (Daily/Weekly)**
  - Power: UPS alarms, battery health, generator test logs.
  - Cooling: CRAC performance, rack inlet temperatures, airflow containment integrity.
  - Racks: Physical integrity, blanking panels, cable management.
  - Security: Access logs review; exception reports.
  - Fire: Detector self-checks; agent pressure levels.
  - Cabling: Bend radius compliance; hot-spot inspection.

- **KPIs to Track**
  - Mean Time Between Incidents (MTBI); Mean Time To Restore (MTTR).
  - Capacity headroom (%) for power and cooling.
  - Change success rate and rollback frequency.
  - Service work-order first-time-right (%).
- **Summary**
- ***DCPI is foundational to a data center and seven elements of DCPI are as mentioned above.***
- ***The key to achieving a solid available and reliable DCPI is standardization, modularity, and scalability.***
- ***Systems must be modular and scalable to match ever-changing needs of data centers, improve the reliability and availability of the infrastructure, and optimize Total Cost of Ownership (TCO).***

References : Schneider Electric University

Contributed by:

Ankit Shah
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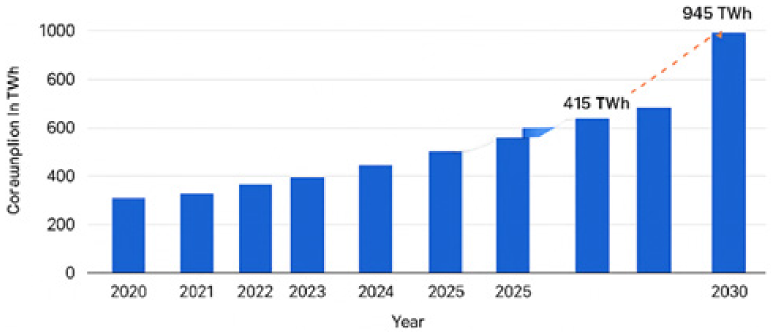
Introduction:

In today's hyper-connected world, data centres are the unseen engines driving our digital lives. From streaming videos and social media to cloud computing and artificial intelligence, every click and interaction relies on these massive facilities. But behind the convenience lies a critical challenge—electricity consumption. Data centres are among the largest consumers of power globally, and their demand is growing at an unprecedented pace.

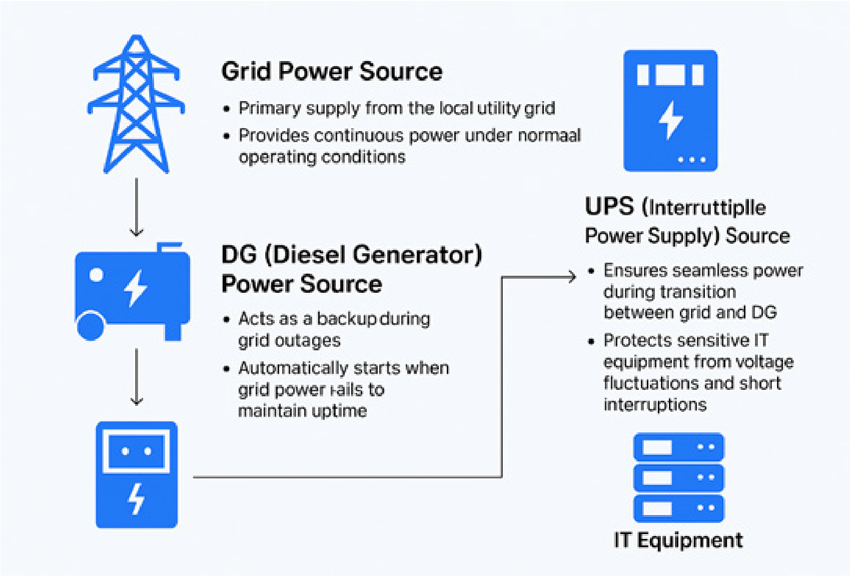
Data centers operate around the clock to ensure uninterrupted services, resulting in significant electricity consumption. The primary contributors to this high energy demand are servers and **Storage Systems** that continuously process and store vast amounts of data. **Cooling Systems** required to dissipate the heat generated by these servers and maintain optimal performance, and **Networking Equipment** such as routers and switches that support seamless data transmission.

Global Electricity Consumption: The numbers highlight a significant trend in data center energy usage. As of 2024, data centres account for approximately **1.5% of global electricity consumption**, which translates to about **415 terawatt-hours annually.** Over the past five years, this demand has grown at an average rate of **12% per year.** Looking ahead, projections indicate that by **2030**, consumption could more than **double to nearly 945 terawatt-hours**, driven largely by the increasing adoption of artificial intelligence and high-performance computing.



