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India's Data Centre Pathway to Digital Sovereignty

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BEYOND INFRASTRUCTURE

*India's **Data Centre** Pathway to Digital Sovereignty*

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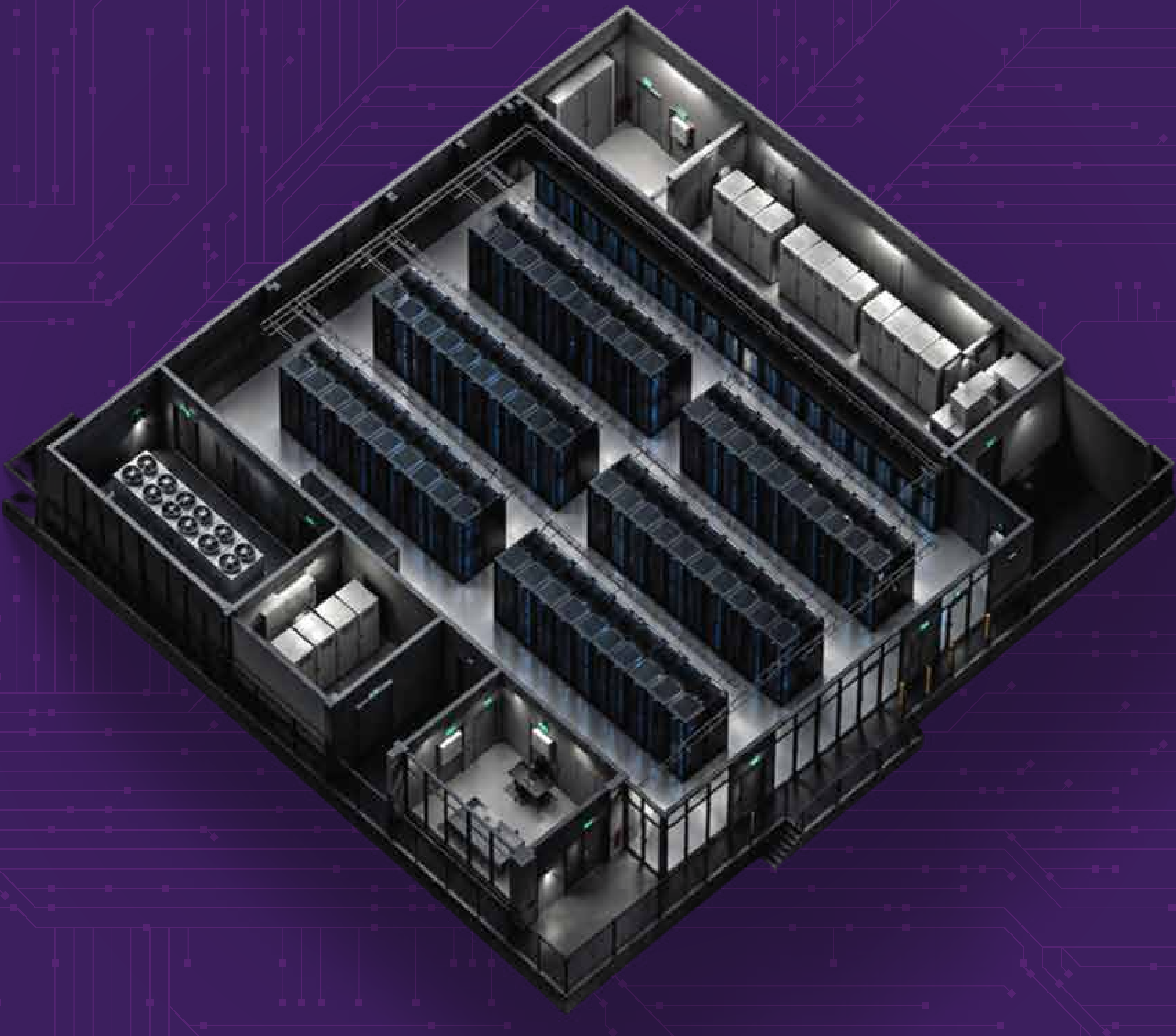


EXECUTIVE SUMMARY

1. Background and Context

India's data centre industry has evolved from a real estate-led business into strategic national infrastructure, comparable to power and telecom. It now forms the backbone of digital sovereignty, economic competitiveness, and India's AI ambitions. However, unlike purely digital systems, data centres are fundamentally constrained by physical resources especially reliable power, water, and land making sustainability and long-term infrastructure planning central to future growth.

2. Current Status of India's Data Centre Industry

India is emerging as a gigawatt-scale data centre economy, with 1.25–1.4 GW of installed load, placing it among the top-tier destinations in the Asia-Pacific region. Growth is increasingly campus-based, with operators developing multi-hundred-MW portfolios at scale.

2.1 Capacity and Momentum

Demand is real, with ~400 MW absorbed in 2024. Shift toward large, hyperscale-ready campus infrastructure confirms bankable demand from cloud and AI providers.

2.2 Investment

The sector has entered a full investment cycle. Multi-billion-dollar capex commitments show that growth is limited by resources like power and land rather than financing.

2.3 Typology of Data Centres

India's ecosystem has evolved into four pillars: hyperscale colocation, enterprise colocation, captive hyperscale campuses, and edge data centres creating a structurally diversified demand base that reduces cyclicality and supports long-term utilisation.

2.4 Reconciling Growth recasts

This section clarifies why estimates range from 3 GW to 9 GW by 2030: lower figures reflect finance-backed, buildable capacity, while higher numbers represent maximum power envelopes implied by land banks and AI ambition. It concludes that 4–5 GW is the realistic planning base, while 8–9 GW is the strategic ceiling if power, land, and renewables scale together.

3. Resource-Demand Modelling

This section quantifies capacity, power, and water requirements. It uses a benchmark model anchored to the US and a climate-linked cooling framework to enable infrastructure-grade planning.

3.1 Projecting Capacity

Using the US as a reference, we track annual incremental additions. This captures investment momentum across technology cycles while accounting for India's specific timing and scale.

3.2 Water-Demand Modelling

Water is the second most critical operational input after electricity, because cooling systems particularly in high-density compute environments require water at varying intensities. Under the low-growth capacity scenario, India's annual operational water use reaches ~20.1 BL/yr at WUE 0.7, ~60.3 BL/yr at WUE 2.1, and ~80.4 BL/yr at WUE 2.8 by 2030. Under the high-growth scenario, annual water use reaches ~40.8 BL/yr at WUE 0.7, ~122.5 BL/yr at WUE 2.1, and ~163.3 BL/yr at WUE 2.8 by 2030.

4. Resource-demand Modelling

India's data-centre growth is being shaped by a dual geography: extreme concentration in Tier-1 metros that host nearly 90% of capacity, alongside a strategic shift toward Tier-2 and Tier-3 cities for resilience and low-latency compute. It demonstrates how hubs like Mumbai, Chennai, Delhi NCR, Bengaluru, Hyderabad, Pune and Kolkata form the structural backbone of India's digital economy due to cable connectivity, power reliability and enterprise clustering, while regulatory and continuity requirements are forcing multi-city architectures. The chapter further explains how edge and modular data centres are enabling the next wave of distributed growth across emerging regional hubs. We came up with a Data Centre Suitability Score (DCSS), a data-driven framework that ranks 84 cities on power, water, risk and renewables to guide where future data-centre clusters should be prioritised or avoided.

5. India's Data Centre Policy Ecosystem

We have mapped the policy ecosystem across three levels - national strategy, state-led competitive incentives, and global policy benchmarks showing how regulation is becoming as important as demand in shaping capacity growth. It explains the evolution from the Draft Data Centre Policy 2020 to infrastructure status and the 2025 draft, alongside how states like Maharashtra, Tamil Nadu, UP, Telangana and Karnataka use fiscal and non-fiscal levers to attract campuses. Finally, global comparisons (Singapore, UAE, EU, US) highlight that India remains in expansion mode using incentives, but will likely need to progressively integrate harder sustainability and efficiency standards as scale and resource constraints tighten.

6. The Sustainability Frontier

India's rapid shift toward a multi-gigawatt, AI-driven data-centre economy is now constrained less by capital and demand and more by the sustainability of its power, water and environmental systems. Rising compute densities and 24×7 reliability needs are forcing a transition from traditional air-cooled, grid-dependent facilities toward liquid and hybrid cooling, clean-firm power portfolios, and advanced operational efficiency, while untreated growth would sharply intensify carbon emissions and urban water stress. The expansion of treated-wastewater reuse, closed-loop cooling and circular-economy practices for e-waste and batteries is therefore becoming essential for viability. Together with ESG frameworks such as IGBC and shared-infrastructure Data-Centre Economic Zones, these sustainability mechanisms will determine whether India can scale digital infrastructure without undermining grid stability, water security, and global investment confidence.

7. Concluding Observations and Policy Recommendations

India's data-centre ecosystem has crossed into the realm of strategic national infrastructure, where AI-driven densities, sustainability limits, and resilience needs now shape competitiveness more than real-estate scale. To avoid power, water and capital-market bottlenecks, the policy pathway proposed centres on national Digital Energy Zones, grid-integrated hyperscale loads, dig-once fibre corridors, and performance-based sustainability standards. State Governments are positioned as execution engines through pre-cleared DC zones, water-secure siting, and incentives tied to PUE, renewables and circular water use rather than capex alone. Operators and financiers are advised to shift toward liquid-ready, modular, and performance-linked investment models so India can build an AI-ready, low-risk and globally investable data-centre backbone.

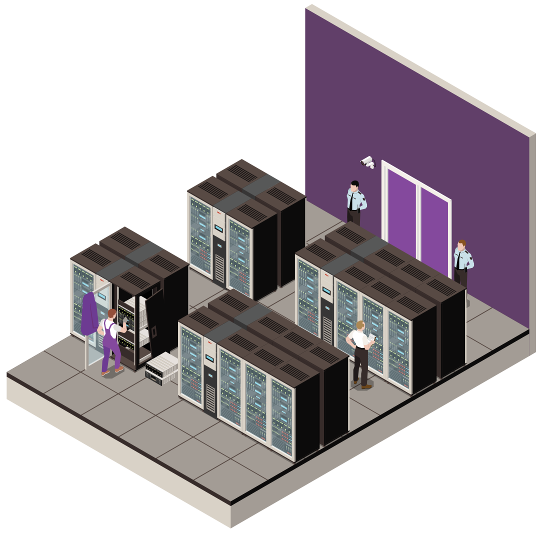
1. BACKGROUND AND CONTEXT

India's data-centre industry has entered a decisive phase in its evolution. What began as a modest, enterprise-driven IT infrastructure market has rapidly transformed into one of the most strategically significant segments of India's national infrastructure landscape. Data centres are no longer simply large server warehouses or a subset of commercial real estate. They now function as the operational backbone of India's digital economy, comparable in strategic importance to power plants, telecommunications networks, ports, and transport corridors.

In a cloud-based, AI-enabled, and data-driven economy, data centres determine where digital value is created, processed, and captured. Their location, energy footprint, resilience, and regulatory treatment have direct implications for economic competitiveness, financial stability, national security, and digital sovereignty. As India pursues its ambition of becoming a $ 5-trillion economy and a global technology hub, the scale and reliability of its data-centre infrastructure will increasingly determine whether that ambition is realised domestically or outsourced to foreign digital ecosystems.

This transition is being driven by unprecedented capital inflows from global hyperscale cloud providers, domestic industrial conglomerates, infrastructure funds, and sovereign investors. However, this surge in investment also exposes a new class of risks. Unlike earlier phases of IT growth, modern data centres are extremely resource-intensive, requiring large and continuous supplies of electricity, water for cooling, land, fibre connectivity, and regulatory clearances. The industry is therefore moving towards a model constrained by the physical limits of energy, water, climate, and grid capacity.

Understanding these constraints and how they interact with policy, technology, and investment is now essential to charting the future of India's digital infrastructure.



1.1 The Digital Imperative

India today represents one of the largest and fastest-growing digital markets in the world. As of June 2025, India had approximately 100.28 crore internet users, and projections suggest that nearly seven out of ten Indians will be online by the end of 2025. This connectivity is overwhelmingly mobile-driven, with 117 crore mobile connections active by mid-2025.

This colossal user base translates into unprecedented data consumption. The average mobile data usage per user per month was projected to be approximately 32 GB in June 2025, It is projected to rise to more than 60 GB by 2030. This data consumption is catalysed by the rollout of 5G networks, and the accelerating demand for Over-the-Top (OTT) media services, video streaming, and online gaming.

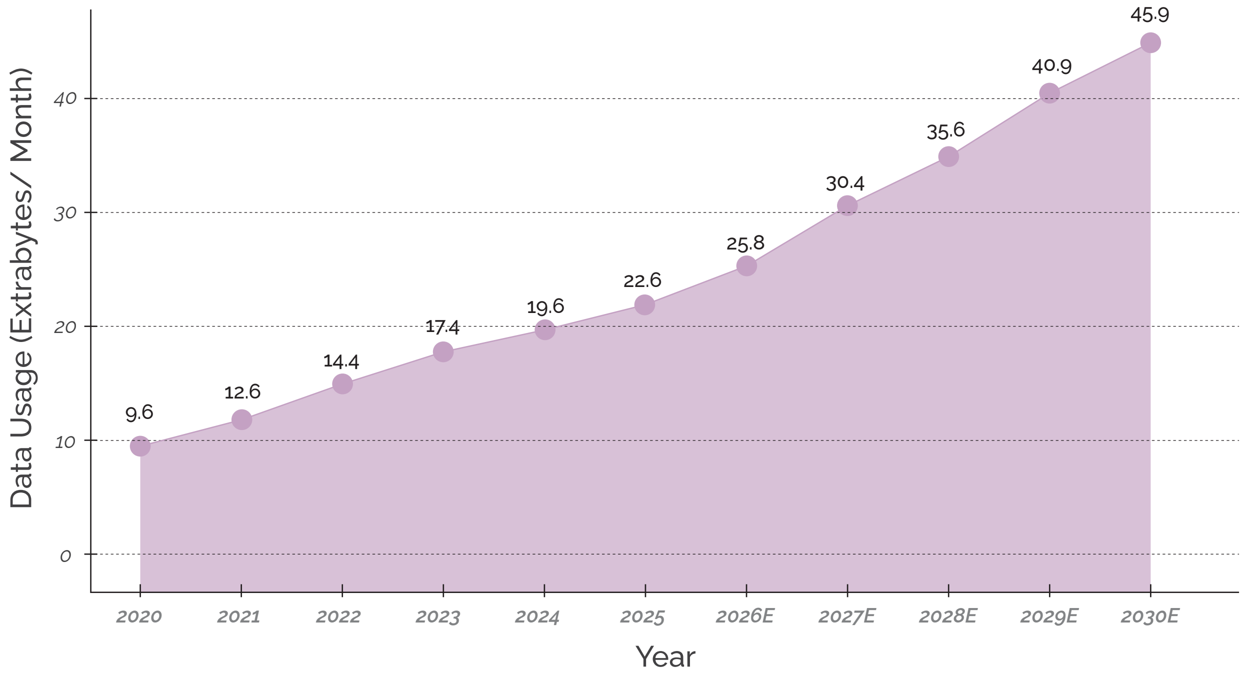


Fig 1.1: Pan India Mobile data Usage/month (ExaByte) (JM Financial, 2025)

The success of the Digital India vision and its associated Digital Public Infrastructure (DPIs) emphasises the need for high-speed, localised processing power. DPIs, such as the Unified Payments Interface (UPI) and the UMANG application, demand ultra-low latency to facilitate real-time transactions and service delivery. For instance, the UPI platform processed 18.39 billion transactions worth ₹ 24.03 lakh crore in June 2025, powering nearly 50% of global real-time digital payments. Similarly, the UMANG app offers over 2,300 services to its 8.71 crore registered users. The essential nature of these and other similar services means data processing cannot rely on remote global hubs, the need for low-latency delivery directly mandates the construction and geographic distribution of high-capacity data centers across the country.

Economically, this digitalisation trajectory is transforming national output. India's digital economy contributed 11.74% of its GDP (equivalent to $ 402 billion) in the fiscal year 2022-23. Projections indicate that the digital economy’s share is expected to accelerate, contributing nearly one-fifth of the country's overall economy by 2030, outpacing the growth of traditional sectors.

1.2 Why This Study Matters ?

India stands at a crossroads in the development of its digital backbone. Without coordinated planning across energy, water, land, and regulation, the rapid growth of data centres could generate systemic risks. While general forecasts exist, this report puts together the intricate regulatory mandates with technological demands to quantify true, sustained demand. Analysis moves beyond simple capacity counting to assess the non-operational risks, specifically the resource scarcity of power and water that threaten long-term operational resilience.

This study provides a necessary strategic framework for stakeholders, investors, operators, and policymakers navigating the confluence of exponential growth and operational constraints in India’s digital infrastructure sector.

1.3 Study Objectives

The primary objectives of this comprehensive report are defined as follows:

1. Develop a granular baseline and projection of India's data centre resource requirements through 2030.

2. To identify and evaluate promising geographic locations for data center development, through connectivity, policy environments, availability of renewable energy, climate vulnerability, and infrastructure readiness.

3. To identify suitable and potentially suitable locations for data centre development.

4. Evaluate the effectiveness and coherence of India's regulatory framework for data centre development.

5. Identifies opportunities for further strengthening policy and procedural frameworks.

6. To study emerging trends towards sustainable practices, energy efficiency, and circular economy principles within the data center sector.

1.4 Study Scopes

This study focuses exclusively on the commercial and technological landscape of data centers in India, which serve as the foundation for modern cloud and digital services.

- **Time Horizon**
  The analysis examines historical market dynamics from with primary market forecasts and extended to 2030, capturing the period of peak expansion.

- **Sector Coverage**
  The scope encompasses major domestic and international infrastructure investors, global Cloud Service Providers (CSPs), leading domestic operators and the crucial supporting ecosystem, including power generation and cooling technology.

- **Exclusions**
  The study intentionally excludes a detailed comparative analysis of non-commercial captive data centers and limits its focus to infrastructure economics rather than granular software or application-layer solutions.

2. CURRENT STATUS OF INDIA'S DATA CENTRE INDUSTRY

India's data center industry has emerged as a critical pillar of the nation's digital economy, experiencing exponential growth over the past five years. As of 2024, the country's installed data center capacity stands at approximately 1.1-1.4 gigawatts (GW) of IT load. This rapid expansion has positioned India as the second-largest market for datacenter electricity demand in Asia-Pacific over the next two years, surpassing Japan and Australia(S&P Global, 2024).

Demand is robust, with 407 MW absorbed in 2024 (Savills India, 2024). Supply rose by 51% in the second half of the year. This growth is driven by AI workloads and enterprise uptake in the BFSI and IT sectors services(JLL, 2024).

India's market infrastructure is also expanding, with the total number of operational data centres across the country reported to be around 130 facilities as of H1 2025, supported by nearly 29 distinct operators active in the space(Cushman & Wakefield, 2024). Industry sources highlight that the Indian market has seen a significant influx of both global hyperscalers (such as AWS, Microsoft Azure, and Google) and domestic large-scale players, contributing to a rapid expansion of capacity and diversity of service providers.

Projections indicate that the market could expand to between $ 12.85 billion and $ 24.78 billion by 2033, depending on adoption rates of emerging technologies and regulatory evolution. The sector's revenue generation extends beyond pure colocation services to encompass managed services, cloud integration, disaster recovery solutions, and increasingly, AI-optimised infrastructure offerings (Astute Analytica, 2024).

2.1 Investment Flows and Capital Deployment

Investment flows into India's data-centre sector have accelerated sharply, reflecting both domestic platform-building and sustained demand. Recent market tracking indicates that India has attracted ~$ 94 billion in data-centre investment commitments since 2019, with ~$ 30 billion committed in Jan–Sep 2025 alone, signalling a step-change in the scale and velocity of capital deployment (CBRE, 2024).

This capex cycle is being anchored by a combination of global hyperscaler infrastructure plans and large Indian data-centre platform expansions. AWS has reiterated its plan to invest $ 12.7 billion in India by 2030 to expand cloud infrastructure capacity (Reuters, 2024). Google has announced an ~$ 15 billion investment (2026–2030) to establish a gigawatt-scale AI hub/data-centre campus in Visakhapatnam, aligned with fibre and clean-energy buildout (Google, 2024). On the domestic side, large multi-city and campus-scale commitments continue to expand, including AdaniConneX's stated ambition to build out a ~1 GW data-centre platform by 2030, alongside ongoing financing activity for its current portfolio.14 In aggregate, these investment commitments reinforce that India's expansion is no longer incremental, capital deployment is now operating at infrastructure scale.

2.2 Typology of Data Centres and Sectoral Demand in India

As India's operational capacity crosses 1.2–1.3 GW of installed IT load, with a comparable quantum under construction or financially committed, distinct structural patterns have emerged in the types of facilities. Together, hyperscale colocation, enterprise colocation, captive hyperscale campuses, and edge or modular data centres now define the architecture of India's digital infrastructure.

