Crisil
Intelligence

## Juniper Green Energy Ltd.

# Assessment of Indian power and renewable energy market

## Final Report

### June 2025

by S&P Global

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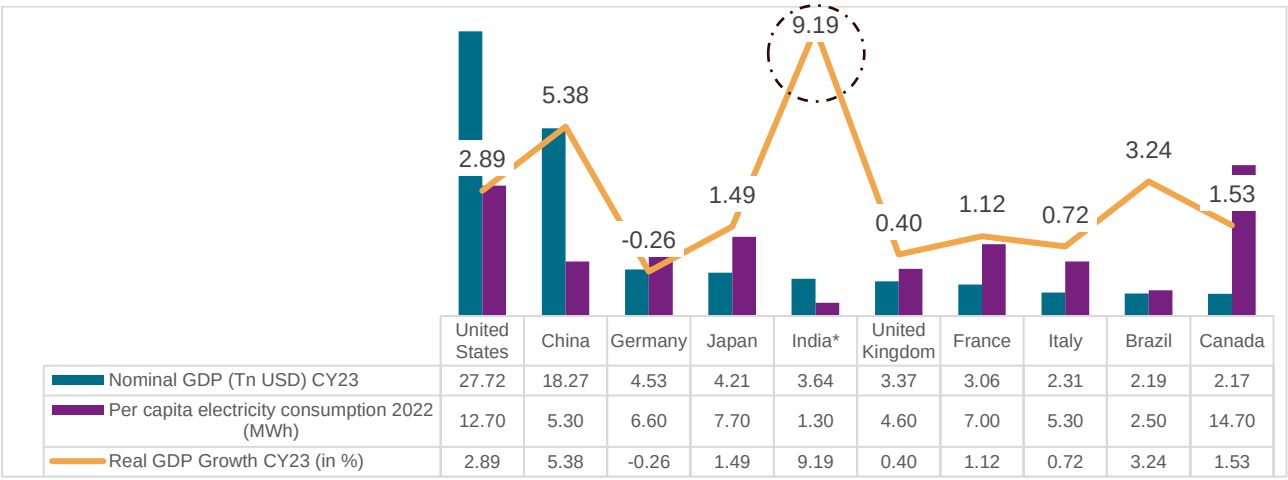
# 1 Macroeconomic Overview

## 1.1 Economic indicators

India became the fifth largest economy in the world in fiscal 2023, according to the International Monetary Fund's (IMF) World Economic Outlook (April 2024). As per IMF GDP Forecasts (April 2025), India's gross domestic product (GDP) growth is estimated at 6.20% in fiscal 2026, the highest among the top 10 economies. Additionally, World Bank has forecasted India's GDP to grow at 6.30% in fiscal 2026.

India's GDP at constant (fiscal 2012) prices was ₹ 176.51 trillion (first revised estimates) for fiscal 2024 vis-à-vis the final estimates of ₹ 161.65 trillion for fiscal 2023 as per data released by the National Statistical Office (NSO) in May 2025. This translates into a growth of 9.19% over fiscal 2023. As per provisional estimates by NSO, India's real GDP is estimated to grow at 6.49% in fiscal 2025. India's real GDP in fiscal 2025 at Constant Prices is estimated to attain a level of ₹187.97 trillion in fiscal 2025.

**Figure 1: Comparison of India's economy with other major nations**




| | United States | China | Germany | Japan | India* | United Kingdom | France | Italy | Brazil | Canada |
|---|---|---|---|---|---|---|---|---|---|---|
| Nominal GDP (Tn USD) CY23 | 27.72 | 18.27 | 4.53 | 4.21 | 3.64 | 3.37 | 3.06 | 2.31 | 2.19 | 2.17 |
| Per capita electricity consumption 2022 (MWh) | 12.70 | 5.30 | 6.60 | 7.70 | 1.30 | 4.60 | 7.00 | 5.30 | 2.50 | 14.70 |
| Real GDP Growth CY23 (in %) | 2.89 | 5.38 | -0.26 | 1.49 | 9.19 | 0.40 | 1.12 | 0.72 | 3.24 | 1.53 |

*Note: India GDP data as of May 2025 as per NSO for Financial Year 2024,*

*Source: World Economic Outlook Database (April 2025) by IMF; International Energy Agency (IEA), Central Electricity Authority of India (CEA), Crisil Intelligence*

Indian GDP has been growing consistently. In the last 10 years, except for years affected by the COVID-19 pandemic, India's growth has been highest amongst the top 10 economies. In April 2025, the IMF released World Economic Outlook (WEO). As per the IMF, economic activity was resilient through the global disinflation of calendar year (CY) 2022–23. Further, as per WEO (April 2025), the IMF estimated global growth to drop to 2.8% in 2025 and 3% in 2026—down from 3.3% for both years in the January 2025 WEO update. For India, the growth outlook is relatively more stable at 6.2% in 2025, supported by private consumption, particularly in rural areas, but this rate is 0.3% point lower than that in the January 2025 WEO Update on account of higher levels of geopolitics and conflicts.

**Table 1: Real GDP annual growth forecast of major economies (figures in %)**

| Country | CY24 | CY25 (P) | CY26 (P) | CY27 (P) | CY28 (P) | CY29 (P) | CY30 (P) |
|---|---|---|---|---|---|---|---|
| Brazil | 3.24 | 3.40 | 2.01 | 1.98 | 2.19 | 2.31 | 2.43 |
| Canada | 1.53 | 1.53 | 1.38 | 1.56 | 1.71 | 1.58 | 1.64 |
| China | 5.38 | 5.00 | 3.95 | 3.96 | 4.22 | 4.06 | 3.70 |
| France | 1.12 | 1.07 | 0.64 | 1.02 | 1.19 | 1.26 | 1.21 |
| Germany | -0.26 | -0.23 | -0.05 | 0.92 | 1.45 | 1.20 | 0.95 |

| Country | CY24 | CY25 (P) | CY26 (P) | CY27 (P) | CY28 (P) | CY29 (P) | CY30 (P) |
|---|---|---|---|---|---|---|---|
| India* | 9.19 | 6.46 | 6.20 | 6.27 | 6.47 | 6.48 | 6.49 |
| Italy | 0.72 | 0.73 | 0.44 | 0.84 | 0.57 | 0.68 | 0.70 |
| Japan | 1.49 | 0.08 | 0.55 | 0.58 | 0.63 | 0.59 | 0.52 |
| United Kingdom | 0.40 | 1.10 | 1.08 | 1.41 | 1.54 | 1.46 | 1.44 |
| United States | 2.89 | 2.80 | 1.83 | 1.74 | 1.98 | 2.12 | 2.12 |

*Note: For India financial Year; (P): Projected*

*Source: World Economic Outlook Database (April 2025) by IMF; Crisil Intelligence*

After strong GDP print in the past three years, Crisil Intelligence[1] expects some moderation to 6.80% in fiscal 2025. The growth however will still be higher than the pre-pandemic decadal average of 6.70%, continuing to position India as the fastest growing major economy.

