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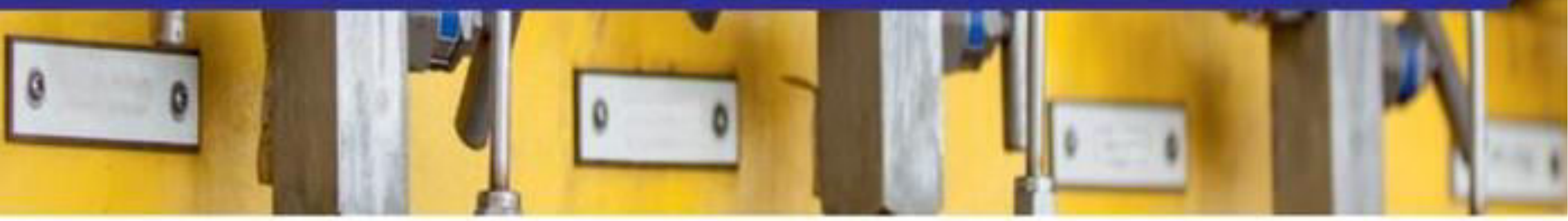

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Are Green Data Centres Possible in India?

A Review of Renewable Energy, Carbon Reduction, and Sustainable Infrastructure Practices

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ABSTRACT: The growing data-centre sector in India is driving up demands for electricity, renewable energy and cooling capabilities. This review aims at understanding the feasibility of green Data centres in India through secondary data from the academic journals and scholarly articles. It is a study of quantitative metrics such as data-centre capacity, electricity consumption, integration of renewable energy, carbon emissions, Power Usage Effectiveness (PUE), cooling efficiency and water consumption. It has been suggested in the literature that the amount of data centre capacity and energy consumption will grow significantly over the coming years and years, causing major sustainability challenges. There are measurable ways, however, to help reduce environmental impacts through renewable energy, through battery storage, through improved PUE, through advanced cooling and water efficient infrastructure. In general, it seems that green Data Centres are technically possible, but at scale, coordinated investments in infrastructure and further efficiency gains must be made to make it sustainable.

KEYWORDS: Green Data Centres; Renewable Energy; Carbon Reduction

I. INTRODUCTION

The digitalisation, adoption of artificial intelligence (AI) and growth of cloud services in India is generating a significant surge in demand for data centre infrastructure. The country's data centre capacity rose from around 375 MW in 2020 to 1,575 MW in 2026, which is over a fourfold increase in capacity in six years. Meanwhile, the demand for electricity by the data centres is expected to increase to around 17 GW by 2031-32, according to the Ministry of Electronics and Information Technology. With this growth comes an important sustainability question since data centres are always on, and have high electricity usage for computing, cooling and power management (Zakarya and Gillam, 2016). India's energy transition provides an important opportunity to reduce this environmental impact. As of December 2025, the share of non-fossil fuels in the installed electricity generation capacity in India was 51.93% and renewable energy capacity has been growing rapidly. Some environmental benefits may be lost, however, as demand for data centres grows, and more electricity is needed relies on carbon-intensive generation (Zakarya and Gillam, 2018). This review, therefore, explores the possibility of the attainment of truly Green Data Centre in India through renewable energy integration, electricity consumption, carbon reduction, and power usage effectiveness (PUE), cooling efficiency, and sustainable infrastructure. Special focus is given to quantitative data and forecasted demand for energy usage, such as data by NITI Aayog that electricity usage in data-centres could rise to around 394 TWh by 2047.

II. RATIONALE AND OBJECTIVE

Rationale

India's data-centre capacity has grown from around 375 MW in 2020 to 1,575 MW in 2026 and the government forecasts data-centre electricity demand could reach 17 GW by 2031-32. As the digital infrastructure continues to grow rapidly, the environmental footprint of digital infrastructure becomes an increasing research problem. The rationale behind this review is to know if India can support this growth and curb emission levels from electricity generation, enhance energy efficiency, and increase the share of renewable energy (Habibi Khalaj, Abdulla and Halgamuge, 2018). Being based on measurable metrics, the study does not rely on general sustainability claims and instead focuses on electricity demand, renewable-energy potential, carbon emissions, Power Usage Effectiveness (PUE), cooling efficiency and water usage.

