Power transmission and distribution, and smart metering

Adani Energy Solutions Ltd

Review and outlook | May 2024

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Module 1: Macroeconomic view

Inflation-linked slowdown hits developed economies

The economic environment remained moderate in calendar year 2023, characterised by central banks raising policy interest rates. This led to elevated credit costs for both industrial and retail segments, impacting investments during the year. Nevertheless, it helped reign in rising inflation levels, which have started moderating, further supported by global supply easing across key commodities.

As per the International Monetary Fund ("IMF") economic outlook for calendar year 2023, global growth is estimated at 3.1%, amid a high-interest-rate environment and moderating inflation. This trend is expected to continue, with growth expected to stay at 3.1% in 2024 and increase moderately to 3.2% in 2025. Growth is expected to be divergent, with advanced economies likely to experience a slight decline in 2024 before recovering in 2025. Conversely, emerging economies are expected to sustain steady growth throughout both years.

Against this backdrop, India is expected to emerge relatively strong amid the prevailing global uncertainties, logging 6.8% gross domestic product ("GDP") growth in Fiscal 2025 (vs. 7.6% in Fiscal 2024).

In calendar year 2020, the Covid-19 pandemic became not only a public health crisis, but also a financial one. Lockdowns, business closures, and trade and movement disruptions wreaked havoc on the global economy. Major economies across the world de-grew in 2020, except China, which expanded 2.2%. Subsequently, green shoots became visible as economies adapted to new ways of working despite reduced mobility. Additional Fiscal support in large economies, particularly developed ones, also contributed to improving the overall economic outlook.

The IMF expected the global economy to bounce back and grow 6.1% in 2021. However, recovery that year on a low base was set back by a gamut of factors the following year. Some of these were geopolitical tensions and global inflation amid a commodity super-cycle induced by supply-chain disruptions stemming from geopolitical challenges.

The second half of 2022 was largely spent battling elevated inflation, while economic growth took a back seat. To tackle inflation, central banks globally adopted monetary tightening. While there were signs (such as a gradual cooling of inflation) that the global economy would achieve a soft landing, the delay in controlling inflation crippled economic growth.

While inflation has come down now — thanks to the steps taken by central banks (such as increasing repo rates) and a decline in food and energy prices — underlying price pressures persist. The side effects of sharp policy rate hikes across geographies are becoming increasingly apparent, exposing banking-sector vulnerabilities.

Table 1: Real GDP growth

YoY (%)	CY17	CY18	CY19	CY20	CY21	CY22	CY23E	CY24P
World	**3.7**	**3.6**	**2.9**	**-3.1**	**6.0**	**3.5**	**3.1**	**3.1**
Advanced economies	**2.5**	**2.3**	**1.7**	**-4.5**	**5.2**	**2.6**	**1.6**	**1.5**
- Euro area	2.6	1.8	1.6	-6.1	5.2	3.4	0.5	0.9
- US	2.3	2.9	2.3	-3.4	5.7	1.9	2.5	2.1
- UK	2.1	1.7	1.7	-9.3	7.4	4.3	0.5	0.6
- Germany	2.7	1.1	1.05	-4.6	2.6	1.8	-0.3	0.5
- Japan	1.7	0.6	-0.2	-4.5	1.7	1.0	1.9	0.9
Emerging and developing economies	**4.7**	**4.6**	**3.7**	**-2.0**	**6.6**	**4.1**	**4.1**	**4.1**
- China	6.9	6.7	6.0	2.2	8.1	3.0	5.2	4.6
- India*^	6.8	6.5	3.9	-5.8	9.1	7.2	7.6	6.8

**India numbers are on a Fiscal-year basis, where CY18 would correspond to Fiscal 2019*

^CRISIL MI&A Research projections

E – estimated, P – projected

Source: IMF World Economic Outlook, January 2024

Interest rate hikes to curb inflation amid moderating demand continue to impact growth

Globally, inflation has been falling since mid-2022, supported by a decline in fuel and energy prices, especially in the United States (“US”), euro area and Latin America.

Since 2021, most central banks globally have been increasing interest rates to suppress demand and lower underlying (core) inflation. This series of rate increases has been more rapid and synchronous than the previous global monetary tightening episode just before the global financial crisis. The slowdown in new home construction reflects the impact of this more restrictive monetary policy.

Since mid-2022, inflation, excluding volatile food and energy prices, has been declining in most (but not all) major economies. While the high interest rate approach adopted by central banks has had a positive impact on moderating inflation momentum, easing global commodity prices also contributed to this trend in 2023. Consequently, the majority of economies experienced lower inflation in 2023 compared with 2022. Moderation is expected to be quicker for advanced economies in 2024 compared with emerging areas, primarily due to stronger monetary frameworks and lower susceptibility to commodity price fluctuations.

Nevertheless, the average headline and core inflation rates continue to be significantly higher than the target levels in almost all countries aiming to curb inflation. Moreover, differences across economies reflect their varying exposure to underlying shocks.

Table 2: Inflation movement across key economies

YoY (%)	CY17	CY18	CY19	CY20	CY21	CY22	CY23E	CY24P
World	**3.2**	**3.6**	**3.5**	**3.2**	**4.7**	**8.7**	**6.9**	**5.8**
Advanced economies								
- Euro area	1.5	1.8	1.2	0.3	2.6	8.4	5.6	3.3
- US	2.1	2.4	1.8	1.3	4.7	8.0	4.1	2.8
- UK	2.7	2.5	1.8	0.9	2.6	9.1	7.7	3.7
- Germany	1.7	1.9	1.4	0.4	3.2	8.7	6.3	3.5
- Japan	0.5	1.0	0.5	0.0	-0.2	2.5	3.2	2.9
Emerging and developing economies								
- China	1.5	1.9	2.9	2.5	0.9	1.9	0.7	1.7
- India*^	3.6	3.4	4.8	6.2	5.5	6.7	5.5	4.5

**India numbers are on a Fiscal-year basis, where CY18 would correspond to Fiscal 2019*

^CRISIL MI&A Research projections

E – estimated, P – projected

Source: IMF World Economic Outlook, October 2023

Currently, inflation expectations are stable, with experts maintaining that inflation rates are expected to return to pre-pandemic levels in the next five years. Major central banks have generally maintained a hawkish stance in their communications regarding the necessity of a restrictive monetary policy to bring inflation under control. This suggests interest rates will remain high for longer than initially anticipated.

India’s macroeconomic overview

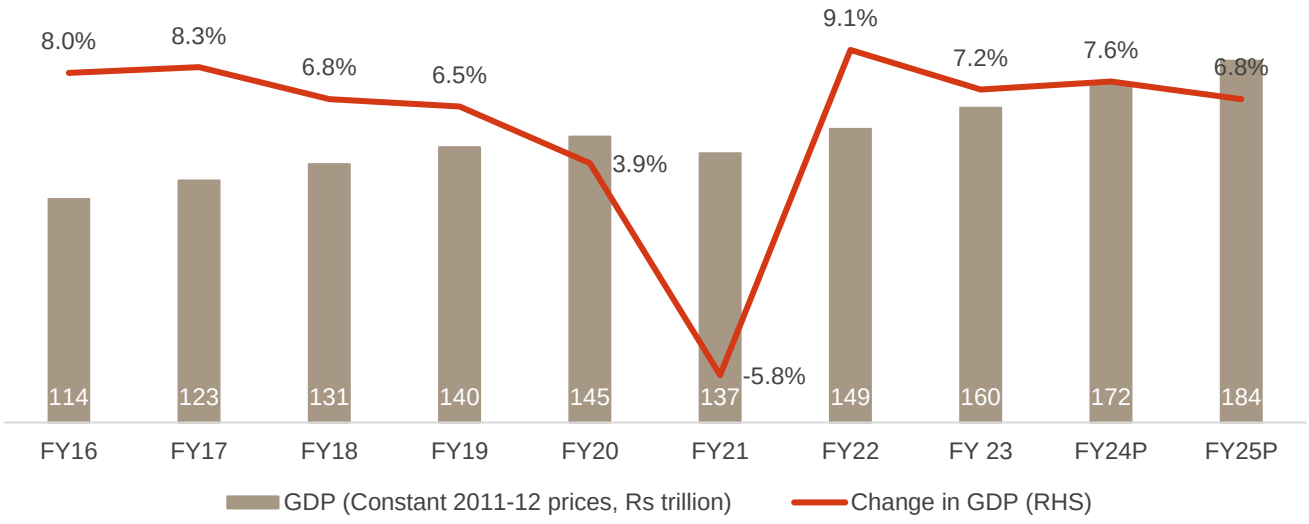
GDP review and outlook

GDP grew 9.1% to ~Rs 149 trillion in Fiscal 2022 on a low base, surpassing the pre-pandemic level of Fiscal 2020. Growth in Fiscal 2022 would have been higher but for the brutal second wave in the first quarter, which impacted consumer sentiment and hurt demand in contact-intensive sectors. The resurgence of Covid-19 since March 2021 forced many states to implement localised lockdowns and restrictions to curb the spread of the virus. The country reported the highest number of daily cases in the beginning of May 2022. The second round of lockdowns was less restrictive for economic activity than the previous one. Manufacturing, construction, agriculture, and other essential activities were permitted to continue in most states. Travel, too, was permitted, unlike during the first wave, where all travel services were shut. The third wave in the fourth quarter of Fiscal 2022 had minimal impact on the economy, thanks to high vaccination rates and adaptation to the new normal.

India's GDP grew 7.2% on-year to ~Rs 160 trillion in Fiscal 2023, building on the robust 9.1% expansion in Fiscal 2022. This suggests strong growth momentum, which was propelled by domestic demand through the year, both from investment and private consumption. Fiscal 2024 is expected to sustain the growth momentum at 7.6%, despite a high base. Up to the third quarter, economic growth was driven by fixed investments, with private consumption trailing overall GDP growth. Meanwhile, industrial activity was a key support on the supply side.

Following a strong GDP print over Fiscals 2022-24E, GDP growth is expected to moderate to 6.8% in Fiscal 2025 as Fiscal consolidation will reduce the Fiscal impulse to growth, rising borrowing costs and increased regulatory measures could weigh on demand, net tax impact on GDP is expected to normalise, and exports could be impacted by uneven growth in key trade partners.

Figure 1: India GDP growth over the years



P – projected

Source: Ministry of Statistics and Programme Implementation ("MoSPI"), CRISIL MI&A Research

Before the pandemic, India was one of the fastest-growing economies in the world, clocking a compound annual growth rate ("CAGR") of 6.6% between Fiscals 2015 and 2020. GDP is estimated to have shot up to Rs 145 trillion in Fiscal 2020 from Rs 105 trillion in Fiscal 2015, based on 2011-12 prices.

The onset of the pandemic and the subsequent imposition of a nationwide lockdown from March 25, 2020, onwards sent the Indian economy reeling, leading to an estimated 5.8% decline in GDP to Rs 137 trillion in Fiscal 2021. While the economy was under pressure in the first half of the Fiscal due to the pandemic-induced, lockdown-led demand shocks and weak global demand, low oil and commodity prices provided some respite. The second half saw an uptick in mobility and economic activity, as sentiment improved, and people became accustomed to living with the pandemic. The opening up of vaccinations in the fourth quarter, albeit limited to a smaller section of the population initially, boosted the sentiment, containing the contraction to 5.8% in Fiscal 2021. Additionally, to stimulate economic growth, the Indian government implemented a slew of measures during the pandemic-impacted

year, under the Atmanirbhar Bharat Abhiyan. The Production-Linked Incentive ("PLI") scheme followed, tying in with the Make in India programme.

Over the medium term, the Indian economy is projected to grow 6-7% on-year, boosted by healthy public capital expenditure (capex), domestic consumption-led growth, the ongoing supply-chain de-risking strategy of global companies that would boost manufacturing in India, and the thrust provided by the PLI scheme. The slowdown in global economies, however, could negatively impact Indian exports, constraining GDP growth.

Table 3: India's GDP and macroeconomic outlook

Macro variable	FY22	FY23	FY24P	FY25P	Rationale for outlook
Real GDP (%, y-o-y)	9.1	7.2	7.6	6.8	Fiscal 2024 is driven by fixed investments, with quarterly estimates till the third quarter indicating strong growth momentum. Fiscal 2025 will moderate on a high base, and rising borrowing costs and increased regulatory measures could weigh on demand.
Consumer Price Index (CPI) inflation (%, y-o-y)	5.5	6.7	5.5	4.5	Inflation is estimated to moderate with expectations of a normal monsoon, softer domestic demand, and benign global oil prices.
Current account balance/GDP (%)	1.2	-2	-1.0	-1.0	Services trade surplus continues to improve, and remittances remain robust. Together, these factors will serve as a healthy counterbalance to goods trade deficit, helping keep full-Fiscal current account deficit in check.
Rs/$ (March end)	76.2	82.3	83	83.5	While a lower current account deficit will support the rupee, challenging external financing conditions will continue to exert pressure.

P: Projected

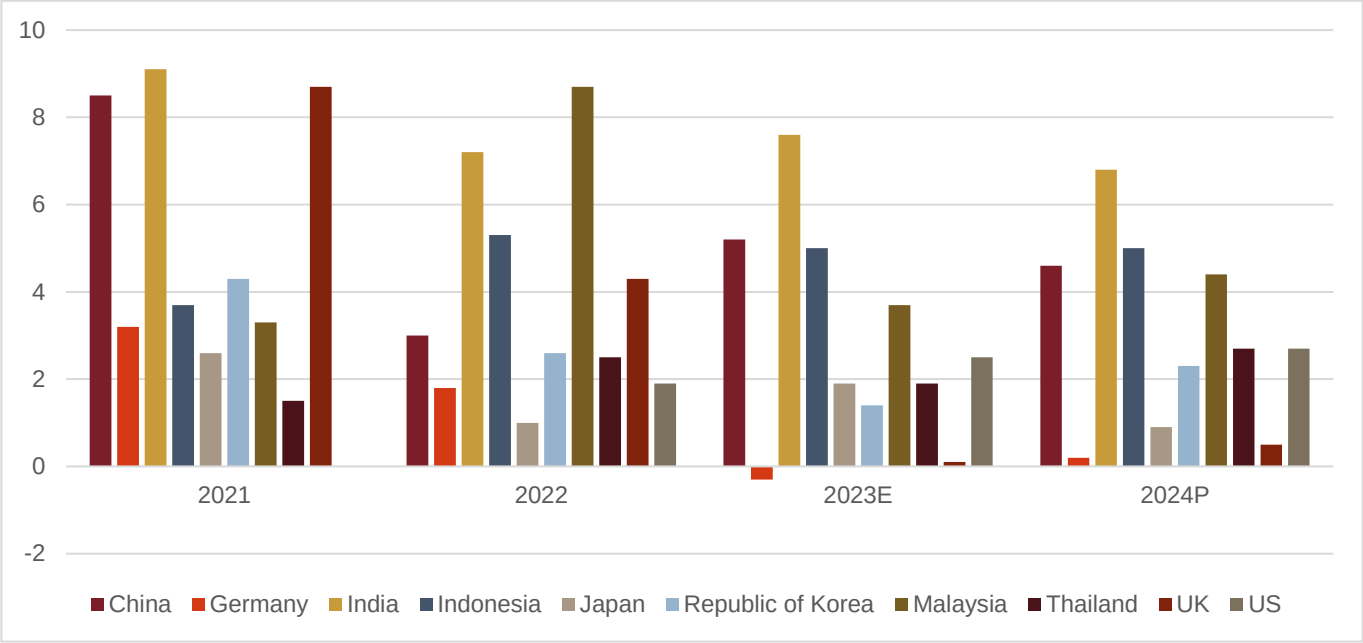
^Second advance estimates

Source: Reserve Bank of India ("RBI"), National Statistical Office ("NSO"), CRISIL MI&A Research

India to remain one of the fastest-growing economies globally

Despite headwinds, India is expected to remain one of the fastest-growing economies in the world. Indeed, this was already the case before the pandemic. India's macroeconomic situation was gradually improving — the twin deficits (current account and Fiscal) were narrowing, and the growth-inflation mix was improving, too, and durably so. The government had also adopted an inflation-targeting framework to provide an institutional mechanism for controlling inflation, while modernising central banking. Consumption recovery, government investments, and healthy balance sheets for a large percentage of India Inc indicates strong fundamentals and it is expected to remain so over the medium term.

Figure 2: GDP growth outlook for key economies



Source: IMF World Economic Outlook, April 2024. CRISIL MI&A Research

Table 4: Economy-wise GDP growth outlook

Country	2021	2022	2023E	2024P
China	8.5	3.0	5.2	4.6
Germany	3.2	1.8	-0.3	0.2
India*	9.1	7.2	7.6	6.8
Indonesia	3.7	5.3	5.0	5.0
Japan	2.6	1.0	1.9	0.9
Republic of Korea	4.3	2.6	1.4	2.3
Malaysia	3.3	8.7	3.7	4.4
Thailand	1.5	2.5	1.9	2.7
UK	8.7	4.3	0.1	0.5
US	5.8	1.9	2.5	2.7

**India numbers are on a Fiscal-year basis*

E: Estimated; P: Projected

Note: All forecasts refer to IMF forecasts

Source: IMF World Economic Outlook April 2024 outlook, CRISIL MI&A Research

Rural economy structurally more resilient, relatively less impacted by Covid-19

The rural economy is far more resilient today due to two consecutive years of good monsoon and increased spending under the Mahatma Gandhi National Rural Employment Guarantee Act ("MGNREGA"), irrigation programmes, the Direct Benefit Transfer ("DBT") scheme, the Pradhan Mantri ("PM")-Kisan scheme, the PM Ujjwala Yojana for cooking gas, the PM Awas Yojana for housing, and the Ayushman Bharat Yojana for healthcare. To supplement this, there has been a continuous improvement in rural infrastructure, such as electricity and roads. These government initiatives have led to reduced leakages and higher incomes in the hands of the rural populace, thereby enhancing their ability and willingness to spend on discretionary products and services. The rural economy accounts for almost half of India's GDP and has performed much better than the urban economy in the aftermath of the pandemic.

There are three reasons for this. First, agricultural activity has continued largely unhindered, with normal monsoon and lower spread of the pandemic in rural areas, given lower population density. Second, the government offered support, making available an additional Rs 500 billion of funding towards MGNREGA as well as disbursing over Rs 2.4 trillion towards the PM-Kisan scheme till March 2023. Third, the structure of the non-agricultural rural economy has helped it bear the Covid-induced shock better. The rural economy accounts for 51% of India's manufacturing GDP, but the rural share in services GDP (excluding public administration, defence, and utilities) is much lower, at ~26%.

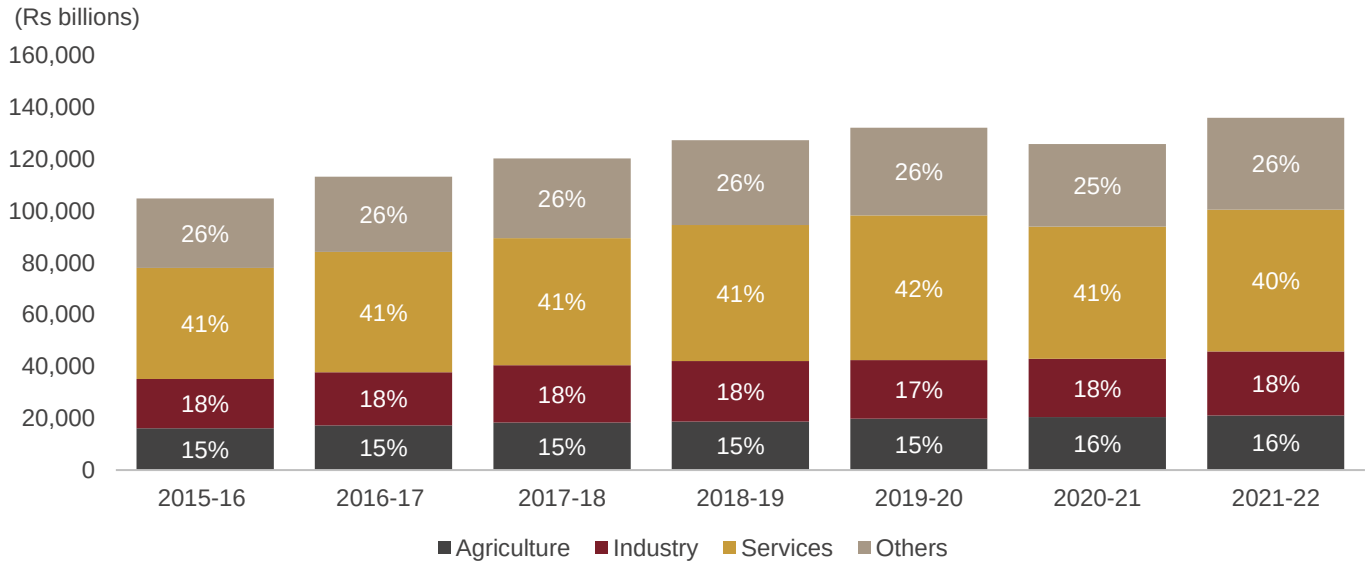
Contribution of key sectors to gross value added

The analysis of India's gross value added ("GVA") shows it has been growing consistently across years except in Fiscal 2021, when it was impacted by the pandemic-induced lockdown. The services sector has remained a significant contributor to GVA over the years. Growth in services exports, accounting for half of the country's overall exports, has continued to outpace economic growth.

Growth in manufacturing GVA (3% CAGR between Fiscals 2017 and 2022) is attributable to various government initiatives, such as Atmanirbhar Bharat, Make in India and PLI scheme. While the share of industry has remained constant at 18%, a large percentage of PLI capex is yet to be commissioned. This is expected to aid growth in the share of both manufacturing and exports.

Agriculture GVA logged a CAGR of 3%, driven by the government's subsidy support to farmers and various other government initiatives, such as the PM Krishi Sinchai Yojana ("PMKSY"). Normal monsoon, implementation of various government schemes and favourable agricultural commodity prices over the past two Fiscals have aided growth.

Figure 3: Contribution of key sectors (industry, agriculture and services) to GVA

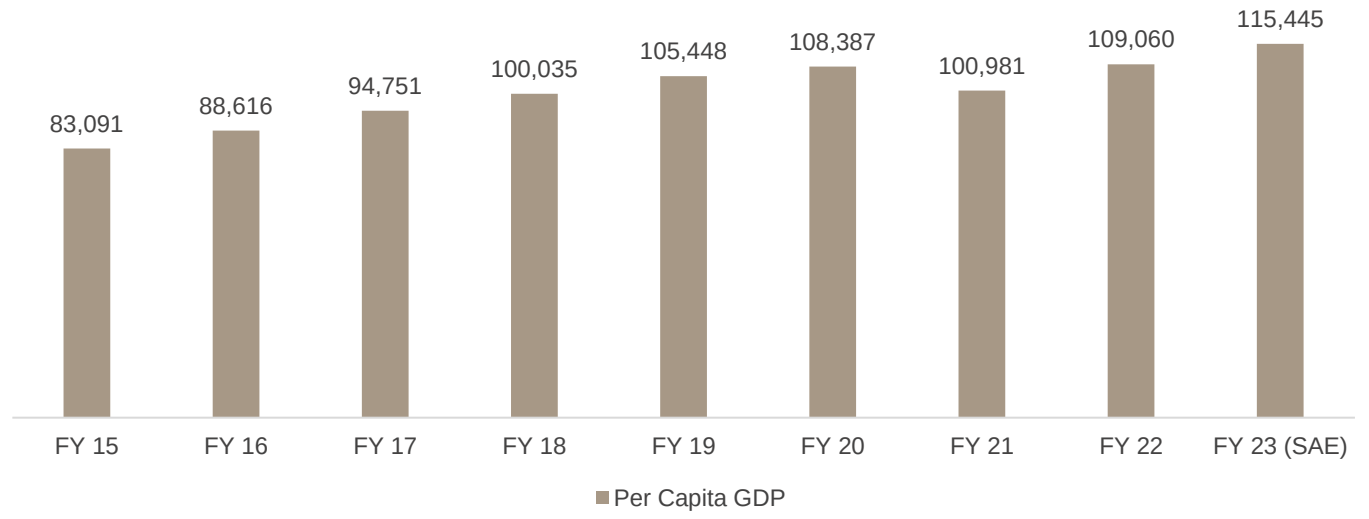


Source: MoSPI, CRISIL MI&A Research

GDP per capita trends

India's GDP per capita in real terms logged 5.46% CAGR between Fiscals 2015 and 2020, rising from ~Rs 83,000 to ~Rs 108,000. The pandemic-induced lockdown led to a decline in income and widespread job losses, pushing GDP per capita down 6.8% on-year to ~Rs 101,000 in Fiscal 2021, back to the Fiscal 2018 level. On this low base, GDP per capita grew ~8% on-year to Rs 109,000 in Fiscal 2022, surpassing the pre-Covid-19 level of Fiscal 2020.

Figure 4: India's GDP per capita (Rs)



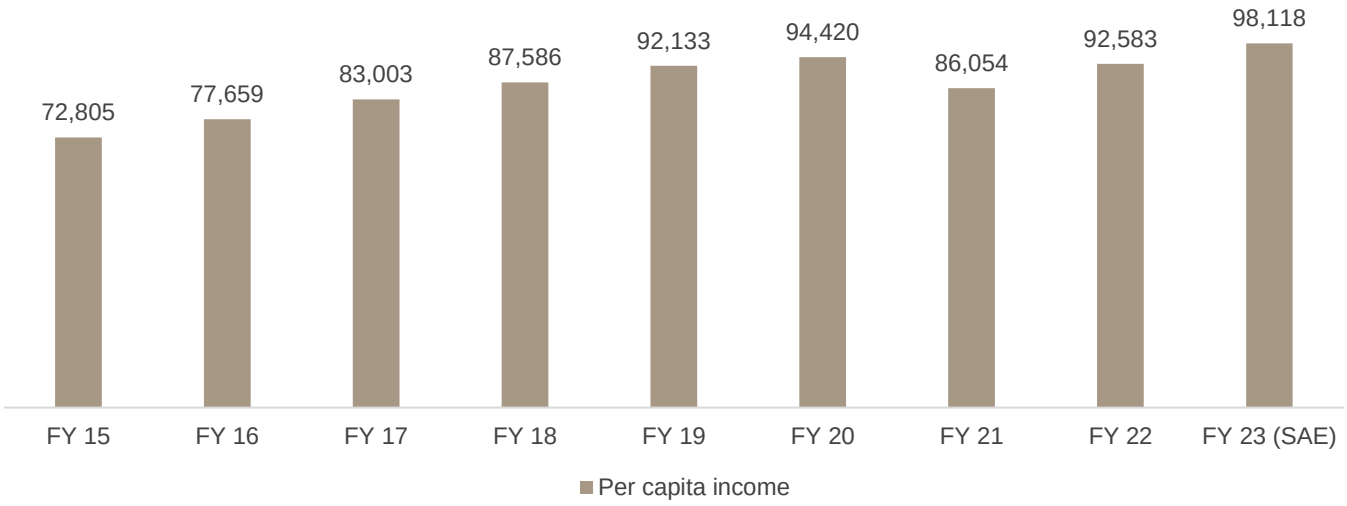
SAE: Small area estimate

Note: Data is based on constant prices, 2011-12 base

Source: National Accounts Statistics, CRISIL MI&A Research

India's national income per capita in real terms logged 5.3% CAGR between Fiscals 2015 and 2020, rising from ~Rs 73,000 to ~Rs 94,000. Impacted by the pandemic, it decreased 8.9% on-year to ~Rs 86,000 in Fiscal 2021 (back to the Fiscal 2018 level). On this low base, it grew 7.6% on-year to ~Rs 93,000 in Fiscal 2022, marginally higher than the pre-pandemic level of Fiscal 2020.