**Table 2: Crisil's key projections**

| Parameters | FY19 | FY20 | FY21 | FY22 | FY23 | FY24 | FY25E | FY26P |
|---|---|---|---|---|---|---|---|---|
| GDP growth (%) | 6.45% | 3.87% | -5.78% | 9.69% | 6.99% | 8.15% | 6.80% | 6.50% |
| CPI (%, average) | 3.41% | 4.77% | 6.16% | 5.51% | 6.65% | 5.40% | 4.60% | 4.30% |
| CAD/GDP (%) | (2.12%) | (0.86%) | 0.92% | (1.23%) | (1.98%) | (0.65%) | (1.00%) | (1.30%) |
| FAD/GDP (%) | 3.44% | 4.65% | 9.20% | 6.70% | 6.40% | 5.60% | 4.80%# | 4.40%# |
| Exchange rate (₹/USD March-end) | 69.17 | 75.39 | 73.50 | 75.81 | 82.22 | 83.37 | 85.58 | 88.00 |
| 10-year G-sec yield (%, March-end) | 7.50% | 6.20% | 6.20% | 6.80% | 7.40% | 7.10% | 6.70% | 6.40% |

*E: Estimated; P: Projected; CPI: Consumer Price Index-linked; CAD: Current account deficit; G-sec: Government security; FAD: Fiscal account deficit*

*#Budget estimates*

*Source: Central Statistics Office (CSO), Reserve Bank of India (RBI), Crisil estimates*

## 1.2 Per capita electricity consumption

With a growing economy and strong GDP growth, the per capita electricity consumption is also expected to grow substantially.

As per the CEA, the electricity consumption per person rose to 1,395 kWh in fiscal 2024 (provisional data), from 1,010 kWh in fiscal 2015 at a CAGR of 3.65%, primarily led by increasing economic activities, rising domestic consumption, rural and household electrification.

As seen in **Figure 1**, despite this healthy increase, the per-capita electricity consumption remains significantly lower than in other major economies. Developing countries, such as Brazil and China, have significantly higher per-capita electricity consumption than India.

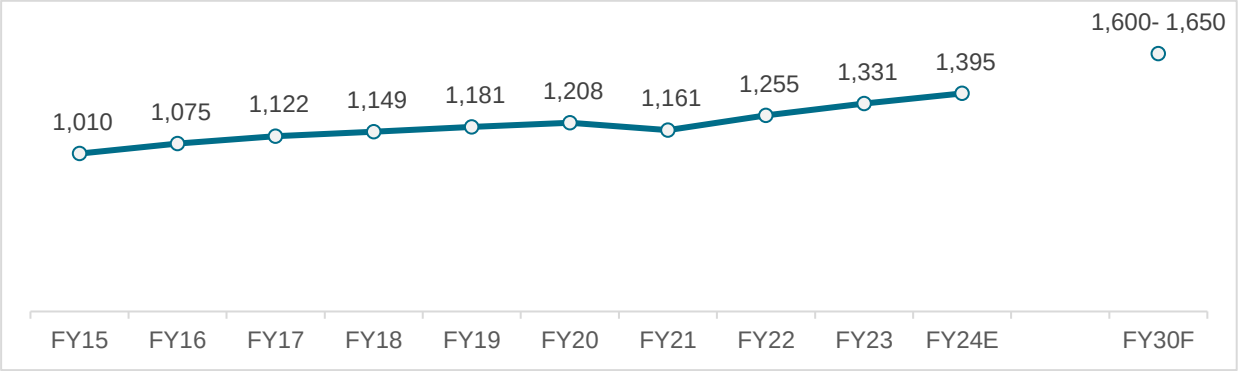
Between fiscals 2024 and 2030, India's per capita electricity consumption is expected to grow at 2.50%-3.00% CAGR. Per capita consumption is expected to gradually improve in the long term as well, as power demand picks up on the back of improvements in access to electricity, in terms of quality and reliability, rising per capital income, increasing electric vehicles (EV) penetration, demand from data centers, railway electrification, intensive rural electrification, resulting in the realisation of latent demand from the residential

[1] Based on Crisil Centre for Economic Research (C-CER) projections
Projections of key economic indicators for India in this Chapter are as per the C-CER

segment, increased penetration of consumer durables. Consequently, Crisil Intelligence expects per capita electricity consumption to reach 1,600-1,650 kWh by fiscal 2030.

With the per capita electricity consumption growing at 2.31% to 2.84%, the electricity demand is expected to grow by 5.70%-6.20% over the same period, underscoring the need for expanding power generation capacity and improving energy efficiency.

**Figure 2: Per capita electricity consumption (in kWh)**




*E: Estimated; F: Forecast*

*Source: CEA, Crisil Intelligence*

## 1.3 Aatmanirbhar Bharat Abhiyan

Production Linked Incentives (PLIs) in the 14 sectors for the *Aatmanirbhar Bharat* vision received an outstanding response, with the potential to create 6 million new jobs (as per government estimates).

