Estimating India's Digital Carbon Footprint: A Preliminary Assessment of Data Centres, Mobile Data Use and Climate Policy

Vedika Shrivastava

Abstract: ***This study presents a preliminary estimate of the operational carbon footprint associated with India's digital infrastructure, focusing on commercial data centres, mobile data transmission, and an illustrative artificial intelligence inference scenario. Publicly available data from government agencies and industry reports were combined with transparent assumptions to estimate electricity consumption and associated carbon emissions. Operational data centres are estimated to emit approximately 8.3 MtCO2 annually using the average grid emission factor, while mobile data transmission contributes a comparable amount. Under the operating margin emission factor, the corresponding estimates increase to approximately 11 MtCO2 each. The AI inference scenario contributes only a small share of total emissions but highlights an emerging reporting category. Overall, India's operational digital carbon footprint is estimated at approximately 15 to 17 MtCO2 annually under average emission factors and 20 to 23 MtCO2 under operating margin factors. The findings highlight the need for systematic reporting, stronger energy efficiency measures, and increased renewable electricity use within India's rapidly expanding digital infrastructure.***

Keywords: digital carbon footprint; data centres; India; mobile data; energy efficiency; climate policy; PAT scheme; digital infrastructure; greenhouse gas emissions; sustainable computing

1. Introduction

India's digital economy is usually discussed through indicators such as subscribers, data use, digital payments, cloud adoption, and artificial intelligence. The electricity demand behind these activities receives less attention. A mobile application or cloud service appears immaterial to the user, but it depends on telecom networks, data centres, cooling systems, backup power systems and an electricity grid that remains heavily dependent on coal.

International agencies have begun treating digital infrastructure as an energy policy issue. The International Energy Agency's Electricity 2024 report, for example, discusses data centre electricity demand in the United States, the European Union, China, and Ireland. India is described as a fast-growing digital market, but a separate Indian estimate is not provided (IEA, 2024). The omission is important because the scale of Indian digital use is already large. TRAI reported about 927 million wireless data subscribers in September 2024, with average wireless data use of 21.1 GB per subscriber per month (TRAI, 2024). Industry estimates also place operational data centre capacity at 1,280 MW by mid-2025 (Cushman & Wakefield, 2025).

The absence of a formal estimate does not mean that the footprint is negligible. It means that the footprint has to be approximated from scattered sources. This article makes such an approximation. The intention is not to replace an official inventory. Rather, it is to give a transparent baseline that can be checked, improved, and corrected when better sectoral data become available.

Four questions guide the article. What is a reasonable order-of-magnitude estimate of India's current operational digital carbon footprint? How does the Indian estimate compare with selected international cases? What distributional issues are visible when data centre geography is compared with the geography of digital access? Finally, what can be done within the regulatory instruments that India already has?

2. Background and Review of Literature

Studies have reported primarily caution and concern. Koomey (2011) and Masanet et al. (2020) showed that data centre electricity use did not grow in direct proportion to computing demand, largely because of improvements in servers, storage, virtualisation and large-scale facility design. Their work is useful because it warns against simple extrapolation from traffic growth alone.

At the same time, recent work has renewed concern about the sector. The growth of cloud services and high-density computing, including AI workloads, has increased attention to data centre demand (IEA, 2024; Malmodin et al., 2024). Koomey and Masanet (2021) argue that internet energy estimates are often weakened by unclear boundaries and outdated assumptions.

For network emissions, the most difficult parameter is electricity intensity per gigabyte of data transmitted. Aslan et al. (2018) review a wide range of estimates, from 0.01 to 0.10 kWh/GB, with 0.05 kWh/GB used here as a midpoint. This range is not a minor technical detail. In the present calculation it is the largest source of uncertainty in the mobile data estimate. India-specific measurement would improve the estimate substantially.

The article also draws on the energy justice framework set out by Jenkins et al. (2016). Their distinction between distributive, procedural, and recognition justice is useful for this subject because digital infrastructure is unevenly located. Data centres tend to cluster in cities with fibre connectivity, power availability and commercial demand, while users are spread across urban and rural India. The environmental burden cannot, therefore, be discussed only as a national total.