Objectives

1. To examine the electricity demand of data centres in India and understand how it is likely to grow in the future, with the help of real data and forecasts.
2. To assess potential for renewable energy and energy-efficiency to lower the carbon footprint of Indian data centres, more importantly renewable energy integration, PUE, cooling technologies and carbon reduction.

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3. To evaluate the overall feasibility status of green data centres in India by comparing the consumption of energy, carbon, water, infrastructure etc with the available renewable energy and sustainable infrastructure capacity.

III. METHODOLOGY

This study uses a secondary data research method which aims to explore if Green Data Centre is achievable in the Indian context. The evidence presented are peer-reviewed academic journals and scholarly research articles and that analysis is based on established academic research. Studies were chosen based on how relevant they were to the issues related to Indian data-centre development, power usage, integration of renewable energy, carbon emissions, cooling efficiency, Power Usage Effectiveness (PUE), water usage and sustainable infrastructure. The review is done through quantitative approach and comparative approach. The numbers reported in selected literature such as Data-centre capacity, Electricity demand (GW/TWh), Projected carbon emissions, Percentage of Renewables, PUE values, and Water consumption are extracted and compared. Existing studies, for instance, discuss power requirement in India data centres, integration of renewable energy and PUE in the Indian scenario and the quantitative evidence on cooling requirement and renewable energy scenarios. There has been recent scenario-based research that also projects Indian electricity consumption, emissions and water withdrawals for the data centres through 2035, enabling comparisons of possible scenarios. The analysis therefore aims to establish statistical trends, relationships, projected changes and measurable sustainability outcomes, instead of a descriptive discussion. Only academic data reported will be used to develop graphs and tables

IV. LITERATURE REVIEW

Theme 1: Growth of India's Data-Centre Industry and Electricity Demand

This theme explores the development of India's data centre industry and the electricity demand.This theme focuses on the growth of the data centre industry in India and electricity demand. Cloud computing, digital services, artificial intelligence (AI), data localisation and online consumption are driving India's data-centre sector to grow at a rapid pace. According to government data, national data-centre capacity rose from about 375 MW to 1,500 MW in five years, in the span of 2020 to 2025, marking a fourfold jump. The more recent sector analysis suggests that installed capacity could reach some 1.5 GW in 2025 and 4.5–6.5 GW by 2030. This is a possible rise of 200% to 333% compared to 2025 (Long et al., 2022).

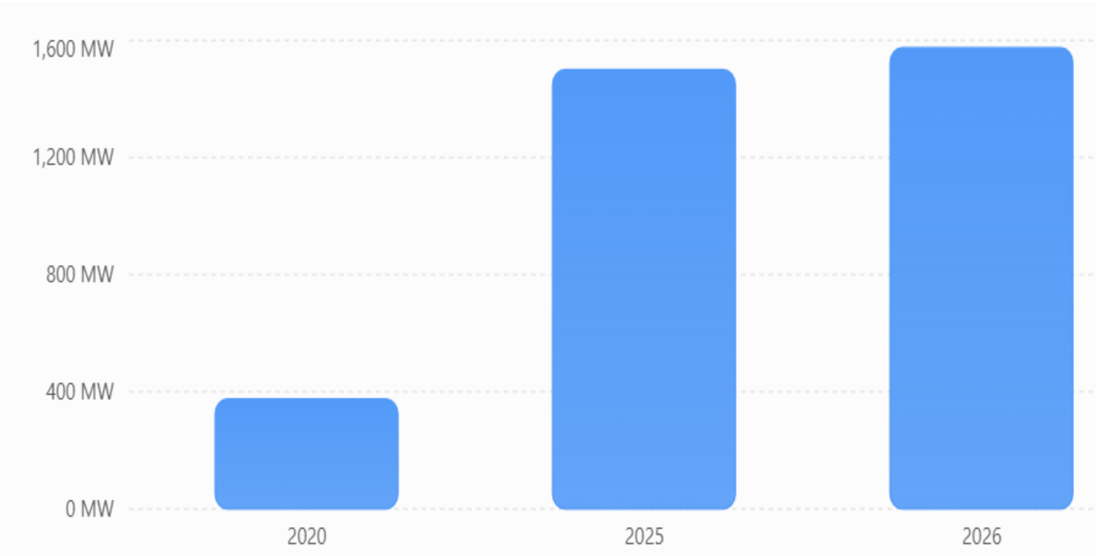

Figure: Government of India, Ministry of Electronics and Information Technology

The increase in physical capacity will have direct consequences for the demand in electricity because data centres run around the clock, not following regular commercial work hours. The IT load for data centres in India is projected to grow to 4 GW by 2030 according to NITI Aayog (Shao et al., 2022). With a utilisation factor of 40% and a Power Usage Effectiveness (PUE) of 1.6, this will generate an electricity demand of roughly 2.6 GW. However, by 2047, IT