The five focus points of the *Aatmanirbhar Bharat Abhiyan* are economy, infrastructure, system, vibrant demography, and demand. Its five phases are:

- Phase I: Businesses including Micro, Small and Medium Enterprises (MSMEs)
- Phase II: Poor, including migrants and farmers.
- Phase III: Agriculture
- Phase IV: New horizons of growth
- Phase V: Government reforms and enablers

**Table 3: Sector-wise focus of *Aatmanirbhar Bharat* Vision**

| Sector | Government spends | Key schemes |
|---|---|---|
| Renewable energy | ~₹ 1,300 billion | • ₹ 45 billion Production Linked Incentive (PLI) Scheme 'National Programme on High Efficiency Solar PV Modules'. This was further increased by ₹ 195 billion in the budget for fiscal 2023, taking it to ₹ 240 billion; in tranche I 8.7 GW and in tranche II 39.6 GW capacity were allocated for domestic solar module manufacturing capacity under the PLI scheme.<br>• PM Surya Ghar Muft Bijli Yojna: This scheme has a proposed outlay of ₹ 750 billion and aims to light up 10 million households (rooftop solar) by providing up to 300 units of free electricity every month. |

| Sector | Government spends | Key schemes |
|---|---|---|
| | | • Public procurement (preference for 'Make in India') to provide for purchase preference (linked with local content) in respect of renewable energy (RE) sector<br>• Implementation of Pradhan Mantri Kisan Urja Suraksha Utthan Mahabhiyan (PM KUSUM) scheme; Ministry of New and Renewable Energy (MNRE), in November 2020, scaled up and expanded the PM KUSUM scheme to add 30.8 GW by 2022 with central financial support of ₹ 344 billion. The scheme has been extended till 31 March 2026<br>• Approved Models & Manufacturers of Solar Photovoltaic Modules (Requirement for Compulsory Registration) Order, 2019<br>• List of manufacturers and models of solar PV modules recommended under Approved Models and Manufacturers of Solar Photovoltaic Module (ALMM) order<br>• Scheme of grid connected wind-solar hybrid (WSH) power projects<br>• Basic customs duty (BCD) of 25% on solar cells and 40% on modules, respectively, effective 1 April 2022 |
| Power distribution companies (Discoms) | ~₹ 970 billion | • ₹ 1.35 trillion liquidity infusion for Discoms via Power Finance Corporation/ Rural Electrification Corporation (PFC/ REC) against receivables<br>• Rebate for payment to be received by generation companies (gencos) to be passed on to industrial customers<br>• Revamped distribution sector scheme (RDSS) to help Discoms improve their operational efficiencies and financial sustainability by providing result-linked financial assistance; outlay of ₹ 3,037.58 billion over 5 years i.e., fiscals 2022 to 2026. The outlay includes an estimated government budgetary support of ₹ 976.31 billion. |
| New energy | ~₹ 388 billion | • ₹ 181 billion under PLI scheme for Advanced Chemistry Cell (ACC) Battery Storage in India launched in May 2021 to achieve 50 GWh manufacturing capacity<br>• Green Hydrogen Policy launched in February 2022 to facilitate production of green hydrogen/green ammonia<br>• PLI scheme on green hydrogen manufacturing with an initial outlay of ₹ 197.44 billion with an aim to boost domestic production of green hydrogen<br>• BCD exemption on critical minerals (cobalt, lead, zinc, etc.), scrap of lithium-ion batteries proposed in Budget 2025-26 |

*Source:, Press Information Bureau (PIB) press releases, Crisil Intelligence*

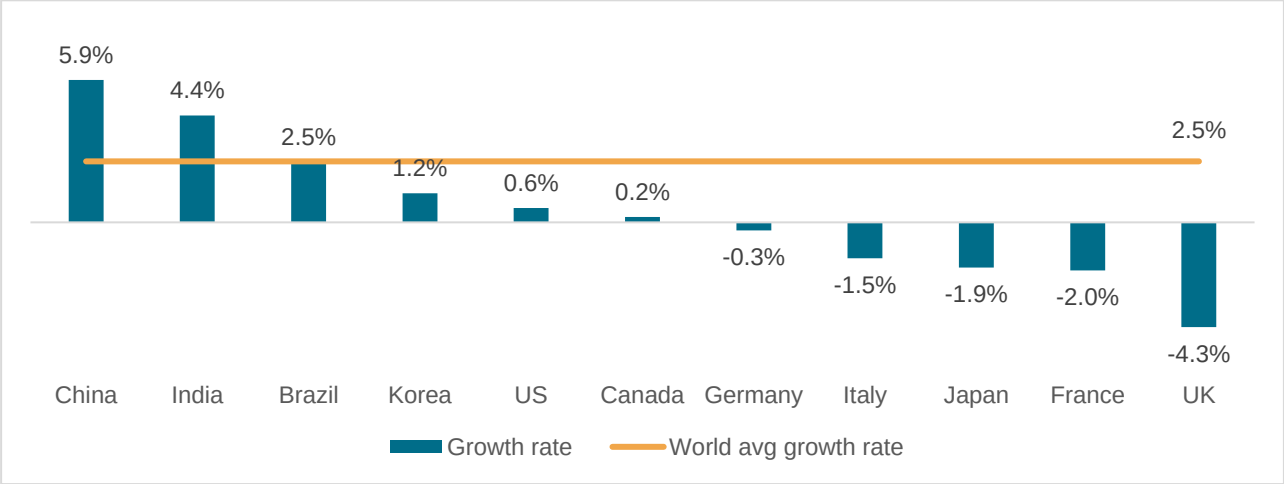
# 2 Overview of Indian power sector

## 2.1 Global growth

The global electricity demand has experienced a CAGR of 2.5% from CY 2019 to CY 2023. However, this growth has been unevenly distributed, with countries like China and India driving the increase with growth rates of 5.9% and 4.4%, respectively, during the same period. In contrast, advanced economies such as France, Germany, the UK, and Italy have seen their electricity demand decline, largely due to a sluggish macroeconomic environment and high inflation, which has negatively impacted manufacturing and industrial output.

The US also experienced a 1.04% decline in electricity demand in CY 2023 and the overall growth rate of only 0.6% between CY 2019 and CY 2023, attributed to milder weather and a slowdown in the manufacturing sector. Similarly, the European Union witnessed a second consecutive year of declining electricity demand in CY 2023, primarily driven by reduced consumption in the industrial sector, where energy prices, although lower, remained above pre-pandemic levels, leading to signs of permanent demand destruction in energy-intensive sectors like chemicals and primary metal production.