In this setting, emissions depend on the number of users, the amount of data used per user, the energy intensity of networks and data centres, and the carbon intensity of electricity. The distinction is important because recent Indian growth appears to be driven less by new subscribers and more by higher data use per existing subscriber.

3. Data and Methods

3.1 Data sources

The analysis uses only secondary data. Electricity emission factors are drawn from the Central Electricity Authority's carbon dioxide baseline database reports for Financial Year 2022–23 and Financial Year 2024–25. For the policy and regulatory discussion, the paper refers to the Bureau of Energy Efficiency Annual Report 2022–23 and the Telecom Regulatory Authority of India's recommendations on data centres. Subscriber numbers and mobile data consumption are taken from the Telecom Regulatory Authority of India Annual Report 2022–23 and its Indian Telecom Services Performance Indicators report for July–September 2024. Data centre capacity is based on Cushman & Wakefield's India Data Centres H1 2025 report. International reference figures are drawn mainly from the International Energy Agency's 2024 report.

Table 1: Variables used in the central estimate

Variable	Central value used	Source	Assessment of reliability
Operational data centre capacity	1,280 MW	Cushman & Wakefield (2025)	Relatively strong, though dependent on market-report definitions
Data centre utilisation	0.65	Modelling assumption; sensitivity 0.55-0.75	Moderate; not directly reported for India
Power Usage Effectiveness (PUE)	1.6; sensitivity 1.5-1.7	Global benchmark	Moderate to low; India-specific public figures are not available
Average grid emission factor	0.71 tCO2/MWh	CEA (2025)	Strong
Operating margin emission factor	0.961 tCO2/MWh	CEA (2025)	Strong
Wireless subscribers and data use	927 million; 21.10 GB per subscriber per month	TRAI (2024)	Strong
Network electricity intensity	0.05 kWh/GB; sensitivity 0.01-0.10	Aslan et al. (2018)	Weakest major input; not India-specific
AI inference volume	100 million queries/day	Scenario assumption	Illustrative only

3.2 Estimation method

Data centre electricity use. Annual electricity use is calculated as installed capacity multiplied by utilisation, PUE and hours in a year. The central estimate uses 1,280 MW of capacity, 0.65 utilisation and a PUE of 1.6. Emissions are obtained by applying CEA's average grid emission factor and operating margin emission factor.

The utilisation value requires comment because it is not reported for India in any consolidated public source. Operational capacity in a market expanding as quickly as India's contains a mix of mature facilities running close to their design load and recently commissioned halls that are still filling. A value of 0.65 was selected to represent that mix, sitting below the levels typically reported for stabilised hyperscale operations and above what newly energised capacity would achieve in its first year of service. Alternative values of 0.55 and 0.75 were tested. These move the data centre estimate to approximately 7.0 and 9.6 MtCO2 per year respectively under the average emission factor, a spread narrower than the uncertainty introduced by network electricity intensity. Utilisation is therefore a moderate rather than a dominant source of error in the present calculation.

Mobile data transmission. Annual electricity use is calculated as the number of wireless data subscribers multiplied by average monthly data use, 12 months and network electricity intensity. Two periods are shown: FY2022-23 and September 2024. The wording 'mobile data transmission' is used because TRAI's traffic data cover all wireless data use, not only video streaming.

AI inference. The AI estimate represents an illustrative scenario rather than an observed national total. It assumes 100 million queries per day at 2.9 Wh per query. The calculation is retained in the paper because AI workloads are likely to become a separate reporting concern, but the number should be treated cautiously.

Projection to 2030. The data centre projection uses the 4,167 MW operational-plus-pipeline capacity figure reported by Cushman & Wakefield (2025). The grid emission factor is assumed to improve at about 0.4 per cent per year, based on the historical movement in CEA baseline factors. This assumption is used only to produce a simple business-as-usual comparison.