Figure 5: India's national income per capita (Rs)



SAE: Small area estimate

Note: Data is based on constant prices, 2011-12 base

Source: National Accounts Statistics, CRISIL MI&A Research

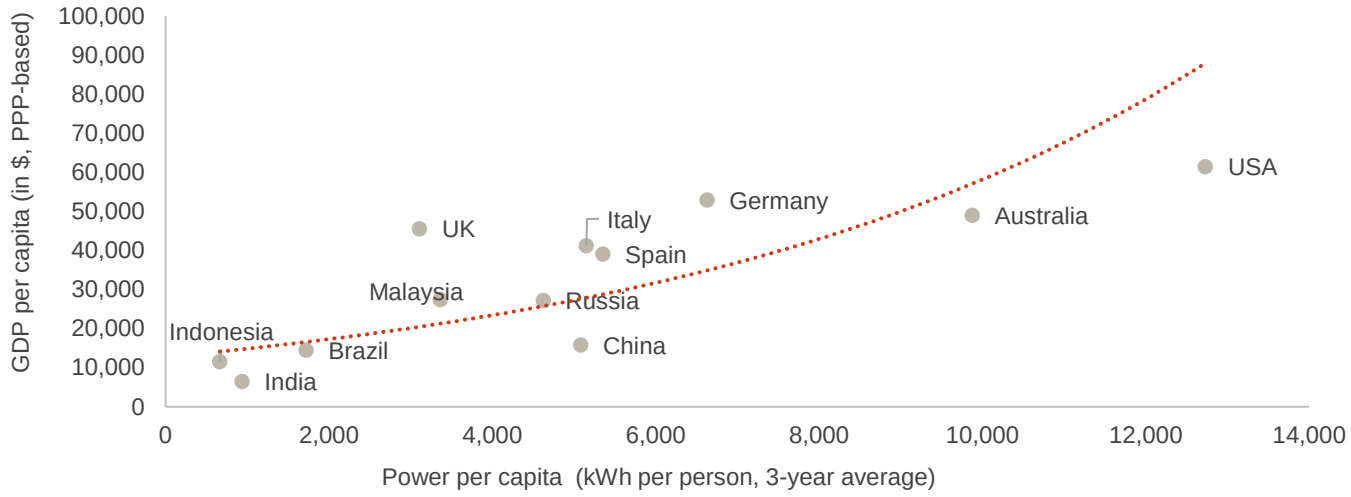
Power demand shows strong correlation with GDP per capita

A 30-year data assessment indicates a strong correlation between power demand and overall GDP growth. Cross-country and cross-state comparisons also indicate the same. Hence, tracking GDP growth and its impact on per capita power demand is considered an established means of understanding the prospects of the power sector.

Further, India's manufacturing GVA share of 18% is lower than that of its other Association of Southeast Asian Nations ("ASEAN") peers, which are factories to the world. That said, the ongoing supply-chain de-risking strategy of global players amid geopolitical disruptions; the Indian government's focus on initiatives such as Make in India and PLI; and the emergence of new-age sectors amid energy transition creating new manufacturing needs are set to improve the contribution of manufacturing to India's GDP. This would further boost power demand prospects.

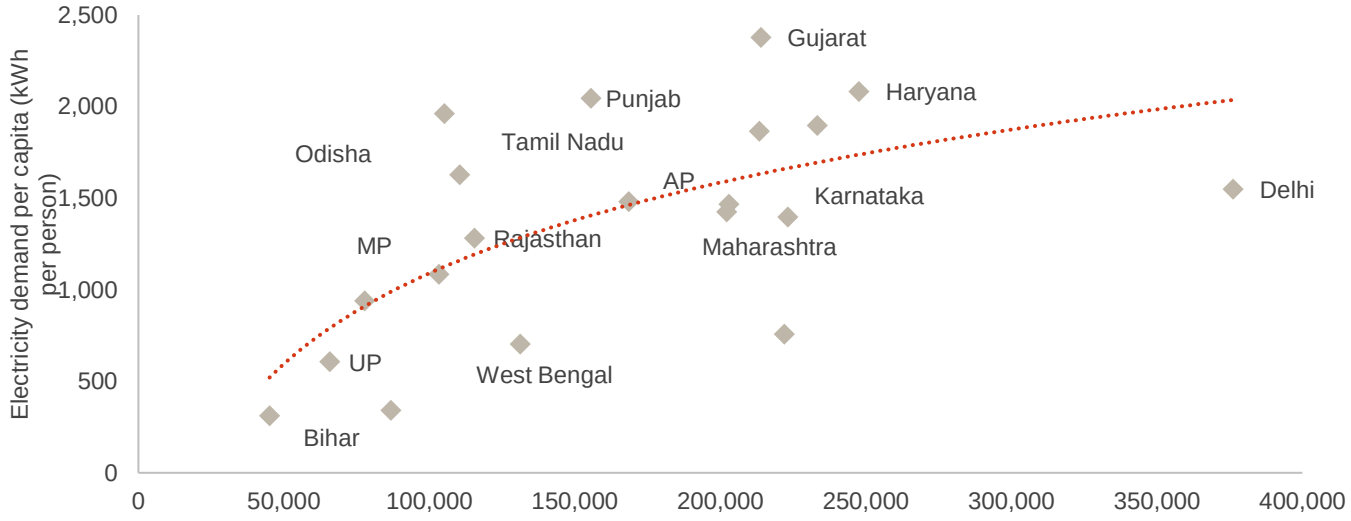
Alongside these developments, an efficient transmission and grid infrastructure would help reduce aggregate technical and commercial ("AT&C") losses and improve energy efficiency in the power sector.

Figure 6: Correlation between power consumption and GDP per capita, by country



Source: National Accounts Statistics, CRISIL MI&A Research

Figure 7: Power demand in India, by state



Source: National Accounts Statistics, CRISIL MI&A Research

Module 2: Power demand

Overview of demand and supply

Power demand has maintained robust growth momentum

Electricity consumption in India has grown at a steady pace, clocking a 4.3% compound annual growth rate ("CAGR") over the past decade. In unit terms, consumption, which was a mere 1,002 billion units ("BUs") in Fiscal 2014, stood at 1,626 BUs in Fiscal 2024, courtesy India's growing population, industrial and economic expansion, and strengthening of the transmission and distribution ("T&D") infrastructure.

- Growth in consumption is projected to continue in Fiscal 2025. Post a strong rise of 7.4% on-year in Fiscal 2024 over a high increase of 9.6% in Fiscal 2023, CRISIL MI&A Research expects power demand to rise 5-6% on-year in Fiscal 2025. In absolute terms, power demand is expected to surge to 1,720-1,730 BUs in Fiscal 2025 as compared to 1,626 BUs in Fiscal 2024. Estimated growth in GDP of 7.3% in Fiscal 2024, along with seasonal vagaries, is expected to sustain high demand for power. CRISIL MI&A Research expects power demand growth to moderate in Fiscal 2025 to 5-6% on year as the strong El-Nino conditions prevailing over Equatorial Pacific currently are expected to moderate at the end of June 2024. Additionally, the growth rate comes on the back of three subsequent years of high growth rates, highlighting the sustained trend of surge in demand but some moderation is expected in 2025. Power demand to increase ~1.5x by 2032 from 1,626 BUs in Fiscal 2024.
- India's utility power demand in Fiscal 2024 was 1,626 BUs (excluding captive consumption). The per capita electricity consumption (including captive consumption) is expected to have increased to 1,340-1,350 units in Fiscal 2024 from 1,255 units in Fiscal 2022

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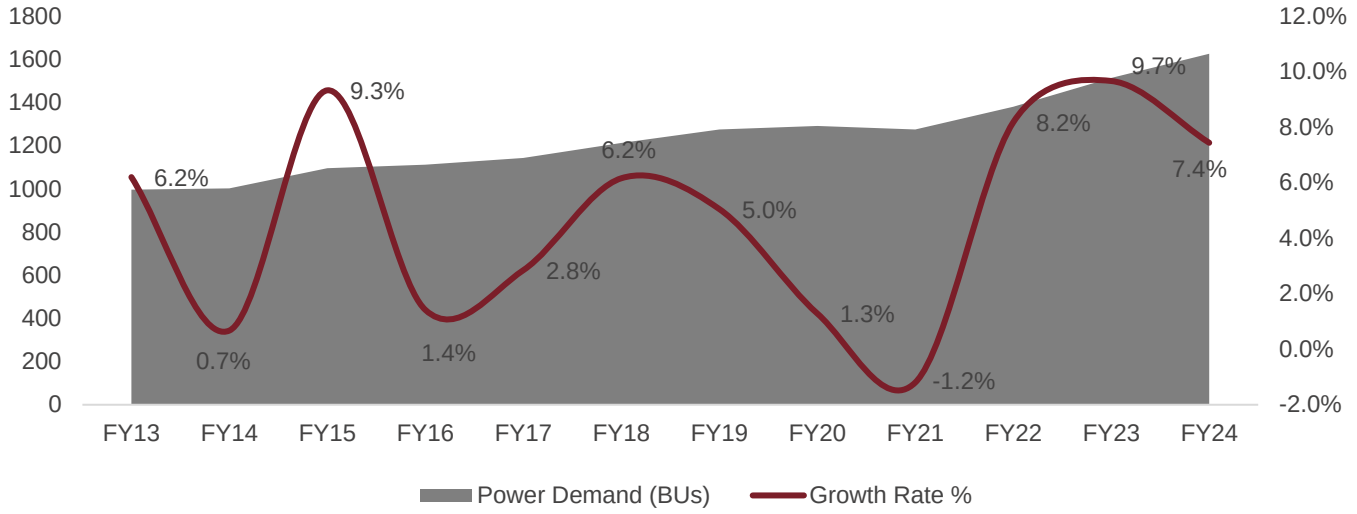
Figure 8: Snapshot on power demand (BUs)



F – forecast

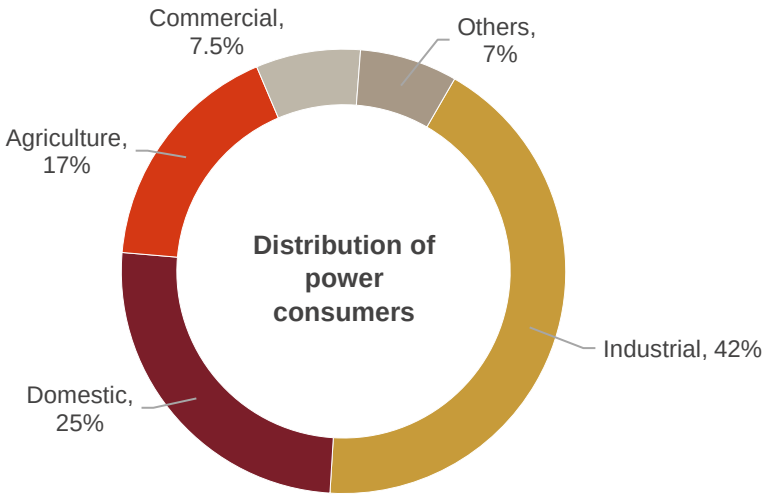
Source: CEA, CRISIL MI&A Research

- While base demand has grown at a CAGR of approximately 5% over Fiscal 2019 to 2024, peak demand has grown at 6.6% during the same period.
- Energy consumption is expected to be bolstered by the government's increasing focus on rural electrification, railway electrification, transition to electric vehicles and policies such as '24x7 Power for All'

In fact, demand surged 7.6% on-year in the first three quarters of Fiscal 2024 as El-Nino led to warmer temperatures in the first and second quarters, which kept power demand high. Surge in economic activity also increased power demand – Index of Industrial Production surged 6.1% on-year between April-December 2023.

To be sure, power demand in India is driven by the industrial and commercial segments, which together account for close to half of India's annual power consumption, with domestic and agriculture sectors constituting 25% and 17%, respectively.

Figure 9: Category-wise share of power demand



Note: The share break-up is based on the latest available data. i.e. Fiscal 2023

Source: CEA, CRISIL MI&A Research

- **Commercial and industrial consumers**

  The government's Make in India policy and ongoing supply chain de-risking strategy of global companies post Covid-19 are expected to drive India's manufacturing sector over the medium-to-long term, thereby supporting power demand from the commercial and industrial segment. In fact, power consumption from the commercial and industrial segment is projected to log a 7-8% CAGR from Fiscal 2025 till Fiscal 2029 on the government's continued push to infrastructure and support to industries through initiatives such as Atmanirbhar Bharat.

- **Domestic consumers**

  Power consumption from domestic consumers is expected to log a 5-6% CAGR over Fiscals 2025 to 2029 on account of increasing urbanisation and fluctuating temperatures. Power demand surged to an all-time high of 152 BUs in August 2023 and peak power demand reached a high of 240 GW in September 2023. Climate change has led to warmer temperatures, causing a spike in cooling demand over Fiscals 2022 to 2024.

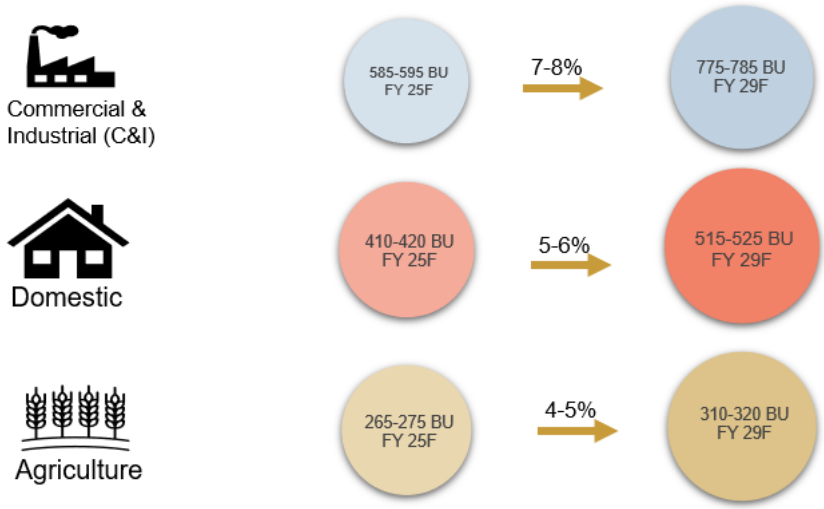
  Electricity demand from the segment is forecasted to remain high. This projection can be extrapolated from the fact that between Fiscals 2023 and 2028, CRISIL MI&A Research expects sales of residential air conditioners to surge at 13-15% CAGR. Also, the current penetration level of air conditioners of ~12% is considerably lower than ~35% globally, indicating substantial headroom for growth.

- **Agricultural consumers**

  Around 50% of India's agriculture land is irrigated. This will be a key driver of power demand, as vagaries in weather become common. As of Fiscal 2022, irrigation, i.e., pump sets and tubewells, comprised ~17% of agricultural power demand, with 26.67 million water pumps vs 20.70 million in Fiscal 2017.

Economic growth and climate change to support high electricity demand

Figure 10: Category-wise demand outlook

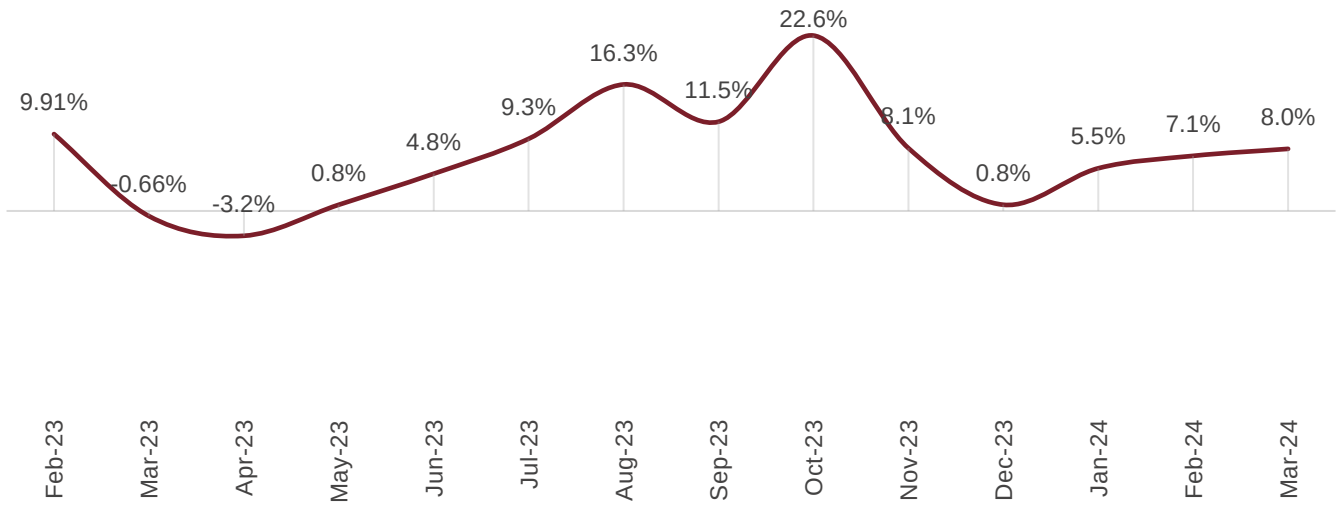


Source: CRISIL MI&A Research

At a regional level, Maharashtra accounted for the largest share of power demand in Fiscal 2024, with demand surging 11% on-year, primarily because of rising commercial and industrial consumption, which accounts for over half of the power demand in the state. But electricity consumption in southern states such as Andhra Pradesh, Karnataka and Puducherry outpaced the pan India demand growth rate, with consumption rising ~17% on-year, driven by industrial, domestic, and agricultural segments.

Overall, the strong growth in power demand during the year bucked the trend in April 2023, where power demand declined for the first time in 24 months in the backdrop of unseasonal rains, which provided a reprieve from soaring temperatures. But lower than normal rainfall in second quarter resulted in increased power demand by 11.3% on-year. The last quarter of the Fiscal is expected to see power demand rise 6-7% on-year owing to an extended winter in the North along with continued economic momentum.

Figure 11: Month-wise power demand (%)

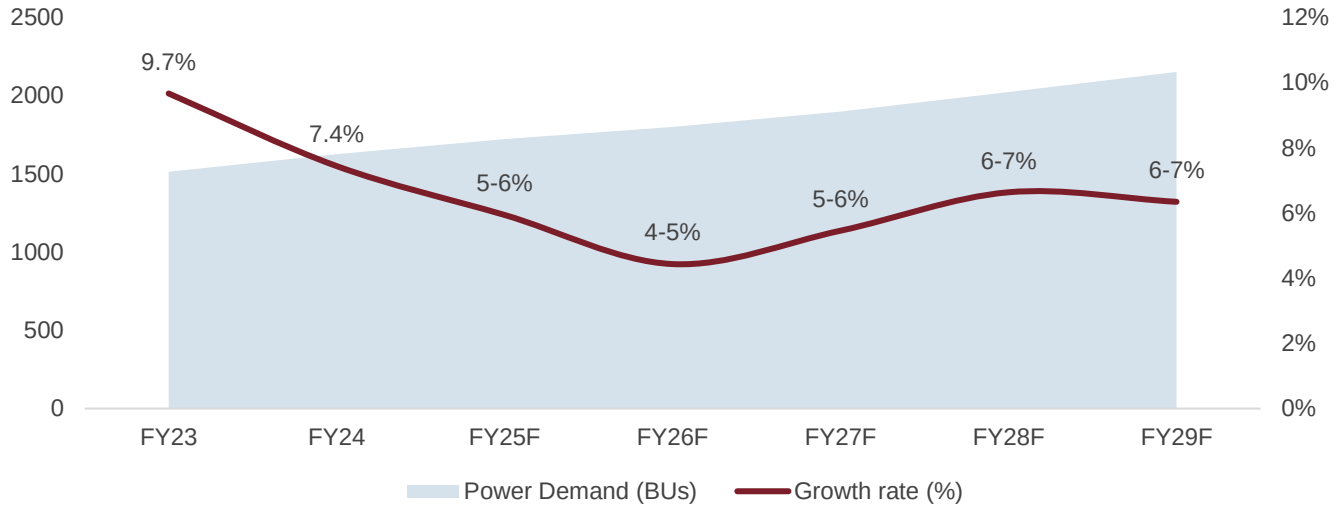


Source: CEA, CRISIL MI&A Research

Power demand to maintain healthy growth from Fiscal 2025 to 2029

Between Fiscals 2025 and 2029, power demand is expected to sustain a high growth trajectory of 5 to 6% CAGR on the back of healthy economic growth and expansion of the electricity footprint via strengthening of the distribution infrastructure. The government's continued infrastructure and industrial manufacturing push is expected to drive power demand as well, with climate change induced temperature fluctuation also a key reason for peak demand surges. Major reforms initiated by the central government towards improving the health of the power sector, particularly that of state distribution utilities, are expected to improve the quality of power supply, thereby boosting power penetration levels as well.

Figure 12: Snapshot of power demand (BUs)



F – forecast

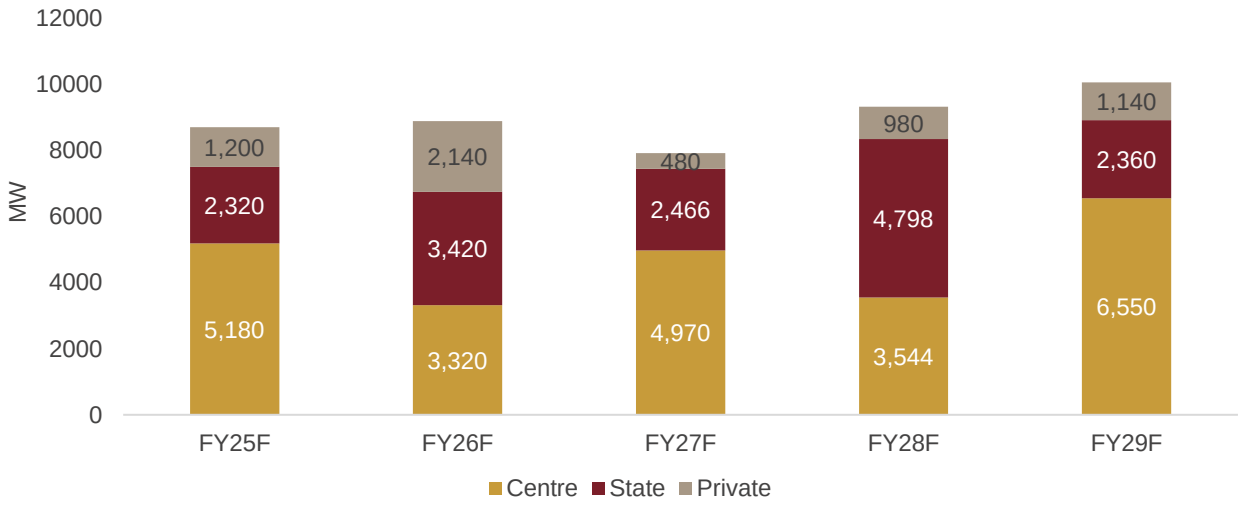
Source: CRISIL MI&A Research

Over Fiscals 2013 to 2023, power demand logged 4.3% CAGR, with power availability rising in step at 5.2% CAGR on the back of strong capacity additions of ~204 GW. As a result, energy deficit is estimated to have declined to a marginal 0.5% in Fiscal 2023 from 8.7% in Fiscal 2013. The sharp decline, particularly in Fiscal 2017, wherein the deficit reduced to 0.7% from 2.1% in Fiscal 2016, was owing to muted demand growth of 2.5% CAGR due to a decline in electricity consumption across categories during the year as well as reform measures in the distribution space under Ujjwal DISCOM Assurance Yojana, or UDAY.

Conventional fuel addition to grow at a steady pace

CRISIL MI&A Research expects 22 to 24 GW of coal-based power to be commissioned over Fiscals 2025 to 2029. In addition, 4.5 to 5 GW of nuclear capacities are expected to come onstream over the same period. In Fiscal 2024, Coal plant capacity additions had strong growth, with total addition of 5.2 GW as against addition of 1.5GW in Fiscal 2023. The capacity of 5.2 GW added in Fiscal 2024 came against a targeted capacity of 14.7 GW. CRISIL MI&A Research expects coal capacity additions to range 3.0 to 5.0 GW in Fiscal 2025.

Figure 13: Snapshot of sector-wise conventional capacity additions (Fiscals 2025 to 2029)



F – forecast

Note: Conventional fuels refer to coal, gas, diesel and nuclear

Source: CEA, CRISIL MI&A Research

Total installed conventional capacity in India increased to 291 GW at end-Fiscal 2023 from 196 GW at end-Fiscal 2013. This is expected to increase to 293-298 GW in Fiscal 2024 and 305-310 GW in Fiscal 2025.

By Fiscal 2029, though, capacity additions will be mainly driven by clean energy sources. CRISIL MI&A Research expects 230 to 240 GW of renewable energy additions (including hydro and pump storage projects (“PSP”) of 15 to 20 GW). This would translate into 85 to 90% penetration of renewables (including hydro and storage components) in capacity addition terms till Fiscal 2029. Within renewables, solar will account for the maximum share in the additions, at approximately 52 to 56%, with total capacity of 117 to 122 GW. A further upside of 37 to 42 GW is expected to arise during the period because of demand for solar through green hydrogen and renewable

generation obligations (“RGO”) of thermal plants. This will cumulatively take the share of solar additions to 65 to 70%. Wind energy will account for 12 to 15% contribution 30 to 35 GW capacity additions. By Fiscal 2032, the solar and wind technologies will have an energy penetration of 35%.

Power deficit trends

CRISIL MI&A Research expects demand for power to increase 5-6% on year in Fiscal 2025 due to warmer temperatures induced by El-Niño and heightened economic activity. Resultantly, generation is expected to increase 6.5-7.5% on-year this Fiscal to 1,860-1,870 BU from 1,744 BU in Fiscal 2024. Of this, coal-based generation is expected to be ~70% with an average plant load factor (“PLF”) for coal-based power plants at ~70%.

In Fiscal 2024, the energy deficit across states and union territories (“UTs”) was 0.3%, indicating slight narrowing of the deficit. To provide a perspective, this is in comparison with energy deficit of 0.5% in Fiscal 2023 and 0.4% in Fiscal 2022.

The southern region has a marginal energy deficit of 0.1% till date this Fiscal. Commissioning of key power projects such as NTPC's Vallur TPP (1 GW), TANGEDCO's North Chennai extension project (1.2 GW), NPCIL's Kudankulam nuclear plant (2 GW) and Adani Power Ltd's Udupi (1.2 GW) over the past few years has led to healthy growth in power supply, narrowing the deficit.

Commissioning of new plants/units in Fiscal 2023 – Unit 2 (800 MW) of Darlipali STPS and Unit 4 (250 MW) of Nabi Nagar TPP for the eastern region, Unit 8 (660 MW) of Suratgarh TPS for Rajasthan, Unit 10 (660 MW) of Harduaganj TPS in Uttar Pradesh, hydro plants in Sikkim and the newly commissioned Vyasi HPS in Uttarakhand (120 MW) in August 2022 – has crimped the deficit numbers for the northern, eastern and north-eastern regions. Augmenting of the transmission network (inter, intra and regional) will also help narrow the deficit.

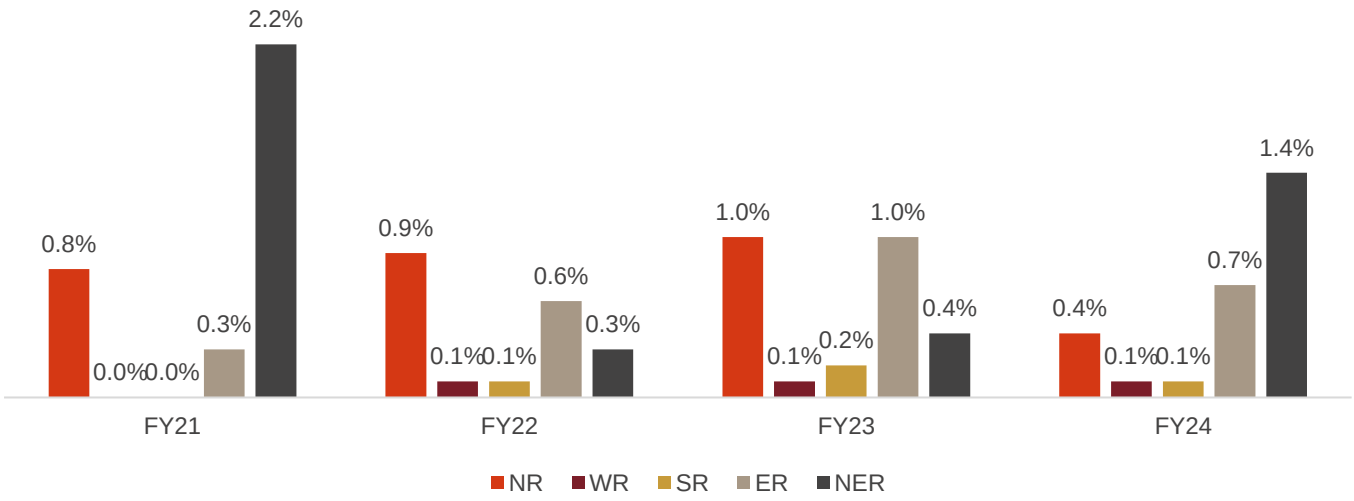
CRISIL MI&A Research expects energy demand to clock 5-6% CAGR between Fiscals 2025 and 2029, with incremental generation being supported by clean energy capacity additions. Power deficits may still persist as rising demand is met by more intermittent nature of power supply through renewables, though this is being tackled by planning of storage elements in the power system.

