India's electricity market and power system (2010-2025)

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Abstract

This report looks at how India's electricity system and power-equipment trade have changed from 2010 to 2025. It discusses the big growth in renewable energy alongside coal's continuing role in meeting demand. Key themes include the need for stronger transmission networks, ongoing problems in distribution companies, and regional differences in access and prices. The report also highlights India's reliance on imported equipment, especially from China, and recent policies to build up local manufacturing. Overall, it shows how India's power sector is changing quickly, shaped by rising demand, cleaner energy goals, and trade dynamics.

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1 Power Sector Overview: Generation, Demand, and Fuel Mix

India's power generation capacity more than doubled over the past decade, nearly doubling from 200 GW in 2012 to 416 GW in 2023. As we can see in Figure 1 this has been a typical growth factor for developing nations of different population sizes.

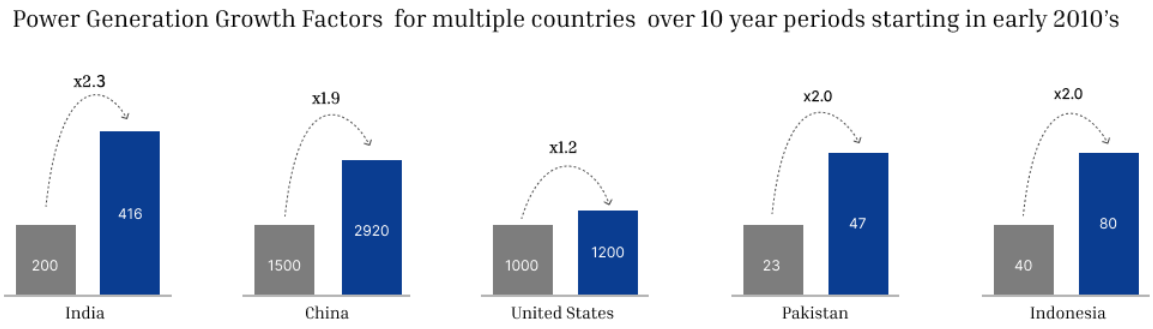

Fig. 1: *Growth of ~10 year periods for various countries occurring at the same time.*

Coal-fired capacity expanded from 112 GW in 2012 to 212 GW in 2023, but its dominance in percentage terms declined as renewables[1] surged from 25 GW to 125 GW over the same period. Large hydroelectric capacity grew modestly (from 39 GW to 46.9 GW). Gas-fired capacity stagnated around 24–25 GW after 2015, reflecting a lack of new investments due to fuel supply issues and high LNG prices. Nuclear capacity inched up from 4.8 GW to 6.8 GW[2]. Diesel generators, once 1–2 GW, have mostly been phased out (now <0.6 GW, 0.14% of capacity).

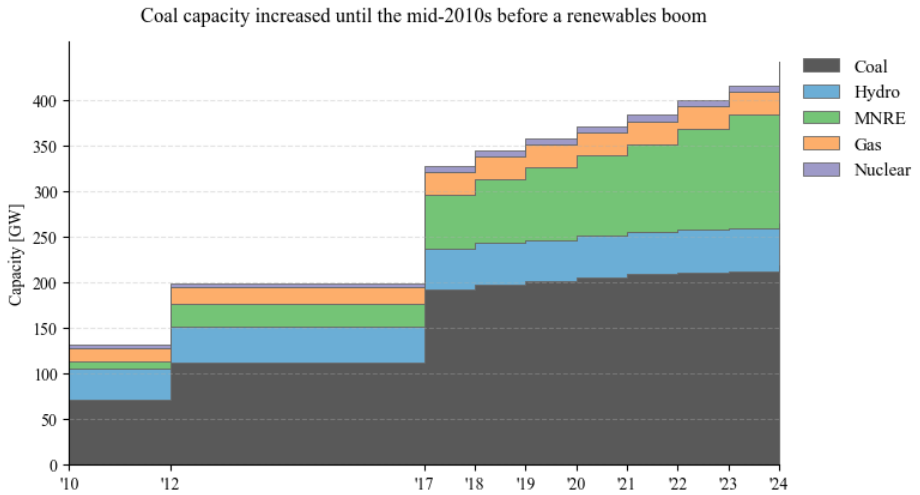

Fig. 2: *India's installed power capacity by Source. Between 2015 and 2016 Coal share started to decline and renewables expanded.*

This capacity trajectory reflects two distinct phases: a thermal build-out phase (2010–2016) when India added over 100 GW of mostly coal-fired plants to eliminate chronic shortages, followed by a renewables-led growth phase (2017–2023) spurred by falling solar costs and climate goals. Annual capacity additions peaked around 2015 (with ~20 GW of new coal in a single year) and have since shifted toward solar – for instance, 2022–23 saw 15.7 GW of new renewable capacity vs. only ~1.5 GW of net new coal. As of March 2023, non-fossil sources (solar, wind, hydro,

[1] Solar, wind, biomass, small hydro

[2] This was caused by the completion of longtime projects of reactors like the Kaprakar Station

nuclear) together account for ~42.9% of installed capacity. In terms of generation, however, the transition is slower: fossil fuels (primarily coal) still supply about 75% of total electricity, given their higher capacity utilization.