3.3 Scope of the estimate

The estimates cover operational electricity-related emissions. They do not include embodied carbon in servers, batteries, cooling systems, buildings, telecom equipment, shipping, or disposal. For that reason, the results reported are lower-bound estimates and do not provide the full picture.

The paper uses order-of-magnitude estimation because several necessary sectoral data points are not yet publicly reported. The uncertainty is not hidden. It is part of the finding, since the absence of routine reporting is itself a policy problem.

4. Results

4.1 Estimated operational footprint

Table 2 reports the central estimates. Using the FY2022-23 mobile data baseline, India's operational digital footprint is estimated at about 15.0 $MtCO_2$ per year, and using the September 2024 scenario, it is estimated at about 16.7 $MtCO_2$ per year. Under the operating margin factor, the range is about 20.3-22.6 $MtCO_2$ per year. Expressed against CEA's FY2024-25 power-sector emissions figure of 1,234 $MtCO_2$, the average-factor estimate is roughly 1.2-1.4 per cent.

Table 2: Estimated operational digital carbon footprint of India

Component	Annual electricity (GWh)	CO_2 using avg EF 0.71 ($MtCO_2$/yr)	CO_2 using operating margin EF 0.961 ($MtCO_2$/yr)	Main source
Data centres (1,280 MW; utilisation 0.65; PUE 1.6)	11,661	8.3	11.2	Cushman & Wakefield (2025); CEA (2025)
Mobile data - FY2022-23 baseline (17.36 GB/sub/month; 898M subs)	9,352	6.6	9	TRAI (2023); Aslan et al. (2018)
Mobile data - September 2024 (21.10 GB/sub/month; 927M subs)	11,724	8.3	11.3	TRAI (2024); Aslan et al. (2018)
AI inference scenario (100M queries/day; 2.9 Wh/query)	106	0.08	0.1	Scenario using IEA (2024) parameter
Total - FY2022-23 baseline	~21,119	~15.0	~20.3	Present estimate
Total - September 2024 scenario	~23,491	~16.7	~22.6	Present estimate
India power-sector emissions, FY2024-25	-	1,234 $MtCO_2$	-	CEA (2025)
Digital share of power-sector emissions	-	~1.2-1.4%	~1.6-1.8%	Present estimate

Note. Figures are rounded. PUE sensitivity of 1.5-1.7 changes data centre emissions to approximately 7.8-8.8 $MtCO_2$ per year under the average emission factor. Utilisation sensitivity of 0.55-0.75 changes the same figure to approximately 7.0-9.6 $MtCO_2$ per year. Network electricity intensity of 0.01-0.10 kWh/GB produces a much wider mobile data range, making it the main source of uncertainty.

The most important point in Table 2 is the scale. Even with conservative assumptions, the operational footprint is large enough to be visible in national power-sector terms. At the same time, the estimate is far from final, because India-specific network electricity intensity and data centre PUE are not reported in a consolidated public form.

The growth pattern is also worth noting. Between the FY2022-23 baseline and the September 2024 scenario, estimated mobile data emissions rise by about 26 per cent. Subscriber numbers increase only slightly. The increase comes mainly from higher data use per subscriber. This suggests that the next phase of digital emissions growth may be driven by intensity of use rather than the expansion of access alone.

A simple projection for data centres gives a sharper warning. If capacity reaches 4,167 MW by 2030 and other assumptions remain unchanged, data centre emissions alone would reach about 26.6 $MtCO_2$ per year under the average grid-factor approach. This projection should not be read as a prediction. It is a business-as-usual indication of what happens if capacity growth is much faster than improvement in the grid emission factor.