Despite improvements in connectivity and generation oversupply, underserviced regions (northern, north-eastern, and eastern) would contribute to pan-India deficit over the medium term. The government is expected to improve connectivity within these regions, and inter-regional transmission capacity of the National Grid is adequate at 112,250 MW as of February 2023.

Although the base deficit has reached below 1% in almost all major states except Jharkhand, Bihar, J&K (“UT”) and Ladakh (“UT”), CRISIL MI&A Research does not consider this as a power surplus scenario. There is still off-grid untapped latent demand in the country, and 100% intensive rural electrification and 24x7 power supply have not yet been achieved. In fact, India’s per capita electricity consumption, estimated at 1,340- 1,350 kwh in Fiscal 2024, significantly lags developing and developed peers. This clearly indicates that lower power demand is on account of

untapped potential and narrower spread of distribution infrastructure, along with the absence of last-mile connectivity in some cases.

Figure 14: Barring NER, power deficit levels moderately pare between April- March 2024

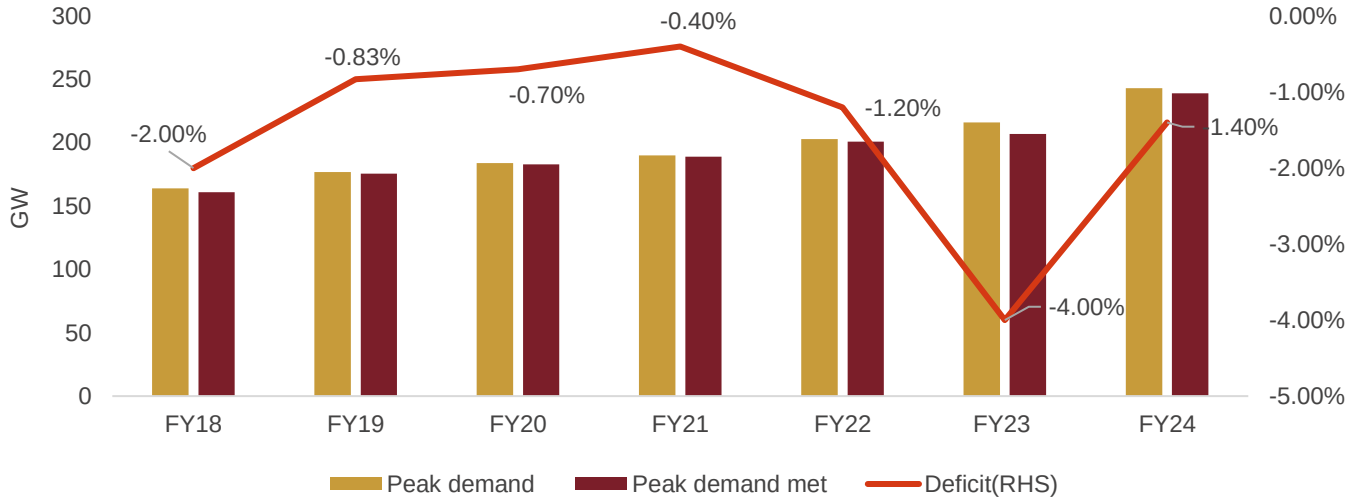


Note: NR - northern region, WR - western region, SR - southern region, ER - eastern region, NER - north-eastern region

Source: CEA, CRISIL MI&A Research

Peak demand in India has grown from 136 GW in Fiscal 2013 to 216 GW in Fiscal 2023 at a CAGR of ~5%. Peak demand has consistently risen over the past few years, even during the pandemic. Rising peak demand can be attributed to an increase in domestic and commercial load, mainly space-cooling load, due to high humidity. Peak demand touched a record high 216 GW in Fiscal 2023 because of increase in demand for cooling as summer was intense. Winter months also witnessed record high peak demand, with demand registering double-digit on-year growth of 13% in November, 12% in December and 9% in January. Increased heating requirement, as several regions reeled under a severe cold, accentuated peak power demand during these months. The constant rise in peak demand can be attributed to economic growth, seasonal vagaries, and an increasing daily average temperature that India has experienced over the past decade, leading peak demand to touch 240 GW in September 2023. Peak demand is expected to continue to witness sharp growth due to persistent high temperatures, rising urbanisation, economic growth and infrastructure push.

Figure 15: Peak demand and deficit scenario



Source: CEA, CRISIL MI&A Research

Demand tailwinds and headwinds

Demand for power is closely associated with a country's gross domestic product ("GDP"); the better the economy more the demand. India is already the fastest-growing economy in the world, having clocked 5.5% average GDP growth over the past decade. The economy is expected to continue to expand beyond Fiscal 2023, with industrial activity gradually picking up over the medium term. The trickle-down effect of the Aatmanirbhar Bharat relief package, government spending on infrastructure through the National Infrastructure Pipeline, commissioning of the dedicated freight corridors, expansion of the services industry, rapid urbanisation and increased farm income from agriculture-related reforms are key macroeconomic factors fostering power demand. Significant policy initiatives such as Production-linked Incentive ("PLI") scheme and low corporate tax rates, among others, have aided large-scale manufacturing in India, which should further boost demand for power.

Apart from macroeconomic factors, demand will be fuelled by railway electrification, upcoming and ongoing metro projects, growing demand from charging infrastructure due to faster adoption of electric vehicles ("EVs"), and higher demand from key infrastructure and manufacturing sectors. However, increasing energy efficiency, reduction in technical losses over the long term, and captive as well as off-grid generation from renewables would cap the growth.

Increase in sales of appliances, driven by increase in per capita income, is another growth driver. For instance, the ~Rs 224.4 billion refrigeration and air conditioner ("RAC") industry, as of Fiscal 2023, is expected to increase to Rs 350-400 billion by Fiscal 2027. RACs, predominantly used in residences, have a low penetration of ~12% in India as of 2023. This is expected to reach 15-17% by Fiscal 2027, driven by the urban population. Additionally, CRISIL MI&A Research expects RAC sales to increase at 10-12% CAGR between Fiscals 2024 and 2028 to 10.5-11 million units.

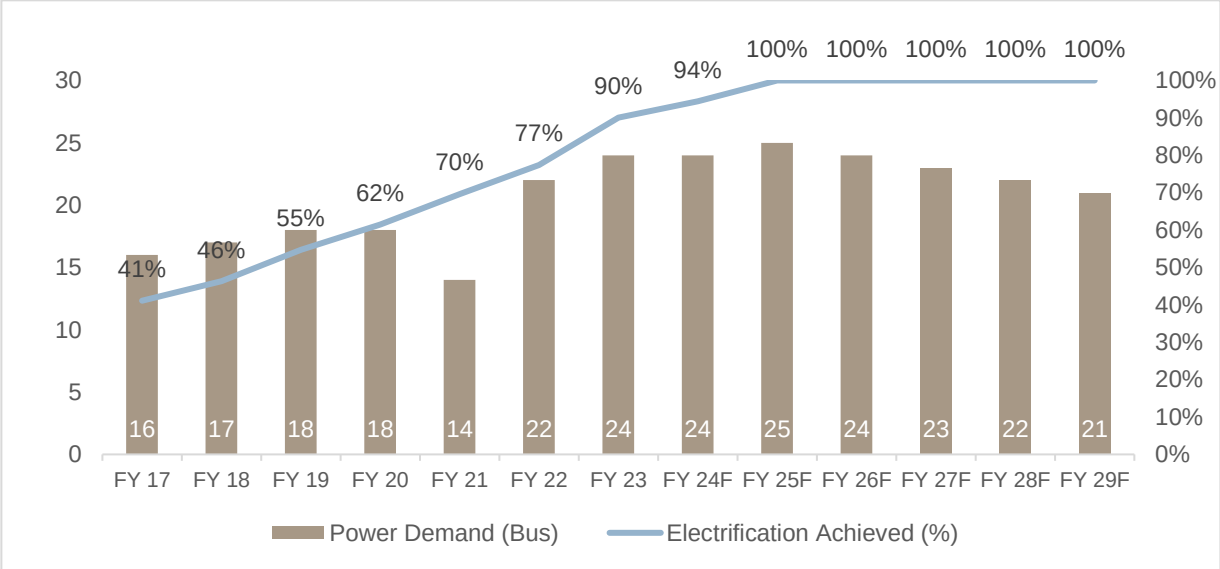
Railway electrification adds demand of 128 BU over Fiscals 2017-2023

Indian Railways (“IR”) is the lifeline of the nation, providing transportation facility throughout the country. IR has one of the world’s largest rail networks, spanning 68,426 km as of Fiscal 2023. Broad gauge constitutes 65,300 rkm, accounting for 95% of the total rail route. By March 2024, electrification has been extended to 62,119 rkm out of the total broad gauge. This constitutes 94% of the total broad gauge railway network.

The Union Budget 2024-25 allocated a capital outlay of Rs 2.52 trillion to IR – the highest-ever allocation to the national transporter. It is in continuation of the trend followed the previous year, with a gross budgetary support of Rs 2.4 trillion. This is expected to provide impetus to the sector in terms of creation of new lines, doubling existing lines and electrification of the existing lines.

In a bid to become a net-zero emitter by 2030, the government’s aim was to achieve 100% electrification of IR by December 2023. However, pandemic-induced lockdowns and a sluggish pace have pushed full electrification to Fiscal 2027. This is expected to lead to an incremental power demand of ~23 BU, on average, every year. The power sector is poised to witness incremental demand from railway electrification. However, a decrease in energy consumption in electrifying per-km route due to improvement in energy efficiency will offset this partially.

Figure 16: Indian railway electrification and additional power demand



Source: CEA, CRISIL MI&A Research

Ramp-up in metro projects to increase electricity requirement

Metros need electricity for train traction and operation of the stations. Metro rail has seen substantial growth in India in recent years, and the pace is only going to exponentially increase across cities. Currently as of March 2024, ~900 km of metro routes is operational across 17 cities. Around 712 km of metro line is under construction and 1,878 km is proposed. Electricity consumption from the aforesaid categories is expected to add an average

incremental power demand of 5.5-6 BU every year. Currently, metro projects constitute a marginal share of the total incremental demand, but the share is expected to increase thanks to the upcoming metro projects.

Gradual transition to EVs to increase the demand for charging infrastructure

The Government of India is focusing on building charging infrastructure and creating a conducive policy environment for faster adoption of EVs to reduce dependence on fossil fuels for transportation. India aims to increase the share of EVs in overall car population to 30% by 2030. Under the National Electric Mobility Mission plan, the government envisages to promote EV adoption through demand-side incentives, in terms of subsidies, promoting charging infrastructure, and encouraging research and development in battery technology, power electronics, battery management and system integration.

In Fiscal 2021, though, the EV market faced strong headwinds as buyers cut down on big-ticket purchases, thus impacting sales of EVs, which are typically costlier than conventional vehicles. However, sales rebounded strongly in Fiscal 2022, spurred by elevated fossil fuel prices, with government incentives such as Faster Adoption and Manufacturing of Hybrid and Electric Vehicles (“FAME”) II worth Rs 100 billion.

This will be supported by the expansion of charging infrastructure across major cities, as well as concomitant growth in the distribution infrastructure, in addition to an appropriate tariff structure for charging of EVs. In fact, the government, in the Union Budget 2019-20, announced Rs 10 billion in subsidies for building a nationwide EV charging infrastructure as a part of FAME-II. Charging stations will be installed on major highways such as Delhi-Mumbai, Delhi-Chandigarh, and Mumbai-Surat-Pune, with plans to have a charging station every 25 km on these highways. Furthermore, Gujarat, Maharashtra, Delhi, and Karnataka have announced favourable policies to boost EV adoption, along with establishing EV charging infrastructure through state-owned and private entities. As a result, EV charging demand is likely to aid power demand over the medium term, with a gradual increase in the share of EVs in the vehicle population.

CRISIL MI&A Research projects that the adoption of EVs will add up to 60 to 65 BUs of power demand between Fiscals 2025 and 2029.

Declining T&D loss to lower demand for power

India's power sector has faced persistently high transmission and distribution (“T&D”) losses, averaging 20% between Fiscals 2011 and 2019, while the ideal range is 6-8%. These losses indicate the amount of power lost during T&D, necessitating additional power generation to compensate for these inefficiencies. Although there has been a slight improvement, with T&D losses declining to 20.66% in Fiscal 2019 from 21.04% in Fiscal 2018 and 21.4% in Fiscal 2017, losses remain above the desired threshold.

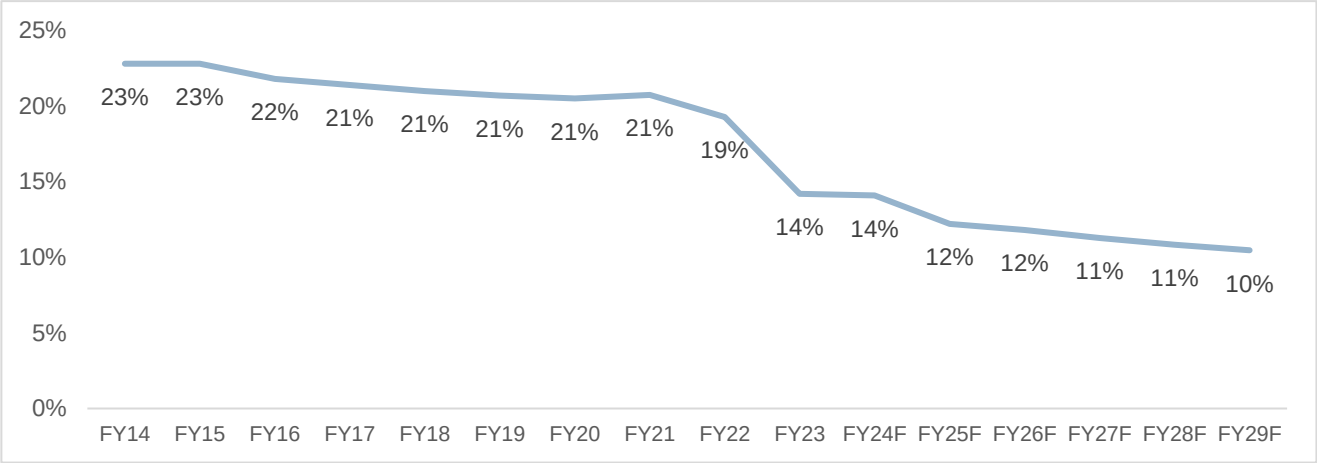
To address this issue, the government has implemented various initiatives to mitigate losses in distribution companies (“discoms”) such as the Revamped Distribution Sector Scheme (“RDSS”). This is a reform-oriented scheme aimed at enhancing the quality and reliability of power supply, ensuring the financial sustainability and operational efficiency of the distribution sector. The scheme's objective is to reduce aggregate technical and

commercial (“AT&C”) losses to 12-15%. Under RDSS, government expects installation of ~250 million smart meters by Fiscal 2025, with the total outlay of ~Rs 3.04 trillion for smart meter installations and loss reduction.

Moreover, the government has granted additional borrowing permissions linked to reductions in AT&C losses and the ACS-ARR (average cost of supply and average revenue realised) gap, amounting to 0.05% of each state's gross state domestic product (“GSDP”). The persistent efforts by the government have yielded positive results, as AT&C losses have decreased from 27% in Fiscal 2011 to ~16% in Fiscal 2022.

Going ahead, T&D losses are expected to continue to decline due to the measures implemented by the government. This reduction will subsequently lead to a decrease in the incremental power requirement needed as a buffer to compensate for these losses. Power demand is projected to reduce by 19-20 BU, on average, every year owing to the improvement in T&D losses over Fiscals 2024-2029.

Figure 17: Snapshot on T&D loss (%)



Source: CEA

Reduction in demand due to an increase in off-grid/rooftop projects

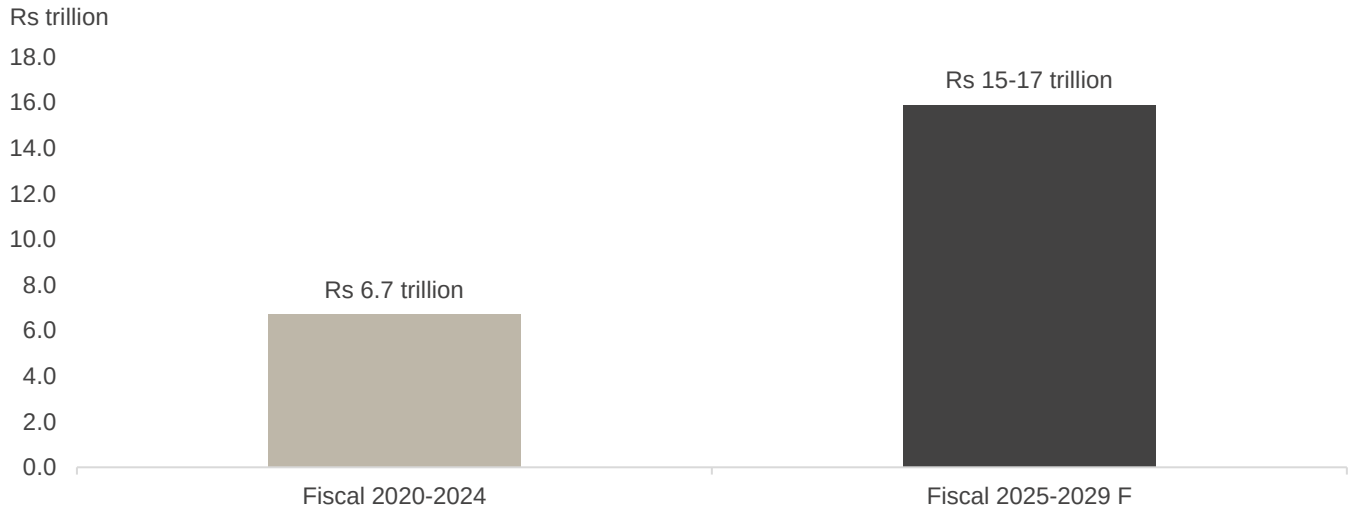
Led by a boost to rooftop solar and declining costs of renewable energy generation, rooftop solar generation is expected to increase, reducing power demand from the grid. By Fiscal 2029, rooftop addition is expected to be 18-23 GW which will increase solar rooftop installed base to 31 to 33 GW resulting in a reduction of 2-3% in base demand.

Reduction in demand due to energy-efficiency schemes

The Unnati Jyoti Affordable LEDs for All (“UJALA”) scheme aimed at replacing 770 million inefficient bulbs with LED bulbs across the country by March 2019; however, the scheme is progressing at a sluggish pace and achieved less than 50% of the target after eight years of its launch, with ~368 million bulbs replaced as of May 2024. Although the scheme will reduce energy consumption equivalent to 88% of conventional bulbs, it only contributes marginally towards power demand reduction.

Brief overview on investment trends and generation outlook

Figure 18: Review of generation investments and their outlook

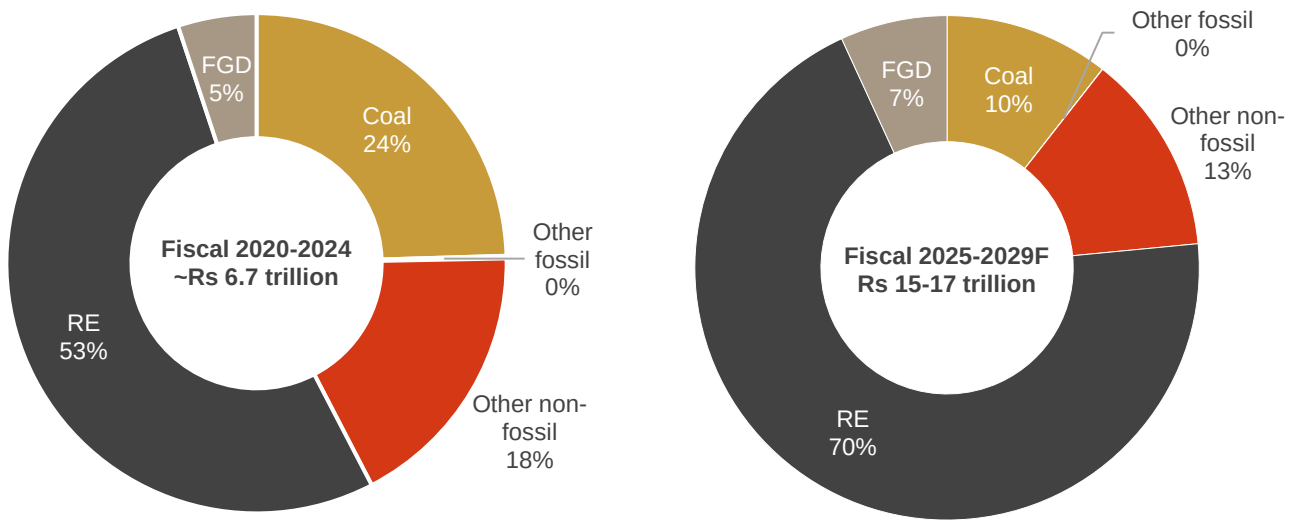


Note: E: estimates, F: forecast

Source: CEA, PGCIL, State discom tariff order, CRISIL MI&A Research

Over Fiscals 2025-2029, investments in generation will be led by renewable energy capacity additions, followed by investments in conventional generation and flue gas de-sulphurisation ("FGD") installations, indicating a shift in investment flows towards clean energy supply. Capacity addition is expected to be 230 to 240 GW from renewable energy ("RE") sources and 22 to 24 GW from coal-based plants over Fiscals 2025 to 2029. Investments in RE capacity will constitute 73 to 78% of overall generation investments over Fiscals 2025 to 2029, up from approximately 56% over Fiscals 2020 to 2024.

Figure 19: RE continues to hold a dominant share of generation investments



Note: Other fossil fuels include lignite, gas, and diesel.

Other non-fossil fuels include hydro and nuclear.

Source: CEA, CRISIL MI&A Research

With the introduction of tariff-based competitive bidding ("TBCB") in 2006 and an anticipated healthy return profile, large private conglomerates invested heavily in generation projects. Capacity additions in the private sector were led by players such as Tata Power Limited, Adani Power Limited, Sterlite Power Transmission Limited, KSK Mahanadi Power Company Limited and Lanco Infratech Limited. However, lack of adequate long-term power purchase agreements and stretched financials of private developers have led to a slowdown in capacity additions and limited private investments in the conventional power generation space. As a result, central and state sectors, which typically have higher funding accessibility and a strong execution record, will lead the investments in conventional generation, accounting for over 89% of investments over the next five years.

Coal-based capacities will account for 22 to 24 GW over Fiscals 2025 to 2029 as coal continues to be the most abundant fuel for power generation, while 4.5 to 5 GW of nuclear capacities will also be added with major capacities from central utilities, Nuclear Power Corporation of India Limited ("**NPCIL**") and Bharatiya Nabhikiya Vidyut Nigam Limited ("**BHAVINI**"), nearing completion.

Pumped storage capacity of 8.5 to 9.5 GW is also expected to be added to the system to compliment high RE penetration for supplying round-the-clock ("**RTC**") power.

Module 3: Transmission sector in India

Review of the sector and its outlook in India

The transmission system in India

A transmission system links the power generation source with the distribution system, which is connected to load/ultimate consumers. These systems are planned and implemented for evacuation of power from generating stations, strengthening the existing transmission network to meet the projected load/demand growth and ensuring optimum utilisation of distributed generation resources in different regions. In India, a licence is required to operate power transmission infrastructure and it is granted by the commissions for a period of 25 years.

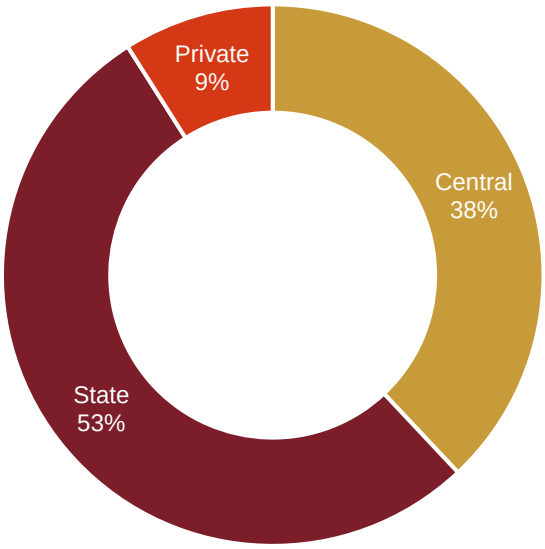
The domestic transmission system has a two-tier structure comprising intra-state transmission ("InST") lines and inter-state transmission system ("ISTS") lines, in addition to a few dedicated transmission lines.

ISTS lines are developed by inter-state transmission licensees. At present, Power Grid Corporation of India Limited ("PGCIL") primarily owns and operates a majority of the ISTS network. ISTS is used for evacuation of power from inter-state generating stations ("ISGS") which have beneficiaries in more than one state. It also handles onward transmission of power from ISGS up to the delivery point of the state grid and transfer of operational surpluses from surplus state(s) to deficit state(s) or from surplus region(s) to deficit region(s) as per relevant regulations.

On the other hand, the InST system is developed by state transmission utilities ("STUs")/intra-state transmission licensees for evacuation of power from the state's generating stations (both under public and private sectors) for beneficiaries in that state. It also handles onward electricity transmission within the state from ISTS boundary up to the various substations of the state grid network and transmission within the state grid for power delivery to load centres within the state.

Regulatory structure and stakeholders

The electricity sector's development in India is the joint responsibility of both central and state governments. Being the central transmission utility, PGCIL plays a vital role in facilitating the transmission of power from central generating utilities ("CGUs"). Currently, as of March 2024, states account for the largest share of the total transmission capacity, at 53%, followed by the central government (38%) and the private sector (9%).

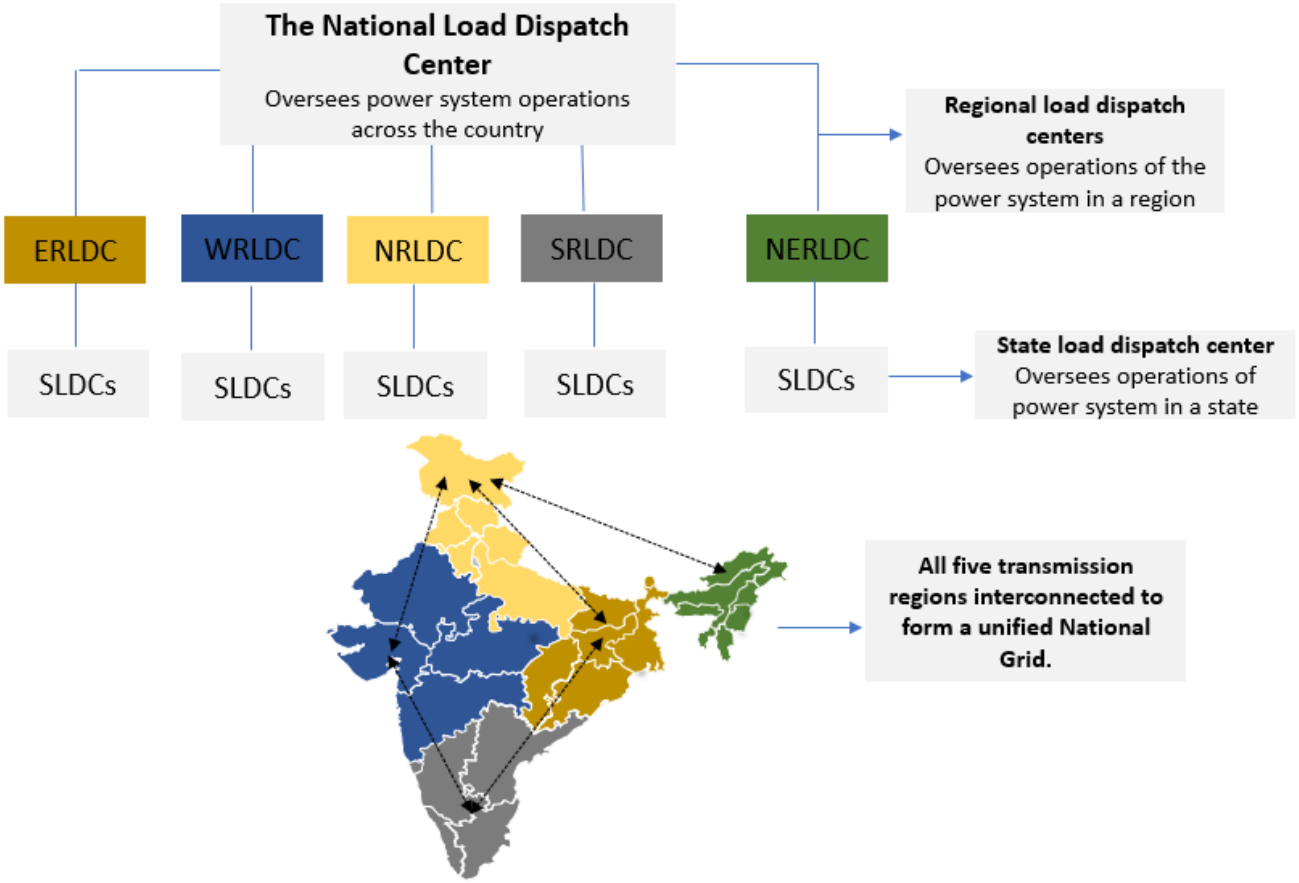


Note: Numbers are as of March, 2024

Source: CEA, CRISIL MI&A Research

India has been divided into five transmission regions: northern, eastern, western, southern, and north-eastern. The northern, eastern, western, and north-eastern regions are interconnected and operate as a single grid, known as the national grid. Each of these regions has a regional load dispatch centre (“RLDC”), which is the apex body for ensuring the power system's integrated operation within the respective region, as mandated by the Electricity Act, 2003. Additionally, the National Load Dispatch Centre (“NLDC”) oversees the power system's integrated operation across the country. The NLDC and RLDCs have together formed a subsidiary called Power System Operation Corporation Ltd (“POSOCO”), wholly owned by PGCIL.