Power Source to Data Center:

Data centers rely on a robust and uninterrupted power supply to ensure continuous operation of servers, networking equipment, and cooling systems. The primary source of power is typically the electrical grid, supported by high-capacity transformers and switchgear. To maintain reliability, data centers incorporate backup systems such as Uninterruptible Power Supplies (UPS) and diesel generators, which activate during outages. In addition,



many modern facilities integrate renewable energy sources and advanced energy storage solutions to improve sustainability and reduce dependency on the grid. This layered approach ensures redundancy and minimizes the risk of downtime.

1. **Grid Power Source:**

   The primary source of electricity for a data center is the local utility grid, which delivers a stable and continuous supply under normal operating conditions. This grid connection is essential for supporting the 24/7 operations of servers, storage systems, networking equipment, and cooling infrastructure. The utility grid acts as the backbone of the facility's electrical system, ensuring reliable power delivery for IT and environmental controls. However, because even a brief outage can disrupt services and cause data loss, additional backup systems are integrated to maintain up time.

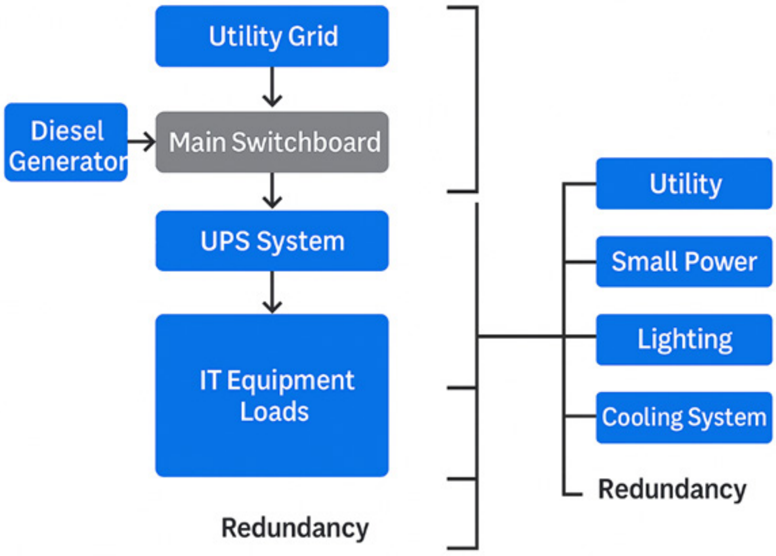
2. **DG (Diesel Generator) Power Source:**

   Diesel generators serve as a critical backup power source during grid outages. When the utility supply fails, the generator automatically starts and takes over the load to ensure uninterrupted operations. This transition is managed through an Automatic Transfer Switch (ATS), which shifts the power source from the grid to the generator seamlessly. Generators are designed to provide extended backup power, allowing the data center to continue functioning until the grid supply is restored or other contingency measures are activated.

3. **UPS (Uninterruptible Power Supply) Source:**

   The UPS system plays a vital role in bridging the gap between the loss of grid power and the activation of diesel generators. It provides instantaneous power to critical IT equipment during this transition, ensuring there is no downtime or data corruption. Additionally, UPS systems protect sensitive electronics from voltage fluctuations, surges, and short interruptions, maintaining power quality and stability. In high-availability data centers, UPS units are often deployed in redundant configurations (N+1 or 2N) to meet stringent uptime requirements.

Electrical Power Flow:

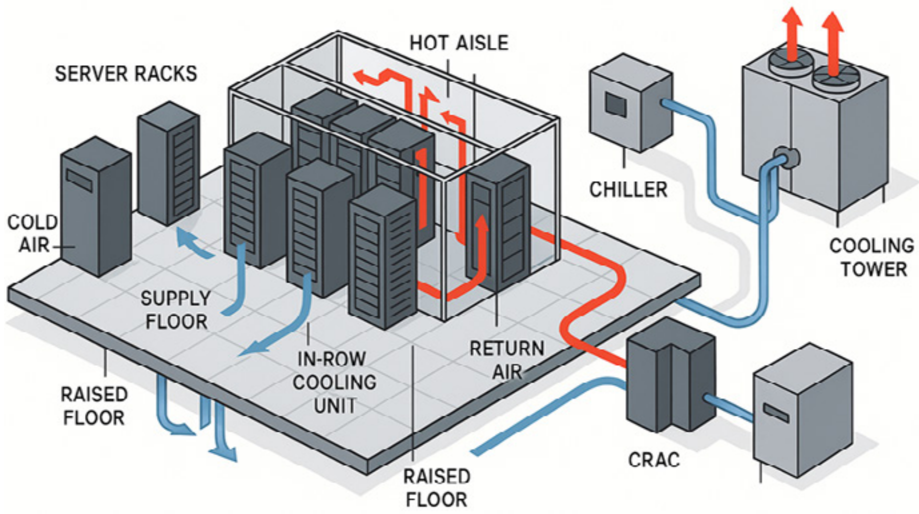


Electrical power flow in a data center is designed to ensure continuous, reliable, and conditioned power delivery to critical IT infrastructure through multiple layers of supply and redundancy.