**Figure 3: Electricity demand growth rate CAGR (2019-23)**



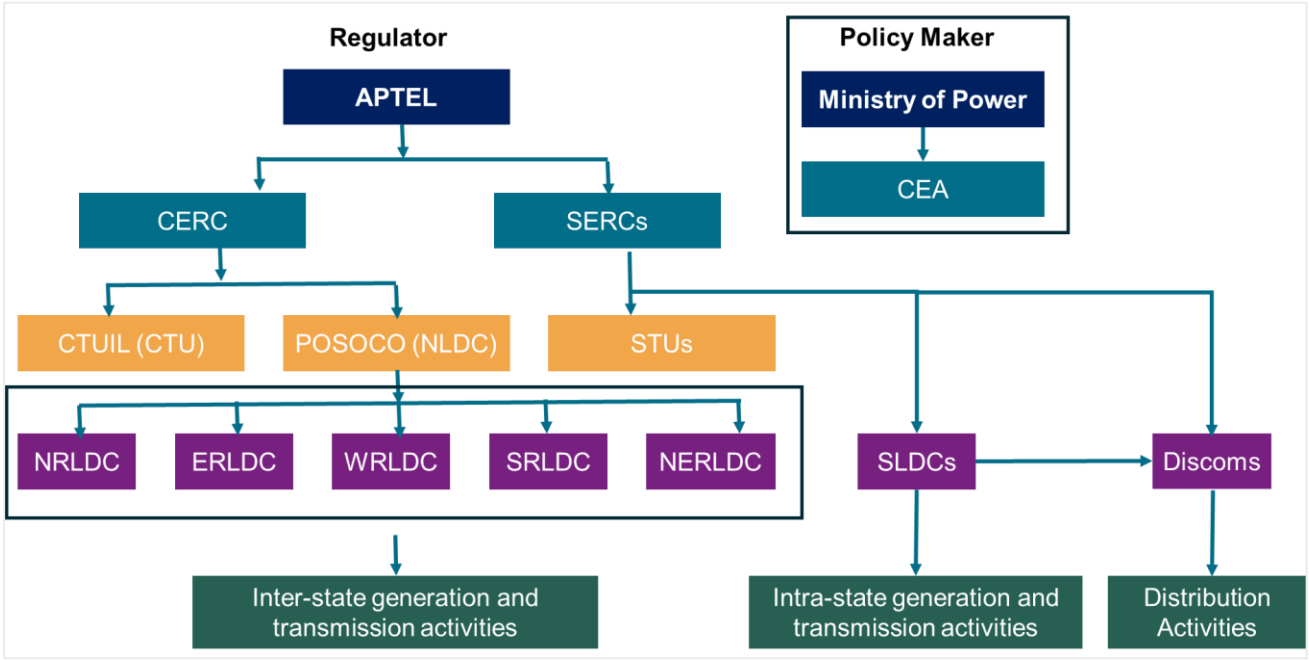

*Source: IEA, Crisil Intelligence*

## 2.2 Regulatory framework

India has a widespread power network with interconnected regional grids. The power generation profile is dominated by conventional (coal, lignite, natural gas, oil, hydro and nuclear power) sources, although, non-conventional sources (such as wind, solar, and biomass and municipal waste) are rapidly gaining traction. Transmission and Distribution infrastructure has expanded over the years for evacuation of power from generating stations to load centres through the intra-state and inter-state transmission system (ISTS).

The sector is highly regulated, with various functions being distributed between multiple implementing agencies. There are three chief architects of the sector namely the Central Electricity Regulatory Commission (CERC), the Central Electricity Authority (CEA), and the State Electricity Regulatory Commissions (SERCs).

**Figure 4: Institutional and structural framework**

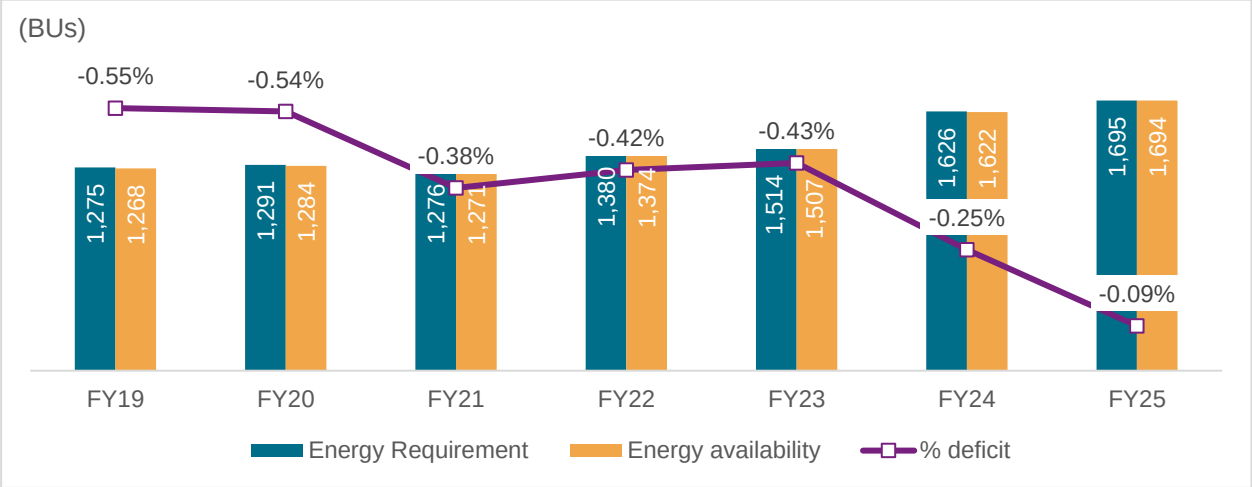



*Note:*
*APTEL - The Appellate Tribunal for Electricity; CERC- Central Electricity Regulatory Commission; CEA- Central Electricity Authority; WRLDC- Western Regional Load Despatch Centre; ERLDC- Eastern Regional Load Despatch Centre; SRLDC- Southern Regional Load Despatch Centre; NLDC: National Load Despatch Centre (Now called as GRID-INDIA); NRLDC- Northern Regional Load Despatch Centre; NERLDC- North-Eastern Regional Load Despatch Centre.*
*SLDC- State Load Despatch Centre; CTU- Central Transmission Utility; STU- State Transmission Utility. Discoms: Distribution Companies*
*Source: Crisil Intelligence*