2.2.1 Hyperscale Colocation

Hyperscale colocation has emerged as the core backbone of India's digital economy. These facilities typically designed in 10–20 MW blocks and scaled across large campuses are built to meet the stringent availability, efficiency, and scalability requirements of global cloud service providers and large digital platforms. Leading operators such as STT GDC India, AdaniConneX, Digital Realty BAM Digital, CtrlS, and Yotta have expanded aggressively in this segment, driven by sustained cloud adoption and the early stages of AI-related workload deployment.

The hyperscale colocation model is characterised by high-volume deployments, relatively standardised configurations, and strong EBITDA margins, where execution speed, power availability, and scalability outweigh customisation. As AI workloads begin to move from experimentation to production, this segment is increasingly incorporating higher power densities, advanced cooling solutions (including liquid and hybrid systems), multi-substation power architectures, and long-tenure renewable energy procurement.

2.2.2 Enterprise and Retail Colocation

Running parallel to the hyperscale backbone is the enterprise and retail colocation segment, which remains critical to the stability and profitability of the market. Enterprise colocation typically involving deployments below 5 MW serves a broad range of sectors, including BFSI, IT and ITeS, telecom, media and OTT platforms, healthcare, e-commerce, and government institutions.

Unlike hyperscale customers, enterprise clients rely heavily on operators for managed services, network interconnection, security integration, compliance support, and hybrid cloud enablement. This service intensity supports stronger pricing power and resilient cash flows. The BFSI sector alone is estimated to account for around 18–20% of occupied data-centre capacity, driven by RBI data-localisation requirements, payments infrastructure expansion, and the rapid digitisation of financial services. IT and ITeS firms continue to use colocation as an intermediary layer between public cloud and legacy on-premise systems, while telecom operators increasingly colocate virtualised network functions as part of 5G core and edge roll-outs. In aggregate, enterprise colocation functions as the operational bridge between legacy IT estates and next-generation cloud environments, anchoring long-term

2.2.3 Captive Hyperscale Campuses

A parallel and increasingly significant trend is the rise of captive, self-built hyperscale campuses. Global cloud providers and large digital conglomerates are investing directly in purpose-built mega-campuses, often spanning tens to hundreds of acres, with highly customised electrical, mechanical, and cooling architectures. These facilities are designed to support AI training clusters, GPU-intensive workloads, proprietary cloud stacks, and ultra-high-density compute environments that are difficult to accommodate within shared colocation frameworks.

Captive builds also offer greater control over energy sourcing and cost structures, enabling operators to lock in long-term renewable power purchase agreements and optimise power usage at scale. Locations such as Hyderabad, Navi Mumbai, Chennai, and Pune have emerged as preferred destinations due to land availability, supportive state policies, grid connectivity, and proximity to major fibre routes.

2.2.4 Edge and Modular Data Centres

India is simultaneously entering a phase of distributed digital infrastructure development through the growth of edge and modular data centres. As latency-sensitive applications such as video streaming, online gaming, real-time payments, ride-hailing, industrial IoT, and AI inference scale rapidly, proximity to end users becomes a decisive factor. Edge facilities, typically ranging from a few hundred kilowatts to a few megawatts, are designed to bring computational resources closer to demand nodes.

Industry analyses suggest that prefabricated and modular data-centre formats will expand steadily across Tier-2 and Tier-3 cities over the next two to five years, enabling faster deployment and incremental scaling. Telecom operators, content delivery networks, smart-city platforms, logistics networks, and industrial IoT ecosystems are expected to be early adopters. While edge capacity will remain modest relative to hyperscale metros, its strategic value lies in latency reduction, network resilience, and geographic diversification, contributing to a more distributed and robust digital economy.

Across these typologies, India's data-centre demand profile remains broad and structurally diversified, distinguishing it from markets dominated by a single vertical. Hyperscalers and cloud providers account for approximately 50–54% of installed capacity, while enterprise demand anchored in BFSI, IT/ITeS, telecom, retail, OTT, healthcare, and industrial sectors forms the backbone of long-term utilisation. This balanced mix mitigates concentration risk and ensures that even if individual sectors experience cyclical slowdowns, aggregate demand for compute, storage, and low-latency processing remains resilient.

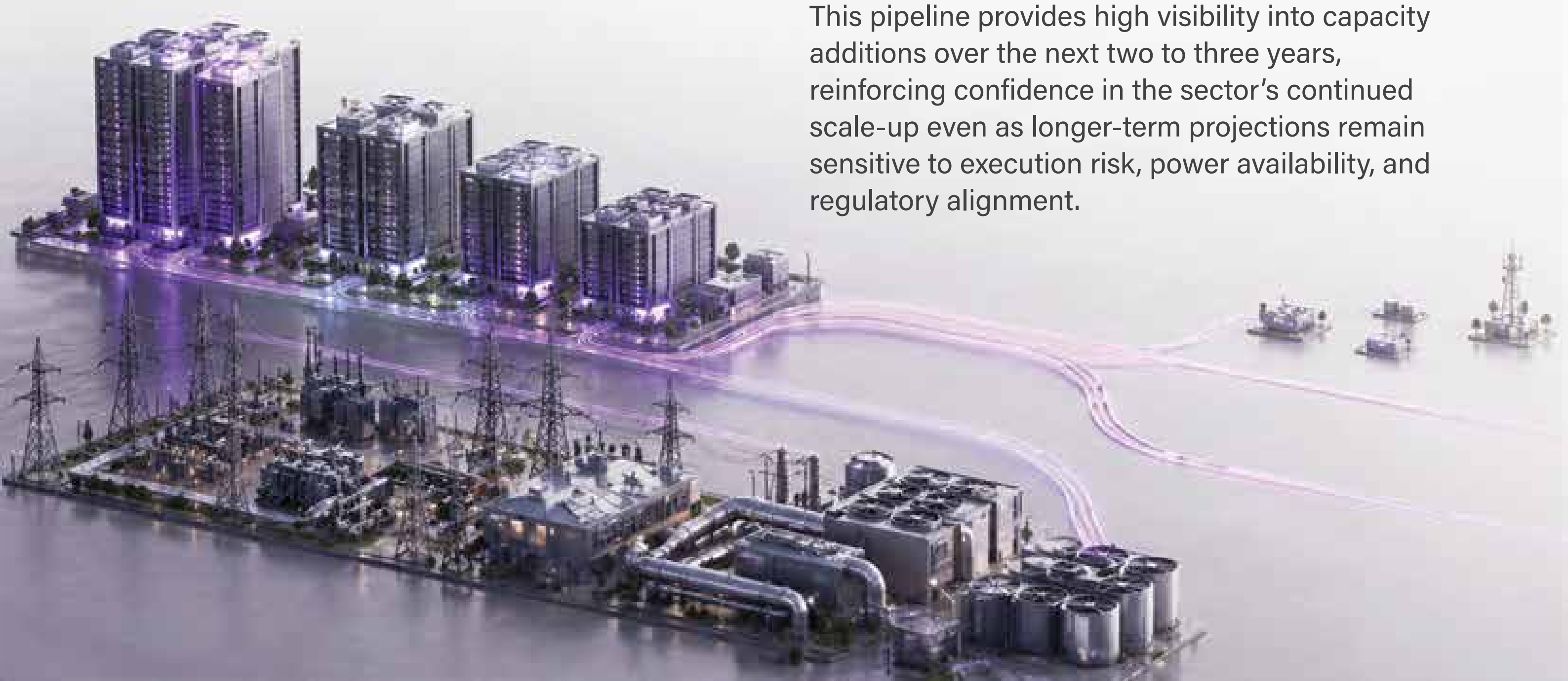
2.3 Reconciling Divergent Forecasts

Growth projections for India's data centre market exhibit wide variance, reflecting differences in methodology, capacity definitions, and planning horizons rather than disagreement on the sector's underlying momentum. Most industry assessments converge on a strong expansion trajectory, with the market expected to grow at a CAGR of ~18–22% between 2024 and 2030, underscoring the pace at which digital, cloud, and AI-driven infrastructure is being added.

Forecasting ranges from a conservative 1.8 GW capacity by 2027, mid-range estimates of 3.4 GW - 5 GW by 2030, to highly aggressive outlooks of 8 GW - 9 GW by 2030 (Savills India, 2024).

This divergence must be carefully analysed for investment planning. The projections, such as 8 GW or 9 GW, often reflect the total potential market size addressable by power infrastructure providers. In contrast, the 3.0–5.0 GW range more closely reflects realistic, finance-backed expansion, grounded in current construction pipelines, absorption trends, and capital availability. For investors, operators, and policymakers, this band offers a more credible basis for revenue modelling, infrastructure planning, and near-term capital allocation.

Near-term expansion is supported by a robust supply pipeline, with industry reports indicating approximately 700–800 MW of additional IT load under active development, backed by investment commitments of roughly $ 4–5 billion (JLL, 2024). This pipeline provides high visibility into capacity additions over the next two to three years, reinforcing confidence in the sector's continued scale-up even as longer-term projections remain sensitive to execution risk, power availability, and regulatory alignment.



Source / Analyst (Year)	Projection	Assumptions / Basis	Interpretation for Planning
JLL (2025)	1.8 GW by 2027	Based on committed, under-construction capacity and current funding cycles.	Conservative; reflects only confirmed IT load expansion over 24–30 months.
Savills India (2024 – Model 1)	3.4 GW by 2030	21% CAGR (2024–2030), uses operational + firmly committed pipeline.	Lower mid-range forecast; good for bankability and realistic modelling.
Savills India (2024 – Model 2)	4.0 GW by 2030	23% CAGR, incorporates broader funded pipeline.	Mid-range bullish; captures higher execution speed.
Avendus / IBEF / Market Consensus (2024)	3.0 GW by 2030	Growth from ~1.1 GW (2024) to 3 GW (2030).	Base-case for policy and market sizing; widely cited.
Avener Capital (2025)	5.0 GW by 2030	India DC capacity is expected to grow from 1.3 GW (2024) to 5 GW by 2030; capex USD 20–22 billion.	Upper mid-range forecast; reflects strong hyperscaler pre-commitments and land banks.
Macquarie / Jefferies (2024–2025)	8 GW by 2030	Considers execution of large planned campuses + hyperscale demand acceleration.	High-end scenario; feasible only if power, land & renewable PPAs scale rapidly.
Moneycontrol / ET (Jefferies-derived)	9 GW by 2030	Continuation of Tier-1 hyperscaler cluster expansion + new greenfield parks.	Aggressive high-end case; reflects potential but not guaranteed capacity build-out.
Jefferies / Takshashila (2024 scenario)	Up to 17 GW by 2030	AI-driven demand surge + large-scale GPU campuses + full realisation of land banks.	Very aggressive / theoretical upper bound represents the maximum potential power envelope, not confirmed IT load.

Table 2.1: Comparative Forecasts of India Data Centre Capacity and Investment (2024–2030)

2.4 India's Data Centre Expansion Trajectory

Capacity is projected to reach 4.1 GW to 8.3 GW by 2030. The lower bound reflects current pipeline absorption, while the upper bound assumes accelerated AI-led growth. This multi-gigawatt expansion puts data center power needs on par with major industrial sectors.

3. RESOURCE-DEMAND MODELLING

As demand grows, understanding the resource implications of data centre infrastructure power, cooling, real estate, and network capacity becomes essential for informed policy, grid planning, land allocation, and environmental governance.

This chapter presents a modelling framework to estimate India's resource requirements under multiple growth scenarios. The approach combines industry forecasts, India-specific datasets, climatic models, and global best practices to produce a forward-looking resource-demand blueprint.

3.1 Projecting India's Data Centre Capacity: A Benchmark-Based Growth Model

The methodology is grounded in the understanding that large-scale digital infrastructure markets expand through distinct, technology-driven phases. Late-adopting economies typically follow the growth trajectory of early adopters, with a time lag and lower adoption intensity.and in a pattern that makes conventional forecasting techniques, including time-series or econometric models, unreliable. This is due to the absence of long, consistent historical data on data-centre capacity in India, along with the presence of structural breaks driven by cloud adoption, hyperscaler entry, 5G deployment, and emerging AI workloads.

Similarly, extrapolating historical trends using compound annual growth rates (CAGR) risks oversmoothing these discontinuities and overstating near-term growth.
For this reason, this study does not rely on trend extrapolation. Instead, it estimates India's future data-centre capacity using a benchmark-based incremental scaling approach, with the United States serving as the reference.

The methodology is grounded in the understanding that large-scale digital infrastructure markets expand through distinct, technology-driven phases. Late-adopting economies typically follow the growth trajectory of early adopters, with a time lag and lower adoption intensity.

3.1.1 Rationale for Using the United States as a Benchmark

The United States is the global lead market for data-centre development, having navigated successive growth waves driven by cloud migration, hyperscaler localisation, mobile data expansion, and AI workloads. By mapping these high-impact phases to specific technology adoption timelines, this study isolates the capacity implications of each driver over a long-term horizon.

A comparative assessment shows that while India is experiencing structurally similar drivers, its expansion occurs with a temporal lag and lower absolute intensity. Empirical evidence indicates that India's annual capacity additions consistently represent a fraction of US incremental growth, rather than a fixed share of total installed capacity.

This relationship enables the scaling of US incremental additions to project India's future expansion. By anchoring projections to phase-aligned growth cycles rather than aggregate capacity, the approach captures directional market similarities while accounting for structural differences in scale and maturity.

Consequently, the United States serves as an empirically grounded reference for forecasting India's capacity under varying technology scenarios.

3.1.2 Historical Validation of India–US Benchmarking and Forecasting Framework

India's data-centre industry does not grow in isolation. Its expansion has been shaped by the same global technology waves that drive infrastructure investment in the United States, including cloud computing, hyperscale platforms, artificial intelligence, and telecom digitisation. What differs is not the direction of growth, but its scale and timing. India enters each wave later and at a smaller magnitude. The key question for forecasting, therefore, is whether this lagged response follows a stable pattern or is merely coincidental.

Most existing data-centre forecasts address this question inadequately, as they rely on absolute megawatt comparisons or compound growth rates. These approaches are dominated by historical stock. Since the United States built its digital infrastructure much earlier, its absolute base is significantly larger, making direct comparisons misleading (Berkeley Lab (Lawrence Berkeley National Laboratory), 2024).

To isolate the underlying technology-driven relationship, this study instead focuses on the pace of capacity addition each year, rather than total installed capacity. The analysis is therefore based on growth slopes, measured in megawatts added per year, which capture investment momentum rather than legacy infrastructure.

For each country, the annual capacity addition in a given year is defined as the difference between installed capacity in that year and the previous year. In formal terms, the US annual addition is defined as follows.

$$\Delta C_{US}(t) = C_{US}(t) - C_{US}(t-1)$$

This tells us how much new data-centre power the global technology leader is adding in a given year as cloud, AI or telecom demand expands.

Historical data for both countries was then segmented according to major technology waves. Because India typically enters each cycle several years after the US, the periods were aligned to reflect this lag. Linear trends were fitted within each era to estimate the slope of expansion, that is, how many megawatts per year each market was adding during that technology phase.

Across all four technology cycles, India's annual capacity additions are a remarkably stable fraction of those in the United States, as shown below.

Sector	USA Period	India Period	US Slope (MW/yr)	India Slope (MW/yr)	Ratio (India/USA)
Cloud Services	2016–2023	2018–2024	5,003.20	171.8	0.0343
Hyperscalers	2016–2023	2018–2024	5,003.20	171.8	0.0343
Artificial Intelligence	2018–2023	2022–2024	6,248.30	288	0.0461
5G & Tele communications	2019–2023	2022–2024	6,954.00	288	0.0414

Table 3.1: Historical India-US Capacity Growth Ratios by Technological Era

When these slopes are compared, a striking regularity appears. During the cloud and hyperscaler wave, the US added about 5,000 MW per year while India added about 170 MW, implying that India expanded at roughly 3.4% of the US rate.

- In the AI-driven phase, the US accelerated to over 6,200 MW per year while India rose to about 288 MW, raising the ratio to 4.6%.
- In the 5G and telecom-driven phase, the ratio remains just above 4%.
- Comprehensively, across all four cycles, despite different macroeconomic conditions and regulatory regimes, India's expansion has consistently tracked between 3% and 5% of US growth.

This empirical stability implies that India's data-centre growth is not opportunistic or erratic; it is structurally linked to global technology diffusion led by the US. India behaves as a fast-follower economy, absorbing a predictable fraction of the digital infrastructure being deployed in the global core.

This allows the adoption parameter r to be empirically estimated. Taking the four technology cycles together, the average adoption ratio is calculated as

$$r_{avg} = \frac{1}{n}\sum_{i=1}^{n} r_i = 0.039$$

GD, where ri is the India/US growth ratio in each technological era i, and n=4. We have n=4 because there are four unique cycles in data center tech history. These cycles consider shifts like from basic servers to cloud, then hyperscale, and now AI-driven. This average of 0.039 means India's yearly additions are about 3.9% of the US ones at the same time. It reflects the differences in market size, investment levels, and how quickly tech is absorbed. Basically, this ratio shows the scale difference, with India growing slower but catching up through spillovers.

This insight allows the US growth rate to be translated directly into an Indian forecast. If the US adds CUS(t) megawatts in a year, India adds a fraction of that amount. That fraction is the adoption ratio r, so India's annual addition becomes

$$\Delta C_{IN}(t) = r \times \Delta C_{US}(t)$$

India's total installed capacity is then built up by accumulating these scaled additions over time:

$$C_{IN}(t) = C_{IN}(t-1) + \Delta C_{IN}(t)$$

This accumulation ensures that forecasts start from India's actual current baseline and then layer future growth on top of it, respecting what India has already built while allowing global technology patterns to drive the trajectory forward.

This methodology is simple but economically powerful. It does not rely on speculative demand curves or arbitrary growth assumptions; it relies on observed historical spillovers between the world's digital infrastructure leader and a fast-growing emerging market. By anchoring India's future capacity to the US through a stable, empirically validated adoption ratio, the model captures how technological leadership in one economy translates into infrastructure expansion in another. It provides a transparent and defensible way to project how India's data-centre ecosystem will scale as cloud, AI and digital

3.1.3 Forecasting Data Center Growth

United States benchmark

US capacity projections used in this study are sourced from Lawrence Berkeley National Laboratory (LBNL) and associated industry consensus reports, which aggregate forecasts from leading hyperscale operators, utilities, and infrastructure analysts.

Two forward paths are considered. The low-growth scenario assumes that efficiency gains in servers, power usage effectiveness, and supply-chain bottlenecks moderate the pace of expansion. The high-growth scenario reflects aggressive hyperscaler and AI-driven investment, where large-scale GPU clusters, model training workloads, and cloud expansion continue to accelerate demand for data-centre power. All US projections are converted from gigawatts to megawatts to maintain consistency with Indian reporting conventions. These US projections form the time-varying driver CUS(t) in the benchmarking equation established earlier.

India baseline

India's data-centre sector has moved through three distinct phases. Before 2000, it consisted largely of government and enterprise server rooms. Between 2000 and 2010, early colocation and enterprise facilities expanded capacity slowly to about 122 MW. The mobile-internet and e-commerce boom after 2010 pushed capacity to roughly 521 MW by 2020. From 2020 onwards, data localisation mandates, cloud adoption, and hyperscaler entry drove a step-change, pushing India past the one-gigawatt threshold by 2024.

India's operational data-centre capacity in 2024 is estimated at 1,352 MW, as reported by Avendus,[18] which covers hyperscale, colocation, enterprise and edge facilities across Mumbai, Chennai, Bengaluru and emerging hubs. This figure is the C_{IN}(2024) term in the accumulation equation and serves as the starting point for all forward projections.