Figure 20: Key stakeholders involved in the transmission sector



Note: ERLDC – Eastern RLDC, WRLDC – Western RLDC, NRLDC – Northern RLDC, SRLDC – Southern RLDC, NERLDC – Northeastern RLDC

Source: CRISIL MI&A Research

Several key players play a significant role in operating and managing the domestic transmission infrastructure. The prominent players include the following:

1. **Central Transmission Utility of India Ltd ("CTUIL"):** The company, a wholly owned subsidiary of PGCIL, owns and operates extensive infrastructure, including ~177,699 circuit kilometre ("ckm") of extra high voltage ("EHV") transmission lines and 278 EHV alternating current ("AC") and high-voltage direct current ("HVDC") substations, with its transformation capacity surpassing 527,446 mega volt ampere ("MVA") as of Fiscal 2024. It ensures the development of an efficient, well-coordinated, and cost-effective system of inter-state transmission lines and handles power transmission between states. PGCIL is the largest transmission company in India, responsible for inter-state transmission operations. It manages a wide network of transmission lines and substations, accounting for 38% of total transmission lines in the country. Through advanced operational and maintenance techniques, PGCIL maintained an exceptional availability rate of over 99% in Fiscal 2024.

2. **State transmission utilities:** Every state in India has its own state electricity board ("SEB") or a power utility responsible for intra-state transmission and distribution. These SEBs are crucial for managing the transmission

infrastructure within their respective states. As of March 2024, state-owned utilities account for 53% of the country's overall transmission capacity.

Some of the key state-owned utilities are:

Tamil Nadu Transmission Corporation Ltd ("TANTRANSCO"): It is the state's transmission utility, and its transmission network spans 37,056 ckm of high-tension lines. TANTRANSCO operates a network of 1,076 substations, equipped with supervisory control and data acquisition ("SCADA") systems as of Fiscal 2023. These substations have been integrated into the Chennai Distribution and Control Centre. TANTRANSCO also operates one state load dispatch centre ("SLDC") in Chennai and three sub-load dispatch centres in Chennai, Madurai and Erode to ensure efficient management of the state's power system.

Maharashtra State Electricity Transmission Company Ltd ("MSETCL"): It holds the distinction of being the largest power transmission utility in the state sector. MSETCL's extensive infrastructure includes 742 EHV substations and an extensive network of 54,288 ckm of transmission lines as of Fiscal 2024. With a transformation capacity of 138,598 MVA and 12,784 mega volt ampere reactive power compensation ("MVAR"), MSETCL has the capability to handle a substantial amount of power. The company has earmarked an anticipated infrastructure expenditure of Rs 236.92 billion for Fiscal 2023 to Fiscal 2027. Its robust transmission system is designed to handle approximately 21,000 MW of power. In Fiscal 2024, MSETCL successfully transmitted 191,536 million units of electricity.

Gujarat Energy Transmission Corporation Ltd ("GETCO"): It is the state's transmission utility and operates a network of transmission lines and substations in Gujarat. As of Fiscal 2023, it had ~73,054 ckm of transmission lines and 2,203 substations, with a transmission availability rate of 99.56%.

Uttar Pradesh Power Transmission Corporation Ltd ("UPPTCL"): It is the state transmission utility of Uttar Pradesh and responsible for the transmission and distribution of electricity and manages a significant transmission network of 53,788 ckm as of Fiscal 2024.

Rajasthan Rajya Vidyut Prasaran Nigam Ltd ("RVPN"): It is the state transmission utility of Rajasthan. It owns and operates a network of transmission lines and substations in the state and manages a network of 42,302 ckm.

Private transmission companies: They develop transmission lines on a build-own-operate ("BOO") model and charge for wheeling electricity within the tariffs specified by the Central Electricity Regulatory Commission ("CERC")/the State Electricity Regulatory Commission ("SERC"). Several private companies have entered the transmission sector through public-private partnerships or competitive bidding.

Growth of the transmission system in India

The Indian power industry is divided into five regions for the planning and operation of electricity generation, transmission and distribution — the Northern, Southern, Eastern, Western and Northeastern regions. Transmission of electricity within the regions is done through regional grids and transmission of electricity between regions via the national grid. The northern, eastern, western, and north-eastern regions are interconnected and operate as a single

grid, known as the national grid. The southern grid was synchronized with the all-India grid, i.e., the NEW grid, in December 2013 through the Raichur-Solapur 765 kV S/C line, thus leading to formation of one synchronous national grid (one grid - one nation - one frequency).

Formation and integration of state grids

During independence, domestic power systems were essentially isolated and developed in and around urban and industrial areas. The country's installed generating capacity was only ~1,300 MW and the power system consisted of small generating stations feeding power radially to load centres. The highest transmission voltage was 132 kV. The voltage level of the state-sector network grew from 132 kV in 1950s to 220 kV in 1960s and 1970s. Subsequently, a 400kV network was also developed in many states (Uttar Pradesh, Maharashtra, Madhya Pradesh, Gujarat, Orissa, Andhra Pradesh, and Karnataka) for bulk power transfer over long distances. With the development of state grids in most states of the country, the stage was set for development of regional grids.

Evolution of regional grids

During the Third Five-year Plan, regional planning was introduced in the power sector. Accordingly, the country was demarcated into five regions, viz. northern, western, southern, eastern, and north-eastern, for power system planning and development. In 1964, regional electricity boards were established in each of the regions for facilitating integrated operation of state systems in the region and encouraging exchange of power among states. To encourage states to build transmission infrastructure for exchange of power, inter-state lines were treated as 'centrally sponsored' and states were provided interest free loans outside the State Plan. Fifty-five inter-state lines were constructed under the programme of which 13 lines connected states located in different regions and this created the initial set of inter-regional links. These lines facilitated exchange of power in radial mode among various regions. Till 1975, the development of transmission was essentially by the SEBs/electricity departments in the states and union territories. In 1975, to supplement the efforts of the states in increasing generation capacities, central sector generation utilities viz. National Hydroelectric Power Corporation ("NHPC") and National Thermal Power Corporation ("NTPC") were created. These corporations established large generating stations for the benefit of states in a region. These corporations also undertook development of associated transmission lines for evacuation of power and delivery of power to the beneficiary states transcending state boundaries. This gave a fillip to the formation of regional grid systems and by the end of 1980s, strong regional networks came into existence.

Development of inter-regional grids

In 1989, transmission wings of central generating companies were separated to set up PGCIL to give thrust to implementation of transmission systems associated with central generating stations and the inter-regional transmission programme based on perspective planning done by the Central Electricity Authority ("CEA"). Till then, the generation and transmission systems in the country were planned and developed based on regional self-sufficiency. The initial set of inter-regional links developed under the centrally sponsored programme for building inter-state infrastructure of state utilities was utilised to facilitate the exchange of operational surpluses among

various regions in a limited manner because regional grids operated independently and had different operating frequencies and power exchange on these inter-regional links could take place only in radial mode.

Development of the national grid

The national grid consists of the transmission system for evacuation of power from generating stations, the inter-regional links, ISTS and InST of the STUs. Thus, development of the national grid has been an evolutionary process. The national grid is a large meshed synchronous transmission grid where all the regional and state grids are connected and operate at a single frequency. In 1992, the Eastern region ("ER") and the North-Eastern region ("NER") were synchronously interconnected through the Birpara-Salakati 220kV double circuit transmission line and subsequently by the 400 kV D/C Bongaigaon-Malda line. The Western region ("WR") was interconnected to the ER-NER system synchronously through the 400kV Rourkela-Raipur D/C line in 2003 and thus the Central India system consisting of ER-NER-WR came into operation. In 2006, with commissioning of Muzaffarpur-Gorakhpur 400kV DC line, the Northern region ("NR") was also interconnected to this system creating an upper India system linking the NR-WR-ER-NER systems. In 2007, NR was also synchronously interconnected with WR through the Agra-Gwalior 765kV S/C line-1 (charged at 400kV level), leading to formation of the NEW grid. The southern grid was synchronised with the all-India grid i.e., the NEW grid in December 2013 through the Raichur-Solapur 765 kV S/C line, thus leading to formation of one synchronous national grid (one grid - one nation - one frequency).

Tariff models in India: RTM and TBCB

Since 1998, the Indian transmission sector has been open, as a matter of law, to investment by private domestic and international entities as transmission licensees.

The tariff-based competitive bidding ("TBCB") guidelines for transmission services were issued by the government of India under section 61, 62 and 63 of the Electricity Act, 2003 in 2008.

This new approach led to highly favourable outcomes for all participants in the power value chain, especially end-consumers. Before implementation of TBCB, PGCIL was the nodal agency for all inter-regional transmission lines. It used the regulated tariff mechanism ("RTM"), which ensured project cost recovery regardless of time or cost overruns.

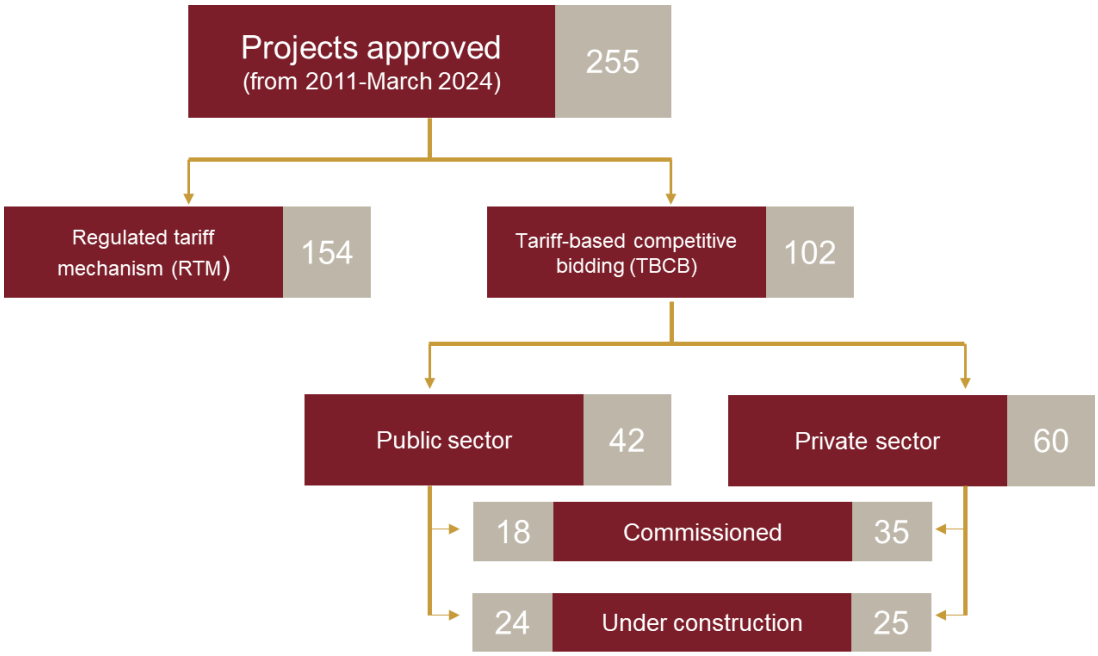
With the advent of TBCB, PGCIL had to compete with private sector contenders through bidding based on tariffs for projects. Consequently, the TBCB mechanism has fostered the emergence of new private sector power transmission developers and significantly lowered tariffs, ultimately benefiting end-consumers. As a result, large private sector groups such as Sterlite Power Transmission Limited and AESL have rapidly become prominent independent power transmission companies ("IPTCs"), while PGCIL still maintains a substantial presence.

The tariff policy of 2016 highlights that all upcoming inter-state transmission projects should be developed through a competitive bidding process. Nevertheless, the consultation paper on determination of the threshold for transmission projects under the competitive bidding framework suggests that the central government has the

authority to grant exemptions to certain projects of strategic significance or those necessary to address urgent situations on a case-by-case basis.

Since 2011, ~255 transmission projects have been awarded under RTM and TBCB, with the majority being awarded under RTM.

Figure 21: Projects awarded under RTM and TBCB between 2011 and March 2024



Note: The above infographic does not include projects under litigation, cancelled or still waiting for financial closure. This does not include state projects.

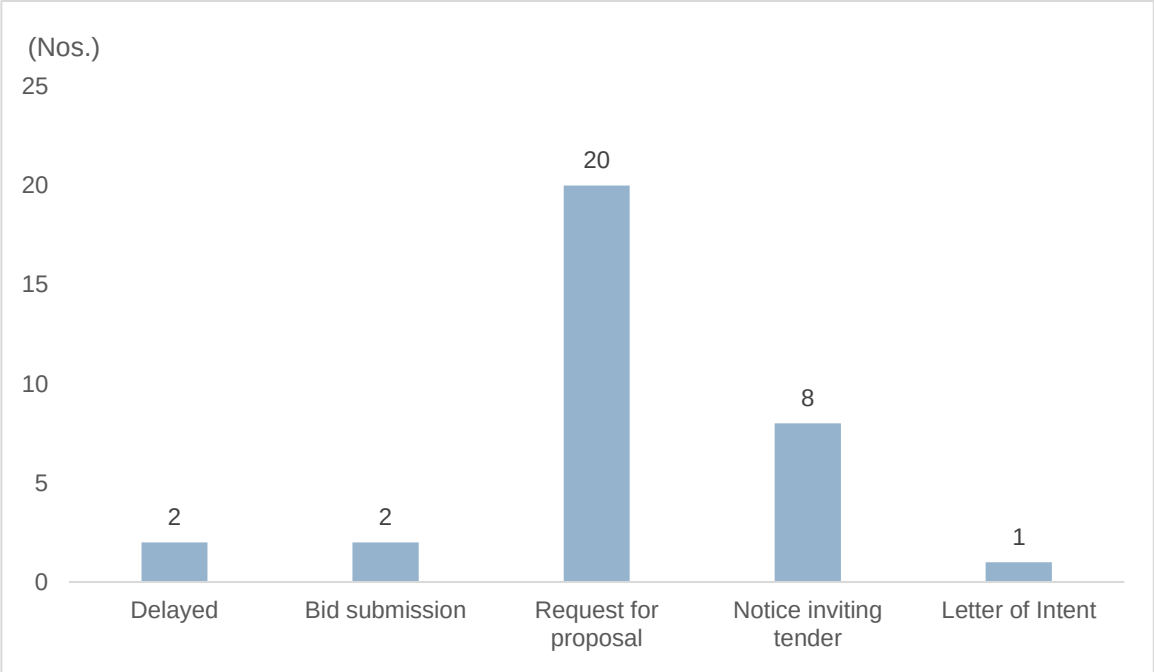
Source: CEA, TERI, CRISIL MI&A Research

Based on the historical performance of numerous projects executed through the TBCB process, Uttarakhand Electricity Regulatory Commission ("UERC") noted that competitive bidding resulted in tariff reduction of 20-56% compared with RTM. Another advantage of the TBCB development mode is its ability to promote private sector involvement, leading to a reduced burden on government finances. Moreover, this approach facilitates risk sharing with private entities and encourages the adoption of innovative technologies through private participation, among other benefits.

Upcoming transmission bids

As of May 2024, there are 33 projects under various stages of the bidding process. PFC Consulting Ltd ("PFFCL") and REC Power Development and Consultancy Ltd. ("RECPDCL") are the agencies responsible to conduct the bidding process.

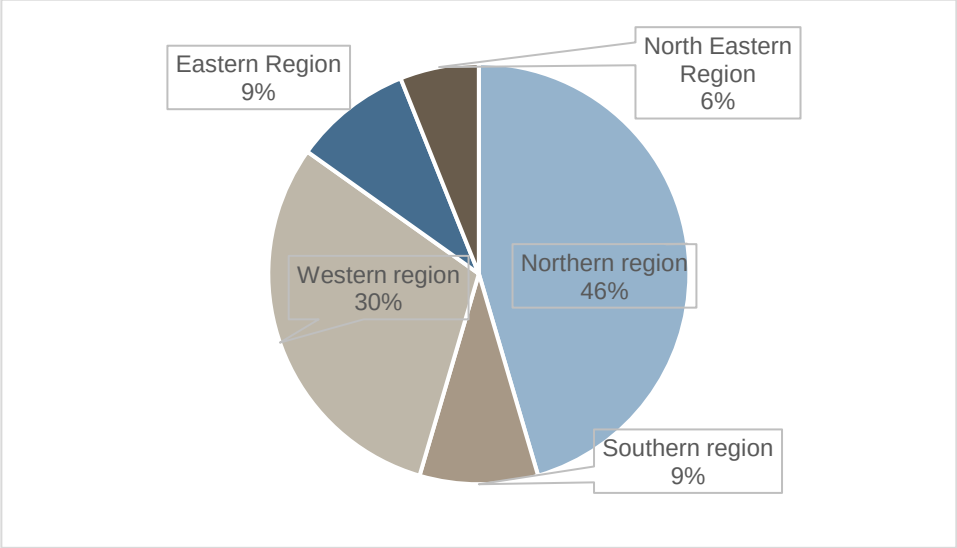
Figure 22: Status of projects as of March 2024



Source: CTUIL, CRISIL MI&A Research

A majority of the projects are centred in the northern region, with 35% of the total 33 projects being focused in Rajasthan.

Figure 23: Upcoming bids in different regions as of March 2024

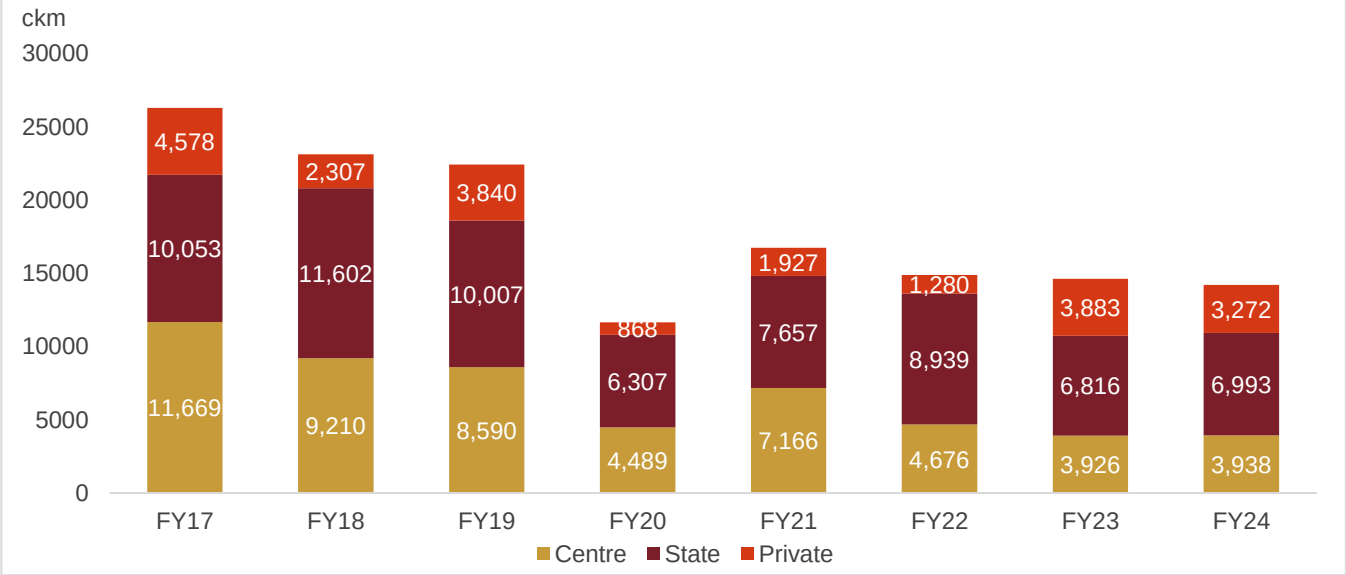


Source: CTUIL, CRISIL MI&A Research

Transmission capacity addition trends

Transmission systems in India play a crucial role due to the skewed distribution of energy resources and the main load centres of the country. As power demand and energy from renewable sources is set to increase, transmission systems are bound to play a crucial part in linking generation and distribution of power to end-consumers.

Figure 24: Transmission line addition in ckm over Fiscals 2017-2024

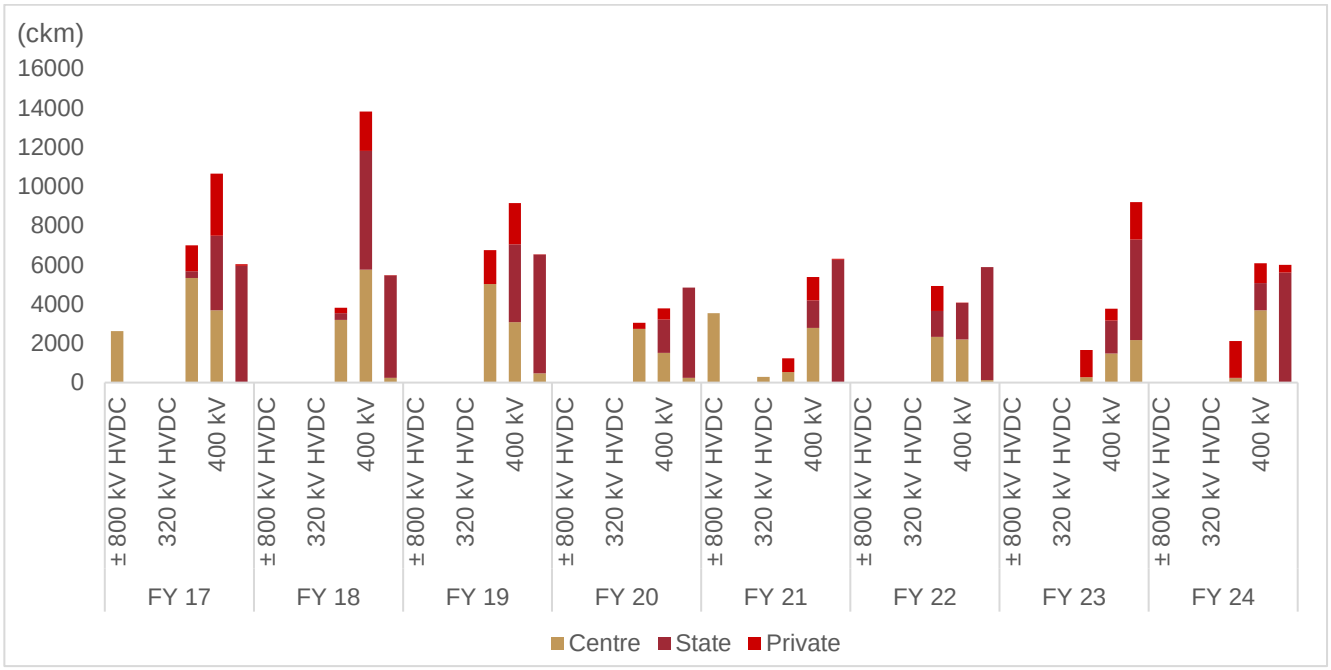


Source: CEA, CRISIL MI&A Research

Evolution of the transmission network at different voltage levels

The share of central players in capacity addition fell from 44% in Fiscal 2017 to 27% in Fiscal 2024 due to an increase in the share of private and state players. Additionally, we note that states added nearly 58% of AC capacities during the same period. On the other hand, central agencies have been majorly active on DC side additions. Over Fiscals 2017 to 2024, the 400 kV line witnessed maximum additions at 56,708 ckm, closely followed by 220 kV at 52,901 ckm.

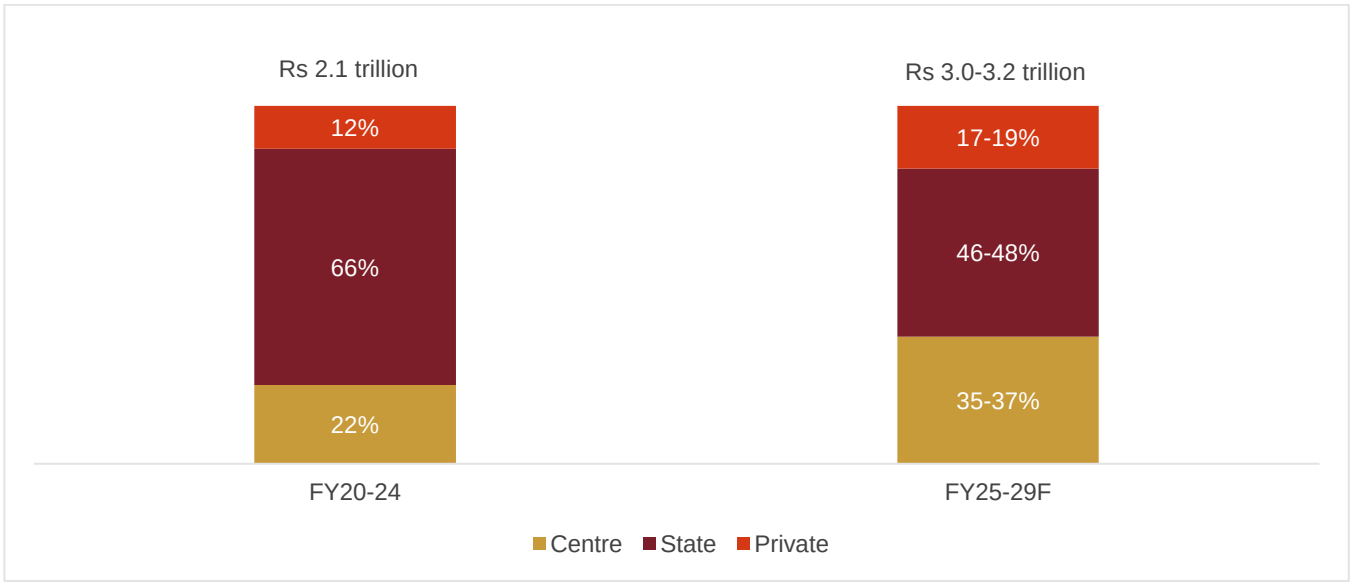
Figure 25: Capacity addition by voltage over Fiscals 2017-2024



Source: CEA, CRISIL MI&A Research

Transmission investment trends

Figure 26: Review of transmission investments and their outlook



Source: CEA, CRISIL MI&A Research

Note(s): Investments of the private sector are estimated by looking at trends in the share of TBCB compared to RTM bids in the past and the potential outlined by the government.

Between Fiscals 2020 and 2024, the Indian transmission sector saw investments of approximately ₹2.1 trillion. Of this, state players held the highest share (66%), followed by central government-run companies (22%) and private players (12%). Between Fiscal 2025 and 2029, we expect investments to increase to ₹3.0 to 3.2 trillion mainly

driven by the expansion of renewable energy (“RE”) projects, as the government targets to install 500 GW of renewable capacity by 2030. To accommodate the additional RE capacity into the national grid, transmission lines of 123,577 ckm in ISTS and InSTS and substation projects of 722,940 mega volt-amperes (“MVA”) are expected to be added over Fiscals 2022-2027.

Of the total investments, the share of the private sector is expected to expand 610 to 620 bps by Fiscal 2029, accounting for 17 to 19%.

Transmission system requirement for evacuation of 500 GW RE

As on January 2024, the installed power generating capacity in the country from RE sources was 182.04 GW (including 46.9 GW large hydro), which is about 44% of the total installed electricity generating capacity in the country. For supporting RE capacity growth, areas with high solar and wind energy potential should be connected to ISTS to enable evacuation of power generated to load centres. The gestation period of wind- and solar-based generation projects is much less than that of the associated transmission system, as the system has to be planned well in advance.