## 2.3 Demand-Supply Scenario

India's electricity requirement has risen at a CAGR of 4.86% between fiscals 2019 and 2025 with the growth increasing substantially to 7.37% in the post pandemic period between fiscals 2021 and 2025. The electricity availability has kept pace with the demand growing at a similar CAGR of 4.94% between fiscals 2019 and 2025 on the back of strong capacity additions, both in the generation and transmission segments. The energy deficit declined to 0.25% in fiscal 2024 and 0.09% in fiscal 2025 from 0.55% in fiscal 2019 due to an increase in capacity addition growth of 4.91% over the same period. Strengthening of inter-regional power transmission capacity over the past five years has supported the rapid fall in deficit levels as it reduced supply constraints on account of congestion and lower transmission corridor availability, thereby lowering the deficit to 0.09% in fiscal 2025.

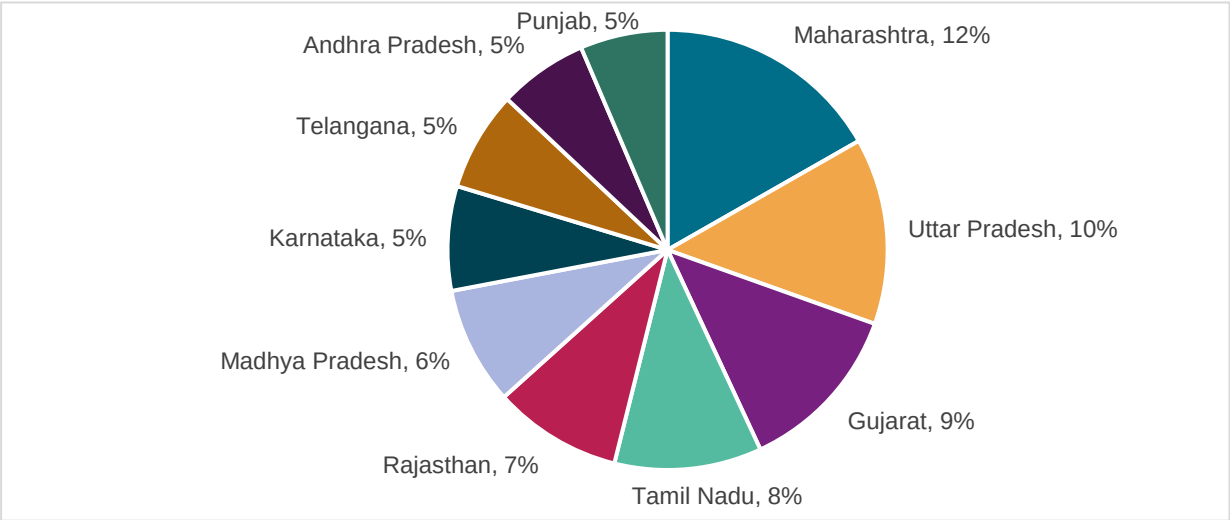
**Figure 5: Aggregate power demand supply**




*Source: CEA, Crisil Intelligence*

Following chart indicates that States namely Maharashtra, Uttar Pradesh, Gujarat and Tamil Nadu have significant energy requirements due to increased urbanisation and industrialisation.

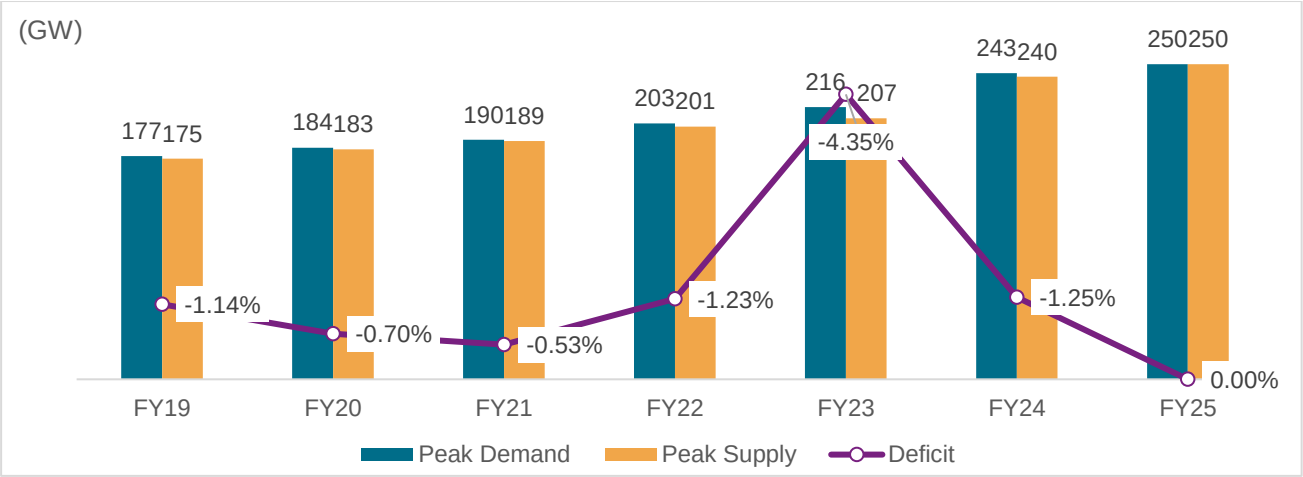
**Figure 6: Energy Requirement by leading States in terms of BUs**




*Source: CEA, Crisil Intelligence*

Peak electricity demand in India has grown from 177 GW in fiscal 2019 to 250 GW in fiscal 2025 clocking an average growth rate of 5.92%. 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 last decade. In Q1 fiscal 2025, power demand surged by 13% on year led by heatwaves and a 6.70% on year growth in GDP. Prolonged and severe heatwaves were especially prominent in the northern part of the country which was also impacted by deficient rainfall in July 2024.