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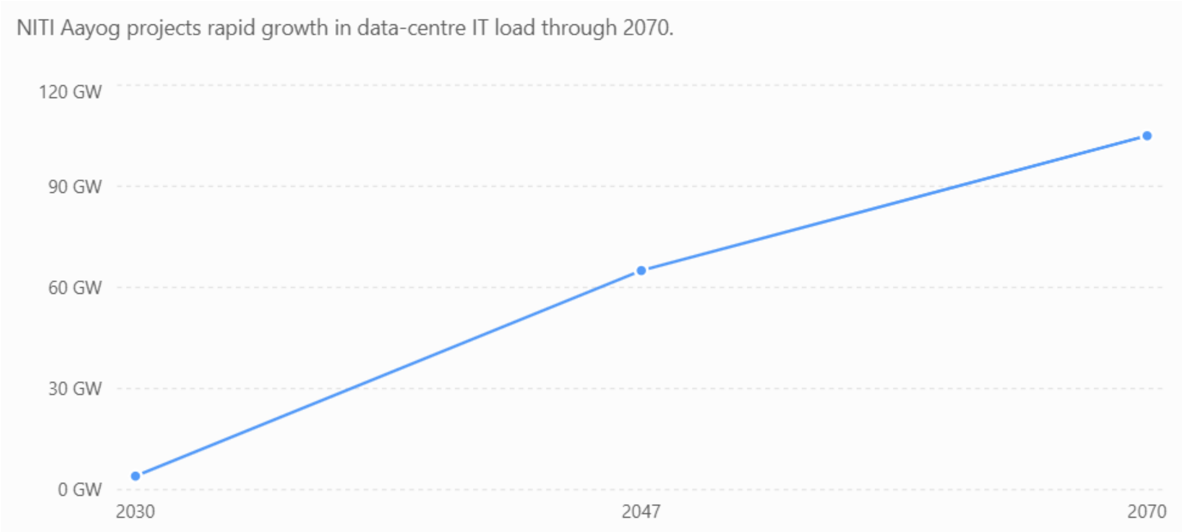
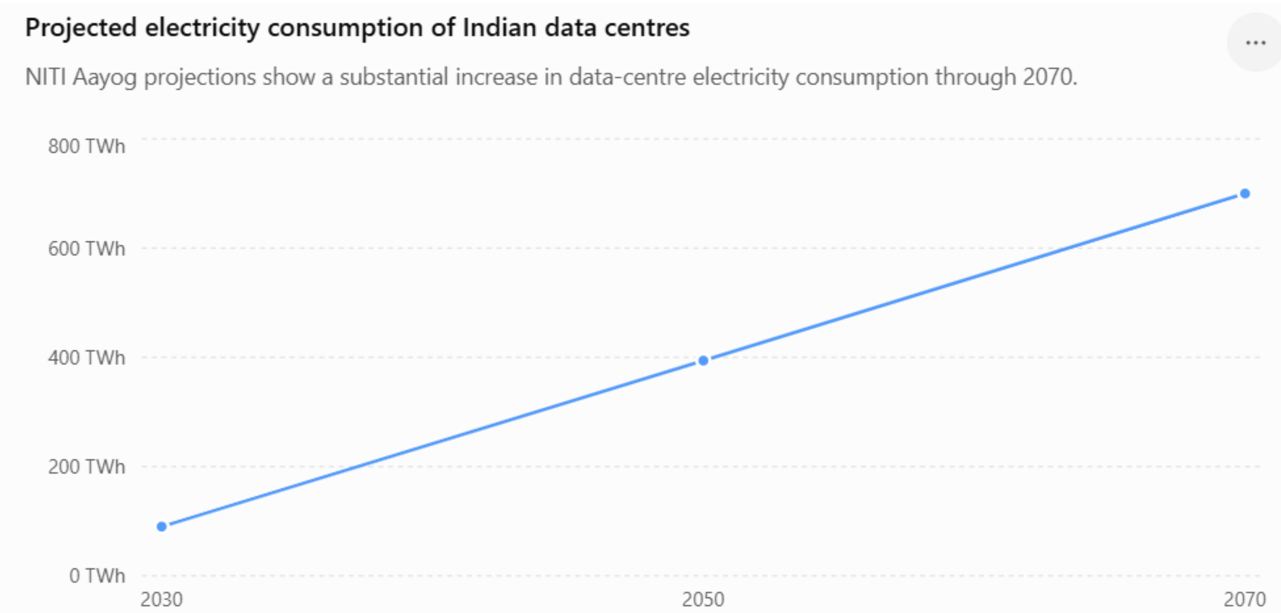
load is expected to be 65 GW and electricity demand will be about 45 GW or 394 TWh per year. The electricity demand is expected to grow to around 700 TWh by 2070.