Table 5: Transmission system for integration of 66.5 GW RE capacity

Sl. No.	Status of transmission schemes	Locations	RE capacity to be evacuated (GW)
1	Commissioned	a) Bhadla (1.05) & II (2.5) - 3.55 GW b) Fatehgarh-I (1.2) & II (2.3) - 3.5 GW c) Bikaner (PG) - 1.85 GW d) Jam Khambaliya- 1.5 GW e) Bhuj-II - 2 GW f) Tirunelveli- 0.5 GW	12.9
2	Under construction	a) Bhadla-II - 1.05 GW b) Fatehgarh-II - 2.2 GW c) Bikaner-II - 2.95 GW d) Fatehgarh-III (erstwhile Ramgarh)-1.9 GW e) Khavda PS1 - 3 GW f) Osmanabad - 1 GW g) Rajgarh - 1.5 GW	19.1 (slated for commissioning in the timeframe of December, 22 to November 23)

Sl. No.	Status of transmission schemes	Locations	RE capacity to be evacuated (GW)
		h) Neemuch - 1 GW	
		i) Koppal - 2.5 GW	
		j) Gadag - 1 GW	
		k) Karur - 1 GW	
3	Under Tendering	a) Khavda PS2 & PS3 - 5 GW	8
		b) Gadag - 1.5 GW	
		c) Chhatarpur- 1.5 GW	
4	Schemes being taken up for bidding/ implementation	a) Anantapur - 3.5 GW	10.5
		b) Kurnool - 4.5 GW	
		c) Bidar- 2.5 GW	
5	Other planned transmission schemes	a) Lakadia - 2 GW	9.5
		b) Solapur - 2.5 GW	
		c) Wardha - 2.5 GW	
		d) Khavda - 2.5 GW	
6	Schemes whose Phase-I is under implementation and Phase-II is to be notified based on progress of Phase-I	a) Rajgarh - 1 GW	2.5
		b) Karur - 1.5 GW	
7	Schemes planned under intra-state	a) Rajasthan – 3 GW	4
		b) Maharashtra – 1 GW	
	Total		**66.5**

Source: CEA, CRISIL MI&A Research

In addition to 66.5 GW of RE capacity, the transmission system has been planned for the uptake of 236.58 GW (55.08 GW+181.5 GW) of RE capacity.

Table 6: Transmission system for evacuation of 55.08 GW RE

Transmission scheme	RE capacity (GW)	Status of the transmission scheme
	14	Transmission schemes are under bidding.

Transmission schemes for 20 GW of RE capacity in Rajasthan under Phase III	6	The transmission scheme comprises 6,000 MW, +800 kV HVDC system between Bhadla-III and Fatehpur. The scheme has been recommended by National Committee on Transmission (NCT) On its 9th meeting held on September 28, 2022. Subsequent activities are in progress for initiating the bidding of the scheme.
Transmission scheme for 13 GW Leh RE park	13	The transmission scheme comprises +350 kV, 5,000 MW VSC-based HVDC link from Pang to Kaithal. The scheme was allocated to PGCIL in January 2022 for implementation through the RTM route.
Transmission scheme for 880 MW Kaza Solar Park, Himachal Pradesh	0.88	Transmission system planned. To be taken up for the implementation in matching timeframe of RE generation
Transmission scheme for additional 17.2 GW of RE capacity from Khavda and 4 GW of RE capacity from Dholera, Gujarat	21.2	Transmission system planned. To be taken up for implementation in the matching timeframe of RE generation
Total	**55.08**	

Source: CEA, CRISIL MI&A Research

Table 7: Tentative phasing of 181.5 GW RE capacity

	Phase I (by March 2025)		Phase II (by December 2027)		Phase III (by December 2030)		Total	
	Wind (GW)	Solar (GW)	Wind (GW)	Solar (GW)	Wind (GW)	Solar (GW)	Wind (GW)	Solar (GW)
Rajasthan	6	13	5	20	4	27	15	60
Madhya Pradesh	2	0	0	3.1	0	2.9	2	6
Maharashtra	2	3	0	0	0	2.5	2	5.5
Gujarat (offshore wind)			2		3		5	0
Andhra Pradesh	4	8	7	11.5	7	13.5	18	33
Telangana	3	2	0	7.5	0	0.5	3	10
Karnataka	7	6	1	3	0	0	8	9
Tamil Nadu (offshore wind)			2		3		5	0
Total	24	32	17	45.1	17	46.4	58	123.5
Total (S+W)	56		62.1		63.4		181.5	

Source: CEA, CRISIL MI&A Research

Transmission system plan until Fiscal 2032

As per Section 3 of the Electricity Act 2003, the CEA must prepare a National Electricity Plan (Transmission) in accordance with the National Electricity Policy and notify it once in five years. The plan would cover transmission and related aspects.

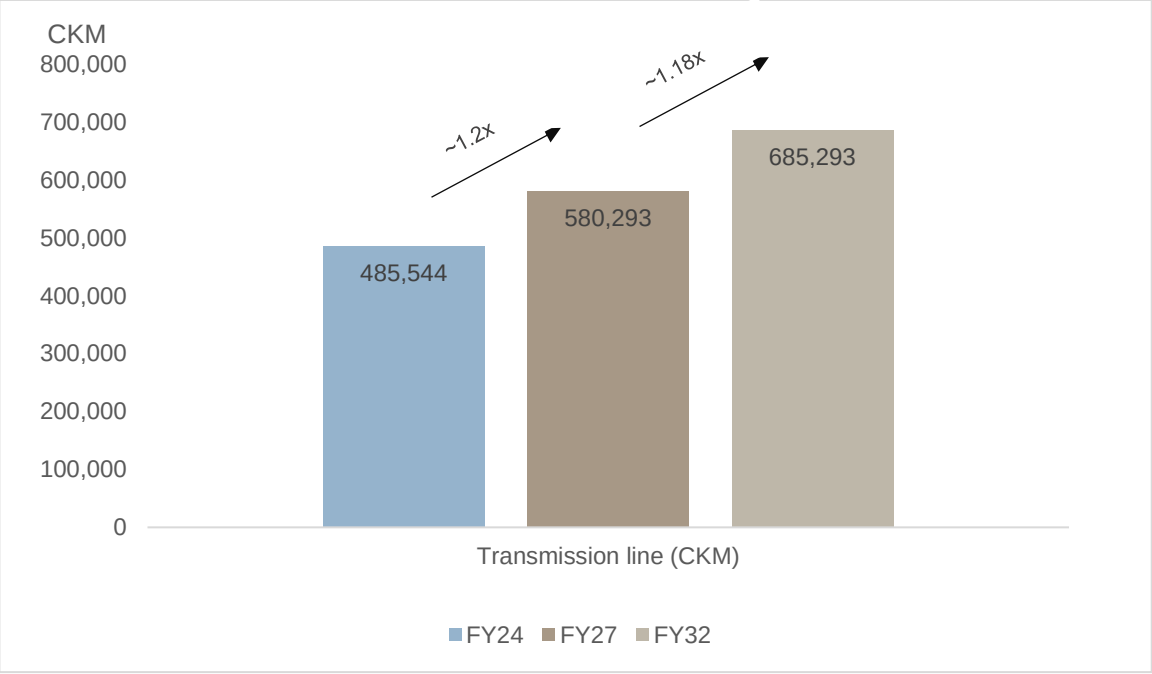
It was estimated that the country would require about 110,281 ckm of transmission lines and about 383,690 MVA of transformation capacity in the substations at 220kV and above voltage levels for the 13th plan period (Fiscals 2017-2022). Against this target, 88,865 ckm of transmission lines and 349,685 MVA of transformation capacity were added during the period.

In December 2023, the CEA released the draft National Electricity Plan (Volume II: Transmission) covering the review of development of the transmission system during Fiscals 2017-2022 and detailing the plan for Fiscals 2022-2027. It also provided some perspective for Fiscals 2027-2032.

The plans for these periods have been prepared based on peak electricity demand projections and expected generation capacity addition. Based on the draft National Electricity Plan for transmission as released on December 2023, transmission line capacity is expected to increase ~1.2x to 580,293 ckm by Fiscal 2027 from 485,544 ckm in Fiscal 2024.

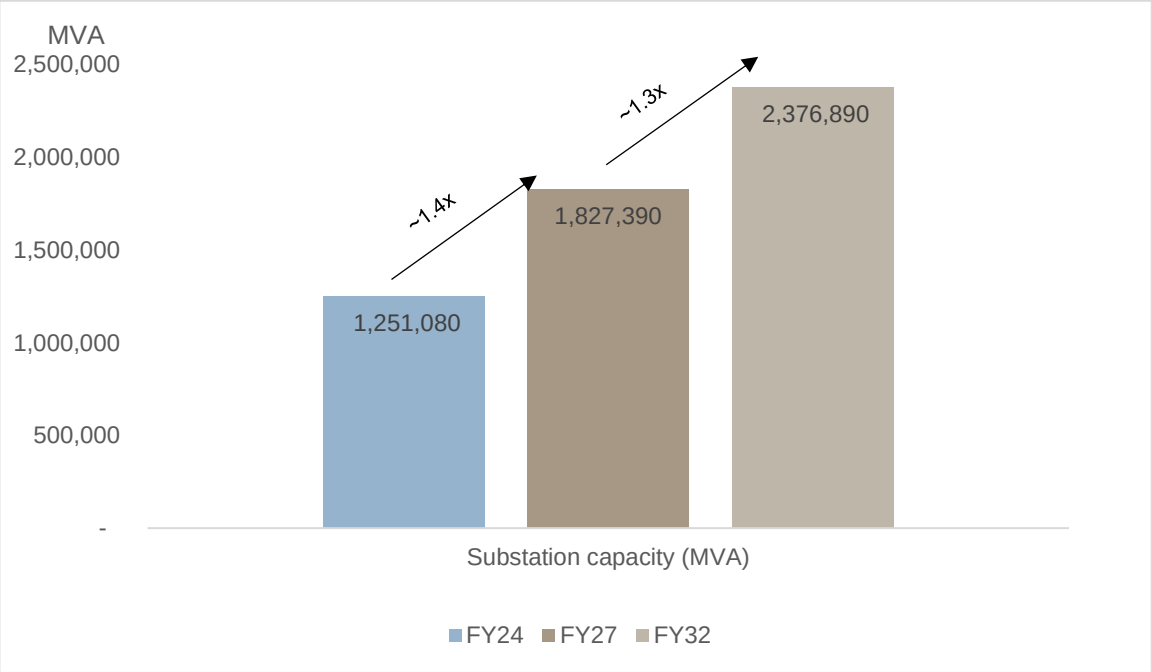
Similarly, transmission line capacity is expected to increase to 685,293 ckm by Fiscal 2032. To aid this growth, substation capacity is expected to rise to 1,827,390 MVA by Fiscal 2027 and by 1.3x to 2,376,890 MVA by Fiscal 2032.

Figure 27: Total transmission line capacity outlined as per NEP



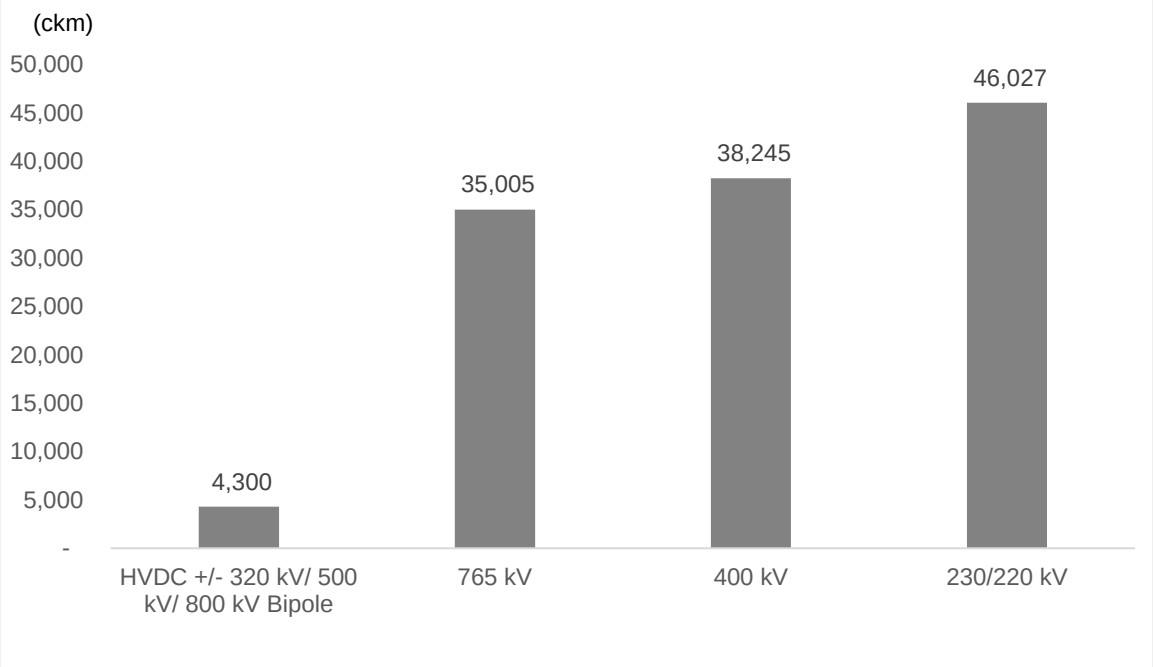
Source: CEA, CRISIL MI&A Research

Figure 28: Total transmission substation capacity outlined as per NEP



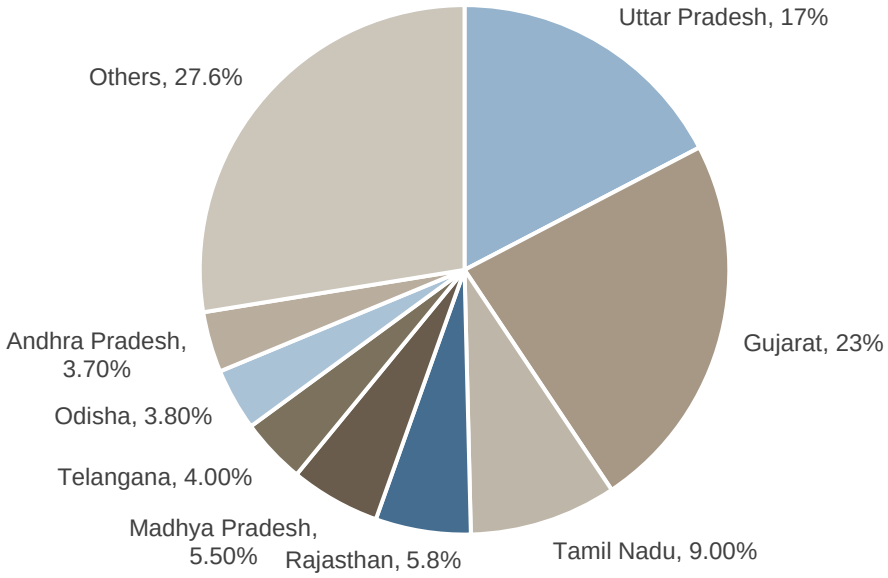
Source: CEA, CRISIL MI&A Research

Figure 29: Outlook for voltage-wise line additions for Fiscal 2022-2027



Source: CEA, CRISIL MI&A Research

Figure 30: Share of states in transmission lines addition over Fiscals 2022-2027

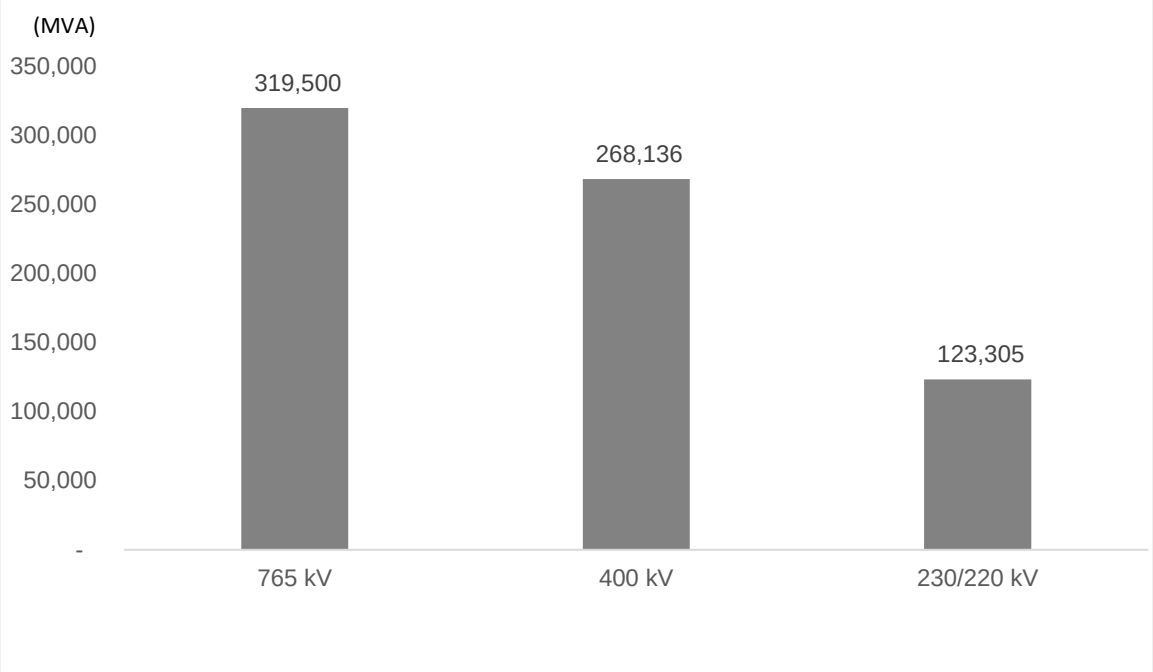


Note: The data pertains to intra-state transmission line additions (ckm)
Source: CEA, CRISIL MI&A Research

To achieve the targeted 500 GW RE capacity by 2030, the central government has proposed an additional of 70,445 ckm of transmission lines under interstate transmission ("InSTS") by 2027 on top of the existing 482,032 ckm (February 2024). Central government agencies will issue the tenders for these lines and bidding will be open for government-owned (central and state) and private players. The top 10 states (by InSTS transmission line additions) are expected to account for ~72% of the transmission line additions by 2027 under InSTS. Gujarat is expected to lead the way with nearly 23% share in expected additions followed by Uttar Pradesh (17%) and Tamil Nadu (9%).

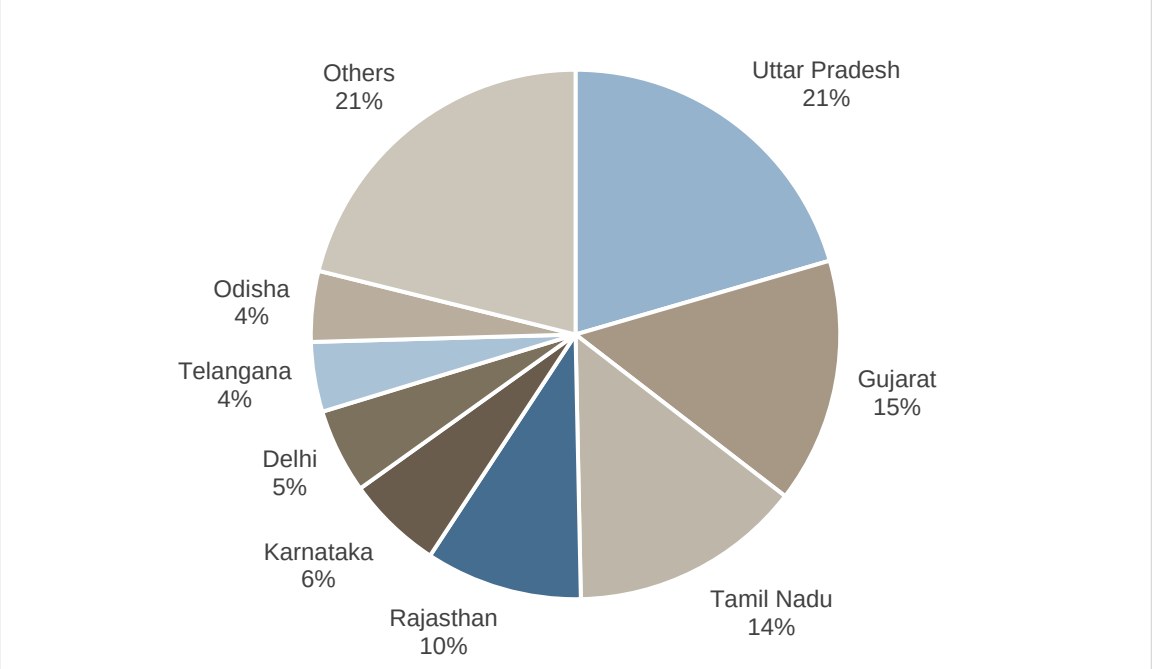
As of March 2024, the total installed substation capacity in the country stood at 1,251,080 MVA against 1,070,950 MVA in Fiscal 2022. As per draft National Electricity Plan for transmission dated December 2023, total substation capacity of 710,940 MVA is expected to be added from Fiscal 2022 till Fiscal 2027.Out of this, 426,675 MVA will be added under ISTS and 284,265 MVA under InSTS. Under, InSTS Uttar Pradesh accounting for the highest share in additions at 21%, most of the additions are expected to take place in 765 kV.

Figure 31: Outlook for voltage wise substation additions for Fiscal 2022-2027



Source: CEA, CRISIL MI&A Research

Figure 32: Share of top states in substation addition over Fiscals 2022-2027



Note: The data pertains to intra-state substation additions (MVA)

Source: CEA, CRISIL MI&A Research

Green energy corridor (GEC)

In 2012, there arose a necessity to establish dedicated infrastructure for the transmission and distribution of power generated from RE sources in states with significant untapped potential. Following an assessment by PGCIL, eight states known for their RE potential (Andhra Pradesh, Gujarat, Himachal Pradesh, Karnataka, Madhya Pradesh, Maharashtra, Rajasthan and Tamil Nadu) submitted their proposals for creating intra-state transmission infrastructure. The GEC Phase I project received approval from the MNRE in Fiscal 2016. This scheme encompassed both inter-state and intra-state components.

The intra-state aspect was designed for implementation by the eight RE-rich states. It aimed to complete transmission lines of ~9,767 ckm and substations with a total capacity of 22,689 MVA. These facilities would support the evacuation of over 24,000 MW of large-scale renewable power and enhance the grid infrastructure within the implementing states. The respective STUs are overseeing implementation of this project and transmission lines of ~9,767 ckm and substation capacities of 22,689 MVA were established as of July 2023 as part of the intra-state component.

Table 8: Status of GEC phase 1 (intra-state component)

State	Transmission lines (ckm)		Substations (MVA)	
	Target	Achievement	Target	Achievement
Andhra Pradesh	1,073	814	2,157	1,265
Gujarat	1,908	1,526	7,980	7,980
Himachal Pradesh	502	485	937	773
Karnataka	618	618	2,702	2,702
Madhya Pradesh	2,773	2,773	4,748	4,748
Maharashtra	771	672	0	0
Rajasthan	1,054	984	1,915	1,915
Tamil Nadu	1,068	1,068	2,250	1,910
Total	**9,767**	**8,940**	**22,689**	**21293**

Source: MNRE, CRISIL MI&A Research

Originally, the intra-state projects were scheduled for completion by December 2022; however, the deadline was extended due to various factors, including issues related to right-of-way (“RoW”), legal cases, delays in obtaining forest clearances, tender issuance delays due to a protracted land acquisition process for substations, and delays in awarding work due to a limited number of bidders for several projects, leading to multiple rounds of re-tendering.

The inter-state component of the scheme, entrusted to PGCIL, was successfully concluded in March 2020. This segment involved the establishment of transmission lines spanning 3,200 ckm and substations with a combined capacity of 17,000 MVA.

Table 9: Status of GEC phase 1 (inter-state component)

State/Region	Lines constructed (in ckm)
Rajasthan	1,194
Gujarat	621
Gujarat - Rajasthan	604
Rajasthan-Punjab	734
Tamil Nadu	48
Total	**3,201**

Source: MNRE, CRISIL MI&A Research

Under GEC Phase 1, funding for intra-state transmission schemes included 20% equity from the state government, a 40% grant from the National Clean Energy Fund ("NCEF") and a 40% soft loan. Meanwhile, inter-state transmission schemes were to be financed with 30% equity provided by PGCIL and a 70% soft loan. Under a cooperative framework between the Indian and German governments, KfW Germany extended a soft loan of €1 billion to support both intra- and inter-state transmission projects related to green energy corridors. Specifically, for inter-state transmission projects, PGCIL entered into a loan agreement with KfW Germany to secure financial assistance totalling €500 million. Furthermore, PGCIL also obtained an additional loan from ADB. In the case of intra-state transmission projects within the GEC, Tamil Nadu, Rajasthan, Himachal Pradesh, Andhra Pradesh, Gujarat and Madhya Pradesh signed loan agreements with KfW Germany to access financial support of €76 million, €49 million, €57 million, €68 million, €114 million, and €124 million, respectively.

In March 2022, the Indian government also granted approval for GEC Phase 2, which encompasses the addition of transmission lines of 10,753 ckm and substation capacity of 27,546 MVA across seven states over a five-year period (Fiscals 2022 to 2026). The scheme primarily aims to establish the necessary infrastructure for evacuating 20 GW of RE from Gujarat, Himachal Pradesh, Karnataka, Kerala, Rajasthan, Tamil Nadu and Uttar Pradesh. The implementation of this scheme will be overseen by the respective STUs. A state-wise overview of transmission projects under the scheme, as evaluated by the Central Electricity Authority ("CEA"), is provided below.

Table 10: GEC phase 2 planned infrastructure

State	Line length (ckm)	Substation (MVA)	RE addition envisaged (MW)
Gujarat	2,470	7,460	5,100
Himachal Pradesh	62	761	317
Karnataka	938	1,225	2,639
Kerala	224	620	452
Rajasthan	659	2,191	2,478

Tamil Nadu	624	2,200	4,000
Uttar Pradesh	2,597	15,280	4,000
Total	**7,574**	**29,737**	**18,986**

Source: MNRE, CRISIL MI&A Research

MNRE devised this programme to support states establish intra-state transmission infrastructure for the integration of RE projects. The central financial assistance ("CFA") proposed under this scheme will help mitigate intra-state transmission charges, thereby helping maintain affordable electricity prices.

The scheme has been approved at an estimated project cost of Rs 120.88 billion, excluding interest during construction. The CFA, which accounts for 33% of the project cost, totals Rs 39.7 billion. A breakdown of the project cost and approved CFA for each state is provided below. The remaining 67% of the project cost will be funded through loans from KfW/REC/PFC.

Table 11: Project cost approved under GEC phase 2

State	Project cost without IDC (Rs billion)	CFA (Rs billion)
Gujarat	36.36	12.0
Himachal Pradesh	4.89	1.62
Karnataka	10.36	3.42
Kerala	4.20	1.39
Rajasthan	8.80	2.91
Tamil Nadu	7.20	2.38
Uttar Pradesh	48.48	16.0
Total	**120.3**	**39.70**

Source- MNRE, CRISIL MI&A Research

Transmission infrastructure demand with electrification of transportation

The Government of India is focusing on building charging infrastructure and creating a conducive policy environment for faster adoption of electric vehicles ("EVs") to reduce dependence on fossil fuels for transportation. India aims to increase the share of EVs in overall car population to 30% by 2030. Under the National Electric Mobility Mission plan, the government envisages to promote EV adoption through demand-side incentives, in terms of subsidies, promoting charging infrastructure, and encouraging research and development in battery technology, power electronics, battery management and system integration.

In Fiscal 2021, though, the EV market faced strong headwinds as buyers cut down on big-ticket purchases, thus impacting sales of EVs, which are typically costlier than conventional vehicles. However, sales rebounded strongly

in Fiscal 2022, spurred by elevated fossil fuel prices, with government incentives such as Faster Adoption and Manufacturing of Hybrid and Electric Vehicles (“FAME”) II worth Rs 100 billion.

This is to be supported by the expansion of charging infrastructure across major cities, as well as concomitant growth in distribution infrastructure, in addition to an appropriate tariff structure for charging of EVs. In fact, the government, in the Union Budget 2019-20, announced Rs 10 billion in subsidies for building a nationwide EV charging infrastructure as a part of FAME-II. Charging stations will be installed on major highways such as Delhi-Mumbai, Delhi-Chandigarh, Mumbai-Surat-Pune, etc, with plans to have a charging station every 25 km on these highways. Furthermore, Gujarat, Maharashtra, Delhi, and Karnataka have announced favourable policies to boost EV adoption, along with establishing EV charging infrastructure through state-owned and private entities. As a result, EV charging demand is likely to aid power demand over the medium term, with a gradual increase in the share of EVs in the vehicle population.