4.2 Comparison with selected economies

Table 3: International comparison of data centre electricity and policy context

Economy	Data centre electricity	Approx. grid EF (tCO_2/MWh)	Internet users per 100	Policy context
United States	200-260 TWh	~0.39	~92	Mainly voluntary federal measures with state-level renewable portfolio standards
European Union	<100-150 TWh	~0.23	~90	Mandatory data centre reporting under the Energy Efficiency Directive
China	~300 TWh by 2026 (projection)	~0.58	~77	Renewable-energy requirements for public and large data centres
Ireland	17-32% of national electricity demand	~0.30	~93	Grid-connection assessment criteria for data centres
India	~11.7 TWh for operational data centres; ~23.5 TWh including the mobile data scenario	0.71 avg / 0.961 operating margin	69.1	No mandatory national data centre energy reporting; draft National Data Centre Policy pending

Note. International figures are drawn from IEA (2024) unless otherwise indicated. The Indian figure is from the present estimate and should be read as an order-of-magnitude figure.

India's absolute data centre electricity use is still smaller than that of the United States and China. The comparison should, however, be read with two qualifications. First, India's internet penetration remains lower than that of the United States and the European Union. Second, India's grid emission factor is substantially higher. As a result, a similar workload can produce higher emissions in India unless it is supplied by renewable electricity.

Ireland is a useful cautionary case because it shows how data centre demand can become a grid-planning issue in a relatively short period. India is much larger and the comparison is not direct, but metropolitan concentration matters. Mumbai, Chennai, Delhi NCR and Hyderabad together account for most of the current operational capacity. Local grid constraints and energy sourcing therefore deserve more attention than the national total alone can provide.

5. Distributional Issues

5.1 Concentration of infrastructure

Data centre capacity in India is not evenly distributed. Cushman & Wakefield (2025) reports that 83 per cent of operational capacity is located in Mumbai, Chennai, Delhi NCR, and Hyderabad. These regions offer fibre connectivity, commercial demand, power infrastructure, and access to skilled services. Similarly, TRAI's September 2024 data show that a large share of internet subscribers are in rural areas. Digital demand is therefore spread across the country, while the infrastructure that processes and stores much of that demand is concentrated in a few urban and industrial regions. This does not mean that emissions can be assigned neatly to individual rural users. This means the benefits, costs, and decision-making power associated with digital infrastructure are unevenly distributed.

5.2 Digital access and carbon burden

The urban-rural digital divide adds another layer to the issue. TRAI reports a large difference between urban and rural internet density. Some states with low rural internet density are also among the most populous. These regions may not yet receive the full benefits of the digital economy, but they remain part of the same national climate system affected by power-sector emissions.

For this reason, a digital footprint has a justice dimension. The people who benefit most directly from new data centre investment, tax revenue, and high-end employment are not necessarily the same people who bear the broader environmental consequences of a carbon-intensive electricity system. A national reporting framework would not solve this imbalance on its own, but it would make the imbalance more visible.

5.3 Uneven capacity to decarbonise

A further difference exists between large and small operators. Large hyperscale firms can sign long-term renewable power purchase agreements and can invest in efficient cooling and monitoring systems. Smaller co-location providers, enterprise server rooms and parts of telecom infrastructure may not have the same access to capital, land, procurement teams or contract structures.

This produces a two-speed transition. Better-capitalised facilities can move toward renewable energy and lower PUEs, while the rest of the market remains closer to the average grid. Voluntary procurement, therefore, improves part of the sector, but it is unlikely to create complete sector-wide decarbonisation. Mandatory reporting is a necessary first step because the unevenness itself is currently difficult to measure.

6. Policy Options

6.1 Use existing energy-efficiency institutions

India already has institutions and policies to address energy-intensive sectors. The PAT scheme has procedures for notifying designated consumers, conducting energy audits, and trading of energy savings certificates. BEE has an audit and compliance framework. The Energy Conservation Building Code covers large commercial buildings. The difficulty lies in data centres being folded into broader schemes, making targeted policy difficult. The lack of clear classification and reporting standards for data centres is a gap that requires attention.

6.2 Notify large data centres under PAT

The most direct step would be to notify large commercial data centres as a designated consumer category under the Energy Conservation Act. A threshold based on IT load, for example 1 MW or above, could focus the requirement on facilities that materially affect electricity demand. Notification would create regular reporting, audits and efficiency targets.

A PUE target could be introduced gradually rather than immediately. For example, a maximum PUE of 1.5 for new large facilities by 2027 and a stricter target later would be consistent with the direction of global practice while giving Indian operators time to adapt. The more important early benefit would be the creation of a reliable dataset.

