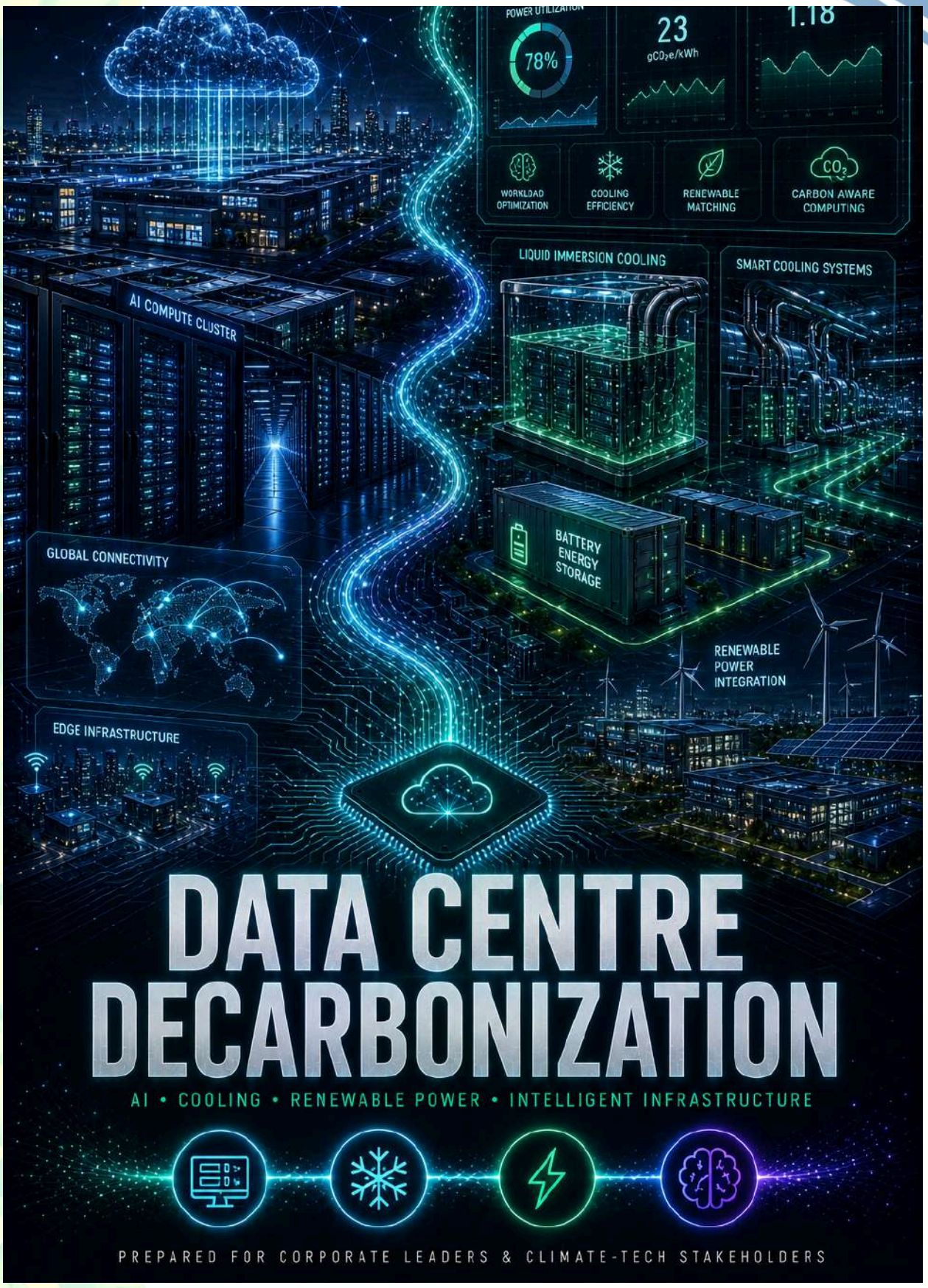
POWER UTILIZATION
78%
23
gCO2e/kWh
1.18
WORKLOAD OPTIMIZATION
COOLING EFFICIENCY
RENEWABLE MATCHING
CARBON AWARE COMPUTING
LIQUID IMMERSION COOLING
SMART COOLING SYSTEMS
AI COMPUTE CLUSTER
BATTERY ENERGY STORAGE
GLOBAL CONNECTIVITY
RENEWABLE POWER INTEGRATION
EDGE INFRASTRUCTURE
DATA CENTRE DECARBONIZATION
AI • COOLING • RENEWABLE POWER • INTELLIGENT INFRASTRUCTURE
PREPARED FOR CORPORATE LEADERS & CLIMATE-TECH STAKEHOLDERS

## *Energy Efficiency & Digital*
# *Data Centre Decarbonization*

*This section provides key inputs on Data Centre Decarbonization Opportunities for corporate leaders.*