As of March 2024, the number of electric vehicles in the country's fleet stood at 3.6 million and is projected to surge to ~30 million units by 2029.CRISIL MI&A Research projects that adoption of EVs will boost power demand by 11-13 BUs annually on average over Fiscals 2025 to 2029. This would amount to a mere 0.6-0.7% of the total power demand for Fiscal 2025 to 2029. Despite the fractional amount of power expected to be consumed by EVs, integration of EV load into the distribution system can potentially result into a significant stress on the grid if EV charging is not coordinated either through smart charging, or the capacity of the distribution network is increased to accommodate the EV load. To facilitate fast chargers for EV charging, it is imperative to establish a dedicated distribution network that includes the installation of a separate transformer specifically designated for the charging station, this will drive the investments in the T&D network. Based on the spike in peak load due to EV charging, various components of the T&D grid will have to been upgraded.

Along with electrification of the transportation sector, several new opportunities are also developing with growth in manufacturing sector. The government under its PLI scheme has introduced incentives for sector which are intensive in nature like Advanced Cell chemistry (“ACC”), solar module, etc. which promote development in transmission segment.

Also, the recent announcement of national green hydrogen mission with target of 5 MTPA of green hydrogen by 2030 will also see investment in transmission segment for easy access of green power.

Table 12: New emerging businesses for transmission segment

Topics	Comment
Green hydrogen	Government has announced National Green Hydrogen Policy with target of 5 MTPA of production by 2030. For production of 1 MT of green hydrogen, 20-25 GW of renewable energy source is to be installed. This requires the development of transmission infrastructure to supply renewable power from RE rich states to production point.
Advanced manufacturing under PLI scheme	To promote manufacturing in India, government has announced production linked incentive (PLI) scheme. Under the scheme government has several sectors which are power intensive like advanced battery manufacturing, solar modules and require additional transmission infrastructure to meet its power demand.
EV infrastructure	Electric vehicle demand has seen growth under FAME policy of central government announced in 2015. EV demand is expected to see growth of 44% till fiscal 2032. To keep them running them, charging station need to be installed. Fast charging further requires large power in short period which requires additional transmission infrastructure investments for fast-charging station.
Offshore wind	To promote renewable energy, government is focusing on offshore wind which requires to set up transmission line through seabed or floating over the sea water which costlier than normal transmission cost seen on land. India has potential of xx GW of offshore wind which will require to invest in transmission infrastructure through sea.
Semiconductors	Several domestic and international players have announced to manufacture semiconductors in India. Semiconductor manufacturing is one power intensive process where manufacturing one 12-inch equivalent wafer would require 1300-1400 Kwh of energy, thus necessitating investments in power generation and transmission

Source: CRISIL MI&A Research

Technology disruptions in the transmission and distribution sector

As part of the Paris Agreement 2015, the Indian government aims to achieve net-zero emissions by 2070. To achieve the target, the electricity sector must address the vagaries of renewable energy and enhance energy

efficiency. Thus, the sector has reached a point of inflection and innovation has become a necessity amid increased financial and operational stress. That said, power transmission and distribution has been at the forefront of deploying solutions such as intelligent grid monitoring control, robotics, aerial technology. Further, investments in technologies such as Big Data analytics, geographical information systems by Adani Energy Solutions Ltd ("AESL") have ensured efficient resource use, enhanced grid stability and integration of renewable energy, thereby supporting the country's efforts to meet its emission targets. Cutting-edge technologies deployed by the industry are provided in the table below.

Table 13: Innovative solutions deployed in the Indian T&D sector

Technology	Problem area	Impact
Blockchain	Ineffective integration of infrastructure resources in communication and electrical power systems	• Real-time monitoring • Maintenance assistance • Fault location detection
Aerial technology	• Power theft • Power loss during transmission • Damage to utility property	• High resolution images for monitoring purposes • Can be used in difficult terrain
Supervisory Control and Data Acquisition (SCADA) System	Ineffective integration of infrastructure resources in communication and electrical power systems	• Real-time monitoring • Maintenance assistance • Fault location detection
Flexible AC transmission system (FACTS)	Grid instability due to the intermittent nature of RE generation	• Voltage stability • Frequency stability • Load flow management

Source: CRISIL MI&A Research

Emerging businesses for utilities

New business opportunities have emerged as co-location power plants, which involve simultaneous electricity generation from multiple sources, such as solar, wind, or battery storage at a single site, enable companies to maximise energy efficiency and grid integration. However, to fully capitalise on the benefits of co-location plants, there is a critical need for robust transmission infrastructure to efficiently transport the combined power output to end-users. Further, to ensure reliable and stable supply of electricity, transmission lines and substations should be upgraded to accommodate the higher capacity and intermittent supply of renewable energy.

As renewable energy gains share in the power generation mix, battery storage plants will play a crucial role in supporting grid stability, renewable energy integration, and peak demand management. As per CEA report, India is expected to see additions of 55-60 GW of battery storage capacity by 2030. That said, a robust and efficient transmission system is essential to facilitate the smooth transfer of stored energy to end-users. Upgrading and

expanding transmission lines and substations can enhance grid flexibility, minimise transmission losses, and enable the efficient dispatch of energy from battery storage plants.

Regulations and policies influencing transmission investments

Policies/steps

Electricity (Late Payment Surcharge) Rules, 2021

The Ministry of Power ("MoP") notified these rules to develop the electricity sector and protect the interests of consumers. Recognising the financial burden of a high late payment surcharge ("LPS") fixed by regulatory commissions (at 18%) on discoms and ultimately consumers, these rules fixed the base rate of LPS at the marginal cost of funds based on State Bank of India's lending rate for one year plus 5%. The rules also had provisions for a staggered increase in the LPS rate at 0.5% per month for delayed payments, subject to a limit of 3% over the base rate or the rate specified in the PPA. Further, the rules also clarified that all payments received from a discom would be first adjusted against LPS and then against monthly energy bills. If the bill is not paid within 25 days, access to the grid will be curtailed.

10 GW of HDVC terminals to evacuate 13 GW of RE under GEC II

The ISTS GEC-II project envisages setting up of transmission lines of 713 ckm and two high voltage direct current ("HDVC") terminals of 5 GW capacity – one each at Pang (Ladakh) and Kaithal (Haryana). The project will facilitate evacuation of power from an RE project of 13 GW capacity along with a 12 GWh battery energy storage system ("BESS") in Ladakh. The project, to be implemented by PGCIL in a single phase, is scheduled to be completed by Fiscal 2030 at an estimated cost of Rs 207.737 billion (excluding interest during construction). The approved CFA will be capped at Rs 8,3.0948 billion or 40% of the DPR cost or 40% of project completion cost, whichever is lower. The balance is to be arranged by PGCIL through debt and equity. The project cost includes the cost of securing land for setting up substations and transition stations, and land compensation, crop/tree compensation, etc for transmission lines. The return on equity for the transmission project under ISTS GEC II will be capped at 14% (post tax). The other components of tariff will be governed by extant CERC tariff regulations for RTM projects and its amendments thereof. The anticipated year wise outgo of CFA is as follows:

Fiscal	Anticipated project expenditure (Rs billion)	Financial progress (%)	CFA (Rs billion)
2026	20.77	10	8.31
2027	37.39	18	14.96
2028	37.39	18	14.96
2029	41.55	20	16.62
2030	29.08	14	11.63

2031*	41.55	20	16.62
Total	**207.74**	**100**	**83.09**

* the last instalment of CFA will be released after commissioning of the project.

Source: MNRE, CRISIL MI&A Research

Interconnection with neighbouring countries

Being centrally located in the South Asian region and sharing its borders with SAARC and BIMSTEC countries, namely Nepal, Bhutan, Bangladesh, Sri Lanka, Afghanistan, Pakistan and Myanmar, India has been playing a major role in planning interconnections with many of these countries for effective utilisation of the region's energy resources. India's efforts to enhance cooperation among neighbouring countries through resource sharing will ensure energy security of the entire region. The cumulative power transfer capacity through cross-border interconnections with neighbouring countries is about 4,230 MW currently and would be enhanced to about 7,000 MW by Fiscal 2027.

Separation of CTU from PGCIL

Section 38 of the Electricity Act, 2003 enables the central government to notify a government company as a CTU to discharge all functions of planning and coordination related to ISTS and other functions assigned in the Act. PGCIL, a central public sector enterprise ("CPSE") under the MoP, was notified as a CTU on November 27, 2003, and many private transmission developers have also emerged since then. As a CTU, PGCIL was involved in transmission planning, but as a developer, it was also involved in implementing and participating in the bidding process for development of the transmission system. Therefore, the conflict of interest over the twin roles of PGCIL as planner and developer was flagged and the CTU functions of PGCIL were hived off and assigned to CTU India Ltd, a new entity to ensure transparency and a level playing field for all transmission developers. In the first stage, CTU India Ltd, a 100% subsidiary of PGCIL was notified as a CTU vide a gazette notification dated March 9, 2021, and started functioning with effect from April 1, 2021. Further, creation of the CTU as an independent government company is in an advanced stage. Separation of the CTU from PGCIL will boost transparency and encourage investments in the transmission sector.

Revamping the planning process to facilitate renewable energy transmission

The Electricity (Transmission System Planning, Development and Recovery of Inter-State Transmission Charges) Rules 2021 were promulgated to give power sector utilities easier access to the power transmission network across the country. The rules underpin a system of transmission access termed as general network access ("GNA") in ISTS, providing flexibility to states as well as generating stations to acquire, hold and transfer transmission capacity as per their requirements. Thus, the rules will bring in rationality, responsibility, and fairness in the process of transmission planning as well as costs. In a major change from the present system of taking transmission access, power plants will not have to specify their target beneficiaries. The rules will also empower state power distribution and transmission companies to determine their transmission requirements and build them. Also, states will be able to purchase electricity through short-term and medium-term contracts and optimise their power purchase costs.

Regional power committees (transmission planning) have been dissolved to obviate the need for dual consultation at the regional level in the transmission planning process and expedite the planning and approval process. Terms of reference of the National Committee on Transmission **("NCT")** have been modified and the Central Transmission Utility ("**CTU**") and the NCT have been delegated powers to approve ISTS up to Rs 5 billion to enable faster implementation of the required ISTS system and achieve the RE target of 500 GW by 2030.

Revised standard bidding documents for award of transmission services on a competitive bidding basis

To encourage private sector participation in the transmission sector, the MoP notified "tariff-based competitive bidding ("TBCB") guidelines for transmission service" and "guidelines for encouraging competition in development of transmission projects" in April 2006. Subsequently, the ministry notified the standard bidding documents ("SBDs") comprising request for qualification ("RfQ"), request for proposal ("RfP") and transmission service agreement ("TSA") in 2008. As the SBDs and the guidelines were issued a long ago, requests were received to align them with other infrastructure SBDs to attract more private investments in the transmission sector. Based on requests received from stakeholders, SBDs and TBCB guidelines for transmission service" and "guidelines for encouraging competition in development of transmission projects" were revised and re-issued on August 6, 2021. The major changes in the revised SBD guidelines include a reduction in the equity lock-in period (from earlier 51% for a period of two years from date of commissioning ("COD") and 26% for a period of three years thereafter to 51% for a period of one year from COD), signing of TSA by the CTU, provisions for quoting of a single tariff in the bid, changing from a build-own-operate-maintain ("BOOM") model to a build-own-operate-transfer ("BOOT") model, provision of independent engineers during the construction phase for monitoring, quality assurance and quantification of cost/time related issues, etc. Revised SBDs and guidelines would promote ease of doing business for private developers in the transmission sector, address concerns of developers on risk sharing, encourage competition in transmission, and facilitate timely completion of transmission lines. All these provisions would bring in more private investments in the transmission sector.

Transmission regulations

Central Electricity Regulatory Commission (Sharing of Inter-state Transmission Charges and Losses) Regulations, 2020

The CERC notified the Central Electricity Regulatory Commission (Sharing of Inter-state Transmission Charges and Losses) Regulations, 2020 ("CERC sharing regulations") on May 4, 2020. These regulations came into force on November 1, 2020, superseding the Central Electricity Regulatory Commission (sharing of inter-state transmission charges and losses) Regulations, 2010. These regulations state that yearly transmission charges ("YTC") as determined or adopted by CERC for transmission elements related to ISTS shall be shared among the users of such transmission systems. The users, termed as designated ISTS customers ("DICs"), include generating stations, state transmission utilities, distribution licensees including state electricity boards or their successor companies, electricity departments of states and any other entity directly connected to the ISTS and the intra-state entity or trading licensee that has obtained medium-term open access or long-term access to ISTS ("DICs") on a monthly basis such that the YTC and any adjustment thereof are fully recovered.

The mechanism for sharing ISTS transmission charges: As per the CERC, monthly ISTS transmission charges shall be a combination of the national component, the regional component, the transformer component and the AC system component as set out in its sharing regulations. The charges, collected on an actual basis, will be based on the peak block for the billing period and the technical and commercial information provided by DICs, ISTS transmission licensees, CTU, NLDC, RLDCs and SLDCs to the implementing agency.

The mechanism for sharing ISTS losses: Transmission losses for ISTS are calculated on an all-India average by the implementing agency for each week, from Monday to Sunday. The drawing schedule of DICs is prepared as per provisions of the grid code considering transmission losses during the week preceding the previous week.

Treatment of transmission charges and losses: The CERC sharing regulations also set specific provisions for treatment of transmission charges and losses and billing in specific cases including where there is a mismatch in commissioning of the generating station or associated transmission system of the concerned ISTS licensees.
Billing, collection, and disbursement: As per the regulations, the CTU is responsible for raising transmission bills, collection of transmission charges and disbursement of transmission charges to ISTS transmission licensees. The bills for the use of the ISTS shall be raised by the CTU on the concerned DICs under three categories, namely first bill, second bill and third bill. The first bill is raised each month and contains transmission charges for the billing period, while the second is a quarterly bill raised in April, July, October, and January every year to adjust variations on account of any revision in transmission charges allowed by CERC, including incentives as applicable. The third bill is raised each month for transmission deviation charges. Notwithstanding any provisions to the contrary in the applicable tariff regulations or TSA under TBCB, a rebate of 1.5% is allowed for the payment of bills within a period of five days of presentation of bills, while a rebate of 1% is allowed where payments are made on any day after five days and within a period of 30 days of presentation of bills. The CTU collects transmission charges on account of the first bill for the transmission system and disburses the amount collected to transmission licensees in proportion to their YTC. In case of a shortfall in collection of transmission charges, the amount to be disbursed to transmission licensees is reduced pro-rata from their share of YTC. The CTU collects transmission charges under the second bill and disburses the same to the respective transmission licensees and collects transmission deviation charges under the third bill and reimburses the same to DICs, in proportion to their first bill in the following billing month. The charges collected are first adjusted towards late payment surcharge on the outstanding transmission charges and thereafter towards outstanding transmission charges, starting from the longest overdue bill. The due date for payment of bill is 45 days from the date of serving the bill. In case the payment of any bill for charges payable under these regulations is delayed by a DIC, beyond the due date, a late payment surcharge of 1.5% per month shall be payable by the concerned DIC.

Electricity Act and its impact and open access in transmission

Under the Electricity Act, 2003, open access means the non-discriminatory provision of transmission lines or the distribution system for use by any licensee or consumer, or a person engaged in generation in accordance with the regulations specified by the regulatory commission.

The act also has specific functions pre-defined for both CTU, STUs and any transmission licensee and one of them is to provide non-discriminatory open access to its transmission system for use by:

- Any licensee or generating company on payment of transmission charges
- Any consumer as and when such open access is provided by the State Commission on payment of transmission charges

Tariff regulations for transmission lines

Section 62 of the Electricity Act, 2003 enables regulatory commissions to determine the tariff of a transmission system. The act also empowers the commissions to make specific regulations consistent with the Act. Subsequently, CERC notified tariff regulations which delineate all terms and conditions for determination of transmission tariff.

The regulations determine the tariff based on the capital cost of the transmission project and the debt-equity structure. The project cost is then recovered based on five parameters:

- Return on equity
- Interest on debt
- Interest on working capital
- Operation and maintenance expenses
- Depreciation

Based on these parameters, annual fixed charges calculated for the transmission asset are paid to the licensee.

Regulatory authorities

Regulatory bodies such as the CERC and SERCs play a crucial role in regulating and overseeing the transmission sector in India. They establish tariff regulations, ensure compliance with technical standards and resolve disputes.

Figure 33: Current ecosystem structure

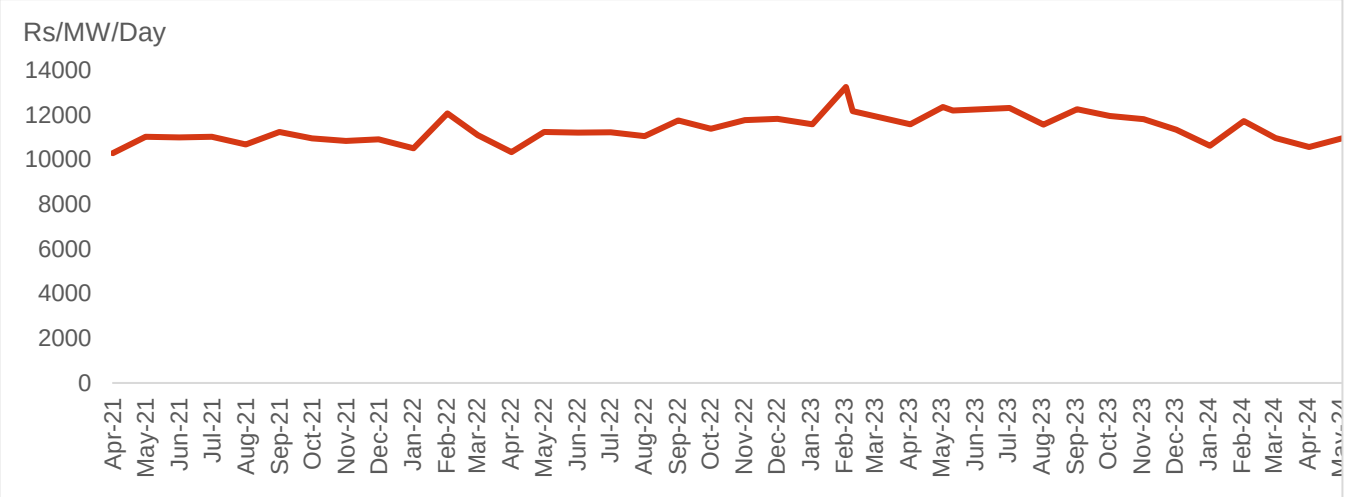
MoP (Perspective planning, policy formulation, processing of projects for investment decisions, monitoring the implementation of power projects, training and manpower development, and administration and enactment of legislation regarding power generation, transmission, and distribution)
Central Electricity Authority of India (“CEA”)

(Advises the government on matters related to the National Electricity Policy and formulates short-term and perspective plans for the development of electricity systems)		
Central Electricity Regulatory Commission (“CERC”) (Regulates tariff and formulates policies regarding subsidies, and promotion of efficient and environmentally benign policies at the central level)	State electricity regulatory commissions (“SERCs”) (Regulate tariff and formulate policies regarding subsidies and promotion of efficient and environmentally benign policies at the state level)	
CTU (Ensures development of an efficient, coordinated, and economical system of inter-state transmission lines and undertakes inter-state transmission)	Private/PPP ventures (Bring investments, expertise, and technological advancements to enhance the infrastructure, improve operations, and drive efficiency in power transmission)	State transmission utilities (“STUs”) (Ensure development of an efficient, coordinated, and economical system of inter-state transmission lines and undertake intra-state transmission)

Source: CEA, CRISIL MI&A Research

Transmission charges: Overview and trends

Figure 34: ISTS charges in Rs/MW/day



Source- POSOCO, CRISIL MI&A Research

The annual transmission charges (“ATC”) computed are the total aggregate revenue requirement of the state transmission utility (“STU”)/transmission licensee. The ATC of STU/transmission license is divided between the beneficiaries of the transmission system on a monthly basis based on the allotted transmission capacity or contracted capacity or certain parameters of peak demand or energy wheeled, depending on state to state.

Table 14: State-wise transmission charges for Fiscals 2022 to 2024

LTA charges (Rs/MW/Day)	Fiscal 2022	Fiscal 2023	Fiscal 2024
Gujarat	4,252	4,048	4,113
Karnataka	5,051	5,434	5,459
Andhra Pradesh	5,151	5,793	6,279
Bihar	6,406	5,506	5,156
Telangana	3,723	4,315	4,838
Rajasthan	5,003	5,124	5,878
Maharashtra	8,767	8,667	10,440
Tamil Nadu	3,037	5,159	5,366
Madhya Pradesh	4,845	4,791	4,687

Source: CRISIL MI&A Research

Table 15: ATC recovery mechanism across states

State	STU	ATC calculation	Mechanism for recovery of ATC from beneficiary	Special concession for RE
Rajasthan	RVPN	Cost-plus approach	Transmission system peak demand, including open access demand	NA
Andhra Pradesh	APTRANSCO		Transmission system peak demand, including open access demand	
UP	UPPCL		Based on the energy wheeled	
Maharashtra	MSETCL		Based on the transmission capacity rights of a transmission system user, which is the average of the coincident peak demand and non-coincident peak demand	
Bihar	BSPTCL			

State	STU	ATC calculation	Mechanism for recovery of ATC from beneficiary	Special concession for RE
Telangana	TSTRANSCO		Based on contracted/allotted transmission capacity, which is the sum of the generating capacities allocated to the long-term or the medium-term transmission customer from the generating stations and the contracted power	Wind, solar and mini-hydel generators are exempt from payment of transmission charges. However, the transmission charges are not increased subsequently for further recovery from other users, and there is no provision of making good the revenue lost due to exemption
Tamil Nadu	TANTRASCO			Concession on transmission charges to solar (50%), wind (50%), biomass (60%) and bagasse (70%)
Gujarat	GETCO			NA
MP	MPPTCL			
Karnataka	KPTCL			

Source: CRISIL MI&A Research

Key risks for the transmission segment

Exposure of intra-state projects to state distribution utilities

The counterparty credit risks arise from the exposure to state utilities. The credit profile of most utilities in India remains moderate to weak owing to the delays in issuing tariff orders, weak operating efficiencies, and inadequate tariffs in relation to the cost of supply.

Payment based on availability of the transmission system

Inter-state power transmission projects receive transmission charges based on transmission system availability, irrespective of the quantum of power transmitted through the system. Availability is calculated according to the terms incorporated in the TSAs, which are based on the provisions of CERC tariff regulations.

The TSAs provide specific guidance on the calculation of availability and take into account the elements in the transmission system (including transmission lines and substations) as well as the reason for any outages, with force majeure outages excluded from such calculation. If a line's availability falls below 95%, the projects are subject to a penalty computed in accordance with the formula specified in TSAs, which shall be apportioned in the ratio of transmission charges paid or payable by the respective customers at the end of the relevant contract year.

Reasons for poor availability could be:

- Failure to obtain, maintain or renew permits and licenses or meet any conditions specified therein
- Operator error, improper installation or mishandling of equipment
- Breakdown or failure of power transmission systems
- Flaws in equipment design or construction of power lines or substations
- Work stoppages or labour disturbances or disputes
- Performance of equipment below expected levels of output or efficiency
- Environmental issues affecting the operations of transmission systems
- Planned or unplanned power outages
- Theft of equipment and line material
- Claims on completed projects and litigations, proceedings, judgments or awards arising therefrom
- Force majeure and catastrophic events, including fires, explosions, landslides, storms, floods, social unrest, earthquakes
- Terrorist acts and pandemics to the extent such events are not excluded from the calculation of availability under TSA
- Right of way

Transmission project delays are typically due to the time taken to acquire private land and right-of-way for transmission lines. Most cases are disputes related to land valuation or the loss of cropland under tower foundations.

Private sector participation in transmission

Notable private players include AESL, Sterlite Power Transmission Limited, and Tata Power Limited. AESL leads the private sector, owning 41.5% of the private operational transmission capacity (41,998 ckm) as of Fiscal 2024.

Table 16: Key players in the segment (as of March 2023)

Key players	Ownership	Transmission lines (in ckm)	Share in total (%)
PGCIL	Centre	1,74,113	38%
Gujarat Energy Transmission Corporation	State	73,053	16%
Uttar Pradesh Power Transmission Corporation	State	53,402	12%

Key players	Ownership	Transmission lines (in ckm)	Share in total (%)
Maharashtra State Electricity Transmission Company	State	50,631	11%
Rajasthan Rajya Vidyut Prasaran Nigam	State	42,302	9%
Tamil Nadu Transmission Corporation	State	37,056	8%
Adani Energy Solution Limited	Private	15,371	3%
Sterlite Power Transmission Limited	Private	10,143	2%
Tata Power Limited	Private	4,194	1%
Total		**4,60,265**	**100%**

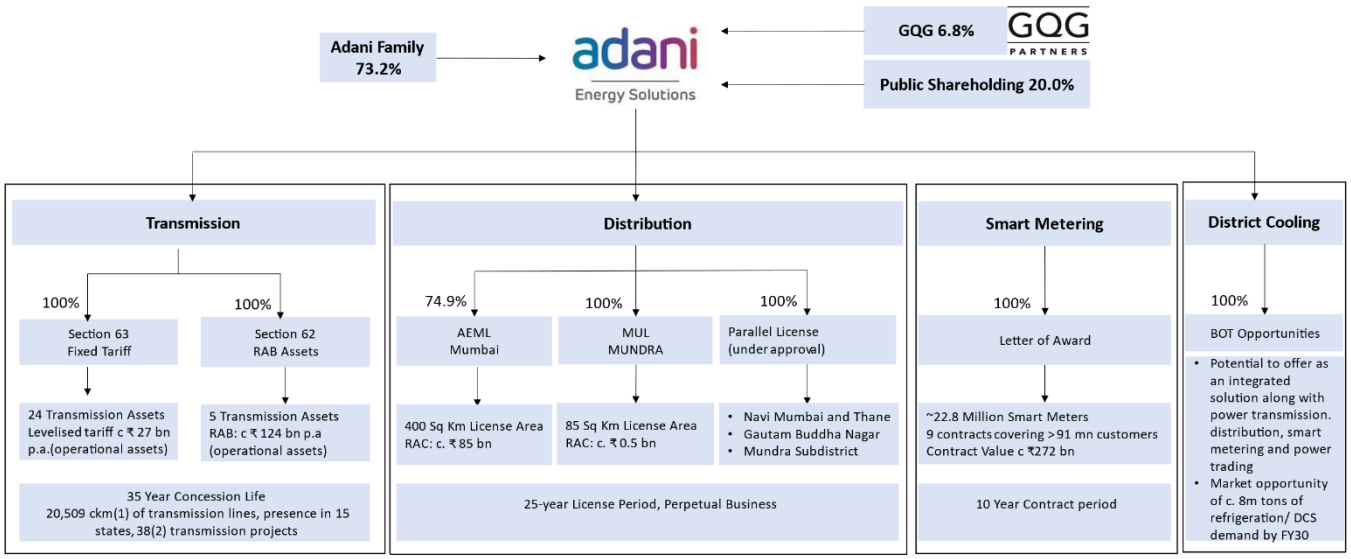
Note: All data above is as per company filings and disclosures for Fiscal 2023

Source: CRISIL MI&A Research

Business Profile of AESL

AESL (Adani Energy Solutions Limited) forms part of the Adani portfolio which is among India's top business houses. Its interests span transport and logistics (seaports, airports, logistics, shipping, road transport and rail), energy and utilities (power generation, transmission and distribution, renewable energy, gas, datacentres), primary industries, (including natural resources, mining services, copper, petrochemicals and direct to consumer, edible oil, food products, digital), real estate, defence, and aerospace.

Figure 35: Business profile of AESL



Note: (1) Includes operational and under construction project as of Fiscal 2024 (2) Includes operational and under construction project as of the Fiscal 2024 for both transmission (37 assets) and distribution (2 assets) segment

Adani's involvement in the transmission sector dates back to 2006, even before the formal establishment of AESL. Initially, the focus was on constructing dedicated transmission lines to evacuate power from Adani's Mundra and Tiroda power plants. These lines, spanning over 3,800 ckm and 1,200 ckm, respectively, connected various locations for effective power evacuation. The Mundra-Mohindergarh Transmission Project was the first +/- 500 kV bipolar HVDC transmission asset set up by a private company, Adani, in India.