**Figure 7: Peak power demand and supply**



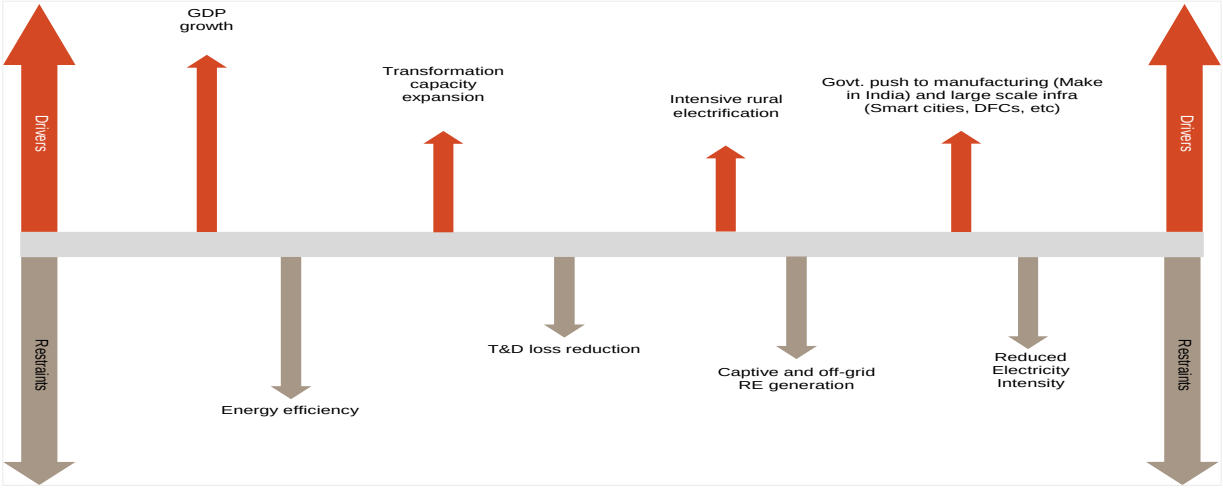

*Source: CEA, Crisil Intelligence*

# 2.4 Power sector growth outlook

## 2.4.1 Long-term drivers and constraints for demand growth

Power demand is closely associated with a country's GDP. A booming economy automatically leads to a surge in power demand. India is already the fastest-growing economy in the world, with an average GDP growth of 5.50% over the past decade. The trickle-down effect of *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.

**Figure 8: Factors influencing power demand**




*Source: Crisil Intelligence*

Apart from macroeconomic factors, power demand would be further fueled by railway electrification, upcoming metro rail projects, growing demand for charging infrastructure due to increased adoption of electric vehicles, and higher demand from key infrastructure, manufacturing sectors and data centers. However, increasing energy efficiency, a reduction in technical losses over the longer term, and captive as well as off-grid generation from renewables would restrict growth in power demand.

**Railway electrification, metro rail projects and EV to drive a majority of incremental power demand**

Indian Railways has planned to become a net zero carbon emission emitter by CY2030. Therefore, the government aims to achieve 100% electrification by fiscal 2026. This leads to incremental power demand of around 27 billion units (BUs) on average every year between fiscals 2026 to 2030. Further, Metro rail has seen substantial growth in India in recent years, and the rate of growth is set to double or triple in the coming years, with multiple cities seeking metro rail services to meet daily mobility requirements. Around 990 km of metro rail is under construction and 1,980 km is proposed to be added. These developments are expected to add incremental power demand of 6-7 BUs every year on average between fiscals 2026 to 2030.

Further, EV charging requirements are likely to boost power demand over the medium term, with a gradual increase in the share of EVs in the vehicle population. Crisil Intelligence projects that the adoption of EVs will boost power demand by 8.5-9.5 BUs annually on average over fiscals 2026 to 2030.

**Energy efficiency and off-grid generation to limit power demand**

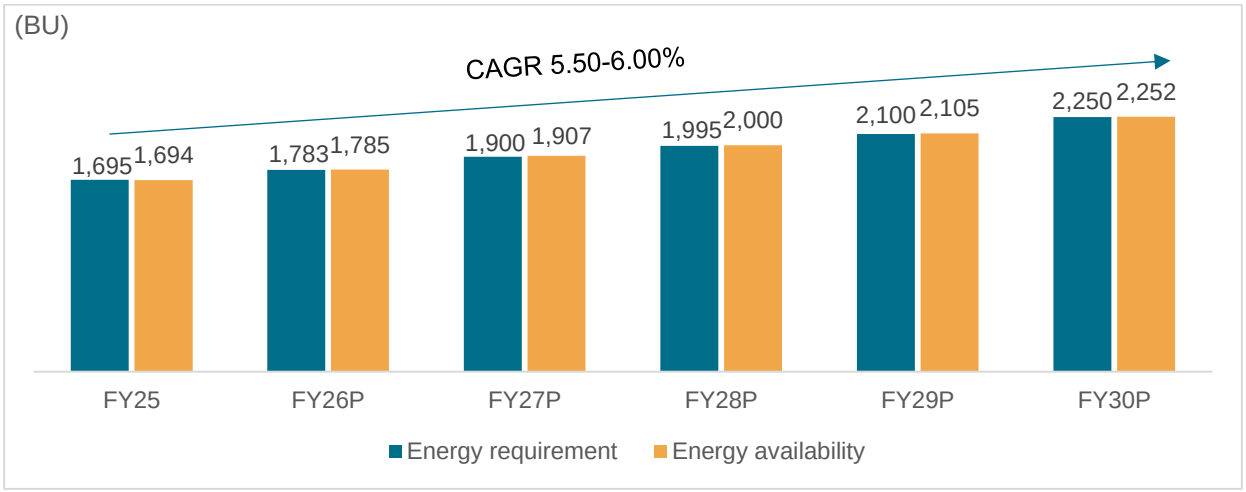
Transmision and distribution (T&D) losses have been declining, and the reduction in losses is expected to continue to be further aided by a slew of government measures, primarily the Revamped Distribution Sector Scheme (RDSS). RDSS is a reform-based and result-linked scheme for improving the quality and reliability of power supply to consumers through a financially sustainable and operationally efficient distribution sector. As a result, the power demand is expected to be reduced by 8-9 BUs on average every year between fiscals 2026 to 2030 owing to lower T&D losses.