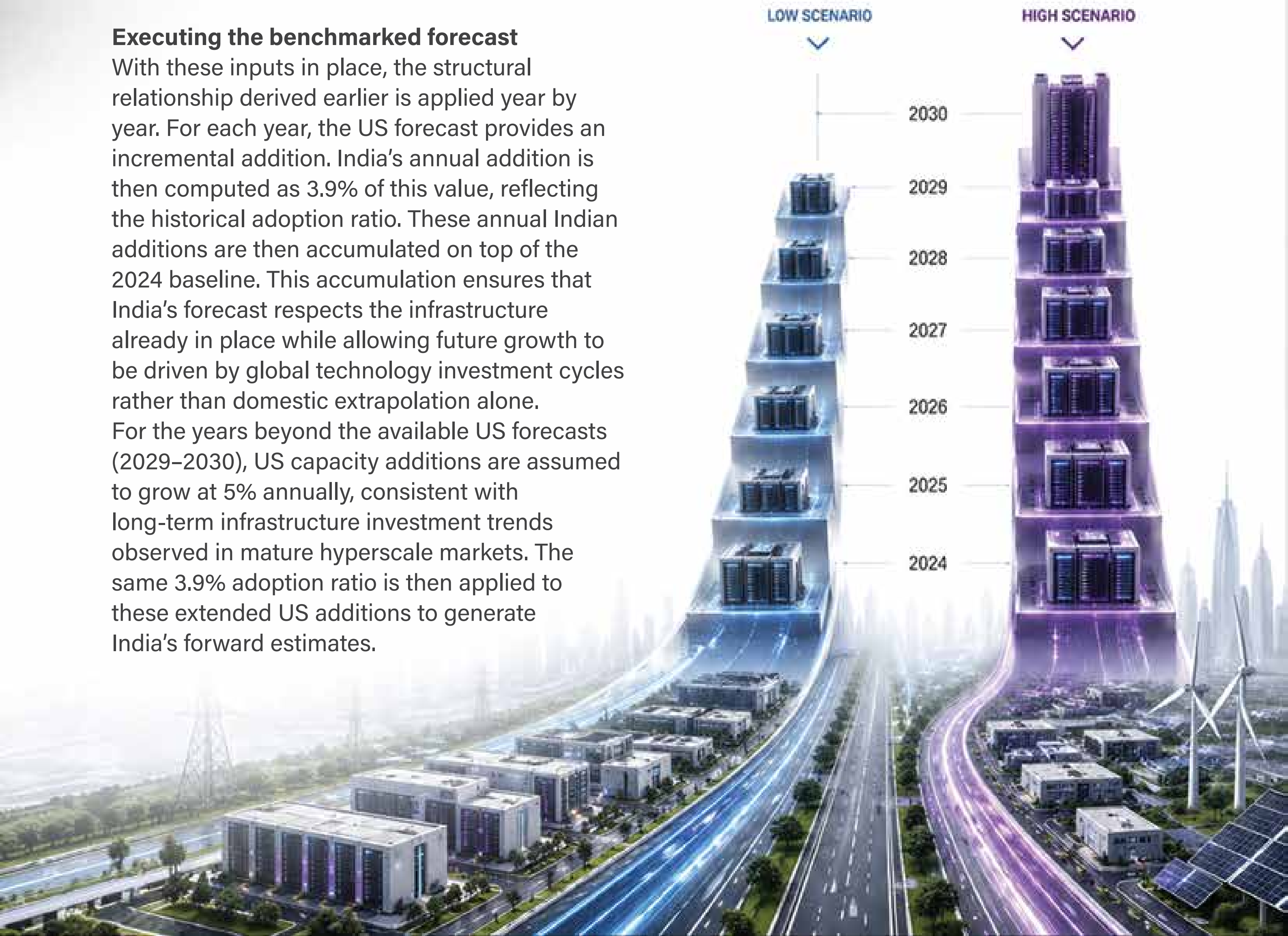
Executing the benchmarked forecast

With these inputs in place, the structural relationship derived earlier is applied year by year. For each year, the US forecast provides an incremental addition. India's annual addition is then computed as 3.9% of this value, reflecting the historical adoption ratio. These annual Indian additions are then accumulated on top of the 2024 baseline. This accumulation ensures that India's forecast respects the infrastructure already in place while allowing future growth to be driven by global technology investment cycles rather than domestic extrapolation alone.
For the years beyond the available US forecasts (2029–2030), US capacity additions are assumed to grow at 5% annually, consistent with long-term infrastructure investment trends observed in mature hyperscale markets. The same 3.9% adoption ratio is then applied to these extended US additions to generate India's forward estimates.

Resulting India capacity trajectory

Years	Low Scenario (MW)	High Scenario (MW)
2024	1352	1352
2025	1486.99	1876.60
2026	1792.18	2747.25
2027	2118.65	3904.90
2028	2715.50	5244.95
2029	3389.19	6744.08
2030	4096.57	8318.17

Table 3.2: India Data Centre Capacity Projection (MW)



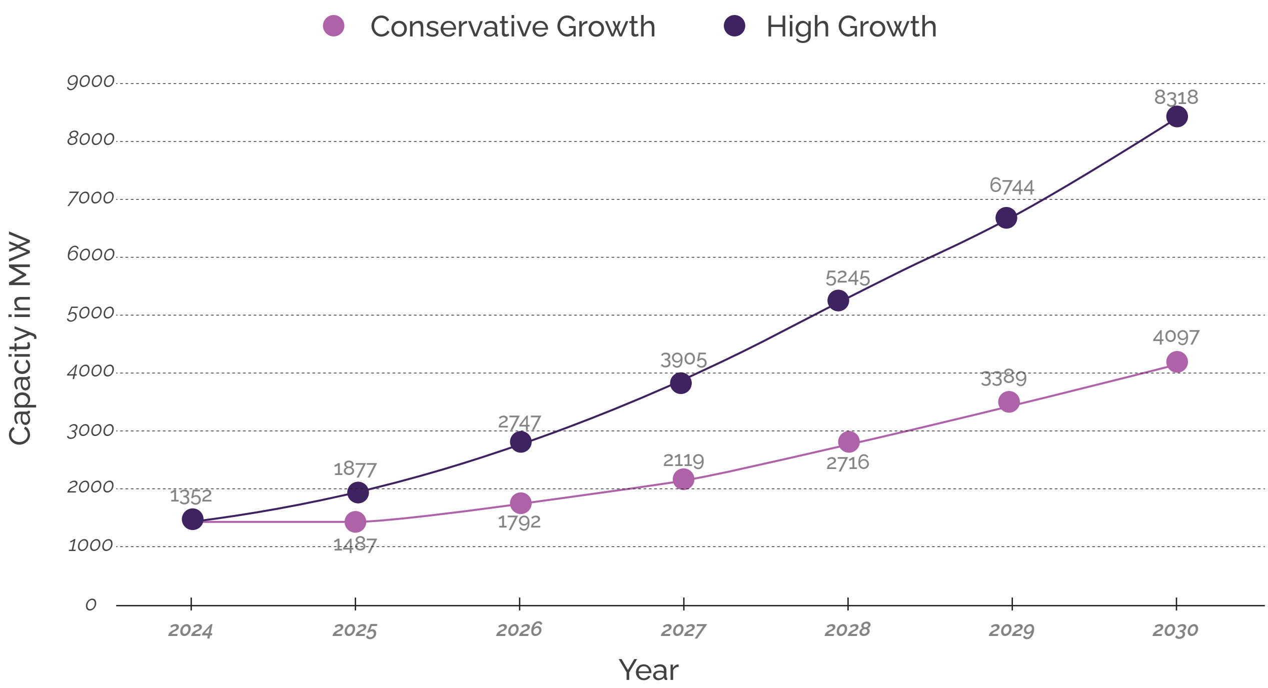


Fig. 3.1: India's Data Center Capacity Projection (2024-2030)

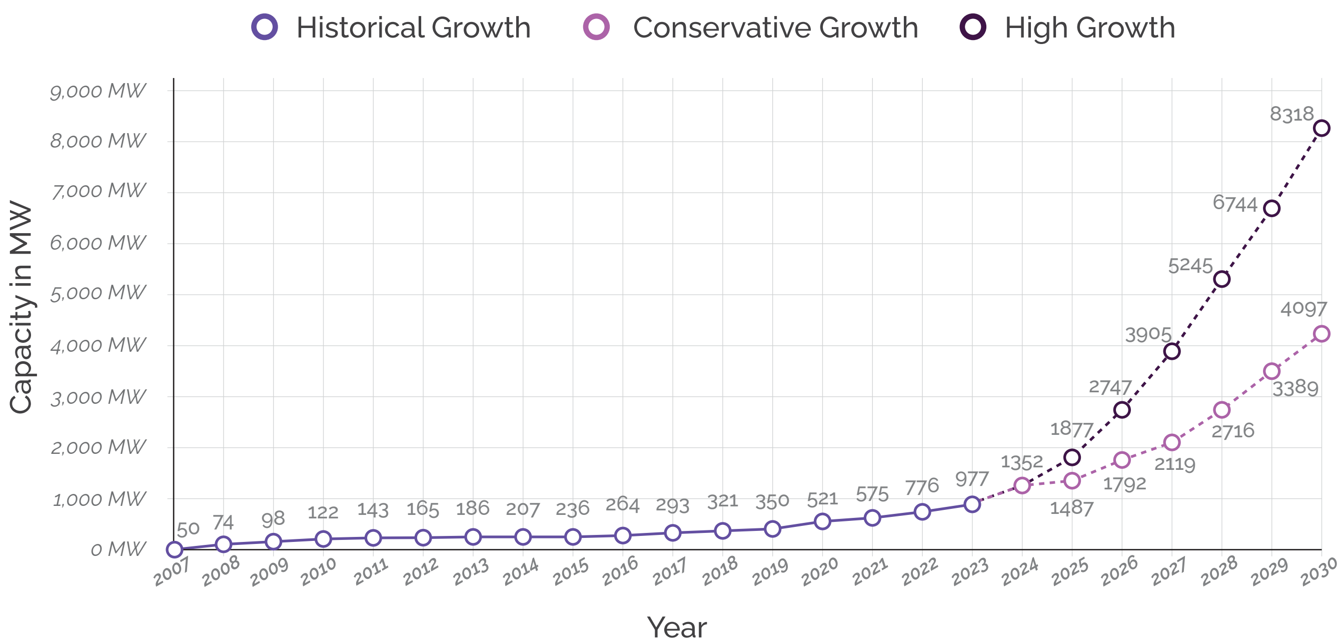


Fig. 3.2: India's Data Center Capacity: Historical and Future Projection

Estimation of Data Center Electricity Demand
Estimation of data-centre electricity demand relies on Power Usage Effectiveness (PUE), which expresses total facility power demand relative to IT equipment power consumption. While leading global operators report fleet-wide annualised PUE values in the range of 1.35–1.40 and have articulated medium-term targets approaching 1.3 for new facilities, direct adoption of these benchmarks requires contextual adjustment for India.

The Indian data-centre market is dominated by hot-humid and composite climatic zones, where elevated ambient dry-bulb and wet-bulb temperatures restrict the applicability of free cooling and increase reliance on mechanically driven cooling systems. In addition, the coexistence of legacy facilities with newly commissioned hyperscale campuses results in a heterogeneous infrastructure base, leading to higher near-term fleet-average PUE values.

Accordingly, an average PUE of 1.6 is assumed for 2024, reflecting prevailing operating conditions and the existing mix of infrastructure. Looking forward, efficiency improvements are expected as a growing share of capacity is added through modern hyperscale and carrier-neutral facilities incorporating advanced airflow management, containment strategies, higher allowable supply-air temperatures, and hybrid or indirect evaporative cooling systems.

Supported by continuous monitoring and operational optimisation, these developments are likely to drive convergence towards global best-practice efficiency levels. On this basis, a forward-looking average PUE of 1.33 is assumed for 2030 (Equinix Sustainability Report, 2025), representing an achievable yet conservative efficiency trajectory for India's expanding data-centre sector while accounting for persistent climatic and locational constraints.

India's data-center electricity demand is estimated using a capacity-based energy accounting approach expressed as:

$$\text{Annual Electricity Demand (TWh)} = \frac{\text{IT Capacity (MW)} \times PUE \times 8{,}760}{1{,}000{,}000}$$

Applying this formulation, India's data-centre sector in 2024, with an installed IT capacity of 1.35 GW and an average PUE of 1.6, is estimated to consume approximately 19 TWh of electricity annually.

Looking ahead, despite efficiency improvements reducing average PUE to approximately 1.33 by 2030, rapid capacity expansion drives a sharp increase in electricity demand. Under a conservative scenario of approximately 4.1 GW IT capacity, consumption rises to about 48 TWh, while a high-growth scenario of approximately 8.3 GW results in nearly 97 TWh per year.

These projections show that efficiency gains are insufficient to offset the scale effects of digital infrastructure growth, highlighting the need for proactive grid planning, high-voltage infrastructure, and large-scale renewable integration.

3.2 Water Demand Modelling

Water has emerged as the second most critical operational resource for data centres after electricity. The rapid expansion of cloud regions, colocation campuses, and AI-driven compute clusters has significantly increased reliance on cooling systems, many of which require substantial volumes of water. Globally, data centres now consume millions of cubic metres of water annually to maintain thermal stability for sensitive IT equipment. In India, where major digital hubs are located in water-stressed and climate-sensitive regions, water modelling becomes central to long-term infrastructure planning.

To support evidence-based decision-making, this chapter develops a city-level Water Usage Effectiveness (WUE) framework that links climate science, cooling engineering, and data-centre design through the following chain:

1. City
2. Climate Zone
3. Temperature
4. Cooling Technology
5. WUE

This structure enables planners, operators, utilities, and policymakers to translate local climate conditions into expected water-use profiles, allowing cooling strategies and site selection to be evaluated on sustainability as well as cost and performance.

India's climatic foundation for this framework is provided by the Energy Conservation Building Code issued by the Bureau of Energy Efficiency. Based on long-term observations of temperature, humidity, solar radiation, and diurnal variation, it classifies India into five climate zones: hot-dry, warm-humid, composite, temperate, and cold. Each zone exhibits distinct thermal and moisture characteristics that determine cooling efficiency and water intensity, making climate zoning a fundamental input for data-centre design(Bureau of Energy Efficiency, 2017).

Within each climate zone, ECBC temperature envelopes are used to represent long-term seasonal operating conditions rather than short-term anomalies. These temperature ranges define which cooling technologies can function efficiently and therefore how much water will be required. Temperature thus acts as the technological inflection point that determines the seasonal mix of cooling systems.

Cooling technologies differ widely in their water requirements. Free Cooling (FC) relies on ambient air or chilled water and requires little to no water, performing best in cold, temperate, and winter periods of composite climates. Adiabatic and evaporative cooling (AD) use water evaporation for pre-cooling and are highly effective in hot-dry regions but perform poorly in warm-humid conditions. Direct Expansion (DX) systems use no water but consume high electrical energy, making them necessary where both heat and humidity are high. Hybrid systems combine FC, AD, and DX, dynamically switching between modes as weather changes, and are essential in composite and warm-humid climates. Liquid cooling, increasingly used in AI and GPU-dense facilities, introduces additional water dependency depending on loop design.

The physical basis for this mapping lies in psychrometrics. Warm-humid air is already saturated, limiting evaporative potential and forcing reliance on DX and mechanical cooling. Hot-dry air supports highly efficient evaporation, making adiabatic and evaporative systems dominant. Cold and temperate climates enable long free-cooling windows, while composite climates require seasonal switching across modes. This ensures cooling strategies are both climate-appropriate and water-optimised.

Empirical WUE benchmarks for these technologies are drawn from the Microsoft Azure Modern Datacenter Cooling21 dataset, which provides operational water-use data across cooling architectures. According to Azure, Free Cooling has near-zero water use; Indirect Evaporative Cooling (IDEC) operates in the range 0.02–0.7 L/kWh; Direct Evaporative Cooling (DEC) ranges from 0.8–2.1 L/kWh; DX and air-cooled systems consume 0 L/kWh; and water-cooled chillers reach 2.3–2.8 L/kWh, making them the most water-intensive option.

These WUE ranges produce a climate-linked interpretation of water demand: cold and temperate cities achieve very low WUE through free cooling; hot-dry regions fall in the mid-to-high WUE range due to evaporative cooling; warm-humid regions rely more on DX with low but stable WUE; and composite climates vary seasonally across all modes.

Building on this climate-technology-WUE framework, future data-centre water demand is estimated using a bottom-up deterministic model that converts projected IT capacity into annual water consumption. Installed capacity is treated as IT load (MW-IT) and converted to energy using 8,760 operating hours per year and a 0.8 utilisation factor, reflecting realistic long-run operations, redundancy, and phased ramp-up. Annual IT energy is then multiplied by scenario-specific WUE values to yield operational water demand, allowing water use to be treated as a design-dependent outcome rather than an inevitable by-product of scale.

Four representative WUE values are used to bound plausible outcomes:

- WUE = 0.0 L/kWh, representing fully air-cooled or refrigerant-based systems (e.g., DX or air-cooled chillers) with no onsite water consumption;
- WUE = 0.7 L/kWh, representing high-efficiency hybrid or indirect evaporative cooling systems;

- WUE = 2.1 L/kWh, representing conventional direct evaporative or adiabatic cooling systems typically deployed in hot-dry climates; and
- WUE = 2.8 L/kWh, representing water-intensive cooling tower-based mechanical systems.

For each year, capacity trajectory, and WUE case, annual water consumption is computed as:

Annual Water Use = Installed IT Capacity (MW) × 1000 × 8760 × 0.8 × WUE

Results are aggregated and reported in billion liters per year, enabling direct comparison with municipal, industrial, and basin-level water demand indicators. The analysis focuses exclusively on direct operational water use attributable to data-center cooling and excludes upstream water consumption associated with electricity generation or infrastructure construction. While this represents a partial lifecycle perspective, it isolates the component of water demand most relevant for siting decisions, regulatory approvals, and local water-stress assessments.

Projected data-center water demand in India across WUE values (2024–2030)

Year	Capacity (MW)	WUE = 0	WUE = 0.7	WUE = 2.1	WUE = 2.8
2024	1352	0.0	6.6	19.9	26.5
2025	1487	0.0	7.3	21.9	29.2
2026	1792	0.0	8.8	26.4	35.2
2027	2119	0.0	10.4	31.2	41.6
2028	2716	0.0	13.3	40.0	53.3
2029	3389	0.0	16.6	49.9	66.5
2030	4097	0.0	20.1	60.3	80.4

Table 3.3: Water consumption as per the WUE over years (Conservative-growth scenario)

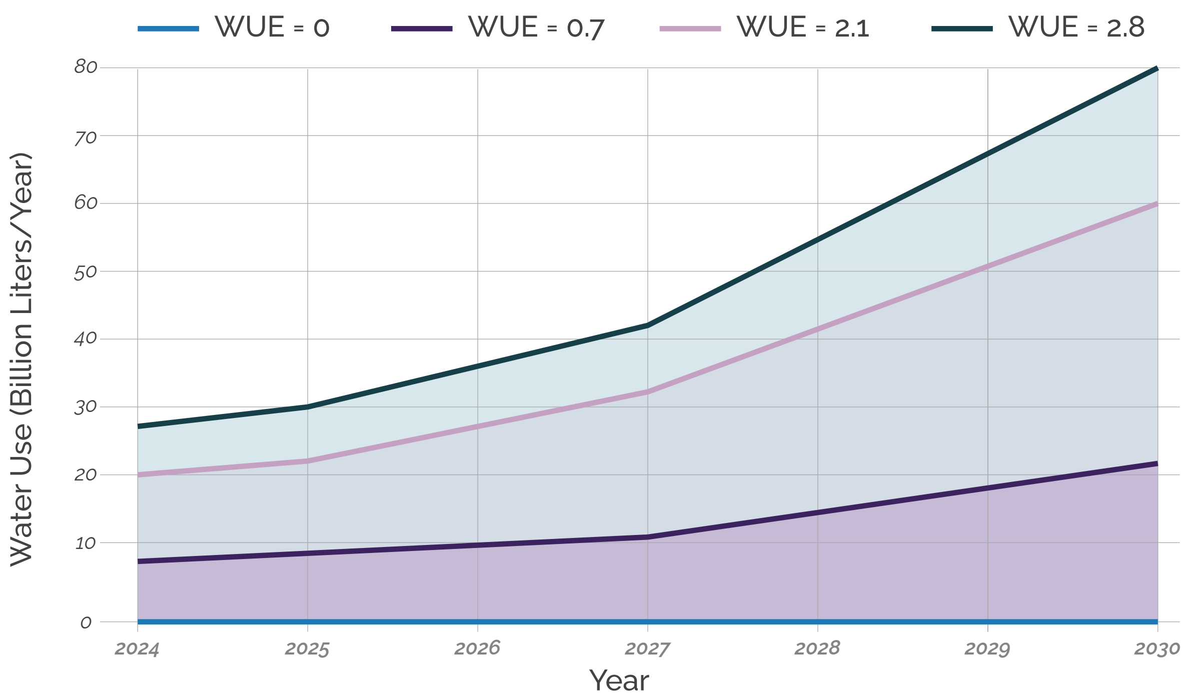


Fig. 3.3: Annual Water Use in Conservative-growth Scenario

Year	Capacity (MW)	WUE = 0	WUE = 0.7	WUE = 2.1	WUE = 2.8
2024	1352	0.0	6.6	19.9	26.5
2025	1877	0.0	9.2	27.6	36.8
2026	2747	0.0	13.5	40.5	54.0
2027	3905	0.0	19.2	57.5	76.7
2028	5245	0.0	25.7	77.3	103.0
2029	6744	0.0	33.1	99.3	132.4
2030	8318	0.0	40.8	122.5	163.3

Table 3.4: Water consumption as per the WUE over years (High-growth scenario)