The projections show the considerable challenge of scale. In 2047, there would be about 152 times the 2.6 GW instantaneous-equivalents figure (when annualised appropriately), but this is a different unit and should not be treated directly as the same figure without considering utilisation. More significantly, NITI Aayog's modelling shows that data centres may grow to be a significant electricity-consuming business enterprise (Mytton, 2021). Thus, the literature suggests that there is a scale-sustainability paradox that emerges in India as technology moves forward, it enhances digital infrastructure while at the same time it generates fast-growing electricity demand. Jindal and Karthik (2026) project an electricity demand growth of 219–372 TWh from 23 TWh in 2025 by 2035 depending on the scenario. Thus, not only the need for increased renewable generation, but also the need to manage the growth of electricity demand (Ismail and Materwala, 2020) is critical in determining the potential for Indian data centres to become truly 'green'.



Theme 1A: Climate Change, Temperature Stress and Data-Centre Cooling

The sustainability challenge for Indian data centres is also affected by rising ambient temperatures and heatwaves. Higher temperatures increase the cooling load required to maintain safe operating conditions for servers, which can increase auxiliary electricity consumption and worsen Power Usage Effectiveness (PUE). This is particularly important

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in hot Indian regions where cooling systems may operate at higher capacity for longer periods. Therefore, future data-centre planning should consider projected temperature conditions, rather than relying only on historical climate data. Advanced cooling technologies, including direct liquid cooling, rear-door heat exchangers, improved airflow management and intelligent thermal controls, can reduce the additional energy required for heat removal (Alkrush et al., 2024; Li et al., 2024). Climate-resilient siting should also consider heat stress, water availability and grid reliability when new facilities are developed.

Indian data centres are also faced with a sustainability problem due to the increase in ambient temperature and heatwaves. The elevated cooling load can also lead to higher electricity consumption in the auxiliary parts of the server rack, and therefore have a negative effect on the Power Usage Effectiveness (PUE). This is especially crucial in warmer areas of India, where cooling systems could be running at a higher capacity level for more extended time periods. Thus, the future data set for use in future data-centre planning needs to take account of future projections of temperature rather than just historical climate data. The additional energy needed for heat removal can be decreased by advanced cooling technologies such as direct liquid cooling, rear-door heat exchanger, better air flow management, and intelligent thermal control (Alkrush et al., 2024; Li et al., 2024). Heat stress, water availability, and grid reliability should also be taken into account for new development to be climate-resilient.