1. **Utility Grid → Main Switchboard**
   - Primary source of power enters through high-voltage feeders.
   - Step-down transformers reduce voltage to usable levels (e.g., 11 kV → 415 V).
2. **Main Switchboard → UPS System**
   - Power is routed to UPS for clean, uninterrupted supply.
   - UPS uses batteries or flywheels to bridge short outages and stabilize voltage.
3. **UPS → IT Load**
   - Critical equipment (servers, storage, networking) receives conditioned power.
   - Non-critical loads may bypass UPS and connect directly to grid or generator.
4. **Backup Path: Diesel Generators**
   - When grid fails, DG sets start automatically.
   - DG feeds the main switchboard, which continues to supply UPS and other loads.
5. **Distribution Panels**
   - Power is distributed via PDUs (Power Distribution Units) and RPPs (Remote Power Panels) to racks.
6. **IT Equipment Loads**
   - Includes servers, storage systems, networking devices, and cooling fans within racks.
   - These loads represent the core computing infrastructure and consume the majority of power.

Cooling System:

Cooling is a critical component in data centers because servers and networking equipment generate substantial heat during continuous operation. Without proper cooling, excessive heat can lead to hardware failures, reduced performance, and even unexpected downtime. Maintaining an optimal temperature ensures stable environmental conditions, allowing systems to run efficiently and reliably 24/7. Effective cooling not only



protects equipment but also enhances overall energy efficiency and operational longevity. Below are the types of cooling system in data center.

1. **Computer Room Air Conditioning (CRAC) Units**
    - Traditional cooling units that blow cold air into the data center.
    - Often paired with raised floors for airflow distribution.
2. **Computer Room Air Handler (CRAH) Units**
    - Uses chilled water and fans to cool air.
    - More efficient than CRAC for large facilities.
3. **Chilled Water Systems**
    - Centralized chillers produce cold water circulated to CRAH units.
    - Common in hyperscale data centers.
4. **Direct Expansion (DX) Cooling**
    - Uses refrigerant-based cooling for smaller setups.
5. **Liquid Cooling**
    - Direct-to-chip cooling using liquid coolant.
    - Ideal for high-density racks and AI workloads.
6. **Free Cooling**
    - Uses outside air when conditions allow, reducing energy consumption.

Cooling systems have a significant impact on data center power usage, often accounting for 30–40% of the total energy consumption. This makes cooling one of the largest contributors to operational costs and overall energy demand. Implementing efficient cooling strategies is essential to reduce Power Usage Effectiveness (PUE), a key metric that measures how effectively a data center uses energy. Lowering PUE not only improves energy efficiency but also reduces environmental impact and operating expenses, making optimized cooling a critical aspect of sustainable data center design.

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QUIZ - JANUARY 2026

1. In a synchronous machine, the power angle is the angle between:
   - A) Rotor axis and stator axis
   - B) Rotor magnetic field and stator magnetic field
   - C) Terminal voltage and internal voltage
   - D) Armature current and terminal voltage

2. Which of the following FACTS devices is used for series compensation in transmission lines?
   - A) STATCOM
   - B) SVC
   - C) TCSC
   - D) UPFC

3. The stability of a power system can be improved by:
   - A) Increasing generator inertia
   - B) Increasing transmission line reactance
   - C) Reducing excitation
   - D) Reducing governor gain

4. In HVDC transmission, the converter operates as a rectifier at:
   - A) Sending end
   - B) Receiving end
   - C) Both ends
   - D) None of the above

5. In a three-phase induction motor, the slip at synchronous speed is:
   - A) 0
   - B) 1
   - C) Between 0 and 1
   - D) Negative

6. Which modulation technique has the highest power efficiency?
   - A) AM
   - B) FM
   - C) PM
   - D) QAM

7. In a transmission line, Ferranti effect is more pronounced when:
   - A) Line is short and loaded
   - B) Line is long and lightly loaded
   - C) Line is long and heavily loaded
   - D) Line is short and lightly loaded

8. The skin effect in conductors increases with:
   - A) Decrease in frequency
   - B) Increase in frequency
   - C) Increase in DC resistance
   - D) Decrease in temperature

9. The synchronous reactance of a machine is the sum of:
   A) Armature resistance and leakage reactance
   B) Leakage reactance and magnetizing reactance
   C) Armature resistance and magnetizing reactance
   D) None of the above

10. Which of the following is NOT a renewable energy source?
   A) Solar
   B) Wind
   C) Nuclear
   D) Biomass

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- The Quiz will be open for 10 days from the date of EMAIL.
- Each correct answer received on DAY 1 will get 100 points
- Next days the points will reduce as 90 – 80 – 70 and on 10th day points will be ZERO even if the answer is correct.
- All participants will receive E certificate signed by CEEAMA President with the points earned mentioned on the same.