Generation and fuel mix

Total gross electricity generation (utility sector) reached 1,618 TWh in 2022-23, up from 922 TWh in 2011-12 and 1,235 TWh in 2016-17. This gives 5.5% CAGR over the past decade; slower than capacity growth, due to improving energy efficiency. By source, generation in 2022-23 was:

- **Coal & Lignite:** 1,182 TWh (73.1% of total). India's coal fleet remains the workhorse, ramping output 9.6% in 2022–23 to meet post-pandemic demand. In the early 2010s, coal's share was even higher (~79% in 2011–12), but it has edged down as renewables rise. Average coal plant load factor (PLF) fell from 73% in 2011–12 to an all-time low of 54.5% in 2020–21, then recovered to 64.2% in 2022–23. Supercritical units commissioned after 2010 have PLFs 5–10 percentage points above the national average, while many older subcritical plants operate at ~40–50% or act as reserve capacity. Coal supply has sometimes constrained generation – domestic coal production rose to 893 MT in 2022–23, yet stockpile shortfalls caused shortages in late 2021 and mid-2022. As a stopgap, blending imported coal (~8% requirement in mid-2022) and emergency rules to run idle imported-coal plants were invoked. These measures helped avert more severe shortages but at higher cost.
- **Natural Gas:** 23.9 TWh (1.5% of total) in 2022–23, down from ~50 TWh in 2020–21. Gas power's role has diminished due to chronic fuel supply issues and high LNG prices (spiking above $30/mmBtu in 2022). Most gas plants (about 25 GW) are running at 20–25% PLF or in cold reserve. Unless LNG prices fall below ~$6/mmBtu, gas plants will continue at minimal levels, primarily for grid stability or captive city supply. Some idle gas capacity is being considered for conversion to synchronous condensers or for future green hydrogen.
- **Hydropower:** 162.1 TWh (10.0%) in 2022-23. Large hydro varies with monsoons – ranging from ~113 TWh in 2016–17 to ~162 TWh in 2022–23. Hydro remains crucial for peaking and grid regulation. Pumped storage is re-emerging: ~4.7 GW exists and 3 GW more are under construction (e.g. Tehri PSP). Targets aim for 30 GW of pumped storage by 2030.
- **Nuclear:** 45.9 TWh (2.8%) in 2022-23, from 6.78 GW across 22 reactors. Nuclear output has grown modestly (32 TWh in 2011–12), constrained by project delays and fuel supply issues. Load factors remain 70–80% on average. Plans to add 10×700 MW PHWRs by 2031 could triple nuclear capacity to ~22 GW by 2035, though delays are likely.
- **Renewables (Wind, Solar, Biomass, Small Hydro):** 203.6 TWh (12.6%) in 2022-23, up from just 51 TWh in 2011–12. Solar grew from <5 TWh in 2012 to ~70–75 TWh in 2022–23 (with ~64 GW utility + 9 GW rooftop by March 2023). Wind output plateaued at ~68–70 TWh/year, while the remainder ~60 TWh comes from biomass, small hydro, and waste-to-energy. Despite 30% of capacity, non-hydro renewables contributed only 12.6% of generation due to lower capacity factors (solar 15–20%, wind ~25%). Seasonal and diurnal variation limit penetration, though national curtailment is low (<2%). Certain states, however, face higher curtailment (e.g. Tamil Nadu curtailed 70 MU of wind in a week in May 2025).

Electricity demand has grown robustly with some disruption during COVID-19. From 2010 to 2019, consumption rose 5-6% annually. 2022-23 saw 1,490 TWh supplied to end-users, a new high. Peak demand grew from 122 GW in 2010-11 to 190 GW in 2020-21 and 216 GW in 2023. Also, demand is increasingly sensitive to weather, with summer peaks driven by air conditioning. Reserve margins of 10-15% are maintained on paper, but effective margins are lower when outages and fuel shortages are considered.

By sector, industry remains the largest consumer (41.1% in 2020-21), followed by households (25.7%), agriculture (17.5%), and commercial (8.3%). A decade ago, industry's share was higher (45%) and residential lower (18%). Rural electrification and appliance uptake boosted household use (fastest growing at 7% CAGR from 2011 to 2021). Per capita consumption rose from 800 kWh in 2010 to 1,255 kWh in 2022, still one-third of the world average.

Regarding regional ideosyncracies, renewable growth is concentrated in resource-rich states: Rajasthan (17 GW solar), Gujarat, Tamil Nadu, Karnataka, Maharashtra, Andhra Pradesh, and Telangana together host 80%+ of India's solar and wind. These states often sell surplus power, while others rely on imports. Tariffs vary widely: industries in