Theme 2: Renewable Energy Integration and Green Power Potential

The feasibility of green data centres is being driven by the use of renewable energy, since electricity use is the biggest opportunity for lowing carbon emissions from operation. The rapidly growing solar and wind electricity generation in India offers a potentially great source of low carbon electricity for data-centre operations (Wang et al., 2023). But data centres' round-the-clock demand puts a more stringent test on the availability of renewables than the requirement to buy renewables as a replacement for annual electricity use. The India's overall electric grid is already a significant decarboniser. According to CEEW's 2025 modelling, India would require about 600 GW of non-fossil-fuel capacity by 2030 on a trajectory that was committed to reliably fulfilling the increasing electricity demand. The study also highlights energy storage, infrastructure for energy transmission and state coordination as key needs in the integration of increasing shares of renewables. These factors are specifically significant in a data centre as it is essential to have uninterrupted power supply to ensure service availability. The situation with Indian data centres is relatively positive. According to the 2026 assessment, renewable energy developers believe it is possible to achieve up to about 80% of renewable electricity for data centres through geographically diversified solar-wind portfolios and battery storage. This is significant as it suggests that the traditional annual renewables procurement model could be replaced with a more stable structure of renewable generation. An 80% renewables share, however, does not necessarily lead to an 80% reduction in the operational emissions (Pomnar et al., 2023). The number of actual carbon emissions saved will vary based on the emissions intensity of the power grid that continues to supply electricity, the amount of renewable energy technology installed, and the time of renewable energy generation compared to demand for electricity from the data centre. Generally, generating electricity from the sun is limited to daylight hours while a data centre needs electricity every minute of the year. Hence the literature justifies a hybrid energy system (not relying on one renewable energy source alone). Bulk renewable generation can be provided by solar and wind, while the intermittency can be addressed by batteries, grid connections and possibly other firming technologies. Geographic diversification can also help to mitigate risk of local weather conditions. Hence, the renewable energy potential in India is technically feasible but also calls for investments in the renewable generation, storage, and transmission network at the same time and on a large scale, not just in the procurement of renewable energy alone.

Increasing renewable electricity for data centres requires policies that go beyond annual renewable-energy procurement. Because data centres operate continuously while solar and wind generation are variable, renewable electricity should increasingly be combined with battery storage and geographically diversified generation. Government could introduce progressive renewable-electricity requirements for large data centres and link fiscal or regulatory incentives to verified renewable-energy performance. Time-of-use electricity pricing and demand-response mechanisms could also encourage flexible computing workloads to operate when renewable electricity is more available. Such measures would improve the practical integration of renewable energy while reducing dependence on carbon-intensive grid electricity.

Theme 3: Carbon Emissions and Carbon-Reduction Strategies

With rapid growth of Indian data centres, the need to reduce carbon footprint is massive as electricity is connected to the carbon intensity of the power system. The environmental effect is thus not only on the electricity consumed by data centres, but also on the source of the electricity. Data centres are a key high-energy-intensive load category with electricity demand projected to grow to around 394 TWh by 2047 and 700 TWh by 2070 as per NITI Aayog (Li et al.,

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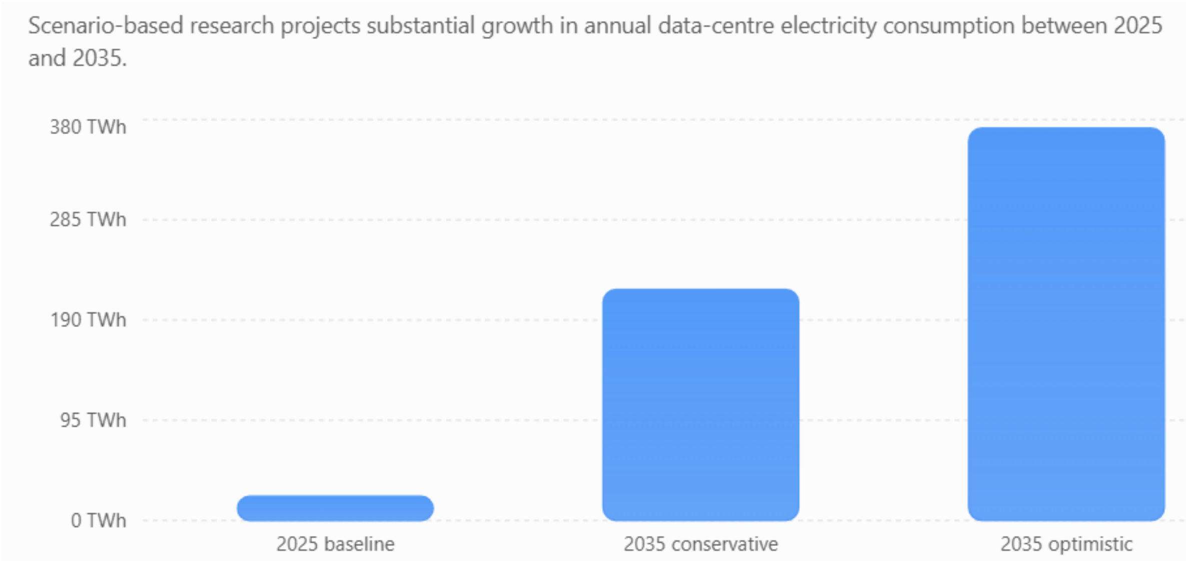
2024). While efficiency gains would be expected to drive down electricity intensity, the growth of computing need could well lead to significant gains in emissions.