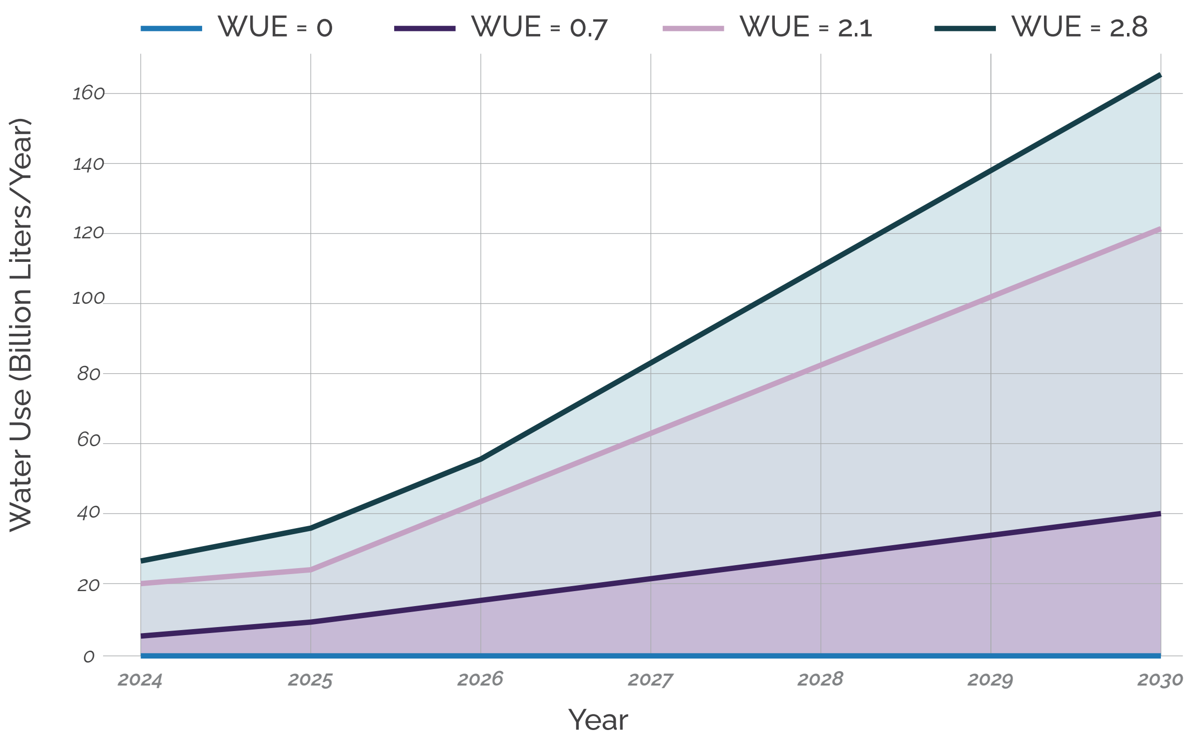


Fig. 3.4: Annual Water Use in High Growth Scenario

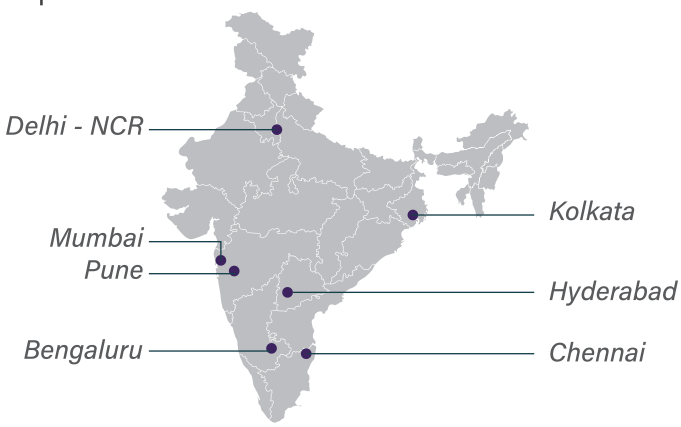
By combining empirically grounded WUE values with transparent operational assumptions, this methodology provides a reproducible and policy-relevant estimate of future data-center water demand. Crucially, it demonstrates that projected water consumption is highly sensitive to cooling-technology choice, reinforcing the role of design standards and regulatory guidance in shaping the environmental footprint of India's digital infrastructure expansion.

4. INDIA'S DATA CENTRE GEOGRAPHICAL FOOTPRINT AND ECOSYSTEM CLUSTERING

The geographic distribution of India's data centre capacity is marked by a dual strategy: intense concentration in connectivity-rich Tier-1 metros and strategic, policy-driven expansion into specialised and secondary hubs.

4.1 Tier-1 Hub Dominance and Strategic Advantage

India's data-centre industry remains overwhelmingly concentrated in its Tier-1 hubs, which together account for nearly 90% of the country's total installed capacity of 1.3 - 1.4 GW. These cities Mumbai, Chennai, Delhi-NCR, Bengaluru, Hyderabad, Pune, and Kolkata have emerged as the backbone of India's digital infrastructure owing to their superior power reliability, robust fibre density, availability of submarine cable landing stations, deep enterprise clusters, and the strong presence of global hyperscalers. The dominance of these metros is a structural outcome of sustained policy support, established connectivity ecosystems, and a continuous flow of colocation and cloud demand that smaller cities have yet to replicate.



4.1.1 Mumbai

Mumbai stands at the epicentre of India's data-centre landscape, commanding an unmatched 490 MW of installed capacity, the highest in the country. With a low vacancy rate of 3.6% and 347 MW under construction, it is expected to contribute more than one-third of upcoming capacity additions. As India's primary undersea cable hub, with around 15 of 17 international subsea cables landing in or routing through the region, Mumbai offers the lowest latency to global markets, making it a natural first choice for hyperscalers. Its strong financial-services ecosystem, concentration of multinational corporations, mature real estate markets, and robust power availability further reinforce its position, making its leadership both structural and enduring.

4.1.2 Chennai

India's second-largest data-centre hub, has firmly established itself as the country's eastern digital gateway. With 147 MW of installed capacity, a moderate vacancy rate of 6.9%, and a substantial 259 MW under construction, it has emerged as a preferred destination for hyperscale cloud and AI workloads. The city's strategic coastal location, along with four cable landing stations connecting India to Southeast and East Asia, strengthens its connectivity advantage, further supported by the upcoming MIST cable system, which is expected to enhance bandwidth and reduce latency. Its favourable climatic conditions, which help lower cooling costs, and the availability of large contiguous land parcels add to its appeal. Backed by Tamil Nadu's business-friendly policies, Chennai is projected to capture nearly one-fourth of India's incremental data-centre capacity in the coming years.

4.1.3 Delhi-NCR

It serves as Northern India's most important data-centre node, with 94 MW of installed capacity and a substantial 162 MW under construction. Although its vacancy rate of 16.5% is the highest among Tier-1 hubs, this largely reflects the addition of new large-scale campuses, particularly in Noida. Its proximity to government institutions, telecom headquarters, BFSI firms, and a vast enterprise base makes it the capital region's key digital infrastructure zone. Strong grid connectivity, competitive real estate, and the availability of large development parcels continue to attract hyperscalers and colocation operators, with NCR expected to contribute nearly 15% of India's data-centre expansion over time.

4.1.4 Bengaluru

with 97 MW of installed capacity and a vacancy rate of 10.5%, Bengaluru anchors India's enterprise and SaaS-driven data-centre demand. The city's growth is shaped less by hyperscaler buildouts and more by dense consumption from IT services, fintech, e-commerce, and global capability centres. While its under-construction pipeline of 50 MW is smaller compared to Mumbai or Chennai, its role as India's technology capital ensures a steady flow of enterprise colocation requirements. Bengaluru's advantage lies in its deep talent pool, highly developed IT ecosystem, and strong interconnection demand, making it a strategic node for private and hybrid cloud deployments.

4.1.5 Hyderabad

It is emerging rapidly as a hyperscale-centric market, with 48 MW of installed capacity and 34 MW under construction. Although smaller today, Hyderabad's trajectory is strong: Microsoft's large land acquisitions for self-build campuses, a technology-driven enterprise base, and proactive state policies offering power subsidies, fast-track land allotment, and dedicated data-centre parks have positioned it as a future Tier-1 heavyweight. Its low vacancy rate of 6.4% reflects strong demand absorption, and the city is increasingly favoured for purpose-built hyperscale facilities.

4.1.6 Pune

Pune operates as a strategic extension of Mumbai, offering risk diversification, lower natural hazard exposure, and access to the same enterprise corridor. With 64 MW of operational capacity, a remarkably low vacancy rate of 1.2%, and 45 MW under construction, Pune has become a preferred disaster-recovery and secondary deployment hub for operators serving Mumbai. Its combination of availability, stability, and proximity provides a strong efficiency advantage for businesses requiring redundancy and business continuity.

4.1.7 Kolkata

Though smaller with 10 MW of installed capacity, Kolkata plays a unique role as Eastern India's only meaningful data-centre hub. With 51 MW of capacity under construction and a low vacancy rate of 1.7%, the region is gaining traction, driven by BFSI, telecom, and government digitisation efforts. As subsea cable connectivity expands on India's eastern seaboard, Kolkata's strategic importance is expected to grow significantly.

Together, these Tier-1 hubs form India's digital backbone. Their combined advantages like dense connectivity networks, hyperscaler clusters, enterprise consumption, policy support, and infrastructure readiness ensure that they will remain the dominant centres of data-centre growth over the next decade. Their leadership is structural, not incidental, and their continued expansion will underpin India's progression toward becoming a global data-infrastructure powerhouse.

Data Centre Hub	Approximate Capacity Share	Primary Strategic Advantage	Key Demand Sector
Mumbai	53%	Submarine Cable Landing, Western Financial Corridor, BFSI Concentration	BFSI, Hyperscale Cloud, Finance 8
Chennai	20%	East CoastConnectivity, Geo-Redundancy /Disaster Recovery	Cloud, Technology
Delhi-NCR	10%	Government Services, North Indian Enterprise Access	Enterprise, Government
Hyderabad	7%	Proximity to Semiconductor Fabs, AI Research Parks, SaaS Exports	SaaS, Chip Design, AI/HPC 8
Bengaluru	7%	Start-up Ecosystem, Technology R&D, AI/HPC Focus	Cloud, Technology

Table 2.2: Geographic Footprint Distribution and Strategic Advantages (2024)

The heavy reliance on coastal cities, particularly Mumbai, creates geographic concentration risk and potential single points of failure from natural disasters or cable outages. However, sectoral regulations, including RBI's IT and cyber-resilience directions and emerging DPDP rules, are pushing critical entities towards multi-geographic architectures. This shift makes geo-redundancy such as pairing Mumbai with Chennai or a major inland hub a mandatory design requirement, ensuring continued investment in secondary and inland locations for business continuity.

4.2 Specialised Clustering and the Rise of Tier-2 Cities

While India's Tier-1 metros continue to dominate the data-centre footprint, a parallel and strategically important shift is underway in Tier-2 cities. This is being driven by rising digital penetration, enterprise workloads moving beyond metros, and the growing need for low-latency edge infrastructure. The next phase of growth is expected to come from edge data centres and prefabricated modular facilities, with significant deployment across Tier-2 and Tier-3 cities over the next 2–5 years.

These markets benefit from lower real-estate costs, expanding enterprise activity, and state-led digital initiatives. This makes them natural locations for distributed workloads, disaster-recovery zones, and sector-specific compute nodes. Instead of replacing Tier-1 hubs, they are emerging as complementary infrastructure that improves resilience and reduces latency.

Tier-2 cities such as Gandhinagar, Jaipur, Kochi, Lucknow, Bhubaneswar, Ahmedabad, and Coimbatore are increasingly being assessed for specialised clustering. Use cases such as government cloud, BFSI regional nodes, manufacturing clusters, and OTT caching require proximity to end users as well as strong enterprise ecosystems.

The importance of edge data centres is further reinforced by rising demand for real-time digital services such as video streaming, gaming, mobility platforms, IoT, and AI-enabled enterprise applications. Prefabricated modular facilities allow faster deployment and phased scaling, making these cities well suited for decentralised compute where speed-to-service and uptime commitments are critical.

Several Tier-2 markets also benefit from strong regional economic clusters that naturally generate compute demand. Gujarat, particularly Gandhinagar and Ahmedabad, is emerging as a hub for fintech, manufacturing, and government digital services. Kochi benefits from strong cable connectivity, while Jaipur, Lucknow, and Bhubaneswar are seeing rapid enterprise cloud adoption driven by IT-enabled services, digital governance programmes, and citizen-facing digital platforms.

Although these cities currently account for a smaller share of national capacity, the rapid growth of AI, IoT, 5G, and state-led digital missions positions them for strong medium-term expansion. Operators are already responding through modular deployments and land pre-commitments in high-potential markets.

Combined with lower land costs, supportive state policies, and rising digital consumption, Tier-2 cities are set to play a transformative role in India's next phase of data-centre growth. The future architecture is likely to be less concentrated and more networked, where compute is increasingly distributed rather than confined to a few metro hubs.

4.3 Identifying Suitable Cities for Future Data Center Development in India

As the market evolves, policymakers and industry leaders are recognising the need to expand India's data-centre footprint into Tier-2 and Tier-3 cities, which represent the next frontier for distributed capacity, regional redundancy, and future-ready digital expansion.

To guide this transition, a Data Center Suitability Score is developed using a structured Multi-Criteria Decision Analysis approach. MCDA is used where decisions must consider multiple factors rather than a single parameter. It combines different criteria, assigns their relative importance, and evaluates how each option performs. This method is widely applied in complex decisions such as site selection, infrastructure planning, and policy evaluation. It involves identifying options, defining criteria, assigning weights, scoring performance, and combining these scores into a final ranking, thereby improving transparency, consistency, and decision robustness.

The objective is to identify locations where data-centre clusters can be established or shifted as India's digital geography diversifies. Moving beyond established hubs, the framework places emphasis on Tier-2 and Tier-3 cities where data centres are currently absent but where ecosystem conditions may be favourable. These locations offer opportunities for greenfield development and decentralisation of workloads from Tier-1 regions.

The Suitability Score integrates six parameters into a unified system reflecting long-term suitability for energy-intensive digital infrastructure. These include power availability, hydrological resources, renewable energy potential, and exposure to seismic and flood risks, forming the core of modern site selection. In Tier-2 and Tier-3 contexts, where infrastructure varies significantly, this composite approach provides a structured basis for policymakers, investors, and developers to evaluate and prioritise locations.

The assessment begins by excluding Tier-1 cities and shortlisting Tier-2 and Tier-3 cities with strong fibre connectivity. Fibre backhaul is a non-negotiable prerequisite, enabling low-latency, high-throughput, and resilient connectivity. Without it, even cities with favourable power or environmental conditions cannot be considered viable, ensuring the analysis remains grounded in infrastructure-ready realities.

To operationalise this framework, the Data Center Suitability Score provides a composite measure of each city's suitability for long-term development, based on infrastructure, environmental risk, and resource availability. Rather than relying on binary feasibility filters, the methodology evaluates all variables as graded performance factors, placing cities on a continuous suitability spectrum. This approach is particularly relevant for Tier-2 and Tier-3 cities, where conditions vary widely and future readiness is as important as current capacity.

4.3.1 Selection of Indicators and Weights

Six indicators were selected based on their relevance to data center siting and data availability. Each indicator was assigned a predefined weight reflecting its relative importance in determining suitability.

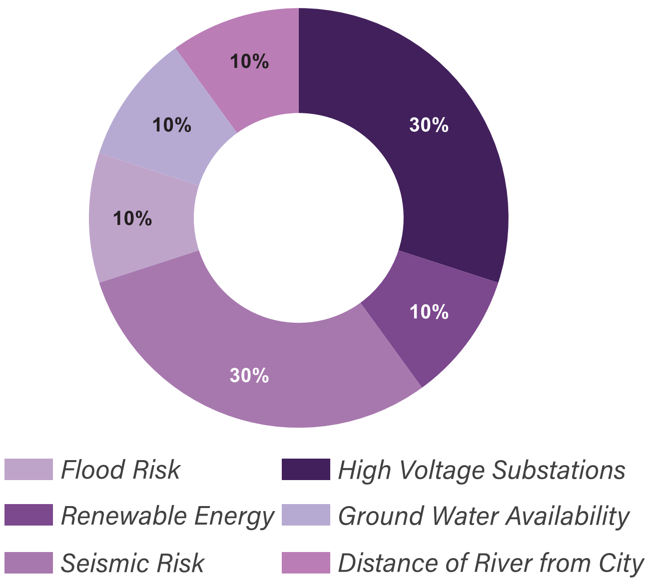


Figure 4.1 : Weights for the Indicators

Based on the literature review and expert consultations, power infrastructure and seismic risk emerged as the most critical factors for data center location decisions. Accordingly, these indicators were assigned higher weights to reflect their strong influence on operational reliability and structural safety (NASSCOM, 2023). while the remaining indicators capture supporting environmental and resource conditions.

4.3.2 Indicator Categorisation and Scoring

City-level data were collected for all six indicators used in the suitability assessment. To ensure comparability across indicators and enable meaningful aggregation, all raw indicator values were standardised into a Suitability Score on a 0-100 scale, where higher scores indicate greater suitability for data center development.

Each indicator was first classified into five ordered categories reflecting varying levels of infrastructure capacity, resource availability, or environmental risk. For risk-based indicators, an inversion method was applied so that higher risk corresponds to lower suitability.

The standardisation method adopted for each indicator is detailed below.

- **Power Availability:** Power availability was assessed based on the highest-voltage electrical substation available within or in proximity to each City. Voltage levels were categorised to reflect gradations in grid capacity and reliability. Cities with higher-voltage infrastructure were assigned higher suitability scores.

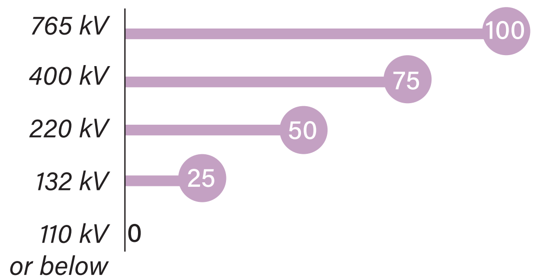


***Figure 4.2:* Voltage Category and Suitability Score**

This categorical representation captures relative differences in power infrastructure adequacy rather than treating power availability as a binary condition.

- **Renewable Energy Availability:** Renewable energy availability was assessed using raw generation or potential values at the regional or City level. These values were grouped using K-means clustering (k = 5) to classify Cities into five distinct availability tiers. The resulting clusters were assigned suitability scores as follows:

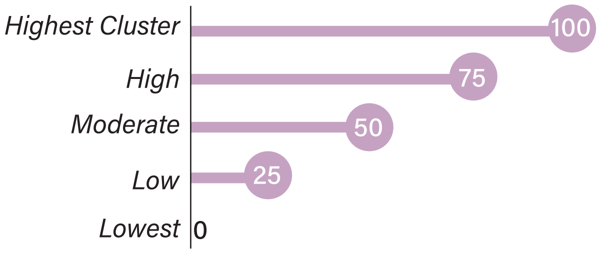


Figure 4.3 : Availability and Suitability Score

The selection of k = 5 balances interpretability with variance reduction and ensures alignment with the five-category scoring framework used across all indicators.

- **Groundwater Availability (Depth to Water Table):** Groundwater availability was evaluated using depth to water table data. Shallower water tables, indicating easier access to groundwater resources, were assigned higher suitability scores.

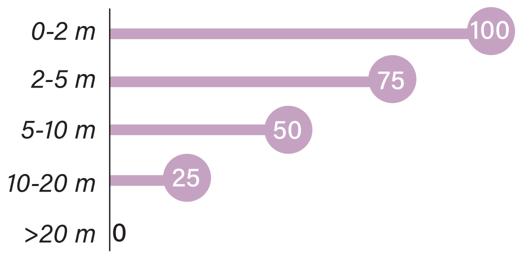


Figure 4.4 : Depth to Water Table and Suitability Score

- **Distance of River from City:** The distance from each City to the nearest river was calculated and categorised into proximity bands. Cities closer to surface water sources were considered more suitable.

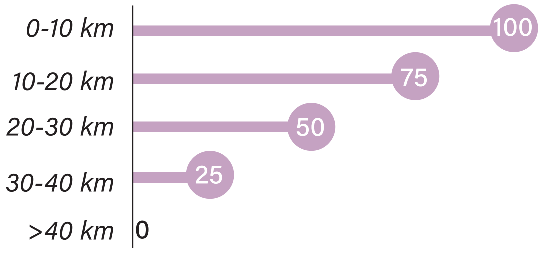


Figure 4.5 : Distance from River and Suitability Score

- **Seismic Risk:** Seismic risk was assessed based on official seismic zoning classifications. For cities spanning multiple seismic zones, the higher-risk zone was selected to maintain a conservative assessment.