Recognising the immense business potential in the transmission sector, AESL was established as a separate entity in 2015, emerging from Adani Enterprises Ltd. AESL pursued strategic growth by seizing inorganic opportunities and acquiring transmission assets from GMR Energy Limited, Reliance Infrastructure Limited and KEC International Limited in different regions of India.
The surge in electricity demand, expected renewable energy growth, the need for additional transmission and distribution infrastructure and competitive bidding are all areas which offer substantial opportunities for AESL.

AESL's position in the power transmission space remains strong

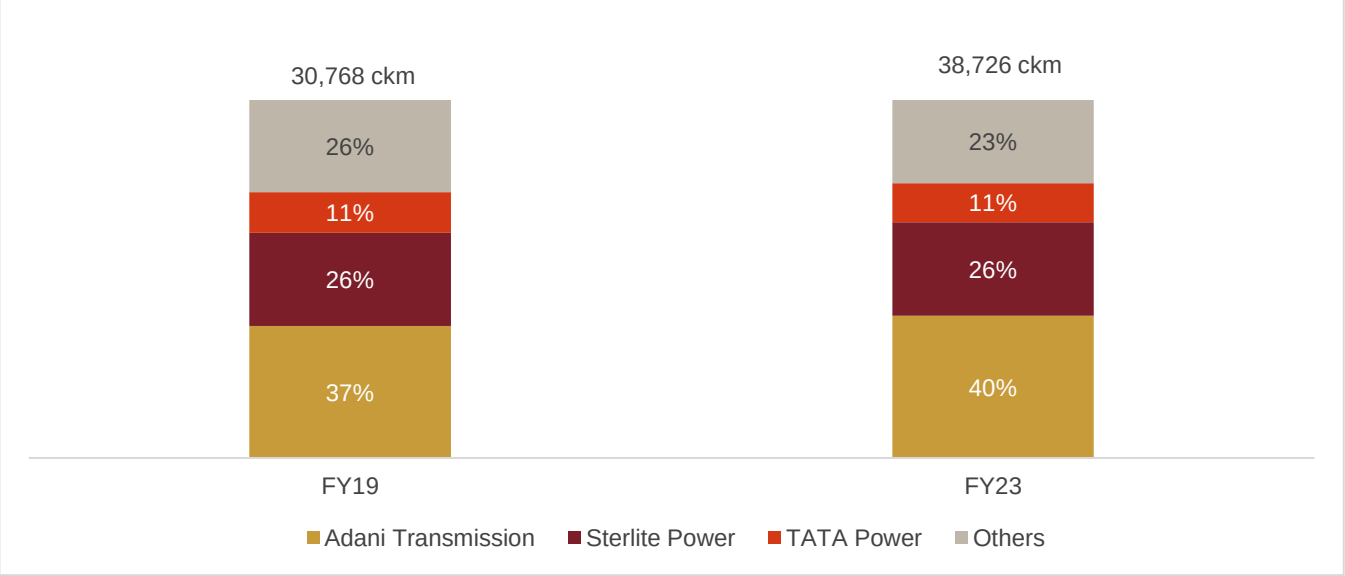
Adani Energy Solutions limited is one of the leading players in the T&D sector. AESL leads the private sector transmission segment, owning 41.5% of the private operational transmission capacity (41,998 ckm) as of Fiscal 2024. Adani Electricity Mumbai Ltd. ("**AEML**") is the largest private distribution licensee in the Mumbai with a consumer base of 3.18 million as of Fiscal 2024.

AESL has budgeted, developed and executed transmission and distribution projects across diverse geographies. In the T&D space, AESL is present across 15 states of India across the Northern, Southern, Eastern and Western transmission regions.

India had a total route length of 4,85,544 ckm by March 2024. PGCIL held the largest share at ~37.8% as a single entity in Fiscal 2023. States accounted for another 55.7%, while private capacities made up around 6.5%. Notably, the market share of private capacities has increased from 4.4% in Fiscal 2014 to 8.6% in Fiscal 2024 , with the share of private players in TBCB projects commissioned till April 2024 remaining as high as 66%. AESL garnered ~17% of projects under TBCB, emerging as the winner in 17 out of total 102 projects bid out (completed and under construction only).

The private transmission capacity grew to 38,726 route ckm as of Fiscal 2023 from 30,768 route ckm in Fiscal 2019, at a 5.9% CAGR. Within private transmission capacity additions, the share of the top three players (AESL, Sterlite Power Transmission Limited, Tata Power Limited) also expanded from 74% in Fiscal 2019 to 77% in Fiscal 2023.

Figure 36: AESL leads the race in private additions



Note: All ckm mentioned are route ckm. Private transmission capacity considered above refers to CEA disclosure under the category labelled JV/private.

Sources: Company reports, CEA, CRISIL MI&A Research

AESL, which held a 37% market share in the private transmission segment as of Fiscal 2019, continued to lead the market in Fiscal 2023, reaching a share of 40%. The company added 4,032 ckm of transmission line capacity between Fiscal 2019 and 2023, vis-a-vis 2,152 ckm and 678 ckm by Sterlite Power Transmission Limited and Tata Power Limited, respectively. AESL led the total private capacity additions and accounted for 50% during the period. The expansion continued in Fiscal 2024, as the company added 2,066 route ckm, representing ~63% of private capacity additions during the period.

Competition in the transmission sector depends on the size, nature and complexity of the project and the geographic region in which the project is being executed. While service quality, technical capability, health and safety track record, availability of qualified personnel, reputation and experience are important considerations, price is the major factor in most tender awards. Furthermore, size, scheduling and complexity of certain large-scale projects preclude participation by smaller and less sophisticated companies that operate in transmission industry. AESL's primary transmission business competitors include Power Grid Corporation of India Ltd (“PGCIL”), Sterlite Power Grid Ventures Ltd and Tata Power Ltd. AESL has become one of the largest private sector operators in India in a relatively short amount of time.

AESL continues to position itself as a market leader in transmission line route ckm, with a robust pipeline of 3,073 ckm as of March 2024, bringing the total portfolio to 20,509 ckm in the transmission and distribution segment. The expansion over the period has been driven by a mix of organic and inorganic expansions. The portfolio comprises 37 transmission and 2 distribution projects (as of Fiscal 2024) with a presence in 15 states spread across the eastern, western, northern, and southern transmission regions of the country. The company has a power distribution license for the Mumbai region, with access to an integrated distribution network catering to 3.18 million households under Adani Electricity Mumbai Limited (“AEML”) as of March 2024.

AESL owns and operates a diverse range of high voltage AC transmission lines and substations, including those with voltage levels of 132kV, 220kV, 400kV and 765kV. Additionally, it manages high voltage DC transmission lines and substations with a voltage level of +/- 500kV ("ckm") and possesses a power transformation capacity of 57,011 MVA as of March 2024. Line availability for 17,437 ckm of operational transmission lines has been 99.6% as of Fiscal 2024, higher than the normative level of 95% as prescribed by Central Electricity Regulatory Commission (Terms & Conditions of Tariff) Regulations, 2004. Furthermore, AESL has an under-construction portfolio consisting of ~3,073 ckm of transmission lines and 21,396 MVA of power transformation capacity as of March 2024. While AESL's network represents 3.6% of the total transmission network in India, the company holds a significant position within the private sector, with a 41.5% share at the end of March 2024.

The company has been able to contain its O&M expenditure, despite an expanding portfolio, owing to the implementation of predictive maintenance procedures and the use of technologies such as hotline washing, energy network operation centre ("ENOC") operations and supervisory control and data acquisition ("SCADA") implementation. Hotline washing is a process where insulators on electrical lines are cleaned with water while the electricity is energised. This helps the company maintain the transmission system and reduce technical losses. For remote operations of sub-stations, the company has set up ENOCs to carry out analytical operations. AESL's new network operations centre ("NOC") is equipped with the latest SCADA system that has a more proactive approach to power distribution, as potential problems can be detected and addressed before they become significant issues for customers.

In 2018, AESL expanded its operations into the distribution space through the acquisition of Reliance Infrastructure's power generation, transmission, and distribution business in Mumbai. This led to the formation of AEML, which serves over 3 million customers in Mumbai suburbs and the Mira-Bhayandar Municipal Corporation in Thane district, with a wide distribution network spanning 400 sq km.

AEML is the leading private power distributor in the Mumbai, with 3.18 million consumers as on Fiscal 2024. However, AEML has recently faced increasing competition from TPCL (Tata Power Company Limited), which is licensed to distribute power in the same area. As on Fiscal 2023, out of the power distributors within Mumbai, AEML caters to 63% of the consumer count. This share is expected to be maintained in Fiscal 2024.

Adani Electricity Mumbai Ltd ("AEML"), which is one of the distribution businesses of AESL, has consistently achieved an average system availability index above 99%. It reported system availability of 99.79% in Fiscal 2024, 99.77% in Fiscal 2023 and 99.68% in Fiscal 2022. It has also been able to consistently reduce the distribution losses. In Fiscal 2024, the losses stood at 5.29%, in Fiscal 2023, 5.93% and in Fiscal 2022, 6.55%.

AEML in Mumbai caters to a diverse mix of consumer categories. AEML caters to 46%, 42% and 12% of residential, commercial and industrial consumers respectively as of Fiscal 2024. With a high share of C&I consumers at 54% for AEML, a positive impact is seen in collection efficiencies. To provide a perspective, collection efficiency for the AEML business has been maintained at 100% over Fiscals 2021 to 2024.

As part of its strategy, AESL forayed into the smart metering business in Fiscal 2023. The government's Revamped Distribution Sector Scheme ("RDSS") and initiative for the nationwide rollout of smart meters by installing 250

million smart meters present a significant growth opportunity. The implementation, however, is slower than expected. CRISIL MI&A Research expects the segment to see investments worth approximately Rs 432 billion by Fiscal 2028 with an achievement ratio of 55-60% against the government's installation target. AESL's experience in implementing and operating smart metering projects, T&D businesses synergies and customer insights position it favourably in the sector. As on 31 March 2024, AESL had received nine letters of award through competitive bidding processes for 22.8 million smart meters —20% of India's smart metering market share.

International expansion opportunities

One of the driving factors for these companies to expand their operations internationally is their significant investment in the construction and upgradation of power networks, particularly for renewable energy integration and electric vehicle ("EV") charging infrastructure. Various Indian companies such as KEC International and Kalpataru Projects International have established a global presence in the T&D segment, spanning more than 50 countries. These companies have successfully executed multiple projects encompassing various aspects of the power sector, such as engineering, procurement, and construction ("EPC") for sub-stations, transmission lines, power distribution, and electrical services for local power networks and renewable energy integration.

PGCIL and Africa50 have signed a joint development agreement to advance Kenya's transmission project through a public-private partnership. The project involves constructing and operating 400kV and 220kV transmission lines. Upon completion, it will be Kenya's first independent power transmission line and Africa's first PPP-financed transmission line. Improving power supply and reliability in Western Kenya, the initiative aims to boost private sector investments in Africa's power transmission networks, addressing the electricity access gap. PGCIL brings technical expertise, while Africa50 provides project development and finance capabilities, acting as a bridge between the Kenyan government and private investors to ensure successful implementation.

Brazil has displayed a strong commitment to advancing its power transmission capabilities. Recently, the country announced an investment of $9.5 billion dedicated to the construction of new transmission lines and supporting infrastructure. This initiative aims to boost and integrate renewable energy sources, such as solar and wind, into the national power grid. Moreover, the Brazilian government has declared its plan to conduct a minimum of three significant transmission auctions in the state of Minas Gerais. By doing so, it seeks to attract further investments in transmission infrastructure, facilitating the integration of new wind and solar capacity. This move will play a crucial role in achieving increased penetration of renewable energy sources throughout the country, helping Brazil move towards a greener and more sustainable energy future. The focus of the Ministry of Mines and Energy on prioritising hybrid solar and wind projects highlights the potential for dual-generation capabilities to enhance the grid's stability.

In Australia, New South Wales transmission line operator, which owns and operates a transmission network of over 13,000 km, is making strides towards a sustainable energy future. With an investment of $11.20 billion in its power transmission network, it aims to prepare the grid for 100% renewable energy and integrate power storage elements for grid security. This ambitious plan includes laying 2,500 km of new transmission lines, ensuring robust and reliable transmission infrastructure to accommodate the increasing share of renewable energy sources.

Meanwhile, the Swedish power transmission system operator has earmarked $1 billion for the construction of new power lines. This strategic investment aims to cater to rising industrial demand and better integrate the growing installation of renewable energy sources. The operator plans to build three new transmission lines and sub-stations, creating a more resilient and interconnected power grid.

Module 4: Distribution sector in India

Overview and outlook

Distribution sector structure: Business models, players, and stakeholders

Distribution utilities play a crucial role in India's power sector by ensuring reliable and efficient supply of electricity to end-consumers.

In India, the distribution sector has undergone vertical unbundling, separating the functions of generation and T&D. However, the degree of practical unbundling varies across states. Gujarat, for instance, has successfully implemented unbundling to improve the performance of distribution companies ("discoms"), while few states are way behind.

Most discoms in India are state-owned. Private distribution licensees serve only ~7% of the country's power requirement. Private players such as Torrent Power Limited, Adani Power Limited, Tata Power Limited, Reliance Infrastructure Limited and CESC Limited participate in specific circles such as Mumbai, Ahmedabad, Surat, Delhi, Agra and Kolkata. Through privatisation, Tata Power acquired distribution licences in several regions of Odisha, while CESC won circles in Kota, Bharatpur and Bikaner in Rajasthan. Reliance Infrastructure sold its Mumbai distribution business to Adani Energy Solutions Ltd. In 2021, Tata Power took over Western Electricity Supply Company of Odisha ("WESCO") and Southern Electricity Supply Company of Odisha ("SOUTHCO"), which now operate under Tata Power Western Odisha Distribution Ltd ("TPWODL") and Tata Power Southern Odisha Distribution Ltd ("TPSODL"), respectively. These developments have brought a significant number of customers in Odisha under Tata Power's service.

The Electricity Act of 2003 in India includes provisions for the establishment of parallel licensees, which refer to multiple providers of electricity supply and distribution services operating competitively within the same region. The authority to approve parallel licences lies with the state electricity regulatory commissions ("SERCs).

Parallel licensing was introduced to drive retail competition in the power distribution segment under the Electricity Act of 2003. It led to active participation of private players in the distribution sector. This approach offers advantages such as providing consumers with choices and fostering competitive tariff rates. The successful implementation of the parallel licence system in Mumbai demonstrates the positive outcomes of healthy competition for both consumers and operators. However, certain obstacles hinder the growth of parallel licensing, notably the requirement for licensees to establish their own distribution systems.

The process of laying a parallel distribution system in densely populated areas already served by an incumbent utility can be time consuming. Concerns such as right of way and returns on investment contribute to the complexities associated with this process. Additionally, granting parallel licences can lead to the following issues:

1. Asset redundancy: This is undesirable in terms of system costs and sustainable competition. Suboptimal utilisation of assets should be minimised.
1. Cherry-picking: If left unchecked, parallel licensing can lead to selective targeting of specific consumer categories, undermining the intended purpose of its establishment.
2. Separate accounting for network costs: To calculate wheeling charges and ensure the segregation of network business in financial records, it is necessary to maintain separate accounting and reporting of costs related to network assets.
3. Complexity of migration: Consumer migration from one licensee to another introduces additional operational complexities. Therefore, it is crucial to strengthen processes and effectively administer the migration of consumers.

Private players have demonstrated efficiency in investments, reducing aggregate technical and commercial ("AT&C") losses and meeting local electricity demand. For instance, in Delhi, where power distribution was taken over by three private licensees, AT&C losses decreased from 55% in Fiscal 2002 to ~9% in Fiscal 2021.

Private participation in the distribution business can occur through two models: distribution licence and distribution franchise. Private parties have ownership or equity in the distribution grid assets under the licence model but no ownership under the franchise model. Both models have seen successes and failures. Metros such as Mumbai, Delhi, Surat, Ahmedabad, and Kolkata operate efficiently under the licence model, while franchise models have been successful in Odisha and Bhiwandi, Maharashtra, leading to improvements in metering, billing and collection.

Table 17: Models of private participation in electricity distribution in India

Distribution franchisee model	Distribution licensee model
Private party has no ownership of the distribution grid assets	Private party holds equity and is part or complete owner of the distribution grid assets
Private party mainly manages billing and revenue collection	Private party manages the distribution of power along with billing and revenue collection services
Example: Torrent Power Limited (Bhiwandi, Maharashtra)	Example: Tata Power Delhi Distribution Limited (New Delhi), Adani Electricity Ltd (Mumbai)

Source: CRISIL MI&A Research

The distribution sector faces financial losses, mounting debt and outstanding dues to power generators. The Covid-19 pandemic worsened the situation due to reduced power demand and lower billing and collection efficiency during the lockdowns.

In March 2023, the distribution sector in India was burdened with significant debt of Rs 6.87 trillion. Tamil Nadu, Maharashtra, Uttar Pradesh and Rajasthan accounted for 55% of the debt. The power sector has been grappling with persistently high levels of regulatory assets, further weakening the discoms' financial health. In Fiscal 2023,

regulatory assets totalled Rs 1.6 trillion, led by substantial contributions from Tamil Nadu, Rajasthan, Delhi, West Bengal, Maharashtra and Kerala.

The distribution sector has faced persistently high AT&C losses, averaging over 20% between Fiscals 2011 and 2021. AT&C losses indicate the amount of power lost during T&D. The implementation of the UDAY scheme resulted in a reduction in AT&C losses and the average cost of supply-average revenue realised ("ACS-ARR") gap to ~21.6% and Rs 0.47 per kWh *(ACS-ARR gap are inclusive of UDAY grants and regulatory income)*, respectively, by the end of Fiscal 2019. However, after UDAY, discoms' financials deteriorated, with AT&C losses and the ACS-ARR gap increasing to ~22.3% and Rs 0.55 per unit, respectively, by March 2021.

Nevertheless, the government's continued efforts to revive the sector have led to a decline in AT&C losses – from 27% in Fiscal 2011 to 15.4% in Fiscal 2023. Resultantly, the ACS-ARR gap decreased from Rs 0.53 per kWh in Fiscal 2021 to Rs 0.30 per kWh in Fiscal 2023. Improved subsidy disbursal by state governments and better customer collections by discoms, as reflected in the improved collection efficiency of 97.3% in Fiscal 2023, contributed to this reduction. Several output-linked schemes initiated by the government also played a role. The Ministry of Power ("MoP") revised the prudential norms of PFC and REC to ensure that loss-making discoms cannot avail financing until they develop an action plan to reduce losses within a specific timeframe, with commitment from their respective state governments. The ministry also decided that future assistance for strengthening the distribution system will be available to loss-making discoms only if they commit to reducing their AT&C losses and ACS-ARR gap to specified levels within a specific timeframe.

To improve operational efficiencies and financial sustainability, the Government of India approved the RDSS. This scheme provides result-linked financial assistance to discoms to strengthen supply infrastructure based on meeting pre-qualifying criteria and achieving basic minimum benchmarks. With an outlay of ₹3.03 trillion over Fiscals 2022 to 2026, including estimated government budgetary support ("**GBS**") of ₹0.976 trillion, the scheme aims to reduce AT&C losses to the pan-India level of 12 to 15% and bring the ACS-ARR gap to zero by Fiscal 2025.

The introduction of the late payment surcharge ("LPS") rules in June 2022 brought the much-needed discipline to the distribution sector. In August 2022, 13 states were barred from buying and selling on power exchange platforms due to non-payment of dues by discoms. The total overdue amount of power discoms to power generation companies decreased 43.7% to Rs 626 billion as on March 28, 2024 within a year of implementing the LPS rules, from Rs 1,113 billion in June 2022. The implementation of the LPS rules has improved the recovery of outstanding dues and encouraged timely payment by discoms.

The government has implemented major reforms to address the persisting issues, including RDSS, LPS rules, additional prudential norms for lending by financial institutions, National Smart Grid Mission, and mandatory energy accounting and auditing. While these programmes have revitalised the sector, resolving larger legacy issues will require more time and interventions.

Key schemes and their impact

The central government introduced various schemes aimed at improving the T&D infrastructure and enhancing operational efficiency. One such scheme was Deen Dayal Upadhyaya Gram Jyoti Yojana ("DDUGJY"), which focused on separating feeders for rural households and agricultural purposes, as well as strengthening the sub-T&D infrastructure in rural areas. Its objective was to provide round-the-clock power to rural households and adequate power to agricultural consumers. Under this scheme, special category states received a grant of up to 90% of the project cost, while others received 75%. Discoms could also receive an additional grant if they met certain conditions, such as timely completion of the scheme, reduction in AT&C losses according to a specified trajectory, and upfront release of revenue subsidy by state governments based on metered consumption.

In contrast, the Integrated Power Development Scheme ("IPDS") had an urban focus with the aim to strengthen the sub-T&D network in urban areas, implement metering for distribution transformers, feeders and consumers, and enable IT integration in the distribution sector. Discoms could also receive an additional grant under IPDS, subject to similar conditions as under DDUGJY.

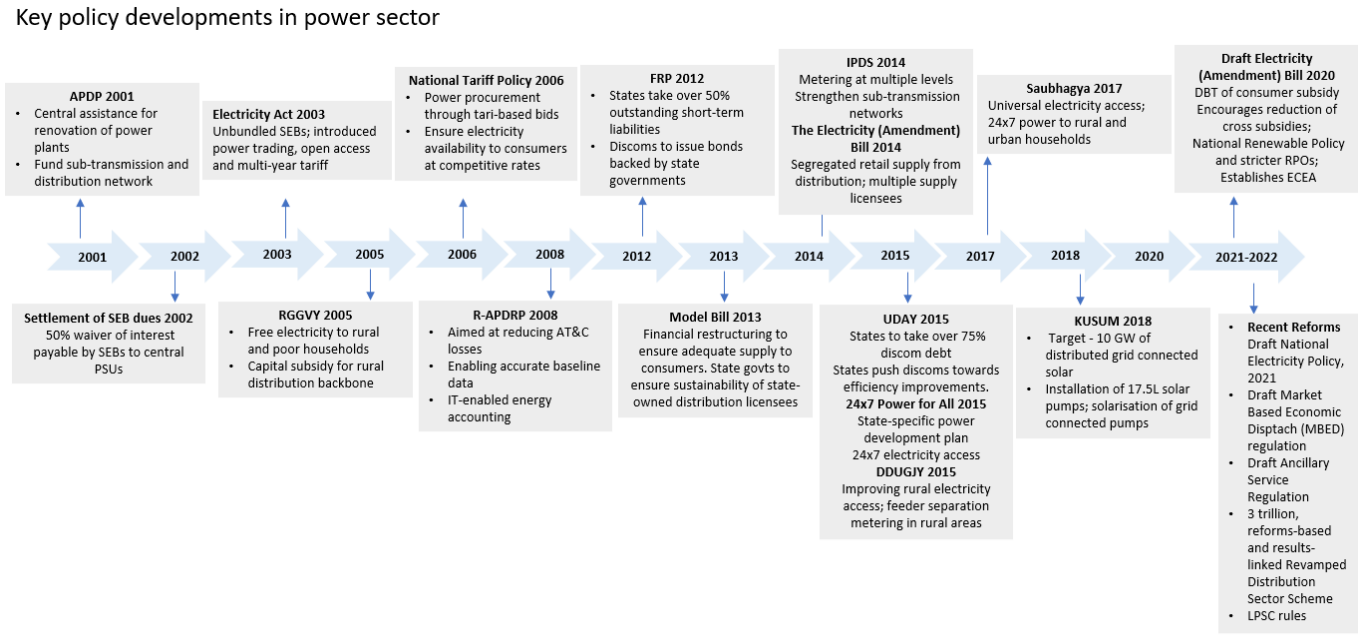
Launched in 2015, Ujwal DISCOM Assurance Yojana ("UDAY") aimed to provide a long-term resolution to the issues faced by discoms by facilitating operational and financial turnaround. The scheme required states to take over 75% of the discoms' debt, reducing their interest costs and future losses. While UDAY helped cash-strapped discoms reduce their debt and overall AT&C losses, it did not fully address challenges related to cross-subsidies and power-procurement costs. By the stipulated timeframe of Fiscal 2019, UDAY aimed to reduce AT&C losses to 15% and achieve an ACS-ARR gap of zero through operational improvements such as mandatory smart metering, distribution infrastructure upgrades and energy-efficient measures. However, despite a slight decline from 23.98% in Fiscal 2016 to ~21.64% in Fiscal 2019 in AT&C losses, the targets were not fully achieved.

The ambitious Saubhagya scheme played a significant role in accelerating electricity access in off-grid areas. However, it faced challenges in ensuring tariff realisation from newly connected consumer groups, ultimately impacting the finances of discoms in some states. In the 2021-22 Union Budget, the central government announced a new scheme to promote the viability of discoms – the Revamped, Reforms-Based, Result-Linked Power Distribution Sector Scheme with an outlay of Rs 3,059.84 billion over five years. The scheme aims to support discoms in infrastructure creation, including prepaid smart metering and feeder separation, as well as system upgrades tied to financial improvements.

In June 2022, the government introduced the LPS scheme, which brought the much-needed discipline to the distribution sector. The scheme's rules allow for consolidation of all outstanding dues, including principal and LPS, into a single consolidated amount. The consolidated amount can be repaid in interest-free equated monthly instalments (EMIs). The maximum number of EMIs allowed is 48 depending on total outstanding dues. The rules also outline the implementation modalities and penalties for non-payment, following the re-determined payment schedule. Additionally, according to the rules of the LPS scheme, if discoms fail to pay their current dues one month after the payment due date or two-and-a-half months after the presentation of the power bill, whichever is later, it will result in regulation of power as specified in the LPS rules of 2022. As a result of implementing the LPS rules, the

total overdue amount of power discoms to power generation companies decreased 43.7% to ₹626 billion as on April 30, 2024.

Figure 37: Timeline of policies in distribution sector



Source: MoP, CEA, CRISIL MI&A Research

Key monitorable for the distribution sector – open access

Open access allows consumers to freely choose their electricity supplier within a competitive and non-discriminatory framework. It provides larger industrial and commercial users the flexibility to purchase electricity directly from their preferred generator or supplier, instead of relying on the local distribution utility. Originally, open access was intended for consumers with loads greater than 1 MW by January 2009.The Green Open Access rules of 2022 allow consumers to choose Green Open Access, with the threshold for open access transactions reduced from 1 MW to 100 kW, specifically for green energy. This modification enables even small consumers to obtain renewable power through open access.

Open access has gained popularity in India owing to the range of exemptions and incentives provided by states to encourage its development. For instance, Karnataka offered waivers on T&D, cross-subsidy surcharges and banking for 10 years to solar projects commissioned by March 2018, resulting in a significant increase in solar open access capacity additions in the state.

Figure 38: Open access volume on power exchanges

Source: CEA, CRISIL MI&A Research

However, Karnataka withdrew all open access incentives for solar projects and proposed a retrospective levy of 25% T&D charges for projects commissioned in Fiscal 2018. Similar instances are arising as state discoms implement restrictive policy measures to discourage high-paying commercial and industrial ("C&I") consumers from migrating to open access.

When a C&I consumer migrates to open access, the distribution utility suffers loss of revenue from that consumer. Since the tariffs for C&I consumers are generally higher than those for domestic or agricultural consumers, discoms are more significantly impacted when a C&I consumer migrates to open access. Consumer migration to open access results in surplus power from power purchase agreements ("PPAs") or power procurement obligations from generating stations. The discom has the option to either curtail the surplus power or reallocate it to underserved consumers within the state, such as domestic and agricultural consumers. However, this can lead to stranded capacity, where excess power is not fully utilised or efficiently distributed.

In recent times, numerous states have introduced policy measures to discourage the migration of high-paying C&I consumers to open access. These measures include imposing high open access charges such as cross-subsidy surcharges and additional surcharges, which significantly increases the landed cost for consumers. Consequently, the economic feasibility of adopting open access is diminished, thereby impeding the growth of open access in the power sector.