Source: Scenario-based assessment of India's data-centre energy and environmental footprint
The analysis shows that, based on the various scenarios, India will consume 3,500MW to 30,000MW of electricity annually by 2030, using a power grid that will generate 150 tons of carbon dioxide and 26 tons of green house gas emissions. This is important as it helps differentiate between energy efficiency and decarbonisation. However, a facility can achieve lower PUE and make significant emissions if the electricity is generated from fossil fuels. Therefore, the growing significance of renewable-energy procurement, onsite solar generation, and long-term renewable power agreements and energy storage should not be overlooked in carbon-reduction strategies (Lei et al., 2025). CEEW's data-centre sector assessment reveals that renewable electricity has the potential to meet a significant share of demand, with evidence from stakeholders suggesting that up to around 80% of demand for renewable electricity may be met via a geographically diversified portfolio of solar and wind resources backed by battery storage. The size of future emissions becomes a special concern. Even if the data-centre electricity demand is assumed to be relatively low carbon, its projection of 700 TWh per year by 2070 shows that it could be a significant absolute energy demand. Meanwhile, aggregate electricity demand in India is growing at a rapid pace, with consumption rising some 9% a year since FY2021, up from the ~5% annual growth rate of the previous decade, according to CEEW. This will result in a competition with other industries for the more valuable "low carbon" electricity that is becoming available as a resource for data centres (Kumar, Meha and Thakur, 2025). The literature then implies that no one intervention will enable carbon neutrality. These renewables, PUE reduction, efficient cooling, storage and carbon-conscious siting must all work together. The question then is not whether the emissions from individual green data centres can be lowered but whether emissions can be lowered while India's data-centre capacity and computing needs are growing at a much faster rate.

Theme 4: Energy Efficiency, PUE and Sustainable Cooling Infrastructure

One of the easiest methods for assessing the degree to which a data centre is becoming environmentally friendly is by its energy efficiency. The most common metric is the Power Usage Effectiveness (PUE), which is the ratio of the total electricity that the facility consumes to the electricity used by the IT equipment within the data centre (Alkrush et al., 2024). A PUE of 1.0 would suggest 100% of electricity use by IT equipment; a higher PUE would show other sources of electricity use such as cooling, lighting and power conversion from other equipment. NITI Aayog has already included PUE as an integral part of its national energy demand model and anticipates a drop in Indian data centre PUE from around 1.6 to 1.4 by 2047 and 1.3 by 2070. This has been an impressive improvement since it makes a relatively small percentage savings in PUE when multiplied by very large facilities. For instance, if the IT load is unchanged, a 12.5% decrease in PUE equates to a 12.5% decrease in total facility electricity use per IT load. This benefit can, however, be tempered by very rapidly growing computing needs. The projections by the NITI Aayog include 65 GW of IT load by 2047 as compared to around 4 GW in 2030 and electricity demand around 394 TWh by 2047. Therefore, the increase in efficiency does not lead to a decrease in overall energy consumption (Siddik, Shehabi and Marston, 2021).