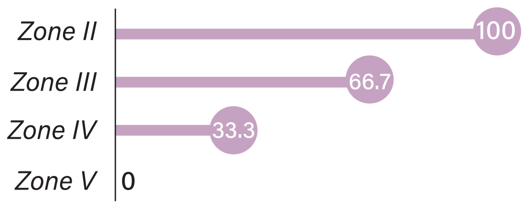
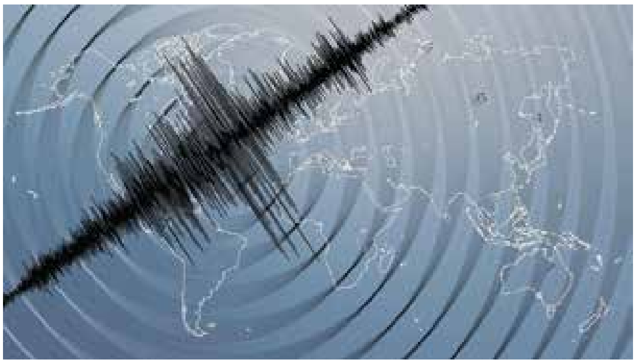


Figure 4.6 : Seismic Zone and Suitability Score



Suitability scores were assigned using a reverse linear normalisation approach to reflect varying levels of seismic risk. Seismic zones range from Zone 2 (lowest risk) to Zone 5 (highest risk). To ensure that higher seismic risk corresponds to a lower score, Zone 2 was assigned a score of 100 and Zone 5 a score of 0. Scores for intermediate zones were calculated using linear interpolation between these two bounds, ensuring a uniform and comparable decline in scores as seismic risk increases across zones.

- **Flood Hazard:** Flood risk was evaluated using categorical flood hazard classes mapped to ordinal levels {1, 2, 3, 4, 5}, where higher values indicate greater flood exposure. An inversion method was applied to convert hazard levels into suitability scores.

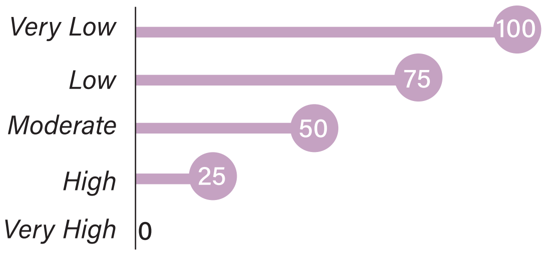


Figure 4.7 : Flood Hazard Level and Suitability Score

This standardized scoring framework ensures directional consistency, comparability across indicators, and transparency in aggregation, forming a robust basis for the composite Data Centre Suitability Score.

4.3.3 Score Calculation, Normalisation and Ranking

All indicators were expressed on a common 0–100 suitability scale prior to aggregation. The composite suitability score (CS_i) for each City i was calculated using a weighted additive model:

$$CS_i = \sum_{j=1}^{7} w_j . s_{ij}$$

Where sij is the indicator value for City i on indicator j, and wj is the fractional weight for indicator j. Since all component scores are scaled 0–100 and the weights sum to 1.00, the resulting raw Score Si is also bounded by [0, 100]

Now to ensure the final Score is globally comparable and spans the full interpretative range, the raw weighted sum (Si) is subjected to Min-Max Normalisation across all Cities. This produces the final DCSSi, which is used for the definitive ranking of City suitability:

$$DCSSi = \frac{CS_{i_i} - Min(CS_i)}{Max(CS_i) - Min(CS_i)} \times 100$$

Higher scores indicate cities with a favorable combination of strong power infrastructure, lower environmental risk, and better access to water and renewable energy resources.

4.3.4 Final Result

Based on the final normalised scores, the analysis reveals clear differentiation in city-level suitability for new data centres, with all 96 cities ranked according to their Data Centre Suitability Score (DCSS). (Annexure 1)

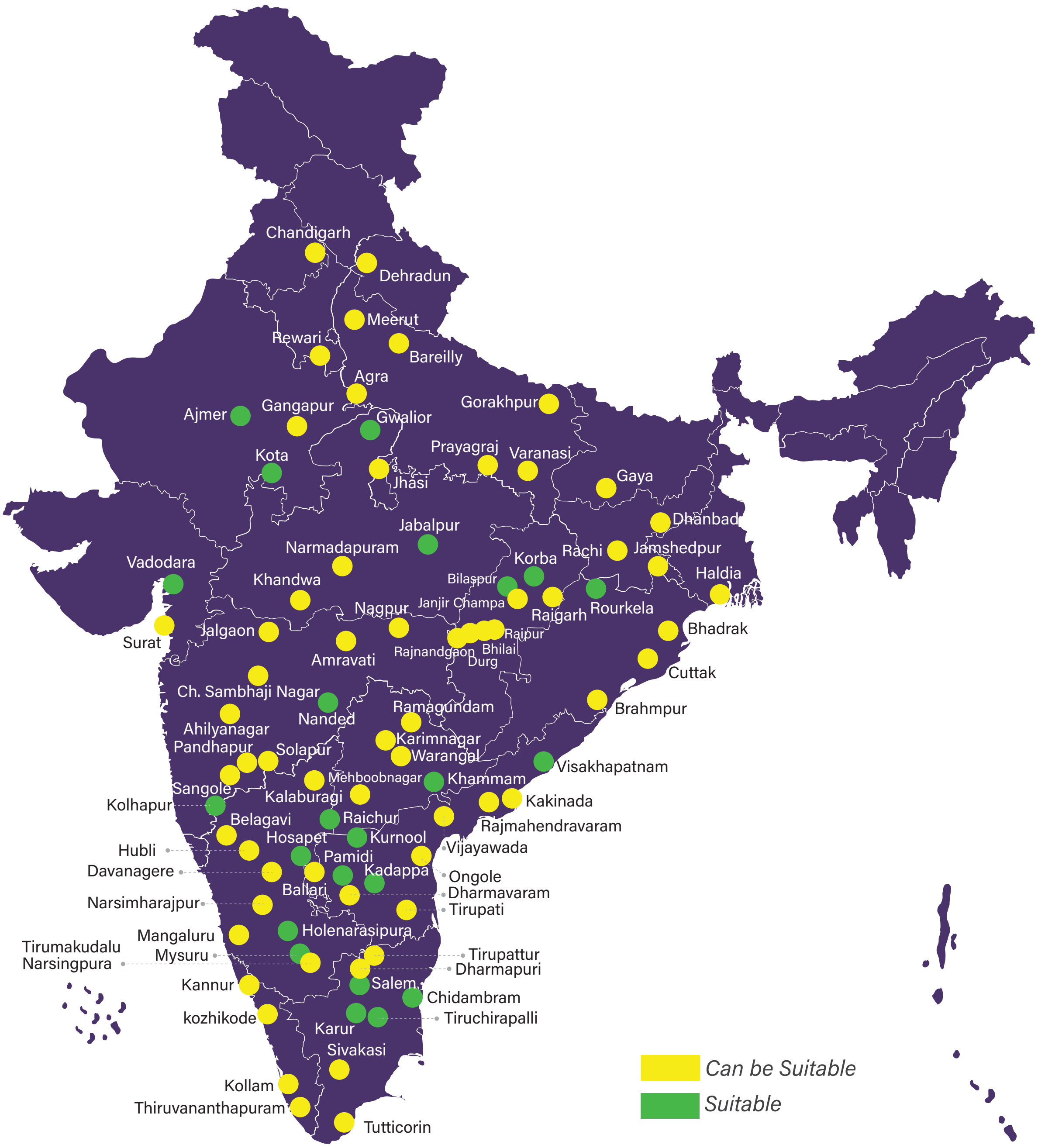


Figure 4.8 : Probable Cities for Data Center Setup

The spatial map generated through our analysis visualises Tier-2 and Tier-3 city suitability using a two-colour classification yellow, and green representing the relative readiness of each city to host data center infrastructure. The yellow category represents cities that are potentially suitable. These cities meet most of the core requirements but lag in one or two critical areas such as renewable energy access, groundwater depth, or proximity to substations. With targeted interventions or minimal infrastructure improvements, these cities can transition into fully suitable locations. Finally, the cities highlighted in green represent the most favorable zones, where the essential conditions of power availability, fiber connectivity, water resources, renewable energy potential, and low environmental risk are already in place. These green-zone cities are immediate candidates for data center siting and reflect strong present-day readiness for both greenfield development and strategic capacity expansion.

5. INDIA'S DATA CENTRE POLICY: NATIONAL STRATEGY, STATE INITIATIVES & GLOBAL CONTEXT

India's ambition to emerge as a global digital and AI powerhouse is intrinsically linked to the strength and scalability of its digital infrastructure. At the core of this ambition is the rapid expansion and formalisation of the data centre sector. This chapter analyzes the policy landscape, a critical engine driving investment and capacity creation by examining the dynamic interplay between the central government's strategic vision, incentive driven policies implemented at the state level, and the overarching global context of data governance and sustainability.

5.1 National Data Centre Policy Framework

5.1.1 Data Centre Policy 2020

- India's central government has articulated a vision to make the country a global data centre hub, recognising the critical role of data infrastructure in the digital economy. In November 2020, the Ministry of Electronics and IT released a Draft Data Centre Policy 2020 that laid out a comprehensive framework for the sector.

- This draft policy proposed several key measures, including establishing single-window clearances to streamline the 30+ approvals needed to build a data centre,[24] publishing a clear list of required approvals with defined timelines, and creating at least four Data Centre Economic Zones (DCEZs) under a central scheme.

- These DCEZs were envisioned as large clusters with pre-cleared land, reliable power, and fibre connectivity to attract investments from hyperscale cloud and colocation providers. (Ministry of Electronics and Information Technology, 2020).

- The draft also proposed establishing an independent Data Centre Industry Council to serve as an interface between industry and government, while emphasising key structural reforms such as declaring data centres as "Essential Services" under the Essential Services Maintenance Act to ensure continuous operations during crises, and introducing a dedicated classification for data centre buildings in the National Building Code to enable tailored construction norms.

- However, while the draft policy of 2020 was well-received, it was never formally adopted at that time. Notably, in the Union Budget 2022–23, the Finance Minister announced that data centres would be given "Infrastructure status", which was implemented via an October 2022 notification. Under this move, any data centre with an IT power load over 5 MW is classified as infrastructure, a change that eases access to financing and loans by enabling data centre firms to tap into infrastructure credit lines at lower rates. This was a landmark decision that recognised large data centres as critical infrastructure akin to utilities.

- By 2023–24, the central government renewed focus on a national data centre policy. MeitY restarted stakeholder consultations to update the 2020 draft in light of the sector's rapid growth. Officials noted that many objectives of the original draft such as simplified approvals, distributed geographical spread of data centres, and promotion of domestic manufacturing remained relevant, but needed to account for new developments like the AI computing boom.

5.1.2 Draft Data Centre Policy 2025

- The 2025 draft policy proposes significant incentives to boost investment, including up to 20-year tax holidays or exemptions for data centre developers meeting specified targets in capacity addition, energy efficiency, and job creation. It also allows input tax credits on GST for capital purchases such as building materials, cooling, and electrical systems to reduce upfront costs.
- Additionally, the draft grants permanent establishment status to large foreign operators (≥100 MW) and offers special incentives for co-locating emerging technology facilities like AI innovation hubs with data centres, underscoring the strategic linkage with AI, cloud, and cybersecurity.
- Coordination across ministries is a central theme in the national strategy. MeitY is collaborating closely with the Ministry of Power, the Central Electricity Authority (CEA), and other agencies to ensure data centres have access to robust power infrastructure. Guidelines are being formulated to facilitate land allocation for data centre parks near industrial corridors and IT hubs, enabling developers to readily obtain suitable land with necessary utilities.
- The National Digital Communications Policy 2018 is leveraged to improve fibre connectivity through common utility ducts and by allowing operators to lay their own fibre cables for reliable, low-latency links. Additionally, the draft policy encourages "dial before you dig" initiatives to prevent accidental fibre cuts and reduce downtime.
- India's national data centre policy aims to promote rapid sector growth while addressing sustainability, security, and data localisation. It focuses on tax incentives, faster approvals, infrastructure support, and easier access to land and power, while also encouraging energy efficiency. Its broader goal is to position India as a global data centre hub and strengthen domestic digital infrastructure. The final policy is expected to build on industry feedback and successful state-level initiatives.

5.2 State-Level Data Centre Policies and Incentives

In parallel with the central efforts, many Indian states have introduced their own data centre policies to attract investments and tailor incentives to local needs. Over the past few years, at least 8–10 states including Maharashtra, Tamil Nadu, Uttar Pradesh, Telangana, Karnataka, Gujarat, West Bengal, Andhra Pradesh, and others have unveiled dedicated policies or provisions for data centres. These state policies complement the national vision by offering region-specific incentives such as tax concessions, subsidies, streamlined clearances, and infrastructure support to data centre developers. Below is an overview of key state-level initiatives:

State	Policy / Year	Key Incentives (Fiscal + Power)	Regulatory / Non-Fiscal Ease	Outcomes / Notes
Maharashtra	IT/ITeS Policy 2015–16; updated 2023	•100% stamp duty exemption • Electricity duty waiver • VAT refunds on capex •Property tax concessions • Push for green energy	•Single-window via MAITRI Fast-track approvals	Mumbai = ~40% of India's colocation capacity. Preferred by global & domestic players.
Tamil Nadu	Data Centre Policy 2021	•Electricity tax exemption •Concessional tariffs / open access (reduced cross-subsidy) •Dual grid feeds •50–100% stamp duty exemption	•Single-window facilitation •Self-certification (labour, pollution) •Treated as essential service (no statutory power cuts) •Relaxed FAR/building norms	Chennai = India's 2nd largest hub (~23%). Hyperscalers like AWS, Google invested.
Uttar Pradesh	DC Policy 2021 (amended 2022)	• Capital subsidy (up to % cap) • Interest subsidy on loans •Land rebates/subsidies •100% stamp duty (1st transaction), 50% (2nd) •Electricity duty exemption (10 yrs) •Dual power grids, RE concessions	•Single-window (Invest UP) •Self-certification & reduced inspections	Large projects in Greater Noida (Yotta, Adani, Nxtra). NCR advantage.
Telangana	Data Centres Policy 2016	•Subsidized land (25–50% rebate) •Building permit fee rebates •Power tariff discounts / reimbursements	•Exempt from Pollution Control Act •Exempt from statutory power cuts •Self-certification under labour laws	Attracted CtrlS hyperscale campus, AWS local zones. Infra-status at state level.
Karnataka	Data Centre Policy 2022–27	•Stamp duty exemption •Reimbursement of land conversion fees • Subsidy for electrical infra •100% electricity duty exemption (5–10 yrs) •Green power tariff reimbursements (cap removed 2023)	•Single-window (Karnataka Udyog Mitra)	Clusters around Bengaluru + secondary hubs (Mangaluru, Hubballi).
West Bengal	Data Centre Policy 2021	• Land subsidies / lease rebates •Utility subsidies (power) • Partial stamp duty/registration waivers • Power duty exemption	• Single-window cell • Flexible height/parking norms	Focus: Kolkata as East India hub.
Other States (Haryana, Odisha, Gujarat, AP, Punjab, Rajasthan, MP, etc.)	Mostly 2022 onward	• Haryana: interest subsidies, dual power, municipal bylaw exemptions •Odisha: subsidized coastal land, IT hardware promotion •Gujarat/AP: capital subsidies, concessional power tariffs, tax breaks	•Single-window clearances • Land allotment in industrial/tech parks	Competitive federalism; common features: infra-status recognition, stamp duty waivers, RE push.

Table 5.1: Overview of key state-level initiatives

5.3 Related Regulatory and Infrastructure Considerations

5.3.1 Data Protection Laws and Data Localisation

Beyond dedicated data centre policies, several related regulatory regimes impact the data centre industry in India. Key among them are data protection laws, infrastructure regulations (power, cooling, land use), and government incentive schemes. These frameworks ensure that data centres operate in compliance with broader national objectives like data security, sustainable development, and economic growth.

- Data protection regulation in India has evolved significantly in recent years and directly influences data centre demand and operations. In August 2023, India enacted the Digital Personal Data Protection Act, 2023 (DPDP Act) , country's first comprehensive privacy law.

- The DPDP Act establishes rules for how personal data is collected, stored, and processed, and it creates a Data Protection Board to enforce compliance. While the DPDP Act's primary focus is on user privacy and accountability of data processors, it also has provisions affecting where data can be stored and transferred.

- Notably, the DPDP Act permits cross-border transfer of personal data by default, except to certain countries that the Indian government may notify on a "negative list" for reasons such as inadequate data protection or national security concerns. In other words, unlike previous draft bills that mandated strict data localisation, the final 2023 Act adopts a balanced approach in which data can be hosted globally, but the government reserves power to disallow transfers to specific jurisdictions (to be identified).

- This approach contrasts with the EU's GDPR (which requires an adequacy decision or other safeguards for foreign transfers), India's law is more open-ended, allowing data flows unless a country is explicitly blacklisted, thereby aiming to support business flexibility while safeguarding privacy.

- The DPDP Act does not impose a blanket requirement for all personal data of Indians to reside in India. However, government restrictions on certain countries or organisational choices for local storage (for performance or compliance reasons) could still boost demand for domestic data centre capacity. Additionally, the Act's strict data security and breach-reporting obligations require robust and secure infrastructure, underscoring the importance of modern data centres for compliance.

- Regulators in certain sectors implemented their own data localisation mandates. A prime example is the Reserve Bank of India's directive in April 2018 requiring that all payments data (transactions, customer details, etc. for domestic payments) must be stored only in India. This RBI rule forced global payment companies and card networks to establish local data storage facilities, many complied by expanding cloud regions or using Indian data centres for their systems.

- Similarly, sectors like telecom (telecom licenses mandate call detail records to be stored in India) and healthcare (draft health data management policies) showed a trend toward keeping sensitive data onshore. The new DPDP Act has superseded most horizontal requirements, but it coexists with such sector-specific mandates. For data centres, this means that certain categories of data cannot leave India's borders, driving localisation.

Overall, India's data protection and data sovereignty framework supports domestic data centre growth by encouraging businesses to store and process data within India. Stronger privacy rules and localisation requirements increase demand for local hosting and certified data centre facilities with high security standards. As the DPDP Act is implemented, further rules on government access and localisation of sensitive data are expected, which could further strengthen the domestic data centre market.

5.4 Infrastructure Regulations: Power, Cooling, and Land Use

Data centres are highly resource-intensive projects, so their success hinges on supportive regulations around electricity supply, environmental controls, and land use. Several policy measures in India address these aspects:

5.4.1 Power Supply and Energy Regulations

- Reliable, affordable power is the lifeblood of data centres. Many states, as noted, treat data centres as essential services or continuous-process industries, which grants them protection from scheduled power cuts. On a national level, the draft Data Centre Policy urged coordination with power authorities (CEA, utilities) to ensure data centre parks get adequate grid infrastructure.

- Open Access regulations which allow large consumers to buy power directly from producers have been a key enabler, data centres are increasingly allowed to procure renewable energy (solar, wind) from off-site projects to both lower costs and meet sustainability goals. Several state policies explicitly provide concessions on open access charges and cross-subsidy surcharges for data centres sourcing green energy, making it financially viable to use clean power.

- Moreover, data centres with >5 MW load now fall under the infrastructure category, which, at the central level, might ease processes like getting dedicated high-voltage feeder lines. Dual power grid connections are encouraged or mandated in many policies, ensuring if one substation fails, the other can supply. The Bureau of Energy Efficiency (BEE) in India has also developed voluntary best practices for data centre energy efficiency (Bureau of Energy Efficiency, 2017), and there are discussions about setting PUE (Power Usage Effectiveness) targets in the future.

- Notably, global trends are influencing India: for example, the EU is moving toward requiring large data centres to achieve certain PUE by set dates (Germany's new law demands PUE ≤1.5 by 2027) and use 100% clean energy by 2030. India's policy is

- Government and industry have begun initiatives like using solar panels, battery storage, and more efficient cooling to reduce data centres' carbon footprint. For instance, a huge solar-powered data centre park (Moro Hub) launched in Dubai is being cited in India as a model for integrating renewables.

5.4.2 Cooling and Water Use

- Data centres require significant cooling, often using water-intensive systems (like chiller plants or evaporative cooling towers). This raises environmental concerns, especially in water-scarce regions. India currently lacks a national policy on data centre water usage, though the issue is increasingly in focus.

- A small 1 MW data centre can consume tens of millions of liters of water per year for cooling, and India's rapid expansion means this footprint is growing. Cities like Mumbai, Chennai, Hyderabad, and Bangalore all major data centre hubs face periodic water stress, so experts are urging early adoption of sustainable cooling practices.

- In practice, operators are already shifting to technologies like air-cooled chillers, liquid cooling, and reusing grey-water for cooling to reduce fresh water draw. The government may in future introduce guidelines or incentives for water-efficient designs (for instance, using coastal locations for seawater cooling, a strategy already noted as viable by researchers (Institute for Energy Economics and Financial Analysis, 2024). Additionally, environmental clearance norms can come into play for very large data centre facilities; if diesel backup generators above a threshold are installed, permissions from pollution control boards might be needed.