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It can open a pandora box for our discussions and arguments and probable solutions. Engineering evolves with conception. It gets fuelled with community discussions and capitalist actions. All stakeholders start realising the need to take a closer look and help improve standards as we have seen in the past century. Surely it makes the world a better place.

Wish you all a better luck this time.

Do spread the word.

October 2025 Quiz Answers

1. C. Both A & B
2. B. 400kV, 132kV, 11kV, 240V, 50Hz.
3. D. All of the above
4. A. Poly Chlorinated Biphenyl
5. B. IEC-62271-1
6. B. Type Tests
7. D. All of the above
8. C. SLD
9. A. All current upto rated load
10. C. Tubular conductors

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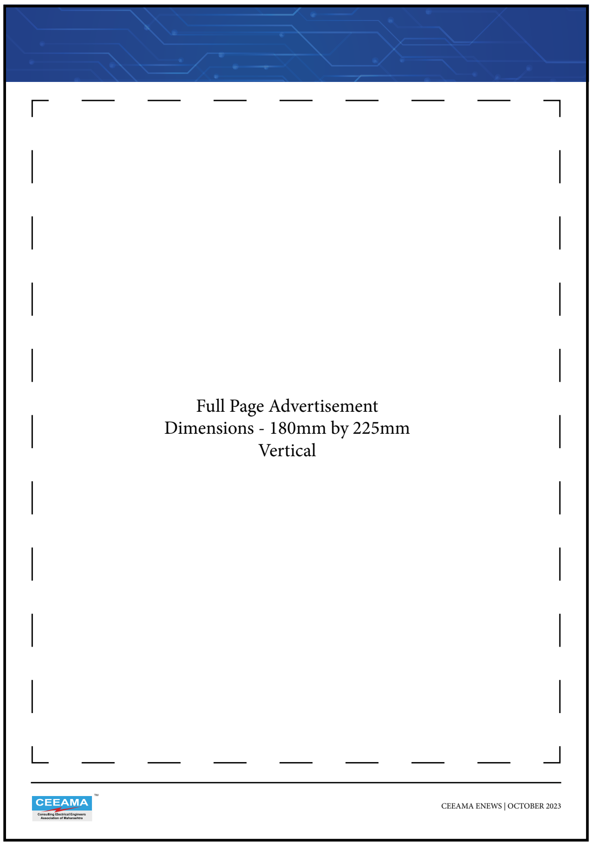

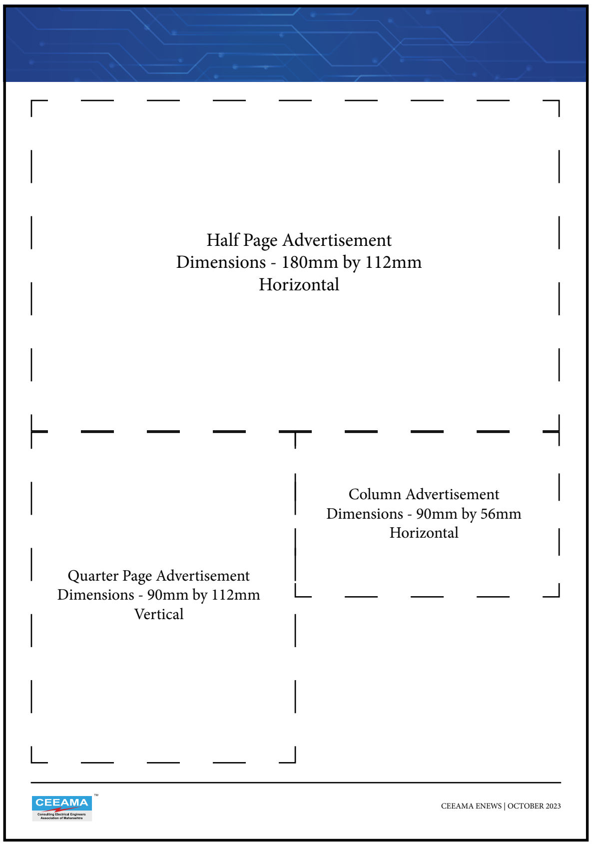

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