# Opportunity Snapshot: Data Centre Decarbonisation

Reduce carbon footprint of data centres via renewable power, efficient cooling, and energy optimization

## Market Signal

- India data centre capacity expected to **3–4x by 2030** (AI & cloud growth)
- **Hyperscalers (AWS, Google)** targeting 100% renewable operations
- **Annual Market size by 2030:** 12,000 - 15,000 ₹ Cr

## What Makes or Breaks It?

- **Advanced cooling** (liquid/immersion) reducing PUE to <1.3
- **24/7 renewable sourcing** (PPAs + BESS integration)
- **Real-time energy optimization** via AI/IoT systems

## Why It Matters NOW?

- **Explosive growth** in AI, cloud, and digital infrastructure
- **ESG pressure** on large tech firms
- Rising power demand hence need for efficient and green operations

## Well Aligned Opportunity for

- **Data centre operators & hyperscalers**
- **Cooling technology providers** (HVAC, liquid cooling)
- **Energy management & IoT platform companies**

## Key Challenges

- **High capex** for cooling upgrades and renewable integration
- **Space constraints** in urban data centres
- **Reliability concerns** with renewable & storage integration

## Business Model

- Retrofit existing data centres with efficient cooling systems
- Renewable PPAs + onsite solar + storage integration
- Deploy AI-based platforms for energy optimization

## Introduction and Business Case

Data centres are the backbone of India's digital economy, but also among the fastest-growing energy consumers. With hyperscale and colocation capacity surging, their carbon footprint is rising sharply.

Decarbonising data centres through renewable energy integration, efficient cooling, circular hardware and carbon accounting delivers a dual win: lower OPEX and stronger ESG performance. For global cloud majors and Indian IT giants, green data centres are not just a compliance requirement but a competitive differentiator to attract clients and capital.

All the above also imply significant business opportunities for businesses that can provide solutions to decarbonize data centers.

## Market Potential for Data Centre Decarbonization in India

The following estimates are for the complete set of solutions that can make data centres green and sustainable

| Year | Market Size (₹ Cr) | Drivers |
|---|---|---|
| 2025 | 4,500-5,000 | Early adoption by hyperscalers (AWS, Microsoft, Google) and large IT parks; renewable PPAs. |
| 2030 | 12,000-15,000 | Expansion of green colocation centres; stronger cooling efficiency norms; ESG-linked financing. |
| 2040 | 30,000-40,000 | Net Zero data centres mainstream; integration of onsite RE + storage + circular IT hardware. |

## Market Segments and Applications

| Segment | Applications | Business Model | Key Drivers |
|---|---|---|---|
| Electrical & Power Efficiency Systems | High-efficiency UPS, power distribution units, busways, HV/LV optimization | Capex equipment sales + long-term service & maintenance contracts | Reduce electrical losses; improve PUE; manage rising AI power density |
| Advanced Cooling Technologies | Liquid cooling (direct-to-chip, immersion), free-air cooling, adiabatic | Equipment sales + installation + O&M services | Cooling = largest non-IT energy load; enables higher rack densities with lower |

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| | systems | | energy/water |
| Energy Management & Monitoring Software | Real-time energy, carbon, and capacity monitoring; DCIM; optimization analytics | SaaS subscriptions (per site/per rack) | Measurement is prerequisite for emissions reduction and reporting |
| Renewable Energy Procurement & PPAs | Off-site solar/wind PPAs, virtual PPAs, on-site renewables | Long-term contracts; energy-as-a-service | Scope 2 emissions reduction; energy price hedging |
| Grid-Interactive & Storage Solutions | Battery energy storage, UPS-to-grid, demand response | Capex + revenue-sharing with utilities or aggregators | Grid congestion, resilience, and higher renewable penetration |
| Low-Carbon Data Centre Design & Engineering | Energy-efficient layouts, modular DCs, prefabricated power blocks | EPC/project-based fees + design retainers | Reduce embodied and operational carbon from day one |
| AI-Optimized Infrastructure | High-density racks, thermal optimization for GPUs/accelerators | Premium infrastructure sales + performance-based contracts | AI workloads dramatically increase power and cooling demand |
| Water-Efficient & Waterless Cooling | Closed-loop cooling, liquid immersion, dry coolers | Equipment + sustainability-linked contracts | Water scarcity; regulatory and community pressure |
| Carbon Accounting & Sustainability Reporting | Scope 1/2/3 tracking, compliance reporting, customer transparency | SaaS subscriptions + advisory services | Regulatory compliance and customer ESG requirements |
| Heat Reuse & Energy Recovery | Waste-heat export to district heating or nearby industry | Revenue-share or infrastructure partnership | Turn waste energy into usable heat; improve overall system efficiency |