- Some states preemptively exempt data centres from certain pollution control norms given their minimal emissions profile as Telangana did. Overall, while no strict regulations exist yet on data centre water or carbon, sustainability is a growing part of the conversation, aligning with global moves like the Climate Neutral Data Centre Pact in the EU (an industry commitment to climate-neutral operations by 2030, including water conservation and waste recycling targets). We can expect future iterations of policy to increasingly bake in green standards for power usage and cooling for example, Singapore has started requiring new data centres to meet stringent efficiency and temperature-operating standards, as discussed later.

5.4.3 Land Use and Building Codes

- Acquiring suitable land is often a challenge for data centres, which need industrial-grade locations with access to fiber and power. Land use regulations in India are largely state-controlled, and states have been proactive in earmarking land for data centre parks (for instance, Tamil Nadu and Uttar Pradesh have identified specific zones for data centre clusters near existing IT parks or industrial corridors).

- Many states offer to facilitate land acquisition or lease government land at subsidised rates to qualified projects. Converting agricultural land to industrial use is expedited for data centre projects in some cases, recognizing them as priority investments. On the urban planning side, one issue has been that the Indian National Building Code (NBC) 2016 did not originally have a separate category for data centres, which are neither typical office buildings nor simple warehouses.

- The 2020 draft policy highlighted the need to create a distinct building code category for data centres to address their unique requirements (like higher floor loadings for server racks, specialised HVAC systems, fire suppression, etc.). Until such a code is formally adopted, governments have been granting ad-hoc relaxations: e.g., Tamil Nadu permitting lower window-to-wall ratios in data centre buildings (since natural light is not needed for server halls), or Maharashtra allowing more diesel generator stacks than a normal commercial building would.

- Another aspect of land use is treating data centres as part of the IT/ITeS sector; many states classify data centres under the same category as IT parks, which often brings benefits like simpler land allotment processes and eligibility for location in IT zones within cities. This categorisation can also affect property taxation and utility tariffs (IT parks often get slightly lower commercial tariffs).

5.5 Government Incentives and Special Schemes

Government support for data centres in India goes beyond policy statements, it includes concrete incentives, subsidies, and schemes to lower the cost of establishing and operating data centres:

- Fiscal Incentives
- Infrastructure Status & Financing Support
- Special Data Centre Zones/Parks
- Subsidies and Grants
- Labor and Skill Incentives
- Ease-of-Doing-Business Measures

In essence, India's combination of central and state incentives creates a very favorable investment climate for data centre infrastructure. Industry analysts note that such government support is one of the reasons India's data centre capacity is projected to grow 3x–4x in the coming 5–7 years. As a result, global data centre developers and cloud giants have announced aggressive expansion plans in India, knowing that both the regulatory environment and the incentive landscape are supportive.

5.6 International Comparisons: India and Global Data Centre Frameworks

India's approach to data centre policy can be contrasted with several other regions and countries that are also major players in the data centre domain. Here we examine how India aligns with or diverges from the policy frameworks in Singapore, the United Arab Emirates (UAE), the European Union (EU), and the United States (US):

Singapore

European Union

United Arab Emirates

United States (US)

5.6.1 Singapore

- Singapore offers a unique case, a global data centre hub that has taken a highly selective, sustainability-oriented policy stance. In the late 2010s, Singapore was booming with data centres due to excellent connectivity and business environment. However, concerned about land and power constraints, the Singaporean government imposed a moratorium in 2019 on new data centre construction.

- This pause lasting about three years diverged sharply from India's unabated encouragement of new data centres. Singapore's aim was to recalibrate growth in a more sustainable fashion. When it lifted the moratorium in 2022, it did so with strict conditions, the government initiated a "Data Centre – Call for Application" process, essentially allowing only a limited number of new projects and only those that could meet stringent resource efficiency standards.

- Applicants for new data centres in Singapore now have to demonstrate innovative solutions for energy efficiency, high uptime with minimal carbon footprint, and efficient cooling tailored for the tropical climate. Singapore made it clear it would be more selective effectively prioritising quality (green, efficient facilities) over quantity of investments.

- One concrete outcome is Singapore's introduction of a new sustainability standard for data centres in tropical climates (launched by the Infocomm Media Development Authority in 2023). This standard allows data centres to operate at higher ambient temperatures (up to 26°C or more, instead of the traditional ~22°C) and at higher humidity, without compromising reliability.

- By doing so, cooling energy consumption can drop by 2–5% per degree increase in temperature set-point. Trials by major operators in Singapore showed a successful reduction in energy use by raising server hall temperatures slightly. The government there is also pushing for 100% renewables and has limited land for new facilities, so it encourages vertical high-rise data centres and creative cooling (like harboring new liquid cooling tech).

India and Singapore both treat data centres as critical infrastructure, but their approaches differ. Singapore uses strict controls and allows only highly efficient green data centres to manage power and environmental limits, while India remains in growth mode, promoting expansion through incentives, easier approvals, and infrastructure support without hard caps. Both focus on reliable power and connectivity, with India proposing DCEZs for this purpose. Singapore does not mandate strong data localisation, while India has historically leaned toward local storage, though this has softened under the DPDP Act. In essence, Singapore prioritises sustainability and efficiency, while India is still focused on rapid capacity growth.

5.6.2 United Arab Emirates (UAE) and Gulf Region

- The UAE, along with other Gulf states, is rapidly emerging as a data centre hotspot, albeit with a different approach tied closely to sovereign strategy and state-led investment. Countries like the UAE and Saudi Arabia view data centres as critical for "digital sovereignty" and economic diversification as outlined in visions like UAE's Digital Economy Strategy.

- A notable divergence from India is the GCC's emphasis on data localization laws for sovereignty for instance, the UAE now requires sensitive personal data and certain categories of data to be stored within national borders, compelling multinationals to use local data centres for that data. This is part of a broader trend in the Gulf of strict data residency regulations to protect state interests, essentially creating guaranteed local demand for data centres.

- On the incentives side, the UAE and neighbors are very aggressive, favorable investment policies including tax incentives, land grants, and fast-track approvals are offered to data centre investors. For example, the UAE leverages its free trade zones (like Dubai Digital Park, Abu Dhabi Hub) where data centre companies get zero corporate tax for decades, zero import duties, and full foreign ownership similar to SEZs.

- The UAE also often provides government land for mega projects and has state entities investing directly in hyperscale infrastructure. In comparison, India offers many state incentives too, but the UAE's packages can be even more tailor-made and backed by sovereign wealth funds.

- Both India and the UAE share a strategy of public-private partnership in data infrastructure but the UAE's style is more top-down and consolidated, big government-backed projects such as the G42 "Stargate" project a planned 5GW hyperscale campus in partnership with tech giants, whereas India relies on multiple private players responding to broad incentives in different states.

- Another alignment is the focus on renewable energy and sustainability: The Gulf's harsh climate and abundant solar resources have driven innovations like Moro Hub in Dubai, the world's largest solar-powered data centre.[48]

- The UAE is marketing itself as a location for green data centres (despite extreme heat, they use techniques like liquid cooling and solar farms to keep PUE low, aiming for PUE <1.3). India similarly encourages renewables for data centres, but the UAE's advantage is the ability to commit large solar capacity and even integrate data centres with desalination plants for cooling water. Both regions emphasise sustainability now as a competitive edge.

- In terms of regulatory facilitation, fast-track approvals in UAE often mean a one-stop government authority that handles everything for an investor even more centralised than Indian states' single windows.

- The UAE also imposes high security and cyber standards given that many data centres serve government and defense (many GCC data centres are dual-use for civilian and military data), so regulations ensure robust cyber-security and even zero-trust architecture adoption at a national policy level. India's policies also mention security best practices (e.g., the national draft talks of minimum security standards for data centres), but enforcement is left largely to operators and market standards rather than detailed government mandates.

In summary, India and the UAE both see data centres as strategic infrastructure and offer strong incentives. India's approach is a market-driven expansion supported by government incentives and light-touch regulation, whereas the UAE's approach is somewhat more state-steered, with direct government investments, strict localisation laws to create demand, and the use of free zones for attracting foreign players. Both are aligning on sustainability goals, but the UAE's small geography forces even more emphasis on efficient design (similar to Singapore's constraints), while India's larger geography allows for more distributed growth (e.g., spreading load to different states).

5.6.3 European Union (EU)

- The European Union doesn't have a singular "data centre policy" akin to India's draft, but EU policies heavily influence data centres through data protection law and environmental regulations.

- The EU's General Data Protection Regulation (GDPR) is a global benchmark for privacy and has strict requirements for data handling. GDPR does not mandate that data of EU citizens must stay in the EU, but it puts tight controls on transferring personal data out of the EU only allowing it to countries with "adequate" privacy protection or with sufficient safeguards (standard contract clauses, etc.). This has an indirect effect of encouraging companies to host EU data within Europe or in approved jurisdictions. By contrast, India's DPDP Act is more permissive in cross-border transfers (no adequate concept, just a negative list). So, on alignment both EU and India value data protection, but the EU regime is stricter, which can drive more data localisation in practice within the EU or its trusted partners, whereas India's regime is more business-friendly.

- Where India is ramping up incentives to attract data centres, many EU countries historically didn't need heavy incentives because the market demand and strict laws already ensured growth in local data centre industries. That said, individual EU member states like Ireland, the Netherlands, Denmark have indeed offered tax breaks or low energy cost contracts to big data centre investors especially the big tech companies. But recently, a different narrative of sustainability and grid impact is emerging .

- The EU has led on pushing the data centre industry toward greener operations. In 2021, a coalition of data centre operators and trade bodies launched the Climate Neutral Data Centre Pact, committing to ambitious targets: e.g., improving energy efficiency (new European data centres to meet PUE ≤1.3 in cool climates by 2025), using 100% carbon-free energy by 2030, water conservation metrics (new data centres to achieve very low Water Usage Effectiveness), and recycling waste heat.

- The EU is incorporating some of these targets into legislation too. For example, Germany's Energy Efficiency Act (2023) mandates existing large data centres to progressively reduce PUE to 1.5 by 2027 and 1.3 by 2030, and new data centres to reuse waste heat where feasible. These are hard regulations unheard of in India's context so far. Additionally, the EU has proposed under the EU Green Deal that data centres should be climate-neutral by 2030, and there are reporting requirements coming (data centres above a certain size must report energy and environmental performance annually to authorities).

- Comparatively, India diverges here, Indian policy is still focusing on expansion and basic infrastructure, and only beginning to talk about green best practices rather than enforce them. However, in aligning with global trends, Indian operators (especially those who are global companies) are voluntarily moving toward renewable power and efficiency to meet their corporate sustainability goals. We might see India follow the EU's footsteps later in setting domestic efficiency standards once the market matures.

- Another difference is energy costs and incentives: EU electricity prices are generally high, so some countries like Sweden or Norway use their cheap renewable power as a lure for data centres, akin to incentives. India's commercial power rates are also relatively high, which is why states offer discounts. So both regions use power pricing as a lever, but EU countries can't easily subsidise due to EU competition rules instead they highlight naturally lower costs in certain regions. India can more directly subsidise or waive charges at state level.

- On data sovereignty, some European nations have considered their own localisation for certain public sector or critical data (France and Germany have initiatives like GAIA-X for European cloud independence). India similarly has expressed desire for sovereign data in certain areas (e.g., government data must be stored locally, etc.), but India has not gone as far as, say, Russia or China in strict localisation. So relative to the EU, India's legal framework for personal data is newer and still being fleshed out, but philosophically both aim to protect privacy just with different mechanisms.

In essence, India's data centre policy is aligned with the EU on the importance of data protection and sustainability in rhetoric, but diverges in execution - the EU model relies more on regulation, and India's on incentives and market forces as of now. As India's market matures, it wouldn't be surprising if some EU-like regulatory measures (energy efficiency mandates, reporting requirements) eventually make their way into Indian policy, especially to manage environmental impact.

5.6.4 United States

- The United States is home to the largest data centre market globally, but notably lacks a centralized federal data centre policy for the private sector. The US approach has been predominantly market-driven, with private enterprises deciding locations based on business factors (like proximity to users, fiber connectivity, power cost) and state/local governments often competing to attract those investments.
- In that sense, India's current state-driven incentive competition has some parallels to how U.S. states and counties offer incentives. For example, Virginia (Loudoun County) famously known as "Data Centre Alley" offers attractive tax incentives like a long-term sales and use tax exemption on data centre equipment (servers, generators, cooling systems are exempt from Virginia's 6% sales tax) for operators that invest above a certain threshold and create a set number of jobs.[53] This incentive, along with affordable land and abundant fiber connectivity, helped Loudoun become the world's highest concentration of data centres (over 8 GW capacity).
- Other states like Arizona, Texas, and Oregon likewise have tax breaks (e.g., property tax or sales tax exemptions) and streamlined permitting for data centres. Comparatively, India's states offering stamp duty and power exemptions are quite analogous to U.S. states using tax tools, both seek to lower the initial and ongoing costs for data centre companies. The scale differs, but the method is similar.
- Where the U.S. diverges significantly is in data protection and localisation. The U.S. has no blanket data localisation requirements, data can freely be stored wherever business deems fit (except some specialised cases like certain government data or healthcare records under HIPAA which must be protected but not necessarily localised). There is also no federal privacy law as stringent as GDPR or DPDP Act yet (though states like California have their own privacy laws). This laissez-faire approach has meant that policy hasn't been a driver for data centre demand in the U.S.

- Demand is driven purely by user growth, cloud adoption, and technological needs. In India, by contrast, policies (like RBI's payment data rule or general sentiment for local control) have explicitly driven data localisation and hence data centre growth. So, India's policy focus is stronger as a demand catalyst, whereas the U.S. growth happened even without such intervention.
- On the regulatory front, the U.S. government's involvement is minimal except for setting some standards and efficiency programs. The U.S. The Department of Energy and Environmental Protection Agency have voluntary initiatives e.g., Energy Star for data center equipment, "Better Buildings" challenge for data centers to improve efficiency but these are not mandates, just encouragement. The federal government did issue regulations for its own federal data centres (the Data Center Optimisation Initiative aimed at consolidating and greening government IT facilities), but that doesn't affect commercial data centres.

- India likewise does not impose efficiency rules on private data centres yet, so in that aspect both are light-touch. One alignment is that industry standards like Uptime Institute Tier certifications for reliability, ANSI/BICSI standards for data centre design are used in both the U.S. and India; these aren't government policies, but common best practices that ensure high quality.

- Another point: Infrastructure and approvals building a data centre in the U.S. can sometimes face local community resistance (e.g., concerns about noise from generators or water use in drought-prone areas like Arizona). Local county boards often decide permits. In India, community opposition is less reported for data centres since they are usually in industrial zones and seen as clean hi-tech projects, but environmental clearances can be analogous if, say, a large diesel backup capacity is planned in a city.

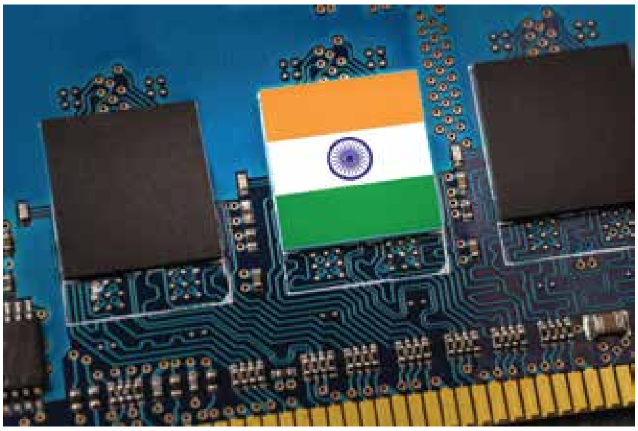
In summary, the U.S. data centre landscape has grown without a national policy – driven by market demand and facilitated by local incentives. India's situation is that the central government is taking a more active role to coordinate and propel a nascent industry, somewhat akin to how China's central government guides its tech infrastructure (though China heavily mandates localization and has central planning of digital infrastructure, which is again a different model). India's alignment with the U.S. is mostly in embracing the private sector-led growth model – multiple companies investing, competition leading to better services – and in using sub-national incentives as catalysts. Divergence lies in the fact that India's government is consciously shaping the industry trajectory (through policies on data, infrastructure status, etc.), whereas the U.S. government has largely left it to the tech industry's own momentum except for providing general support (like funding research in energy efficiency).

5.7 Conclusion – Global Alignment and Divergence

To conclude the comparative analysis, India's data centre policy journey shows elements of alignment with global best practices as well as unique divergences shaped by its context:

5.7.1 Alignment

Like leading jurisdictions, India recognises data centres as critical digital infrastructure and is investing in their growth. It shares the goal of improving ease-of-business and increasingly, the goal of sustainability. India's push for localised capacity has parallels with trends in the UAE/Gulf (data sovereignty) and even Europe's strategic autonomy narrative.



Furthermore, India's multi-layered approach (central + state) reflects a mix of federal incentives and national vision like China or EU to some extent. On data protection, India's new law aligns philosophically with global frameworks (GDPR etc.) in protecting personal data, even if the mechanisms differ.

5.7.2 Divergence

India is still in a hyper-growth phase of data centre development, so its policies are expansionary and incentive-led, whereas a place like Singapore has moved to manage growth and focus on efficiency. India's regulatory stance is more lenient on data flow compared to the EU's stringent rules, but more interventionist than the US's. Unlike the Gulf countries that heavily use sovereign capital to build data centres, India relies on attracting private investment through incentives and market opportunities. Culturally, India also faces different challenges - for example, power reliability in some regions is a bigger issue than it would be in, say, Northern Europe, so policies must tackle basic infrastructure readiness in a way some Western countries don't need to. Conversely, India doesn't (yet) face the land scarcity of Singapore or the extreme climate of the Gulf to the same degree, so it hasn't needed drastic measures like a moratorium or building only in specific zones - there's more geographic flexibility.

India's data centre policy is thus forging a path that learns from the world: encouraging investment and innovation like the U.S., insisting on data accountability somewhat like Europe, planning for sustainability with hints from Singapore, and aspiring to digital sovereignty and domestic capacity in resonance with trends in the Gulf and elsewhere. The coming years will likely see India fine-tuning this balance as it becomes one of the world's major data centre hubs, ensuring that policy supports not just growth in quantity but also quality, security, and sustainability of data centre infrastructure in line with global standards.

6. THE SUSTAINABILITY FRONTIER OF INDIA'S DATA-CENTRE ECOSYSTEM

India's data-centre sector has shifted from a support industry to critical national infrastructure. Growth in cloud services, fintech, digital platforms, and especially AI driven by the IndiaAI Mission and major investments from hyperscalers and Indian firms is pushing India from gigawatt-scale capacity toward multi-gigawatt expansion by 2030. The challenge is no longer just building more capacity, but doing so without straining power grids, worsening water stress, or creating environmental bottlenecks.

In this new phase, sustainability is not a "green add-on." It is a system-level requirement for growth. As facilities become larger, denser, and more AI-ready, sustainability is increasingly defined by five interlinked frontiers: (i) energy efficiency and cooling architecture, (ii) renewable and clean-firm power procurement, (iii) water stewardship and reuse, (iv) circular economy practices and waste management, and (v) ESG standards, disclosure and governance. For policymakers, these are not separate workstreams; together they determine India's competitiveness as a destination for hyperscale and AI infrastructure.

6.1 Power, Carbon and the Reliability–Decarbonisation Tradeoff

Data centres are fundamentally electricity-intensive infrastructure with continuous, high-quality power requirements. Even brief disruptions can cause widespread service failures across financial systems, cloud platforms, consumer services, and public digital infrastructure. As India scales toward several additional gigawatts of IT load, power reliability is shifting from a facility-level engineering issue to a broader grid-planning and regulatory challenge.

At the same time, India's coal-heavy electricity generation means incremental data centre load will, by default, draw from a carbon-intensive grid. This creates a core sustainability tradeoff: the need for uninterrupted high-quality power to guarantee uptime versus the demand for low-carbon electricity to meet corporate net-zero commitments and national climate goals. In practice, data-centre sustainability is constrained not only by on-site operations but also by grid procurement structures, open access rules, and the availability of firm low-carbon power at scale.

While some states have begun medium-term procurement planning and renewable access facilitation for large consumers, sustainability planning remains fragmented and state-led. A coordinated national framework that aligns power planning, renewable procurement, and water policy is still required.

6.2 Energy-Efficiency Technologies: Moving Beyond PUE as AI Densities Rise

Energy efficiency is the first and fastest lever for sustainability, because it reduces emissions, lowers operating costs, and most importantly reduces stress on already constrained power systems. The traditional metric is Power Usage Effectiveness (PUE), which captures the ratio of total facility power to IT equipment power. Industry benchmarks place average PUE around 1.58 globally;54 India-focused industry reporting indicates average design PUE around 1.5, with operational PUE varying by load and climate.