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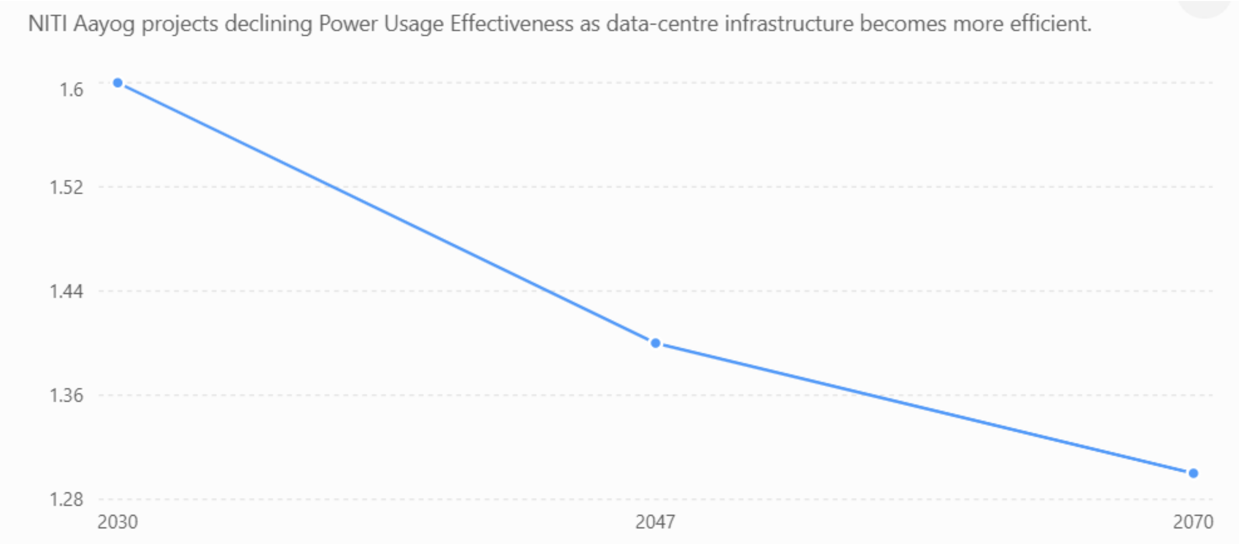

Cooling is especially crucial as high performance computing and AI applications generate significant heat (Masanet et al., 2020). Direct liquid cooling has been studied recently for its potential in the high-density computing, and it is one of the challenges in complexity of integrating it. A numerical simulation of a 30 MW reference data centre with heat exchangers located on the rear of the room has resulted in a PUE of around 1.25-1.33, with an average of 1.27 per year. It also revealed that about 46% of cooling system energy would be related to the chillers, 21% to the fans, and 33% to the pumps. These figures illustrate the value of quantitatively assessing cooling optimisation instead of it being considered as a generic sustainability indicator. Auxiliary energy consumption can be reduced by improving temperature management, air flow, heat exchangers and liquid cooling and control systems. The most appropriate technology however, is determined by workload density, climate, facility design and availability of water. Thus, the Indian green-data-centre program must not focus on efficiency gains as an alternative to renewable electricity (Shao et al., 2020), and must rely on energy efficiency as well as on rapidly growing IT capacity, with lower PUE being one of the key factors.

PUE should be adopted as a performance metric for the large data centres of India, and not just as a voluntary indicator of sustainability. The new facilities may be subject to increasingly ambitious PUE targets, and existing facilities may have to undertake a path of improvement depending on their current performance and based on climate characteristics and workload. Government incentives could be tied to verified PUE reduction, incentivize investments in efficient UPS systems, airflow optimization, variable speed cooling equipment, liquid cooling and intelligent thermal management. The requirement to report PUE, compulsory, ideally seasonally, would also create transparency and enable regulators to spot facilities that are inefficient. The performance based approach would guarantee that increased renewable electricity generation is matched by a decrease in electricity needed for every unit of computing use.

Theme 5: Water Consumption, Sustainable Infrastructure and Overall Feasibility

Water is also a major environmental concern for Indian datacentre, many cooling systems rely on water intensive heat rejection processes. Indian data centres use around 150 billion litres of water every year and both water and electricity use will more than double by 2030 as the industry grows, CEEW estimates. This is a sustainability challenge as data centre development is focused in these key urban, tech-heavy geographical regions where water usage is already quite high (Zhang et al., 2020). Water is strongly related to the cooling efficiency. Water is needed in tremendous amounts for heat rejection in a conventional cooling system, while other cooling methods like air cooling, direct liquid cooling, closed loop system and treated wastewater can minimize the need for freshwater. The technology selection is also crucial as India's broader energy-water literature also shows that water savings from electricity sector technology implementation could reach around 7–28% if they are adopted at 50% of the targeted level, and up to 97% if they are fully implemented when compared to the baseline (Cho et al., 2020). These figures show the scale of the potential water savings from technology and infrastructure changes, though not specifically in data centres, but in the electricity sector.