Further, with a boost to rooftop solar and decentralized distributed generation, a reduction of 2-3% in base demand from the grid is expected with the addition of 49-50 GW of rooftop capacities by fiscal 2030. Industries are expected to add ~3-4 GW of captive capacity over the next five years, adding on average 290-300 BUs of demand over the period, which may lead to a reduction in demand from the grid.

### 2.4.2 Demand – Supply Forecast

Despite the high base of preceding three years (fiscals 2022 and 2025) with electricity demand growth at ~ 7.10%, Crisil Intelligence expects power demand to grow at a CAGR of 5.50-6.00% in the next five years which will be supported by infrastructure-linked capex, strong economic fundamentals along with expansion of the power footprint via strengthening of T&D infrastructure. This coupled with major reforms initiated by the GoI for improving the overall health of the power sector, particularly that of state distribution utilities, are expected to improve the quality of power supply, thereby propelling power demand.

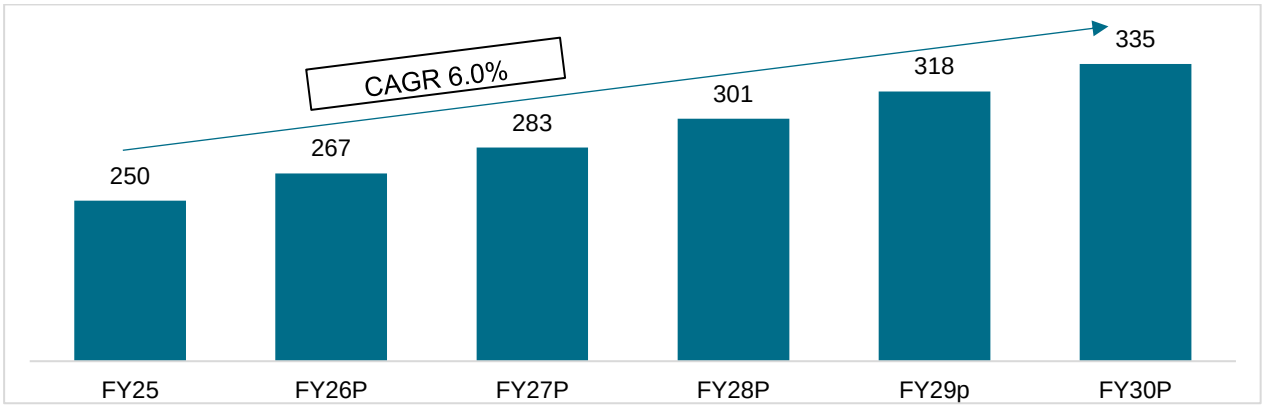
**Figure 9: Energy demand outlook (fiscals 2026-30)**




*P: Projected, Source: CEA, Crisil Intelligence*

Peak demand is expected to grow at an annual average CAGR of 6.00% over fiscal 2025 to fiscal 2030 to reach nearly 335 GW by fiscal 2030 with expected persistent high temperatures, rising urbanization, economic growth and infrastructure push leading to higher power consumption.

**Figure 10: Peak demand to increase by 85 GW between fiscals 2025 and 2030 to cross 300 GW**

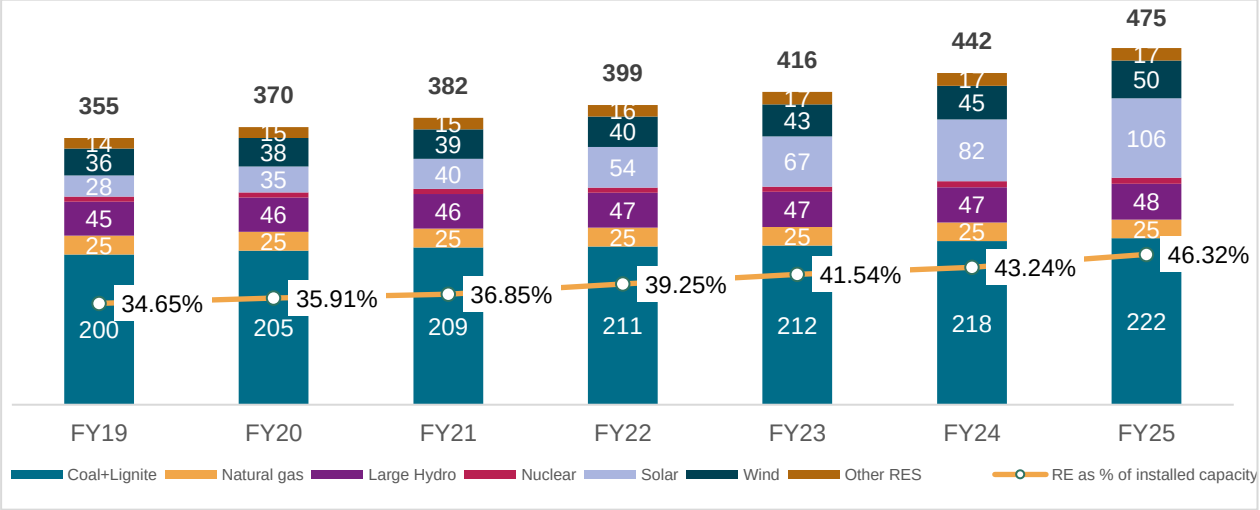



*P: Projected, Source: CEA, Crisil Intelligence*

## 2.4.3 Installed capacity

The total installed generation capacity as of fiscal 2025 was 475 GW, of which ~120 GW of capacity was added over fiscal 2019 to fiscal 2025. The overall installed generation capacity has grown at a CAGR of 4.93% over fiscals 2019– 25. Coal and Lignite-based installed power generation capacity has maintained its dominant position over the years and accounts for ~46.68% as of March 2025. However, RE installations (including large hydroelectric projects) have reached ~220 GW, compared with 63 GW as of March 2012, constituting ~46.32% of total installed generation capacity as of March 2025. This growth has been led by solar power, which rapidly rose to ~106 GW from 0.9 GW over the same period. The remaining 7.01% is from Gas, Diesel and Nuclear.