The sustainability frontier is now shifting because AI workloads push far higher rack densities and heat loads than conventional enterprise compute. As compute densities increase, conventional air-cooling can become both energy-intensive and space-inefficient. This is why the global frontier is moving toward liquid and hybrid cooling architectures, and why India's sustainability strategy must increasingly be framed as a question of future cooling design, not just today's operating efficiency. Three classes of technologies are shaping this transition:

6.2.1 High-performance Cooling Architectures

Closed-loop liquid cooling and direct-to-chip systems (cold plates and single-phase coolant loops) reduce fan and chiller loads and are increasingly necessary for high-density racks. Immersion cooling offers a pathway to very low parasitic power, while supporting high-density AI compute. In parallel, advanced air-economy and hybrid systems can deliver incremental gains in India's climatic conditions where water constraints or retrofit limitations prevent immediate adoption of liquid systems.

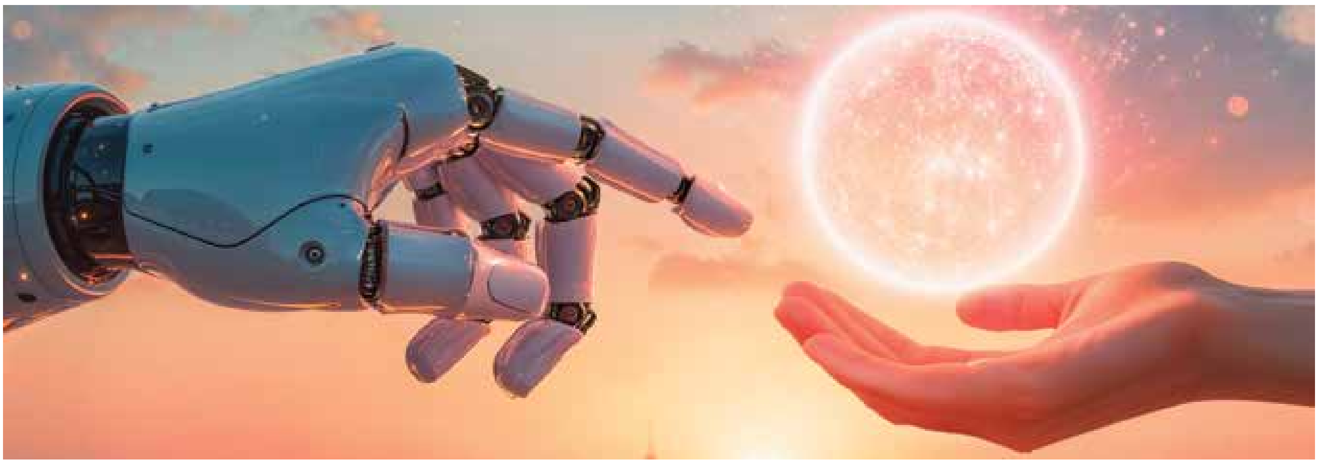
6.2.2 Electrical efficiency and power chain optimisation

Beyond cooling, energy losses in UPS systems, transformers, and power distribution become material at scale. Next-generation UPS designs, improved power factor correction, and tighter electrical segregation reduce conversion losses. As data-centre campuses grow larger, even small efficiency gains across each stage of the power chain add up to significant reductions in energy use, costs, and carbon emissions.

6.2.3 Digital optimisation and operational intelligence

Real-time monitoring, AI-enabled DCIM, and predictive maintenance systems increasingly determine whether facilities sustain low PUE under variable load and climate conditions. For large campuses, operations and maintenance maturity becomes as important as the initial build.

For policymakers, the implication is clear: India's multi-GW expansion cannot be sustained if the majority of new builds remain locked into older, air-only architectures. Efficiency must become a planning parameter in policy, zoning and certification not merely an operator aspiration.



6.3 Renewable Procurement and the Shift to Clean-Firm Power Portfolios

Because data centres operate 24×7, sustainability cannot be met through standalone variable renewables. The sector's decarbonisation challenge is therefore less about "adding solar" and more about building clean-firm portfolios that combine low-carbon supply with reliability and cost control.

In India, data-centre power strategies broadly following procurement models:

6.3.1 Utility Green Tariffs

Utilities offer green power at a premium. For many operators, however, the commercial impact of green tariff premiums is often smaller than the impact of electricity duty/tax waivers, which can reduce delivered costs by ₹1–₹2/kWh in some states. This creates a policy reality: if green tariffs are to drive decarbonisation, they must be paired with predictable premium structures and aligned incentives, not merely offered as an optional add-on.

6.3.2 Open Access Renewable Power Purchase Agreements; PPAs (Green Energy Open Access)

Open access (OA) renewable procurement allows data centres to buy power directly from renewable generators through long-term contracts. This helps diversify supply across solar, wind, hybrid, and hydro sources while improving cost stability and sustainability.

However, the financial viability of OA depends heavily on state-level rules for Cross-Subsidy Surcharge (CSS), Additional Surcharge (AS), and banking provisions, which differ widely across India. In states like Maharashtra, high surcharges can make OA less attractive despite strong renewable availability. In Tamil Nadu and Maharashtra, banking charges and restrictive banking rules significantly affect project economics. By contrast, Uttar Pradesh is often seen as more commercially favourable because of stronger surcharge waivers and more supportive banking provisions, making renewable procurement more viable for large data-centre operators.

6.3.3 From Renewables to Clean-firm

Given intermittency constraints, operators are increasingly moving beyond simple solar/wind toward integrated solutions:

- **Solar-wind hybrids** (to smooth daily/ seasonal variability)
- **Hydropower** (storage-based or run-of-river as a firming resource)
- **Battery storage** (for balancing and reliability)
- **Biopower** (dispatchable and location-flexible where feasible)

Stakeholder consultations and market practice indicate that large data-centre operators increasingly prefer diversified long-term PPAs under OA, combined with firming resources, to meet sustainability commitments while protecting uptime.

6.3.4 Indian examples and emerging clean-firm technologies

India is also beginning to test behind-the-meter alternatives. Nxtra's pilot installation of solid oxide fuel cells (SOFCs) in Bengaluru is a notable example of modular clean-firm power that improves power quality and can reduce reliance on diesel back-up, with a pathway to partial hydrogen blending. Over the longer term, Small Modular Reactors (SMRs) are being discussed globally as a source of compact, zero-carbon baseload for AI campuses; India's growing policy interest in SMRs underscores their potential relevance. The recently passed Sustainable Harnessing and Advancement of Nuclear Energy for Transforming India (SHANTI) Act 2025 establishes a framework to expand SMR capacity for reliable, round-the-clock power to national data centres and future-ready applications.

6.4 Cooling, Water Stress and Water-Reuse Frameworks

If power is the first sustainability constraint for data centres, water is the second. Cooling is indispensable to keeping facilities efficient and reliable, yet it also creates significant water demand, particularly where evaporative and hybrid cooling systems are deployed at scale. As India moves toward larger campuses and AI-driven high-density compute, thermal loads rise sharply, making the balance between cooling efficiency and water consumption far more difficult. Without deliberate planning, the growth of digital infrastructure could begin to compete directly with urban water security, turning water demand into both an operational risk and a source of public and political friction.

In this context, treated wastewater is no longer a peripheral solution but the most viable pathway for reducing dependence on potable water. However, stakeholder consultations make it clear that operators will not shift to reuse at scale on intent alone. Adoption depends on four practical conditions: a clear regulatory mandate for industrial reuse in data-centre parks, dedicated pipeline infrastructure rather than unreliable tanker-based supply, guaranteed quality and continuous flow backed by enforceable standards, and financial support for early pilots where reuse integration requires additional capital expenditure.

At the same time, sustainability cannot rely only on replacing freshwater sources; it also requires rethinking the cooling architecture itself. A resilient strategy must therefore move on two fronts using treated wastewater wherever water-based cooling remains necessary, while also adopting technologies that reduce or eliminate water dependence altogether. Closed-loop liquid cooling and direct-to-chip systems improve efficiency and can significantly reduce water use depending on the heat rejection design. Immersion cooling, including two-phase systems, offers even greater gains, with the potential to eliminate evaporative water use in certain configurations. Waterless dielectric and advanced direct-to-chip systems are designed specifically to remove reliance on municipal water, while advanced air-cooling and hybrid approaches remain practical near-term solutions where risk appetite is lower.

Early examples show that this transition is already possible. Greater Noida's industrial ecosystem has enabled treated non-potable water supply for data-centre parks, while operators such as Yotta have incorporated treated water sourcing and on-site sewage treatment plants into their cooling strategy. If these efforts are matched by pipeline infrastructure and enforceable quality guarantees, they can create the foundation for large-scale, water-secure growth ensuring that India's digital expansion does not come at the cost of its water resilience.

6.5 Circular Economy Practices and Waste Management

Sustainability in data centres extends beyond energy and water to the full lifecycle of materials and equipment. Rapid growth in server deployments, UPS systems and batteries creates significant waste streams, including hazardous waste and e-waste. Without structured disposal and recycling pathways, sustainability risks shift from operational emissions to material externalities.

Circular economy practices for data centres include:

1. Formal e-waste segregation and recycling chains for IT hardware,
2. Safe handling and recycling/disposal of batteries and UPS components,
3. Lifecycle optimisation through asset refurbishment and reuse where feasible, and
4. Responsible procurement standards to reduce embedded carbon exposure in imported equipment.

At scale, these practices are most effectively delivered through shared infrastructure and enforceable compliance frameworks rather than operator-by-operator solutions.

6.6 Standards, ESG and the Role of IGBC Green Data Center Certification

As India competes for global digital capital, sustainability must be measurable. ESG expectations are increasingly defined by verifiable performance: PUE, renewable share, water reuse rates, diesel runtime, and waste compliance. This makes standards and disclosure frameworks central to both investment attractiveness and regulatory legitimacy.

A key Indian benchmark is the IGBC Green Data Center Rating System, which provides a structured, credit-based framework spanning energy efficiency, water conservation, site planning, materials, and operations. IGBC emphasises resource management (energy and water), safe disposal of hazardous and e-waste, and operational stability through monitoring and preventive maintenance. For energy, IGBC seeks improved PUE outcomes for "green" data centres (with strong emphasis on efficiency and eco-friendly refrigerants), and for water it pushes reduce–recycle–reuse approaches and mandates rainwater harvesting.

The market impact is visible: leading operators have used IGBC certification to signal sustainability performance and differentiate facilities for hyperscale and enterprise customers

Despite its value, three gaps will shape the next phase of sustainability planning:

1. Renewable energy is incentivised, the gaps remain the mandates. It is also important to align BESS (Battery Energy Storage System) policies for data centers, to have 24×7 power.

2. AI-era cooling and density requirements are evolving rapidly, and certification thresholds shall be developed for variety/combination of cooling solutions including liquid cooling and DCLC (Direct-Chip-to-Liquid Cooling) for high-density infrastructure as new standard.

3. Supply chain and embedded carbon risks are significant since core components servers and advanced cooling equipment are often imported, limiting operator control over upstream emissions and creating vulnerability to global supply constraints. Through Make-in-India and other programs shall be mandated to reduce dependency on imports, which results in lower embodied

These gaps are not merely technical; they determine whether sustainability standards keep pace with the infrastructure India must build to remain globally competitive.

6.7 Sustainable Data-Centre Zones and Shared Infrastructure

One of the most policy-relevant sustainability developments in India is the emergence of **Data Centre Economic Zones (DCEZs)** and plug-and-play digital infrastructure hubs. These zones represent a shift from passive land allocation toward proactive "prefabricated" ecosystems designed to shorten commissioning timelines while embedding sustainability and compliance infrastructure.

Several features of DCEZ-style planning directly support sustainability:

1. **Integrated waste and effluent systems,** including Common Effluent Treatment Plants (CETPs) and access to Treatment, Storage and Disposal Facilities (TSDFs) for hazardous waste such as batteries and e-waste.
2. **Water security planning,** including perennial supply solutions and explicit recycling/zero-liquid-discharge approaches in water-stressed contexts.
3. **District cooling systems** in certain hubs, reducing the need for individual chillers and improving efficiency at scale.
4. **Pre-built redundancy and corridor planning,** ensuring that power, fibre and utilities are routed with resilience in mind reducing the risk of simultaneous failures due to urban works, right-of-way disruptions, or corridor constraints.

For sustainability, the most important contribution of DCEZs is that they convert environmental compliance from a scattered, site-by-site burden into a shared infrastructure outcome, enabling faster growth with more consistent standards.

7. CONCLUDING OBSERVATIONS AND POLICY RECOMMENDATIONS FOR INDIA'S DATA CENTRE ECOSYSTEM

7.1 Concluding Observations: A Sector Shifting from "Real Estate" to "Strategic Infrastructure"

India's data centre ecosystem has crossed a threshold where it can no longer be treated as a conventional real-estate-led infrastructure play. It is fast becoming the operational backbone of digital sovereignty supporting DPI-scale platforms, cloud migration, and increasingly, AI workloads that will define national competitiveness. This transition is being shaped by three simultaneous shifts that are structural, not cyclical.

First, a thermal architecture reset is underway.

The industry's long-standing design baseline air-cooled halls optimised for low-to-mid rack densities is being displaced by the physics of AI compute. Cooling is no longer a back-of-house engineering function; it is a competitive differentiator that directly determines what workloads a facility can host, at what cost, and with what reliability.

Second, sustainability has become an operational licence not a branding layer.

Power, water, and carbon are now binding constraints that can delay, derail, or delegitimise capacity expansion. The sector's credibility with regulators, lenders, and communities increasingly depends on measurable performance (PUE/WUE/CUE), transparent disclosures, and verifiable transitions to renewables and circular water systems.

Third, geography is being rewritten by latency and resilience

India's data centre map is expanding beyond the Mumbai–Chennai axis as edge use cases grow and as operators pursue new clusters where land, power availability, and policy clarity can support rapid scale. But decentralisation exposes hard gaps: power-quality variability, inconsistent right-of-way execution, water stress risks, and a limited local workforce trained for critical-facilities operations. Tier-2 expansion will only succeed if these constraints are addressed upfront through coordinated planning rather than reactive approvals.

Collectively, these shifts define a simple reality: India's next phase of scale must be "resource-efficient by design." Capacity growth that remains tightly coupled to proportional increases in electricity draw, water withdrawals, and grid strain will invite friction policy pushback, community resistance, and rising cost of capital. The opportunity is significant, but the window for proactive coordination (before fragmented incentives and uneven standards harden into lock-in) is narrowing.

7.2 Policy Recommendations

7.2.1 Central Government: from "Regulator" to "Market-maker"

The central policy objective should be to create a nationally coherent, investment-grade operating environment where land, power, connectivity, and sustainability standards are predictable across states, and where India's comparative advantages translate into faster, lower-risk deployment.

- **Establish "Digital Energy Zones" as a national instrument for scale-with-sustainability.**
  Create pre-notified zones anchored in renewable-rich regions and strong transmission potential, with assured inter-connection timelines and predictable open-access frameworks. The intent is to move from ad-hoc PPAs and uncertain surcharge regimes to a structured geography where renewable procurement, storage integration, and high-quality power supply are baked into the siting logic. A zone-based approach also enables shared infrastructure common transmission upgrades, shared battery capacity, and standardised compliance lowering cost and execution risk for operators while strengthening grid planning.

- **Establish captive SMR plants adjacent to major data centre hubs, with streamlined land clearances, grid interconnection, and standardized safety protocols.**
  Building on the regulatory foundation set by the SHANTI Act 2025, India should establish dedicated captive SMR adjacent to major digital hubs through public-private partnership models. These plants would provide round-the-clock, low-carbon power, ensuring uninterrupted operations for hyperscale data centres that demand high reliability. By streamlining land clearances, grid interconnections, and safety approvals, private operators can rapidly deploy SMRs while sharing infrastructure costs. This approach strengthens energy resilience, reduces dependence on fossil fuels, and future-proofs India's data centre ecosystem against rising digital and AI workloads.

- **Recognise large data centres as grid-participating assets, not passive loads.**
  Introduce a framework to integrate hyperscale facilities into demand response and ancillary service markets especially where AI workloads offer flexibility (batch training, non-real-time processing) and where onsite storage can provide stabilisation. This should be structured as a two-way value exchange: operators receive tariff-linked incentives and priority interconnection; the grid receives measurable flexibility and reliability services.

- **Enact a national "dig-once / common duct" framework for digital infrastructure corridors.**
  Data centres scale only as fast as their fibre and interconnect ecosystems. A dig-once approach embedded into highway projects, municipal works, and new townships reduces repeated excavation, lowers rollout costs, and enables distributed architectures by making backhaul and redundancy feasible outside metros. This is a classic coordination problem that central standards and enforcement can solve.

- **Extend industrial policy to "cloud sovereignty hardware" and thermal infrastructure.**
  If India continues importing most servers, high-density racks, liquid-cooling components, and monitoring/control systems, it will remain exposed to supply-chain shocks, currency risk, and time-to-deploy constraints. A targeted manufacturing push focused on thermal infrastructure, power distribution, and monitoring platforms can deliver faster self-reliance gains than attempting to localise the entire server stack at once. There should be emphasis on non-tariff driven incentives such as expanded PLI schemes, R&D grants, and accelerated depreciation to attract global majors for local assembly and component ecosystems without distorting market competition. The goal is not autarky; it is resilience, domestic value addition, and ecosystem capability for the AI era.

- **Create national standards and disclosure norms for energy, water, and carbon performance.**
  Voluntary adoption alone is no longer enough, especially when some operators reduce costs by ignoring environmental impacts. India should adopt a phased standards approach starting with mandatory reporting of PUE, WUE, and water sourcing, followed by performance-based rules in water-stressed and power-constrained areas, and eventually stricter benchmarks for new projects. These standards should reflect India's climate, water availability, and grid conditions while remaining aligned with global investor expectations.

- **Create national standards and disclosure norms for energy, water, and carbon performance.**
  Use the ₹1 lakh crore Research and Development Innovation Fund (RDIF) under ANRF to support data centre innovation, especially in AI-based cooling, edge computing, and green energy solutions. Create dedicated funding for public-private pilot projects and use ANRF to build talent and testing facilities in Digital Energy Zones, helping India move from being a technology user to a technology leader.

7.2.2 State Governments: predictable execution, not competitive fragmentation

States remain the decisive interface for land, power connections, local clearances, water sourcing, and on-ground enforcement. The key is to shift from "incentive announcements" to "execution-grade ecosystems" that reduce uncertainty and time-to-operate.

- **Notify "Data Centre-Ready Zones" with pre-clearance and hard service-level commitments.**
  States should consult with MeitY and the Ministry of Power to designate specific clusters where land conversion, environmental clearances, trunk fibre, and power evacuation plans are pre-aligned. This collaborative approach reduces the approval cycle from a multi-department negotiation to an industrial product, where investors choose between ready options with transparent performance obligations.

- **Link incentives to outcomes (efficiency, renewables, water circularity) not just capex.**
  Electricity duty exemptions, subsidies, and facilitation support should be linked to measurable performance such as renewable energy use, PUE and WUE targets, non-potable water consumption, wastewater treatment, and audited reporting. This ensures incentives support state priorities like grid reliability and water security, while also attracting ESG-focused investment.

- **Build localised water governance for data centres in stressed regions.**
  In high groundwater-stress areas, approvals should be granted only if operators ensure non-potable water sourcing, strong reuse and recycling systems, metered withdrawals, and third-party verified WUE disclosures. This helps prevent conflicts between data-centre expansion and local water needs by setting clear and transparent water-use rules from the beginning.

- **Create a state skilling pipeline for critical facilities, not generic IT training.**
  Tier-2 data centre expansion will struggle without a skilled operations workforce trained in electrical safety, cooling systems, uptime management, remote monitoring, and basic cybersecurity. States must strengthen partnerships with IITs, NITs, polytechnics, ITIs, and industry to create job-ready technicians, operators, and supervisors.

7.2.3 Operators and Investors: competitiveness will be operational, not spatial

The business model is shifting. Winning operators will not merely "build space"; they will deliver measurable efficiency, high-density readiness, and community legitimacy.

- **Treat "liquid-first" as the default design posture for new capacity.**
  The market is shifting toward AI-ready, high-density data halls. Facilities that need major retrofits to support next-generation racks risk shorter asset life and lower returns. Operators should build for high-density readiness from the start by standardising cooling systems, power distribution, monitoring, containment, and modular upgrade pathways, so AI workloads can be added without major structural changes.

- **Commit to water circularity as a licence-to-operate.**
  In water-stressed regions, "non-potable use" claims will not be enough. The credible path is closed-loop systems, reuse and recycling, and transparent WUE reporting. Operators that can demonstrate water-responsible operations will face fewer community conflicts and fewer regulatory delays and will be better positioned for performance-linked incentives.

- **Lower cost of capital through performance-linked financing.**
  Green or sustainability-linked instruments should be tied to auditable KPIs (PUE/WUE/renewables share, certification milestones, disclosure standards). This turns sustainability from a cost centre into a financing advantage and builds investor confidence in long-horizon assets.

- **Build modular and distributed capacity as a resilience strategy.**
  Instead of betting only on megacampuses, operators should develop a portfolio approach: modular pods for speed, distributed sites for resilience, and interconnect-heavy designs for workload mobility. This reduces single-site concentration risk, improves regional latency performance, and aligns better with future demand patterns.

