6. Data Centre Ecosystem - Science & Technology

India's data centre capacity expansion from ~375 MW (2020) to ~1500 MW (2025) reflects the accelerating digital economy driven by cloud computing, artificial intelligence, and data localisation policies. This growth, however, raises critical concerns regarding energy demand, sustainability, and infrastructure planning.

What are Data Centres

1. Definition and function
    1. A data centre is a specialised physical facility that centralises IT operations for storing, processing, and managing large volumes of digital data.
    2. It acts as the backbone of digital services such as cloud computing, e-commerce, fintech, and AI systems.

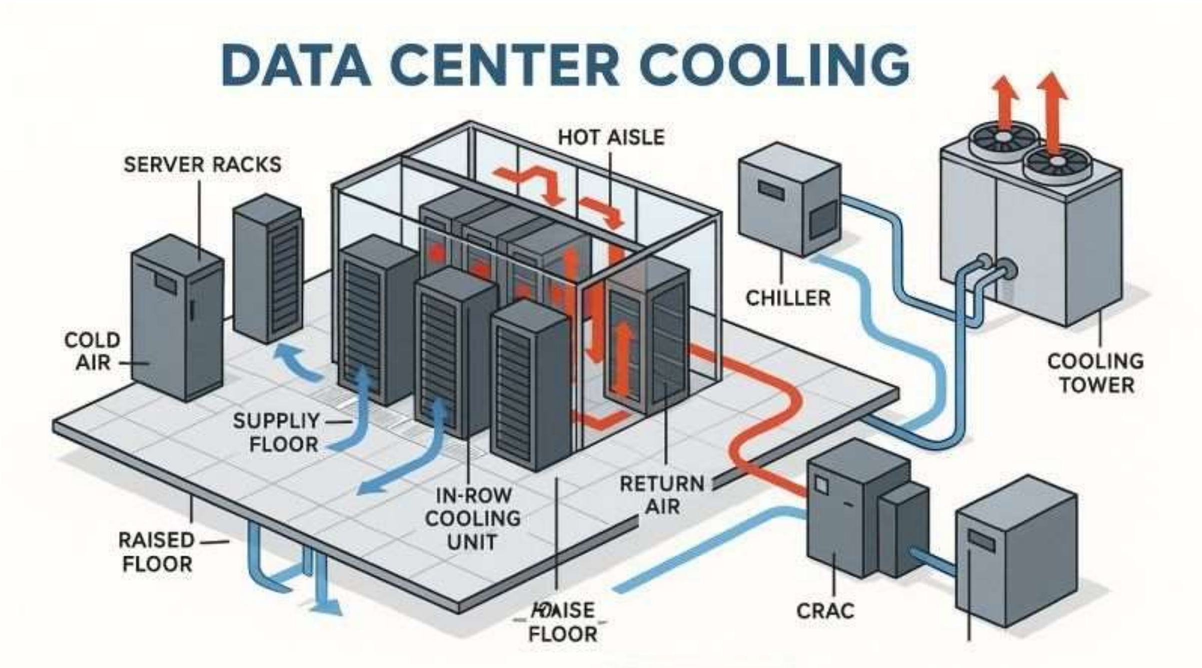
Core Components of Data Centres

IT Infrastructure

1. Servers
    1. High-performance computing systems that execute applications and process data.
    2. AI workloads increasingly rely on GPU-based servers for parallel processing.
2. Storage systems
    1. Consist of SSDs and HDDs arranged in large-scale arrays.
    2. Enable high-speed data retrieval and redundancy for reliability.
3. Networking
    1. Includes routers, switches, and fibre-optic cables.
    2. Ensures seamless data transfer between servers and global networks.

Support Infrastructure

1. Power systems
    1. Include grid connectivity, backup generators, and UPS systems.
    2. Ensure uninterrupted operations (near 100% uptime requirement).
2. Cooling systems
    1. Use CRAC/CRAH units, liquid cooling, or immersion cooling.
    2. Prevent overheating caused by dense computing loads.
3. Security systems
    1. Physical security includes biometric access and surveillance.
    2. Digital security includes firewalls and cyber protection layers.



India’s Data Centre Ecosystem

1. AI compute expansion
    1. Around 38,231 GPUs have been onboarded under the AI compute capacity framework.
    2. Implemented through 14 empanelled service providers and data centres.
2. Geographic distribution
    1. Major hubs include Mumbai, Hyderabad, Bengaluru, Noida, and Jamnagar.
    2. These locations offer strong connectivity, power availability, and proximity to demand centres.
3. Policy push
    1. Driven by data localisation norms, Digital India initiatives, and AI ecosystem development.
    2. States are offering incentives such as land, power subsidies, and tax benefits.

Rising Power Demand from Data Centres

1. High energy intensity of AI workloads
    1. GPU-based racks consume 80–150 kW compared to 15–20 kW in traditional systems.
    2. AI training and inference significantly increase electricity consumption.
2. Rapid demand growth
    1. Data centres are becoming one of the fastest-growing electricity consumers.
    2. According to the Ministry of Power, demand may reach 13.56 GW by 2031–32.
3. Environmental implications
    1. Increased carbon footprint if powered by fossil fuels.
    2. High water usage for cooling systems adds to ecological stress.

Role of Nuclear Energy in Powering Data Centres

1. Need for reliable baseload power
    1. Data centres require uninterrupted 24×7 electricity supply.
    2. Renewable sources like solar and wind are intermittent.
2. Advantages of nuclear energy
    1. Provides stable, continuous, and low-carbon power.
    2. Reduces dependence on fossil fuels and complements renewables.

3. Policy framework
    1. The SHANTI Act (Sustainable Harnessing and Advancement of Nuclear Energy for Transforming India) aims to strengthen nuclear capacity.
    2. Promotes deployment of Small Modular Reactors (SMRs) and micro-reactors.
4. Strategic relevance
    1. Nuclear-powered data centres can support India's AI ambitions sustainably.
    2. Enhances energy security and reduces emissions

Challenges in Data Centre Expansion

1. Energy sustainability
    1. Increasing reliance on coal-based power threatens climate commitments.
2. Infrastructure constraints
    1. Limited availability of reliable power and transmission networks.
3. Water usage concerns
    1. Cooling systems consume significant water resources.
4. Regulatory and land issues
    1. Land acquisition and environmental clearances can delay projects.

Way Forward

Technological Solutions

1. Adoption of advanced cooling
    1. Direct-to-chip liquid cooling reduces heat more efficiently.
    2. Immersion cooling minimises water consumption and improves energy efficiency.
2. Energy-efficient hardware
    1. Development of low-power chips and efficient GPUs.
    2. Use of AI for optimising energy consumption within data centres.

Strategic Planning

1. Location optimisation
    1. Establish data centres in cooler climates and regions with surplus power.
    2. Reduce cooling costs and environmental stress.
2. Integration with clean energy
    1. Combine renewables with nuclear for hybrid energy systems.
    2. Promote green data centres with carbon neutrality goals.
3. Policy and governance
    1. Strengthen regulatory frameworks for energy efficiency standards.
    2. Encourage public-private partnerships in infrastructure development.

Conclusion

India's data centre expansion is central to its digital and AI ambitions, but it also creates significant energy and sustainability challenges. A balanced approach combining advanced technologies, strategic planning, and clean energy—particularly nuclear—will be essential to ensure sustainable and resilient growth of the data centre ecosystem.

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