In Karnataka, the cross-subsidy surcharge for industrial consumers has been pegged at Rs 1.95-Rs 2.08/kWh for Fiscal 2025. However, Bangalore electricity supply company limited ("BESCOM"), a state utility within Karnataka, has significantly decreased the additional surcharge from Rs 2.15/unit in Fiscal 2023 to Rs 1.37/kWh in Fiscal

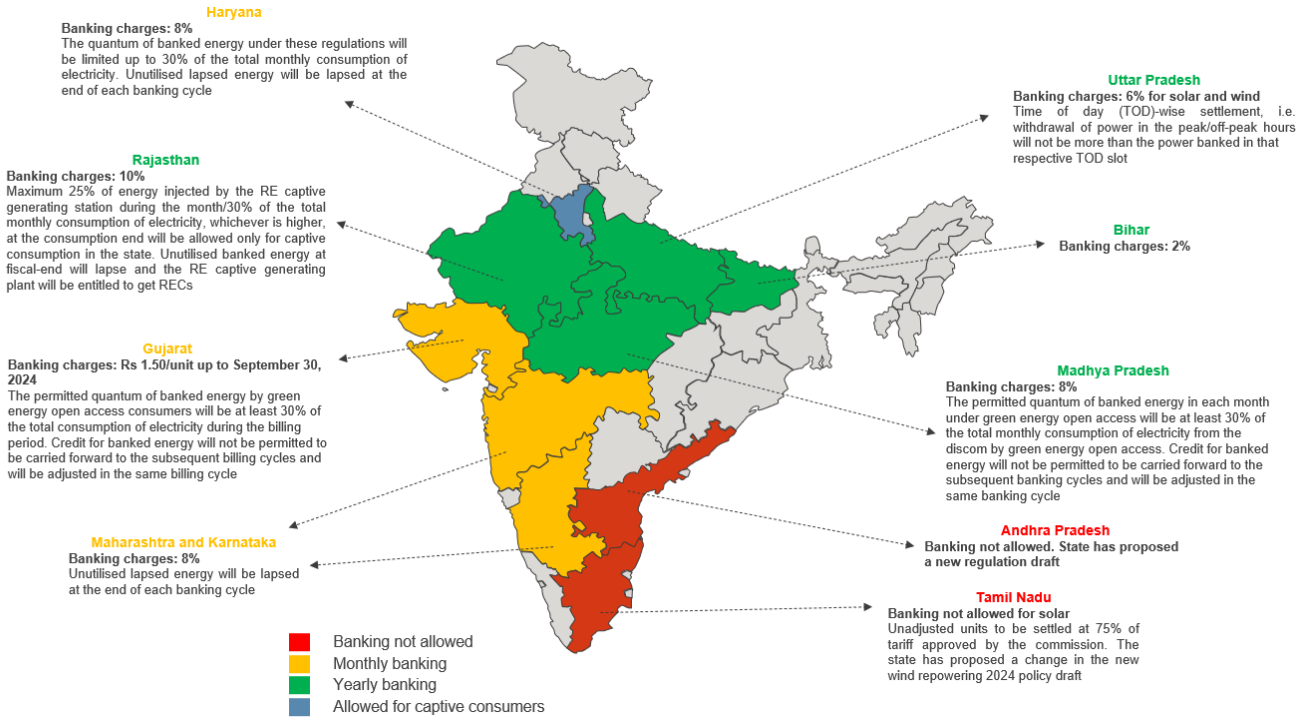
2025. In Maharashtra, additional surcharge increased ~9% from Rs 1.27/unit in Fiscal 2023 to Rs 1.39/unit in Fiscal 2025, and the CSS (Cross Subsidy Surcharge) for industrial consumers increased a marginal ~2% from Rs 1.76/unit to Rs 1.79/unit. Similarly, in Tamil Nadu, the CSS for commercial consumers rose 10% to Rs 2.57/unit, and for industrial consumers, 7.3% to Rs 1.92/unit.

Several states are reversing the banking provision to discourage open access. Banking of power allows generating plants to supply excess power to the grid for later retrieval. Discoms are restricting banking provisions to prevent the loss of high-paying C&I consumers. By implementing and restricting banking facilities and withdrawing waivers for open access renewable projects, discoms aim to deter C&I consumers from shifting to alternative renewable energy (“RE”) procurement models.

Discoms argue that consumers in some states exploit the banking provision by drawing on banked energy during peak demand periods while injecting power during off-peak periods, resulting in higher power procurement costs. To address this, some states have transitioned from annual to monthly banking periods, while others have eliminated banking facilities for RE. For instance, Andhra Pradesh withdrew the banking of 100% of energy for solar, wind and hybrid projects, following a policy amendment in November 2019. Tamil Nadu also does not allow energy banking for solar. However, discoms have now reoriented their banking stance with majority states offering banking charges of 6-10%, with Bihar being an exception at 2%. The quantum of banked energy under these regulations is limited to 30% of the total cycle consumption of electricity from the distribution licensee by the consumer. Credit from banking is not permitted to be carried forward to subsequent banking cycles and has to be adjusted during the same banking cycle as per energy injected in the off-peak and peak period determined by the commission in its retail supply tariff order from time to time.

Furthermore, with increasing demand for open access, Andhra Pradesh and Tamil Nadu have proposed a draft regulation on green energy open access energy rules in 2023 and 2024, respectively. Andhra Pradesh has proposed 8% banking charges while the draft on new wind repowering policy in Tamil Nadu proposes to allow banking to the existing generation as per the old banking norms and additional generation up to 50% in a repowered project.

Figure 39: Summary of banking provisions in key states



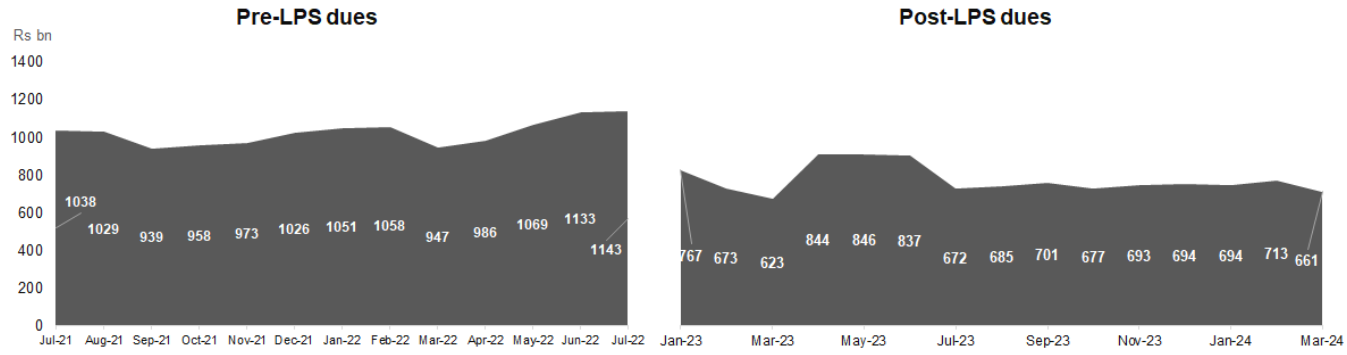
Source: CRISIL MI&A Research

Solar installed capacity under open access is expected to be in the range of 12-13 GW as of March 2024. We expect 14-16 GW to be added between Fiscal 2024 and Fiscal 2029, with 3.0-3.5 GW to be added in Fiscal 2025 due to waiver of charges. Post Fiscal 2025, with ISTS charges being levied, open access additions are expected to average 2.5-3.0 GW each year until Fiscal 2029.

Dues of discoms: Trends and status

The MoP introduced LPS rules on June 3, 2022, to tackle the problem of non-payment of generator dues by discoms. The rules enable Power System Operation Corporation Ltd (“POSOCO”) to penalise discoms for non-payment of current dues and overdue by blocking their access to the short-term energy market.

Figure 40: Dues of discoms



Note: Above data has been sourced from government disclosures over a period of time, discrepancy/restatement in subsequent disclosures may be seen.

Source: PRAAPTI, CRISIL MI&A Research

Discom dues have declined approximately 44% as on April 30, 2024 to ₹626 billion vis-a-vis the pre-LPS period of June 2022 (₹1,133 billion).

Establishment of parallel licensees

The Electricity Act, 2003 includes provisions for the establishment of 'parallel licensees,' enabling multiple power supply and distribution service providers to operate competitively within the same region. State electricity regulatory commissions (“SERCs”) can approve these parallel licences.

As per the provisions outlined in the Electricity Act, 2003, obtaining a parallel licence for electricity distribution requires a private company to possess its own substations and network of lines within the specified area of the licence application. According to the rules, the licensee is supposed to pay 30% equity towards the cost of infrastructure investments. Regulatory approval secures an annual assured return of 16% on equity. However, the proposed Electricity Amendment Bill of 2022 seeks to alter this requirement, leading to a significant backlash from state distribution companies (“discoms”). If passed, this amendment would enable new licensees to utilise the existing network infrastructure by paying "wheeling charges". The move would enable private licensees to leverage the extensive network established in the past without making any substantial investments, and the wheeling charges may not even cover the interest on the initial investment to set up the network. This proposed change has attracted considerable criticism from state discoms.

Although implementation of parallel licensing faces various regulatory hurdles, a clear framework for parallel operation of multiple distribution licensees is required to tap the potential for new load growth. That said, there are risks related to underutilisation of assets, resource lock-in, and the potential for cherry-picking of consumers if parallel licensing is implemented without proper planning. The central electricity regulatory commission has already identified some of these risks.

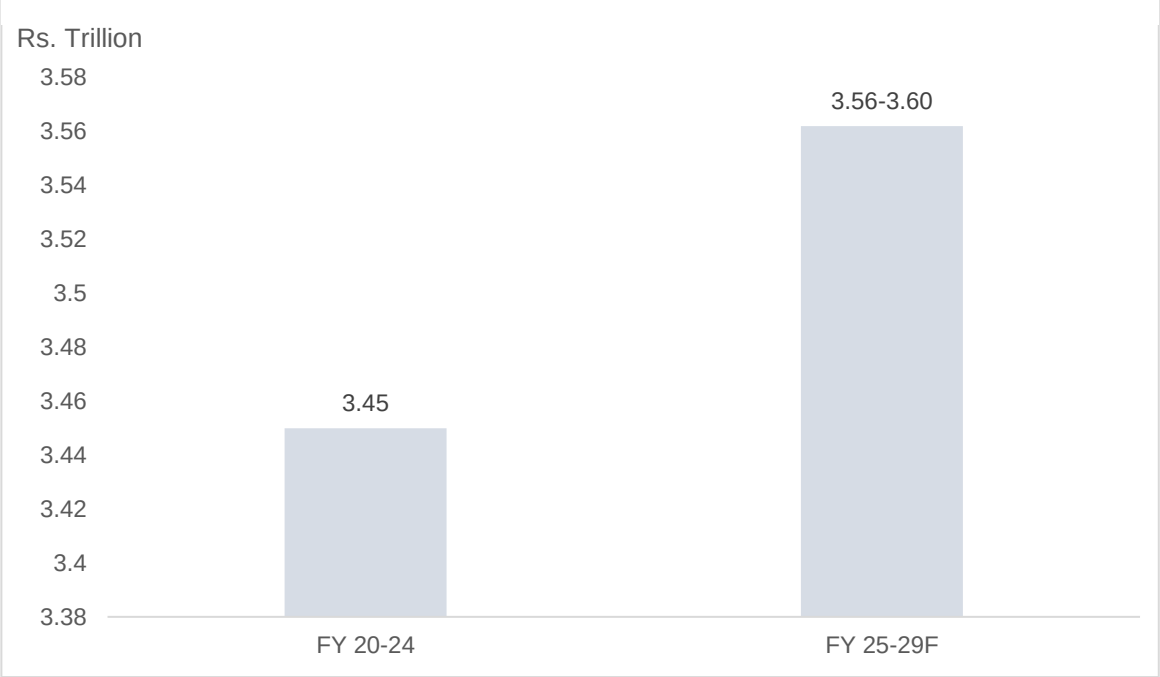
Overall, while parallel licensing could increase competition and consumer choice in the power transmission and distribution sector, the related challenges must be addressed to ensure smooth implementation and maximise the benefits for all stakeholders involved.

RDSS impact, forecast on investments and parameters such as AT&C loss

Distribution investments include creation of distribution infrastructure, which includes works taken under the following:

1. Electrification of unelectrified villages, hamlets or area with an objective to make electricity available to all within the area of supply.
2. Supply of electricity for agricultural pump sets or community lift irrigation schemes.
3. Reduction of sub-T&D system losses, which will comprise:
    a. Creation of new 33KV and 11KV substations near the load centre
    b. Reduction in the ratio of length of low voltage lines to high voltage lines, including low tension-less system. The desirable ratio of low voltage lines to high voltage lines would be as specified by the respective regulatory commission.
    c. Adoption of aerial bunched conductors
    d. Capacitor installation
    e. Change of conductor or double circuiting of lines
4. System strengthening of the sub-transmission system to effect improvement in:
    a. Voltage regulation at the existing or envisaged load demand
    b. Reliability of the system to reduce outage time and also to cater to outage of the line and/or transformer.
5. System augmentation schemes: Addition of transformation capacity at substations to match the envisaged loading condition.
6. System improvement: To provide switchgear, control gear and protection to reduce fatal accidents and the failure rate of transformers.

Figure 41: Distribution investments from Fiscal 2020-2024 and 2025F-2029F



Source: CRISIL MI&A Research

CRISIL MI&A Research expects investments to increase by 3 to 4% to ₹3.56 to ₹3.60 trillion during Fiscals 2025 to 2029, because of RDSS along with other key schemes. For instance, Rajasthan discoms are expected to invest in the rural electrification scheme responsible for implementing domestic connections in rural areas along with energisation of irrigation wells. Similarly, development and improvement schemes of the distribution network form a major part of discoms in Gujarat.

Under RDSS, loss reduction works will include armoured cabling, high voltage distribution system, AB cables, reconductoring, feeder bifurcation, feeder segregation, information technology/operational technology (“IT/OT”)-related works, including enterprise resource planning (“ERP”) and billing software, etc.

Of the total outlay of Rs 3.03 trillion under RDSS over Fiscals 2022-2026, the government has promised GBS of Rs 9.7 trillion. Of this, Rs 2.8 trillion has been budgeted cumulatively till Fiscal 2025. This corresponds to 29% of overall funding requirement from the central government, suggesting that funding requirement in the next budget may go up significantly.

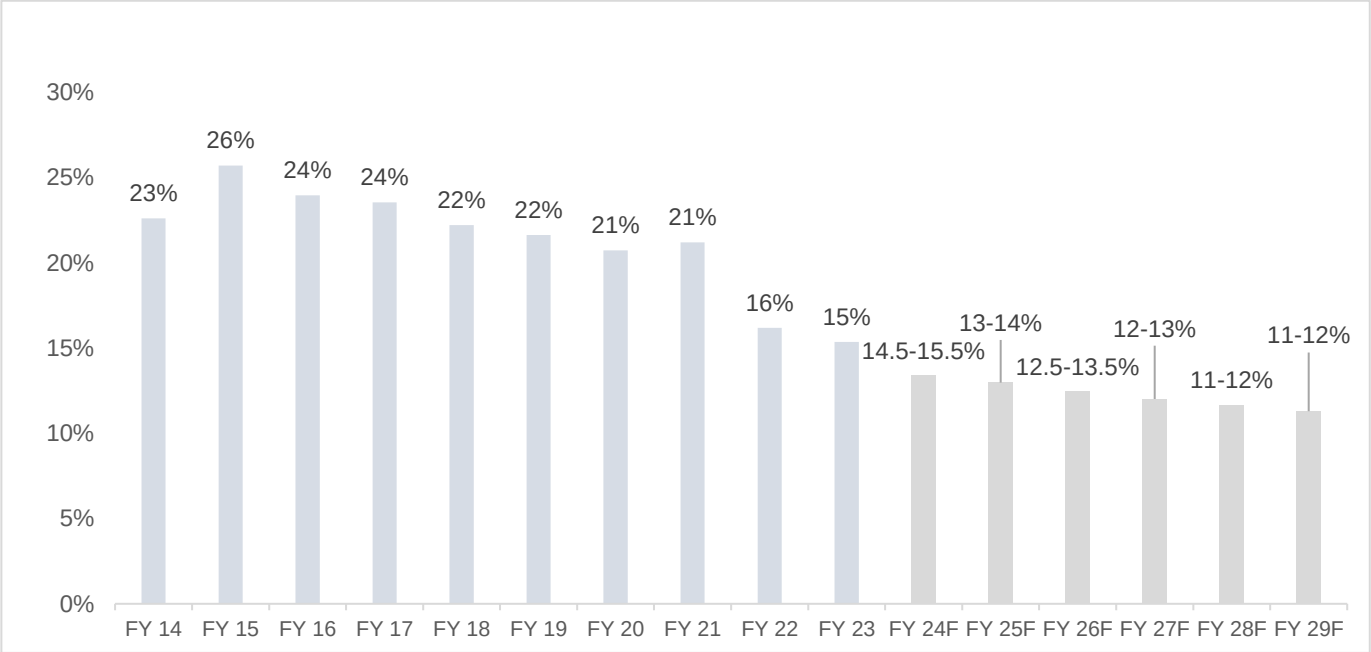
Table 18: ~Rs 2.5 trillion allocated for loss reduction and smart metering under RDSS

State	Smart meter (₹billion)	Loss reduction (₹billion)
Andaman & Nicobar Islands	0.54	4.52
Andhra Pradesh	41.28	92.93
Arunachal Pradesh	1.84	9.23

Assam	40.50	26.09
Bihar	20.21	70.81
Chhattisgarh	41.05	35.98
Delhi	0.12	3.24
Goa	4.69	2.47
Gujarat	106.42	60.21
Haryana	0	31.58
Himachal Pradesh	17.88	22.81
J&K	10.64	46.36
Jharkhand	8.58	32.62
Kerala	82.31	23.47
Ladakh	0	8.76
Madhya Pradesh	87.69	94.03
Maharashtra	152.15	141.58
Manipur	1.21	4.01
Meghalaya	3.10	7.96
Mizoram	1.82	2.37
Nagaland	2.08	3.91
Puducherry	2.51	0.84
Punjab	57.69	38.73
Rajasthan	97.15	93.71
Sikkim	0.97	3.98
Tamil Nadu	192.35	90.66
Tripura	3.19	4.85
UP	189.56	170.90
Uttarakhand	10.51	16.83
West Bengal	126.70	72.23
Total	**1,304.74**	**1,217.78**

Source: CRISIL MI&A Research

Figure 42: AT&C loss trajectory



Source: CEA, CRISIL MI&A Research

Under RDSS, discoms will be assessed annually on their performance based on an evaluation matrix. Before being considered for evaluation, the discom needs to meet the following pre-qualification criteria:

- Audited annual accounts by December-end of the following year during the first two years of operation of the scheme (Fiscals 2022 and 2023); thereafter, audited annual accounts by September-end of the following year from the third year onwards
- Quarterly un-audited accounts within 60 days of the end of each quarter during the first two years of the scheme's operation (Fiscals 2022 and 2023); thereafter, audited quarterly accounts within 45 days from the third year onwards
- Ensure that no new regulatory asset has been created in the latest tariff determination cycle
- State government to ensure 100% payment of subsidy for the previous year and advance payment of subsidy up to current period in line with Section 65 of EA 2003, and wipe out the remaining subsidy amount by the end of the project period
- All government departments/ attached offices/ local bodies/ autonomous bodies/ boards/ corporations have made 100% payment of current electricity dues for the year under evaluation
- Number of days payable to creditors, including generation companies, for the year under evaluation is equal to or less than the projected trajectory as per results of the evaluation framework
- Tariff order for the current year in which evaluation is being done and true-up of penultimate year has been issued and implemented w.e.f. April 1 of the respective current Fiscal.

Subsidy payment and the state government department's electricity dues form a significant chunk of overall receivables for discoms, which impacts AT&C losses. With RDSS aiming to do away with all subsidy arrears and receivables and ensuring timely electricity payment by state government departments, AT&C loss is targeted to be contained at 15% by Fiscal 2027.

Debt and regulatory assets

Table 19: Debt and regulatory assets across 10 states as of Fiscal 2023

States	Regulatory asset (Rs billion)	Debt (Rs billion)
Madhya Pradesh	-	490.53
Tamil Nadu	-	482.72
Gujarat	-	110.08
Karnataka	28.44	343.03
Bihar	-	104.78
Rajasthan	-	727.80
Maharashtra	396.39	601.16
Andhra Pradesh	-	510.51
Telangana	-	300.50
Uttar Pradesh	-	716.74

Source- CRISIL MI&A Research

When a regulatory commission acknowledges the gap in cost of supply and revenue and allows discoms to recover this through future tariff hike, the gap is registered as regulatory asset. Regulatory assets of key states stand at Rs 0.42 trillion in Fiscal 2023. This remains huge pain point for the sector since these are accounted as receivables without any solid action plan of liquidating these assets.

Discoms in four states – Maharashtra, Uttar Pradesh, Rajasthan and Andhra Pradesh – together held nearly 37% of the sector's debt of Rs 6.8 trillion in Fiscal 2023. Debt in Fiscal 2023 grew 9% over Fiscal 2022.

Module 5 - Smart meters

Drivers for smart metering in India

A well-functioning distribution infrastructure is essential for the success of a modern economy. Availability of reliable, quality and affordable power 24x7 is key to the country's economic development.

The Indian government has been working relentlessly to assist the states and discoms through various schemes since 2014, namely Deen Dayal Upadhyaya Gram Jyoti Yojana ("DDUGJY"); Pradhan Mantri Sahaj Bijli Har Ghar Yojana ("SAUBHAGYA"); and Integrated Power Development Scheme ("IPDS"). The distribution system has been strengthened under the DDUGJY and IPDS in rural and urban areas, respectively. As a result of the implementation of these schemes, India has achieved universal electricity access by connecting ~27 million households in 18 months under Saubhagya. This was the largest expansion of access anywhere in the world in such a short time frame. Implementation of these schemes has also improved access to electricity. Steps have been taken for automation and use of information technology in the distribution sector under IPDS and R-APDRP, which includes the establishment of data centres, GIS mapping of consumers, asset mapping, online energy auditing and accounting, consumer care centres, AMI meters on feeders and distribution transformers, provision of smart metering to reduce losses, etc., in urban areas.

Despite the above measures, consumers do not get reliable 24x7 electricity in many parts of the country. Aggregate Technical & Commercial ("AT&C") losses and the average cost of supply-average revenue realised ("ACS-ARR") gap remains high. This sub-optimal performance of the distribution sector is owing to structural and management deficiencies and some remaining weakness in the infrastructure.

One way to improve the operational efficiencies of discoms, maintain their financial sustainability and improve consumer services is through installation of smart meters. A smart meter is a digital meter that replaces old analog meters used in homes to record electrical usage. These digital meters can transmit energy consumption information to the utility (since they are connected to the internet) at frequent intervals, and can monitor consumption more precisely, thereby enabling more informed energy choices. These meters nullify power theft and help improve a discom's billing efficiency.

Policies and regulations

The Central Electricity Authority of India notified Installation and Operation of Meters (Amendment) Regulations, 2019, on December 23, 2019. Further amendments to this were announced with the Installation and Operation of Meters (Amendment) Regulations, 2022, on February 28, 2022. These amendments stipulated that all new consumer meters would be smart meters with prepayment feature. Further, existing meters, other than smart meters, were to be replaced with smart meters with a prepayment feature within a time frame as specified by the central government.

The Ministry of Power ("GoI") notified the timelines for installation of smart meters vide its Gazette notifications dated August 17, 2021, and May 23, 2022. The amendment has mandated the installation in phases (as per timelines stipulated under the RDSS scheme) for all discoms irrespective of their participation in the RDSS scheme.

State-wise smart meter investment and installation plan

As per RDSS guidelines, the implementation of smart meters would be taken up in mission mode in identified contiguous areas. The guidelines state that installation would be taken up in two phases—the first phase is to be completed by December 2023, where the following areas will be taken up on priority. However, the scheme is running delayed:

- All union territories
- All electricity divisions of 500 Atal Mission for Rejuvenation and Urban Transformation ("AMRUT) cities, with AT&C Losses >15% in the base year
- Industrial and commercial consumers
- All government offices at the block level and above
- Other areas with high losses, which would mandatorily include electricity divisions having more than 50% consumers in urban areas and with AT&C losses more than 15% and other electricity divisions with more than 25% AT&C losses

The second phase is to be completed by March 2025 and will include consumers in electricity divisions with more than 50% consumers in urban areas and with AT&C losses of 15% or less; and other electricity divisions with AT&C losses of 25% or less.

Under the RDSS, states have been sanctioned an amount for smart metering works as shown below:

Table 20: State-wise sanctioned amount for smart meters under RDSS as of December 2023

State	Sanctioned cost of smart metering (₹ billion)	No of sanctioned smart meters (million)
Arunachal Pradesh	1.84	0.3
Andhra Pradesh	41.28	5.7
Assam	40.50	6.4
Bihar	20.21	2.4
Chhattisgarh	41.05	6.0
Goa	4.69	0.7
Gujarat	106.42	16.5
Haryana	-	-
Himachal Pradesh	17.88	2.8
J&K	10.64	1.5
Kerala	82.31	13.2

Madhya Pradesh	87.69	12.9
Maharashtra	152.15	23.5
Manipur	1.21	0.2
Meghalaya	3.10	0.5
Mizoram	1.82	0.3
Nagaland	2.08	0.3
Puducherry	2.51	0.4
Punjab	57.69	8.7
Rajasthan	97.15	14.2
Sikkim	0.97	0.1
Tamil Nadu	192.35	30
Tripura	3.19	0.5
UP	189.56	26.9
Uttarakhand	10.51	1.6
West Bengal	126.70	20.7

Source: CRISIL MI&A Research

While guidelines have given a clear timeline for installation of smart meters, execution will likely spill over to subsequent Fiscal. We expect an investment of Rs 400-450 billion for installation of a total of 140-150 million smart meters in the country over Fiscals 2024-2028. Uttar Pradesh, Bihar, and Maharashtra will lead investment with 16%, 13% and 10% share, respectively.

Table 21: Smart meter installation trajectory

	FY24E	FY25F	FY26F	FY27F	FY28F
Smart meter additions (million)	3.9	17.5	29.9	41	48.1

Source- CRISIL MI&A Research

Table 22: Smart meter investment trajectory

	FY24E	FY25F	FY26F	FY27F	FY28F
Investments in smart meter installation (Rs billion)	10.99	42.22	79.60	126.63	172.58

Source- CRISIL MI&A Research

Table 23: Top 10 states to see investment of Rs 280-300 billion for smart meter installation by Fiscal 2028

States	Investments during FY24-FY28P (Rs billion)

Uttar Pradesh	65-70
Bihar	53-58
Maharashtra	40-45
Rajasthan	27-32
Gujarat	21-26
Madhya Pradesh	21-26
Tamil Nadu	19-24
Andhra Pradesh	13-18
Karnataka	5-10
Telangana	2-7
Total	**280-300**

Source: CRISIL MI&A Research

The top 10 states are expected to add 95-100 million smart meters between Fiscals 2024 and 2028 with an investment of Rs 280-300 billion. The additions will be driven by the central RDSS to reduce high inefficiencies. Therefore, a part of the investment requirement will also flow through central grants under the RDSS to ease the financial burden on discoms (distribution companies). Bihar is expected to lead the additions, amounting to comparatively high investment quantum of Rs 53-58 billion, an investment higher than the four states in the southern region. The western pool of Gujarat, Madhya Pradesh, and Maharashtra are expected to invest Rs 87-92 billion.

Emerging business models

Smart meters in India are being installed under two modes of operation—total expenditure (totex) and operational expenditure (opex).

RDSS has recommended implementation in totex mode through PPP. Under this mode, a service provider (“AMISP”) will supply, maintain and operate the metering infrastructure. It will make both capital and operational expenditure under design, build, fund, own, operate, and transfer (“DBFOOT”) or similar modes and will be paid for a portion of its capital expenditure initially, with the remaining payment made over the O&M period.

Under the opex mode, a single agency (“AMISP”) contracted will incur both capex and opex during the built-up and O&M phases. The discom will then pay the agency a cost per meter every month over the recovery period (usually up to 7-8 years).

As per the RDSS scheme, the discom is to receive budgetary support from the central government which will be 15% of the approved cost for metering works, including the operational cost, subject to a maximum of Rs 900 per consumer prepaid smart meter. The remaining amount will be paid by the discoms over the O&M period. As part of the main features and guidance notes of the standard bid document (“SBD”) for appointment of advanced metering

infrastructure service provider for smart prepaid metering in India, issued by the government on October 22, 2021, under the RDSS scheme, the accounting process of AMISP payment will be as follows:

- *Transaction nature*: Payment to the AMISP by the discom will be considered as an operational expenditure on the discom's account
- *Regulatory treatment*: The discom is to consider AMISP payments as opex, while filing ARR and a tariff review petition to the state electricity regulatory commission ("SERC").

Almost all states are to opt for the totex mode for the smart metering scheme under RDSS.

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