- **Institutionalise local partnerships to secure social licence.**
  Tier-2 and edge deployments must be seen as local economic assets, not extractive utilities. Structured local skilling, vendor development for non-core services, and transparent water and power practices reduce friction and accelerate time-to- operate. Prefabricated data centre zones with large captive power can extend surplus electricity to nearby communities, enhancing local energy access. This integration strengthens social equity, reduces outages, and directly uplifts living standards by powering homes, schools, and essential services.

7.2.4 Technology providers: India needs climate-ready, interoperable, automation-led solutions

Vendors that treat India as a "clone market" will underperform. The country's climate, grid variability, and tier-2 expansion create a distinct demand profile.

- **Tropicalise hardware and thermal systems for Indian operating conditions.**
  Solutions should be optimised for higher ambient temperatures, variable humidity, and the operational realities of non-metro grids. This is not only about reliability; it is about cost because equipment that tolerates warmer operating envelopes reduces cooling burden and improves efficiency outcomes.

- **Move DCIM from monitoring to autonomous operations.**
  As facilities scale and staff availability becomes a constraint, AI-enabled operations predictive maintenance, anomaly detection, workload-aware thermal control, and grid-aware scheduling will become essential. Providers that can offer automation with strong cybersecurity foundations will become central to Tier-2 expansion.

- **Prioritise open standards and interoperability to avoid lock-in and fragility.**
  Operators will increasingly run mixed-vendor estates especially as they expand across cities and retrofit older sites. Open APIs, hardware-agnostic monitoring, and clear upgrade roadmaps reduce integration risk and increase long-run adoption.

7.2.5 Ecosystem stakeholders: enabling institutions must pivot with the market

Scale will not be achieved by operators alone. Finance, utilities, urban bodies, academia, and standards institutions determine whether growth is frictionless or conflict-prone.

- **Financial institutions**
  should move from commodity-infrastructure risk templates to performance-based underwriting rewarding measurable efficiency and transparent governance with better pricing and longer tenors.

- **Utilities and urban bodies**
  must treat data centres as anchor loads requiring integrated planning power quality, redundancy, treated water supply, and corridor-based fibre readiness.

- **Academia and skilling ecosystems**
  should embed critical-facilities training into mainstream engineering pathways and scale certification programs that map to industry roles.

- **Construction and EPC players**
  should standardise modular deployment capability to reduce timelines and improve predictability.

- **Standards bodies**
  should evolve from adopting global norms to contextualising them for India (climate, water stress, grid codes) while ensuring global comparability.

7.3 Towards a “Digital Factory of the World”

India can credibly position itself as a globally competitive data centre market supported by cost advantages and accelerating demand. But the winning pathway will not be “maximum build-out at minimum cost.” It will be a scale that is resource-efficient, grid-aligned, water-responsible, and geographically distributed.

The strategic reframing is straightforward: data centres should be treated with the policy intensity reserved for core national infrastructure power, transport corridors, and manufacturing clusters. If central and state governments coordinate on predictable standards and execution-grade zones, and if industry responds with liquid-ready designs, transparent sustainability performance, and local partnerships, India can build a resilient, high-trust, AI-ready data centre ecosystem by the end of this decade.

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APPENDIX I: LITERATURE REVIEW

Appendix 1.1 Overview

Over the past decade, a rapidly expanding body of academic, industry, and policy literature has examined the evolution of data centres from enterprise IT facilities into core components of national digital infrastructure. In India, this transition has been accelerated by cloud adoption, hyperscale investment, digital public platforms, and the rise of AI-driven computing. This literature review synthesises global and Indian evidence on data-centre growth, infrastructure intensity, spatial clustering, sustainability, and governance, situating the present study within broader debates on digital infrastructure planning and resource management.

Appendix 1.2 Growth Dynamics and Market Expansion

Several industry and policy studies document India's emergence as one of the fastest-growing data-centre markets globally. S&P Global (2024), JLL (2025), and Savills (2024) estimate that India's installed IT capacity crossed the 1-gigawatt threshold in 2024, with demand driven primarily by cloud service providers, BFSI digitisation, OTT platforms, and enterprise migration to hybrid cloud models. These studies consistently identify Mumbai, Chennai, Delhi-NCR, Bengaluru, and Hyderabad as the dominant hubs, reflecting their superior power reliability, fibre density, and proximity to submarine cable landing stations.

Grant Thornton (2024) and Astute Analytica (2024) project that India's data-centre market value could double from approximately $ 4 billion in 2024 to $ 8–10 billion by 2026, with further expansion toward $ 12–25 billion by the early 2030s. However, these market-sizing studies rely primarily on absorption trends and announced project pipelines and offer limited insight into the underlying physical constraints such as electricity, water, and land that increasingly govern feasible expansion.

International research, particularly by the Lawrence Berkeley National Laboratory (LBNL, 2024) and the International Energy Agency (IEA, 2024), places India's growth within a global context of hyperscale-driven infrastructure build-out. These studies show that global data-centre power demand is rising at 15–20% per year, largely due to AI training workloads, GPU clusters, and cloud region expansion. India's growth is thus part of a global technology cycle rather than a purely domestic real-estate boom.

Appendix 1.3 From IT Facilities to Resource-Intensive Infrastructure

A central theme in the recent literature is the re-characterisation of data centres as resource-intensive infrastructure systems rather than merely digital facilities. US Department of Energy (2024) and OECD (2022) studies show that electricity accounts for 40–60% of data-centre operating costs, while cooling and water availability are emerging as binding constraints in warm and water-stressed regions.

In India, NASSCOM (2023) and the Data Center Council of India (DCCI, 2024) report that power availability and grid stability are now the single most important determinants of site selection, outweighing land or construction costs. High-voltage substations, dual-feed grid connections, and access to renewable energy procurement have become prerequisites for hyperscale investment. These findings align with global experience in markets such as Northern Virginia, Singapore, and Frankfurt, where grid congestion and renewable power shortages are already limiting new data-centre development.

Appendix 1.4 Water, Cooling Technologies, and Environmental Sustainability

An expanding body of global research highlights water as the next major sustainability frontier for the data-centre industry. Microsoft (2023), Google (2024), and AWS have introduced Water Usage Effectiveness (WUE) as a standard metric, measured in litres per kilowatt-hour of IT energy. Their operational data demonstrate that cooling technologies vary by more than an order of magnitude in water intensity, with free cooling and air-cooled systems consuming almost no water, while cooling-tower-based mechanical systems can exceed 2.5 L/kWh.

Studies further show that climate is a critical determinant of cooling design: hot-dry regions favour evaporative cooling, warm-humid regions depend more on mechanical and hybrid systems, and temperate or cold regions can rely heavily on free cooling. This climate-technology linkage is increasingly used by policymakers in the EU, Singapore, and the US to guide zoning and permitting for new facilities.

In the Indian context, these insights are especially salient. Many of India's major data-centre hubs lie in warm-humid or composite climate zones, where evaporative cooling is less effective and water stress is often high. Yet, most Indian market studies do not incorporate climate-specific water modelling, creating a major blind spot in sustainability planning.

Appendix 1.5 Spatial Concentration, Risk, and the Rise of Tier-2 Cities

Global experience shows that data-centre industries tend to cluster heavily in a few metropolitan hubs, driven by network effects, fibre density, and enterprise demand. However, excessive concentration creates systemic risks, including exposure to natural disasters, cable outages, and grid failures. Studies from the World Bank (2023) and the Singapore IMDA (2025) highlight the importance of geographic redundancy for financial stability, cyber resilience, and disaster recovery.

In India, RBI's IT and cyber-resilience guidelines, as well as the emerging Digital Personal Data Protection (DPDP) framework, effectively mandate multi-location data storage and processing for critical sectors such as BFSI and government. This regulatory pressure is driving growing interest in secondary and inland hubs, including Pune, Hyderabad, Kolkata, and a range of Tier-2 cities for disaster recovery, edge computing, and regional cloud nodes.

Industry analyses by Cushman & Wakefield (2024) and JLL (2025) note that Tier-2 markets such as Kochi, Bhubaneswar, Ahmedabad, Jaipur, and Coimbatore are increasingly being evaluated for modular and edge data centres, driven by lower land costs, improving fibre connectivity, and state-level digital initiatives. However, these studies remain largely descriptive and do not provide systematic, multi-criteria assessments of city-level suitability.

Appendix 1.6 Location Selection, Infrastructure Risk, and Multi-Criteria Frameworks

Internationally, data-centre site selection increasingly relies on multi-criteria decision analysis (MCDA) frameworks that integrate power infrastructure, seismic risk, flood risk, water availability, renewable energy, and network connectivity. Such frameworks are used by the US Department of Energy, the European Commission, and Singapore's digital infrastructure agencies to ensure that data-centre growth aligns with long-term infrastructure and climate resilience goals.

NASSCOM (2023) and several state-level Indian data-centre policies identify similar factors but do not operationalise them into quantitative, comparable city-level metrics. As a result, investment decisions are often driven by developer heuristics and short-term incentives rather than systematic risk-adjusted infrastructure planning.

ANNEXURE 1: PROBABLE CITIES FOR DATA CENTER SETUP

State	City	District	Distance of River from City Score	Ground water Info Score	Power Score	Flood Hazard Score	Seismic Score	Renewable Energy Score	Normalised Score
Tamil Nadu	Chidambaram	Cuddalore	100	100	75	50	100	100	100.00%
Andhra Pradesh	Kurnool	Kurnool	100	75	100	25	100	50	100.00%
	Kadappa	YSR Kadapa	100	75	100	25	100	50	100.00%
Karnataka	Hosapet	Vijayanagara	100	100	75	25	100	75	96.15%
Tamil Nadu	Karur	Karur	100	75	75	25	100	100	96.15%
Chhattisgarh	Bilaspur	Bilaspur	100	75	100	50	100	0	96.15%
Madhya Pradesh	Gwalior	Gwalior	50	75	100	50	100	50	96.15%
	Jabalpur	Jabalpur	100	50	100	25	100	50	96.15%
Karnataka	Raichur	Raichur	75	50	100	25	100	75	96.15%
Andhra Pradesh	Pamidi	Anantapur	100	75	75	50	100	50	92.31%
	Vishakhapatanam	Vishakhapatanam	100	75	75	50	100	50	92.31%
Karnataka	Mysuru	Mysuru	75	100	75	25	100	75	92.31%
Rajasthan	Kota	Kota	100	50	75	25	100	100	92.31%
Chhattisgarh	Korba	Korba	100	50	100	50	100	0	92.31%
Tamil Nadu	Tiruchirapalli	Tiruchirappalli	100	50	75	25	100	100	92.31%
Maharashtra	Kolhapur	Kolhapur	100	50	100	50	66.7	75	88.48%
Gujarat	Vadodara	Vadodara	100	50	100	25	66.7	100	88.48%
Karnataka	Holenarasipura	Hassan	100	100	50	50	100	75	88.46%

State	City	District	Distance of River from City Score	Ground water Info Score	Power Score	Flood Hazard Score	Seismic Score	Renewable Energy Score	Normalised Score
Odisha	Rourkela	Sundargarh	100	75	75	50	100	25	88.46%
Telangana	Khammam	Khammam	100	50	75	50	100	50	88.46%
Tamil Nadu	Salem	Salem	25	75	75	50	100	100	88.46%
Rajasthan	Ajmer	Ajmer	25	75	75	50	100	100	88.46%
Maharashtra	Nanded	Nanded	100	50	75	25	100	75	88.46%
Karnataka	Davanagere	Davanagere	75	100	50	50	100	75	84.62%
Maharashtra	Ch. Sambhaji Nagar	Aurangabad	50	50	75	50	100	75	84.62%
Gujarat	Surat	Surat	100	75	75	25	66.7	100	80.78%
Uttar Pradesh	Varanasi	Varanasi	100	50	100	50	66.7	25	80.78%
Karnataka	Tirumakudalu Narasipura	Mysuru	100	75	50	25	100	75	80.77%
	Kalaburagi	Kalaburagi	75	75	50	50	100	75	80.77%
	Narsimharajpur	Mysuru	100	50	50	50	100	75	80.77%
Tamil Nadu	Tutticorin	Thoothukudi	100	50	50	25	100	100	80.77%
Jharkhand	Jamshedpur	East Singhbhum	100	50	75	50	100	0	80.77%
Chhattisgarh	Raigarh	Raigarh	100	50	75	50	100	0	80.77%
	Raipur	Raipur	100	50	75	50	100	0	80.77%
Jharkhand	Ranchi	Ranchi	100	50	75	50	100	0	80.77%
Uttar Pradesh	Prayagraj	Prayagraj	100	0	100	0	100	25	80.77%
Tamil Nadu	Sivakasi	Virudhunagar	75	50	50	50	100	100	80.77%
Maharashtra	Solapur	Solapur	50	50	100	25	66.7	75	76.94%
Andhra Pradesh	Dharmavaram	Sri Sathya Sai	100	75	50	25	100	50	76.92%
Karnataka	Belgavi	Belgavi	75	50	50	50	100	75	76.92%
Uttar Pradesh	Agra	Agra	100	25	75	25	100	25	76.92%

State	City	District	Distance of River from City Score	Ground water Info Score	Power Score	Flood Hazard Score	Seismic Score	Renewable Energy Score	Normalised Score
Maharashtra	Amravati	Amravati	25	25	75	50	100	75	76.92%
Karnataka	Ballari	Ballari	0	75	75	25	100	75	76.92%
Andhra Pradesh	Vijaywada	NTR	100	75	75	25	66.7	50	73.09%
Telangana	Ramagundam	Peddapalli	100	50	75	50	66.7	50	73.09%
Maharashtra	Nagpur	Nagpur	100	50	75	25	66.7	75	73.09%
Uttar Pradesh	Aligarh	Aligarh	0	100	100	50	66.7	25	73.09%
Chhattisgarh	Bhilai	Durg	100	75	50	50	100	0	73.08%
Telangana	Karimnagar	Karimnagar	100	50	50	25	100	50	73.08%
Rajasthan	Gangapur	Gangapur City	75	25	50	25	100	100	73.08%
Telangana	Mehboobnagar	Mahabubnagar	0	50	75	50	100	50	73.08%
Karnataka	Mangaluru	Dakshina Kannada	100	50	50	75	66.7	75	69.25%
Tamil Nadu	Tirupattur	Tirupattur	75	75	50	50	66.7	100	69.25%
Jharkhand	Dhanbad	Dhanbad	100	75	75	50	66.7	0	69.25%
Uttar Pradesh	Gorakhpur	Gorakhpur	100	50	75	50	66.7	25	69.25%
Chhattisgarh	Durg	Durg	100	50	50	50	100	0	69.23%
Karnataka	Hubli	Dharwad	0	75	50	50	100	75	69.23%
Chhattisgarh	Rajnandgaon	Rajnandgaon	100	50	50	50	100	0	69.23%
Kerala	Kozhikode	Kozhikode	100	50	75	25	66.7	25	65.40%
Madhya Pradesh	Narmadapuram	Narmadapuram	100	0	75	50	66.7	50	65.40%
	Khandwa	Khandwa	50	75	75	25	66.7	50	65.40%
Tamil Nadu	Dharmapuri	Dharmapuri	0	50	75	50	66.7	100	65.40%
Bihar	Gaya	Gaya	100	0	100	25	66.7	0	65.40%
Uttar Pradesh	Bareilly	Bareilly	0	75	100	25	66.7	25	65.40%

State	City	District	Distance of River from City Score	Ground water Info Score	Power Score	Flood Hazard Score	Seismic Score	Renewable Energy Score	Normalised Score
Kerala	Thiruvananthapuram	Thiruvananthapuram	100	50	75	25	66.7	25	65.40%
Uttar Pradesh	Jhansi	Jhansi	100	75	25	50	100	25	65.38%
Chhattisgarh	Jangir Champa	Jangir Champa	100	50	50	25	100	0	65.38%
Maharashtra	Pandharpur	Pandharpur	100	50	50	25	66.7	75	61.55%
West Bengal	Haldia	Purba Medinipur	100	75	75	0	66.7	0	61.55%
Maharashtra	Jalgaon	Jalgaon	75	50	25	25	100	75	61.54%
Odisha	Cuttack	Cuttack	100	0	50	25	100	25	61.54%
Telangana	Warangal	Warangal	0	50	50	50	100	50	61.54%
Rajasthan	Bhiwadi	Bhiwadi	0	50	100	50	33.3	100	61.52%
Kerala	Kollam	Kollam	100	100	50	0	66.7	25	57.71%
Andhra Pradesh	Rajamahendravaram	East Godavari	100	75	50	0	66.7	50	57.71%
	Ongole	Prakasam	100	50	50	25	66.7	50	57.71%
Maharashtra	Sangole	Solapur	100	50	25	50	66.7	75	53.86%
Kerala	Kannur	Kannur	100	50	50	25	66.7	25	53.86%
Andhra Pradesh	Tirupati	Tirupati	25	75	50	50	66.7	50	53.86%
Odisha	Bhadrak	Bhadrak	75	0	50	0	100	25	53.85%
	Brahmapur	Ganjam	50	0	50	25	100	25	53.85%
Uttarakhand	Dehradun	Dehradun	100	75	75	25	33.3	25	53.83%
Maharashtra	Ahilyanagar	Ahmednagar	75	50	25	50	66.7	75	50.02%
Andhra Pradesh	Kakinada	Kakinada	50	75	50	0	66.7	50	50.02%

ANNEXURE 2: GLOSSARY OF TERMS

1. **Low Latency:** Low latency describes a computer network that is optimised to process a very high volume of data messages with minimal delay
2. **Enterprise Data Center:** Owned and operated by a single organisation to support internal IT workloads and sensitive data. Offers maximum control and security but involves high capital costs and lower scalability.
3. **Colocation Data Center:** Third-party facilities where multiple customers lease space, power, and cooling for their IT equipment. Enables rapid deployment, cost efficiency, and carrier-neutral connectivity through shared infrastructure.
4. **Edge Data Center:** Small, decentralised data centers located close to end users or data sources. Primarily used to minimise latency for applications such as 5G, IoT, and real-time analytics.
5. **Hyperscale Data Center:** Large-scale facilities designed to support massive cloud, AI, and big-data workloads. Characterised by extreme scalability, high automation, and very low unit operating costs.
6. **Pan-India Mobile Data Usage/month (Exabyte):** It refers to the total volume of data consumed by all mobile users across India in one month, exabytes (EB), where 1 EB = 1 billion GB.
7. **PUE (Power Usage Effectiveness):** A ratio that measures overall energy efficiency of a data center, calculated as Total Facility Power ÷ IT Equipment Power; lower PUE means higher efficiency.
8. **IT Load:** The actual electrical power consumed by core computing equipment such as servers, storage, and networking devices.
9. **Facility Load:** The total power drawn by the data center, including IT load plus cooling, power conversion losses, lighting, and auxiliary systems.
10. **WUE (Water Usage Effectiveness):** A metric that measures water efficiency, defined as annual water used by the data center ÷ IT energy consumption, usually expressed in liters/kWh.
11. **Utilisation Factor:** The average fraction of installed IT capacity that is actively used over time, reflecting how much of the data center's potential load is actually operating.
12. **Rack Density:** The amount of power consumed per server rack (kW/rack), indicating computing intensity and strongly influencing cooling and power design.
13. **Uptime / Redundancy (N, N+1, 2N):** Design standards that indicate backup capacity levels to ensure continuous operation during equipment failure or maintenance. N means just enough equipment to meet the required load with no backup; N+1 adds one extra backup unit to handle a failure, while 2N provides a full duplicate system so operations continue even if one entire system fails.
14. **HVAC (Heating, Ventilation, and Air Conditioning):** The system that controls temperature, humidity, and airflow in a data center to keep IT equipment operating safely.

15. **Dry-bulb temperature:** The normal air temperature you see in a weather app or thermometer, it tells how hot or cold the air actually feels.
16. **Wet-bulb temperature:** The coolest temperature air can reach by evaporation it shows how much cooling is possible and depends on both heat and humidity.
17. **Racks:** Metal frames that hold and organise servers, storage, and networking equipment, designed for efficient power and cooling distribution.
18. **Pod:** A modular group of racks designed as a repeatable unit for power and cooling, allowing data centers to scale capacity in phases.
19. **Closed-loop liquid / Direct-to-Chip cooling:** Uses liquid in sealed pipes to cool server chips directly instead of cooling the whole room.
20. **Immersion cooling:** Submerges servers in a special non-conductive liquid that absorbs heat very efficiently.
21. **Waterless dielectric & two-phase DTC cooling:** Cools chips using special fluids in sealed systems without using any external water.
22. **Advanced air & hybrid cooling:** Improves traditional air cooling using outside air or limited liquid assistance.
23. **Heat Rejection System:** Infrastructure such as cooling towers or dry coolers that expel heat from the data center to the environment.

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Digital India Power To Empower

CAIG CENTRE FOR ACCELERATING INDIA GROWTH An initiative of NFPRC

NFPRC FOUNDATION

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