## Typical Project Capacities & Investments Required in India

| Project Type | Typical Scale | Indicative CapEx (₹ Cr) | Notes |
|---|---|---|---|
| Green retrofit (operational DC) | 10-30 MW IT | 80-250 | PUE optimisation (airflow, controls), chiller upgrades, hot/cold aisle, server refresh. |

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| Liquid-ready expansion | 20-60 MW IT | 300-900 | New white space with liquid cooling loops, high-efficiency UPS, high-density racks. |
| Greenfield hyperscale (tier III/IV) | 50-150 MW IT | 1,000-3,000 | Integrated design for low PUE (≤1.3), on-site RE/BESS interconnects, water-lite systems. |
| Renewable PPAs / Open-Access | 50-300 MWp RE | 175-1,200 | Sleeved solar/wind/RTC hybrids to offset Scope 2; CapEx if captive/SPV. |
| Battery Energy Storage (behind-the-meter) | 20-100 MWh | 90-500 | Peak-shaving, DG reduction, ride-through; LFP with EMS. |
| Heat-recovery & re-use systems | 5-20 MW thermal | 20-70 | District cooling, process heat to neighbours/campuses. |

## Underlying Technologies & Processes

| Element | Options | Key Traits |
|---|---|---|
| Power sourcing | Renewable PPAs, on-site solar, BESS integration | Cuts Scope 2 emissions; ensures round-the-clock green power. |
| Cooling efficiency | Liquid cooling, immersion cooling, free-air cooling, AI-based HVAC optimisation | Reduces PUE; critical for India's hot climate. |
| IT hardware lifecycle | Circular servers, modular racks, reuse/refurbishment | Cuts embodied carbon; supports circular economy. |
| Automation & monitoring | AI/ML-based energy management, DCIM software | Real-time optimisation of loads, cooling and capacity. |
| Carbon tracking | ESG dashboards, carbon accounting tools | Enables compliance with client and investor sustainability requirements. |

## Key Challenges

| Challenge Area | Key Issues | Business Impact | India Specific | Strategic Implications |
|---|---|---|---|---|
| Reliable Green Power Procurement & Grid Constraints | Difficulty sourcing firm renewable energy for 24/7 operations | Risk to uptime commitments and sustainability targets | Grid variability, open-access charges, curtailment risk, limited RTC | Hybrid RE + storage strategies and diversified procurement |

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| | | | renewable availability | essential |
| High Capital Requirements & ROI Complexity | Investments in renewable energy, cooling innovation, storage, and efficiency upgrades | Longer payback periods impacting project viability | Rising financing costs, infrastructure-heavy investments | Integrated planning linking energy savings with long-term operating cost reduction |
| Cooling Technology & Energy Efficiency Challenges | Cooling accounts for major energy consumption | Operational efficiency directly tied to PUE improvements | Hot climate zones, humidity variation, water availability constraints | Adoption of advanced cooling (liquid cooling, AI optimization) becomes critical |
| Supply Chain & Technology Dependencies | Reliance on imported equipment (chips, cooling systems, power electronics) | Cost volatility and deployment delays | Geopolitical risks, localization policies, global semiconductor supply dynamics | Supplier diversification and long-term procurement planning required |
| Regional Infrastructure & Regulatory Complexity | Land, power infrastructure, and local approvals vary significantly | Uneven expansion timelines across regions | Regional concentration (Mumbai, Chennai, Hyderabad, NCR); grid capacity and water access issues | Site selection strategy balancing sustainability, infrastructure, and cost |

## Prominent Players in the Indian Market

| Company / Entity | Focus Areas |
|---|---|
| MPower India | Provides UPS batteries, precision cooling systems, racks, and power infrastructure tailored for data centers to ensure uptime and efficiency. |
| Delta Electronics India | Supplies data center infrastructure products including power and cooling solutions for efficiency. |
| Tata Power/Keppel | Delivers Cooling-as-a-Service (CaaS) via district cooling systems, reducing energy use by up to 40% and emissions by 50% for data centers. |
| Hitachi Energy | Provides smart, sustainable power solutions like transformers and substation automation for data center decarbonization. |

| | |
|---|---|
| Turner & Townsend India | Turner & Townsend provides consulting expertise on data center decarbonization through power optimization and low-carbon infrastructure |
| NTT Global Data Centers | Large global presence facilitating data centers.First in India to use Liquid Immersion Cooling (LIC) + Direct Contact Liquid Cooling (DCLC). |
| PRASA Technologies | Offers Direct Contact Liquid Cooling (DCLC) and Dielectric fluid immersion systems; emphasizes CAPEX/OPEX cuts + sustainability. |
| Schneider Electric India | Provides energy efficient data centre infrastructure, optimisation services and EcoStruxure IT Expert Cooling (proprietary direct-to-chip + immersion) |