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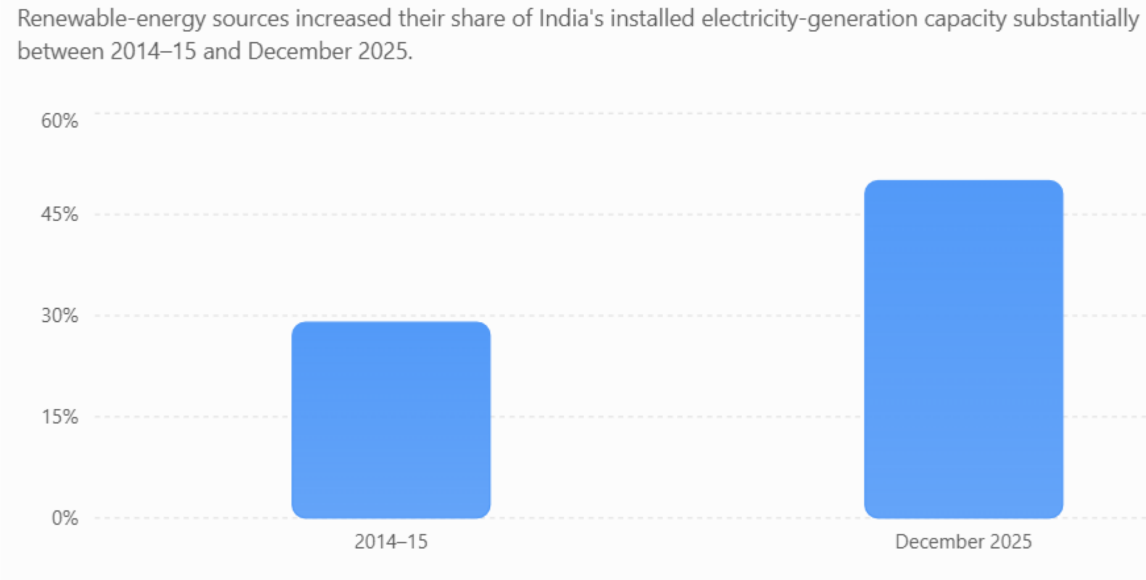

Sustainability therefore is emerging as an important measurable aspect of data-centre planning. India's data-centre market is highly concentrated with Maharashtra, Tamil Nadu, Telangana, Delhi-NCR and West Bengal being the key regions, whereas Mumbai, Chennai, Hyderabad and Bengaluru are key data-centre locations, according to CEEW. This concentration may cause stress on electricity networks, land and water resources, even if the resources are fine at the national level. The over-all feasibility should, therefore, be evaluated based on a combination of different indicators, instead of a single definition of "green". The PUE of the data centre, percentage of renewable energy usage, carbon intensity, water efficiency and resilient infrastructure are evidence of a truly sustainable data centre in India (Jindal and Karthik, 2026). According to projections from NITI Aayog, this electricity demand in data-centres may rise to 700 TWh by 2070 and the water and infrastructure footprint of the industry will grow rapidly as well, as per the evidence provided by CEEW. Based on the available evidence, it therefore appears that scaleable, green data centres are technically feasible in India; but can be achieved at a national scale with coordinated investment in renewable generation, storage capacity, efficient data centre cooling, water management, and grid infrastructure. The technical feasibility of the measures is not the main issue, but whether they can be rolled out in time to keep up with the industry's very fast growth.

V. CONCLUSION

In summary, India's green data-centre policy should incorporate renewable energy procurement and battery storage, progressive PUE standards, cooling and water efficiency requirements that are climate resilient. A set of measurable indicators of renewable electricity, PUE, carbon intensity, water usage and climate resilience, rather than a definition of a facility as "green" based on renewable-energy use alone, could be used to assess a facility.

The review has pointed out that there is technically no reason why green data centres can't be made in India, but sustainability on a large scale would be difficult. If the capacity grows rapidly and demand for electricity continues to rise, the environmental impacts may be significant unless there are simultaneous increases in renewable energy and efficiency. Solar and Wind energy combined with battery storage can make a significant contribution in increasing renewable energy use, whereas a decreased PUE and advanced cooling can help to lower energy consumption as described in the literature. Additionally, water-efficient cooling is crucial as data-centre growth could put greater strain on freshwater resources. Despite all this, India is very well geared to build a more green data centre infrastructure, but the trick is to do this with some mix of renewable energy, energy efficiency, carbon reduction, water management, and resilient infrastructure – not one or the other.

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