6.3 Strengthen green data centre certification

Certification can be useful if it is connected to permits, incentives or disclosure. India already has green building and green data centre certification systems. At present, however, voluntary certification does not guarantee sector-wide change. New commercial facilities above a defined size could be required either to meet a recognised green data centre standard or to disclose why they do not.

State governments also have a role. Tamil Nadu's renewable-energy requirement for data centres indicates that state-level action is possible. Since much of the upcoming data centre capacity is concentrated in a few states, coordinated state rules could cover a large portion of new capacity even before a national rule is finalised.

6.4 Start with public-sector digital infrastructure

A politically easier route may be to begin with public-sector digital infrastructure. Government data centres, cloud services and public digital systems can be required to report electricity use and increase renewable-energy procurement. This would establish templates for reporting, auditing and procurement before requirements are extended to private operators.

Public procurement has shaped infrastructure markets in India in the past. It can do so here as well. If government digital infrastructure adopts transparent reporting and renewable procurement, it creates a standard that private facilities will find harder to avoid.

7. Discussion

7.1 The pace of grid improvement

The estimates in this paper point to a rate problem. Data centre capacity is growing quickly, while the grid emission factor has improved slowly. Renewable capacity additions are important, but coal still accounts for a large share of electricity generation. If a sector grows faster than the grid decarbonises, its absolute emissions can increase even while the grid becomes cleaner on average.

This is not an argument against grid decarbonisation. It is an argument that sector-specific measures are also needed. Data centre efficiency, renewable procurement and mandatory reporting can reduce emissions without waiting for the entire grid to become low-carbon. For a fast-growing sector, that distinction matters.

7.2 Access should not be treated as the problem

India's digital inclusion agenda remains important. The results should not be read as an argument for restricting internet access, especially in rural or low-connectivity regions. The more appropriate policy question is how to reduce electricity use and carbon emissions per unit of digital activity.

Possible measures include better cooling, improved server utilisation, efficient content delivery, caching, video compression, network planning and renewable electricity sourcing. These measures do not ask users to disconnect. They ask infrastructure providers and regulators to make digital growth less carbon-intensive.

7.3 Limitations

Several limitations should be noted. First, India-specific PUE data for data centres are not publicly available. The use of a global benchmark is therefore a necessary approximation. Second, the network electricity intensity value is taken from international literature and may not accurately represent Indian mobile networks. Third, the AI inference figure is illustrative and should not be used as a measured national estimate. Fourth, the analysis excludes embodied emissions in equipment, buildings and supply chains.

These limitations affect precision, but they do not remove the usefulness of the exercise. An order-of-magnitude estimate based on transparent assumptions is preferable to the absence of any estimate, provided the uncertainty is clearly stated. The paper's main contribution is therefore not a final number; it is a case for routine measurement and disclosure.

8. Conclusion

This study provides a transparent preliminary estimate of the operational carbon footprint associated with India's digital infrastructure using publicly available data and clearly stated assumptions. The current footprint is placed at approximately 15 to 17 $MtCO_2$ per year under average grid emission factors and 20 to 23 $MtCO_2$ per year under operating margin factors, while a business-as-usual projection indicates that data centres alone could reach about 26.6 $MtCO_2$ per year by 2030. Although the estimates are subject to uncertainty, they demonstrate that digital infrastructure has become a meaningful contributor to electricity-related emissions and deserves greater attention in national climate and energy policy. Establishing mandatory reporting, improving energy efficiency, increasing renewable electricity procurement, and incorporating large data centres into existing regulatory mechanisms would provide an effective foundation for future decarbonisation. As more detailed sector-specific data become available, the estimates presented here can be refined to support evidence-based policymaking and long-term monitoring.

Declarations

Ethics approval: Not applicable. The article uses only secondary data from publicly available sources.

Data availability: All data sources used in the article are cited in the reference list.

Conflict of interest: The author(s) declare no conflict of interest.

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