## Innovation Perspectives

| **Innovation** | **Business Opportunity** | **For Senior Management** |
|---|---|---|
| AI-Driven Energy Orchestration Platforms | Cross-layer optimization (IT load ↔ cooling ↔ grid carbon signals); autonomous dispatch | Platform economics, sticky data moats, recurring SaaS margins |
| 24/7 Carbon-Aware Compute Placement | Real-time workload shifting based on grid carbon intensity | Turns decarbonization into a **performance feature**, not compliance |
| Liquid Cooling as a Service (LCaaS) | Outcome-based cooling (€/kW cooled); vendor owns thermal risk | Converts infrastructure into predictable OPEX; high switching costs |
| Grid-Interactive Data Centres | DCs as virtual power plants (UPS + BESS + AI control) | New revenue streams + regulatory influence |
| Embodied Carbon Optimization Platforms | Digital twins for materials, modular carbon-rated designs | First-mover advantage before regulations harden |
| Water-Neutral / Water-Positive DC Models | Closed-loop cooling + water credits + reuse ecosystems | Unlocks permits and community acceptance |
| Heat Reuse Ecosystems | DC-anchored district energy platforms | Transforms DCs from “energy sink” to “energy hub” |
| Carbon-Indexed SLAs for Customers | SLAs tied to $gCO_2e$/compute hour | Premium pricing + brand leadership |
| Prefabricated, Low-Carbon | Carbon-rated modular blocks | Scale, repeatability, and |

| | | |
|---|---|---|
| DC Modules | with rapid deployment | margin expansion |
| Decarbonization Data Marketplaces | Monetizable carbon, energy, and water datasets | Data monetization + ecosystem lock-in |

## Concentric & Satellite Opportunities

- Green design & retrofit engineering firms: Specialists optimising airflow, cooling and power systems to achieve sub-1.3 PUE in new and existing facilities.
- Renewable energy & storage integrators: Concentric developers structuring RTC solar-wind-BESS PPAs tailored to 24×7 data-centre load curves.
- Liquid and immersion cooling manufacturers: Local OEMs producing cooling distribution units, dielectric fluids and high-density rack systems.
- Smart energy management & thermal AI platforms: Software providers using real-time analytics to balance efficiency, reliability and uptime.
- Waste-heat recovery & reuse ventures: Systems capturing excess heat for nearby campuses, process industries, or district-cooling networks.
- Water-lite and closed-loop cooling solutions: Innovations in adiabatic and TSE-based cooling designed for water-stressed Indian cities.

## Key Takeaway for Senior Management

| **Takeaway** | **Details** |
|---|---|
| Data centre decarbonization is an infrastructure strategy, not an ESG add-on | • Power cost, reliability, and carbon intensity now directly affect competitiveness, expansion approvals, and customer acquisition<br>• ***Examples****:* hyperscaler sustainability requirements, customer carbon clauses, regulatory scrutiny on grid impact |
| Energy efficiency and cooling are the largest, fastest value pools | • Cooling alone can account for 30–40% of energy consumption<br>• ***Sustainable cooling solutions include:*** liquid/immersion cooling, AI-driven airflow management, hot/cold aisle containment, waste-heat recovery<br>• **Competitive advantage:** sustained PUE improvement that compounds savings year after year |
| Clean power sourcing determines scalability and margin stability | • As data centres scale, grid constraints and carbon intensity become bottlenecks<br>• ***Examples****:* captive solar/wind, open-access |

| | |
|---|---|
| | PPAs, hybrid RE + BESS, 24/7 carbon-free energy matching<br>• **Competitive advantage:** predictable energy costs and reduced exposure to grid and carbon risks |
| Digital energy intelligence is the control plane for decarbonization | • Manual energy management cannot keep up with dynamic IT loads and grid signals<br>• ***Examples****:* AI-based load forecasting, real-time carbon-aware workload shifting, predictive maintenance<br>• **Innovation focus:** software-driven energy and carbon orchestration platforms |

## Next Steps for Corporate Leaders

Data centre decarbonization is accelerating as hyperscalers, colocation operators, and enterprise IT face rising energy intensity, 24/7 clean power expectations, and emerging disclosure requirements around Scope 2 and embodied emissions. Power usage efficiency (PUE) improvements, renewable procurement, electrification of backup systems, advanced cooling, and circular IT strategies are becoming central levers. As AI, cloud, and edge workloads surge, decarbonization is shifting from incremental efficiency to structural energy system integration and lifecycle carbon management.

This could be an attractive climate tech opportunity for industries and firms in specific sectors and industries keen on catering to this fast growing market.

**Connect with Team EAI to know more about this opportunity and take your corporate's initial steps. Send a note to consult@eai.in or talk to Muthukrishnan - 9952910083**