**Figure 11: Historical Fuel-wise installed capacity (GW)**




*Other Renewable energy sources (RES) include biogas, bagasse, small hydro and waste-to-energy*
*Source: CEA, Crisil Intelligence*

The share of renewable energy (including large hydro) in the total supply mix was ~17.28% in fiscal 2015, which has now increased to 22.13% in fiscal 2025. The RE generation (including large hydro) has increased at a CAGR of ~7.77% in the last 10 years. Share of thermal and nuclear sources was 77.87% in the total energy supplied as of fiscal 2025. The share of solar and wind energy was ~7.90% of the total energy supplied as of fiscal 2025. The share of large hydro was ~8.15% and the remaining 1.51% is from other RE sources.

## 2.4.4 Capacity addition outlook

As per Crisil Intelligence, India's installed power capacity is expected to reach 700-710 GW by fiscal 2030 from its current capacity of 475 GW in March 2025. This would require a net capacity addition of ~ 230 GW over the next 5 years.

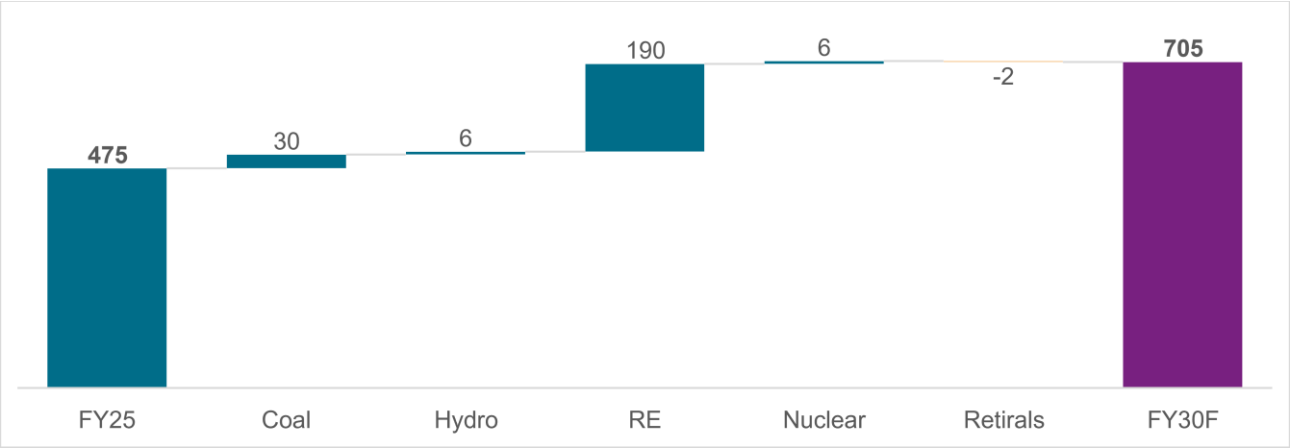
RE capacity (excl. large hydro) is expected to be the major contributor in the capacity addition with a share of ~ 190 GW. This explosive growth of ~ 40% in renewable energy capacity is expected to be driven by higher than decadal average power demand and various government initiatives, favourable policies, competitive tariffs, innovative tenders, development of solar parks and green energy corridors, etc. RE capacity is estimated to account for about 50% of the installed capacity of 700-710 GW by fiscal 2030. RE is expected to account for over 80% of the additional capacity between fiscal 2026 and 2030.

As per Crisil Intelligence estimates, the capacity additions in the conventional power generation segment are projected to be around 32-35 GW cumulatively from fiscals 2026 to 2030. Fresh project announcements are limited as players are opting for the inorganic route for expansion given the availability of assets at reasonable valuations, with 3.6 GW of stressed power assets awaiting debt resolution. Coal capacity additions are expected to be driven entirely by the central and state sectors, as major private gencos continue to focus on expanding RE capacity. 2-3 GW of coal-based capacity is expected to retire as per CEA's National Electricity Plan 2023.

Nuclear power capacity additions of 6-7 GW are expected during the period as ongoing projects at Kakrapara, Kalpakkam, and Rajasthan are nearing completion. Nine reactors with a total capacity of 7.3 GW are under construction which are expected to be commissioned by fiscal 2030.

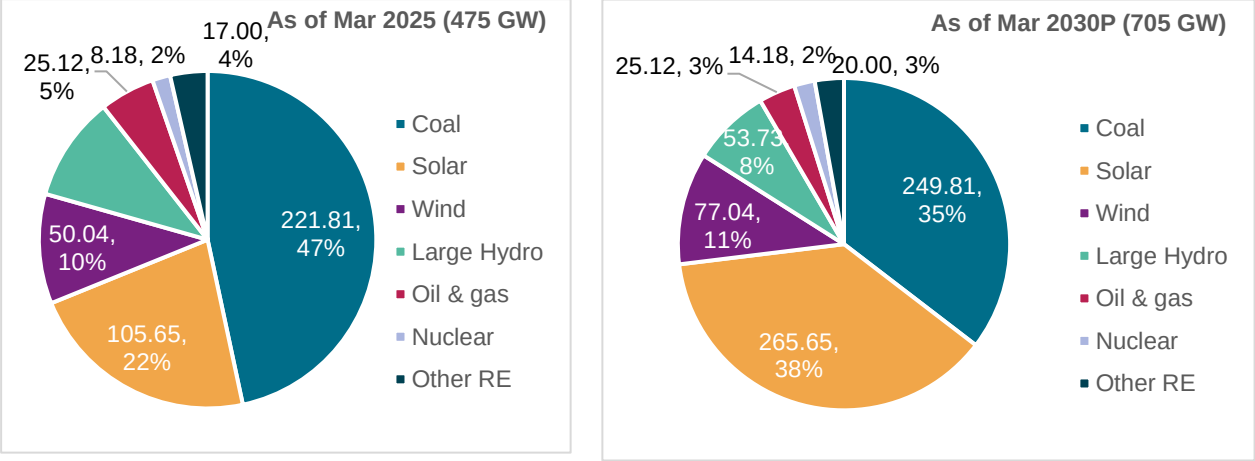
Crisil expects 6-7 GW of hydro power installations and 32-35 GW of energy storage solutions including 8.5-9.5 GW pumped hydro storage projects (PSP) capacity additions and 23-24 GW of Battery Energy storage system (BESS) over fiscals 2026-2030.

**Figure 12: All India installed estimated capacity addition by fiscal 2030 (in GW)**



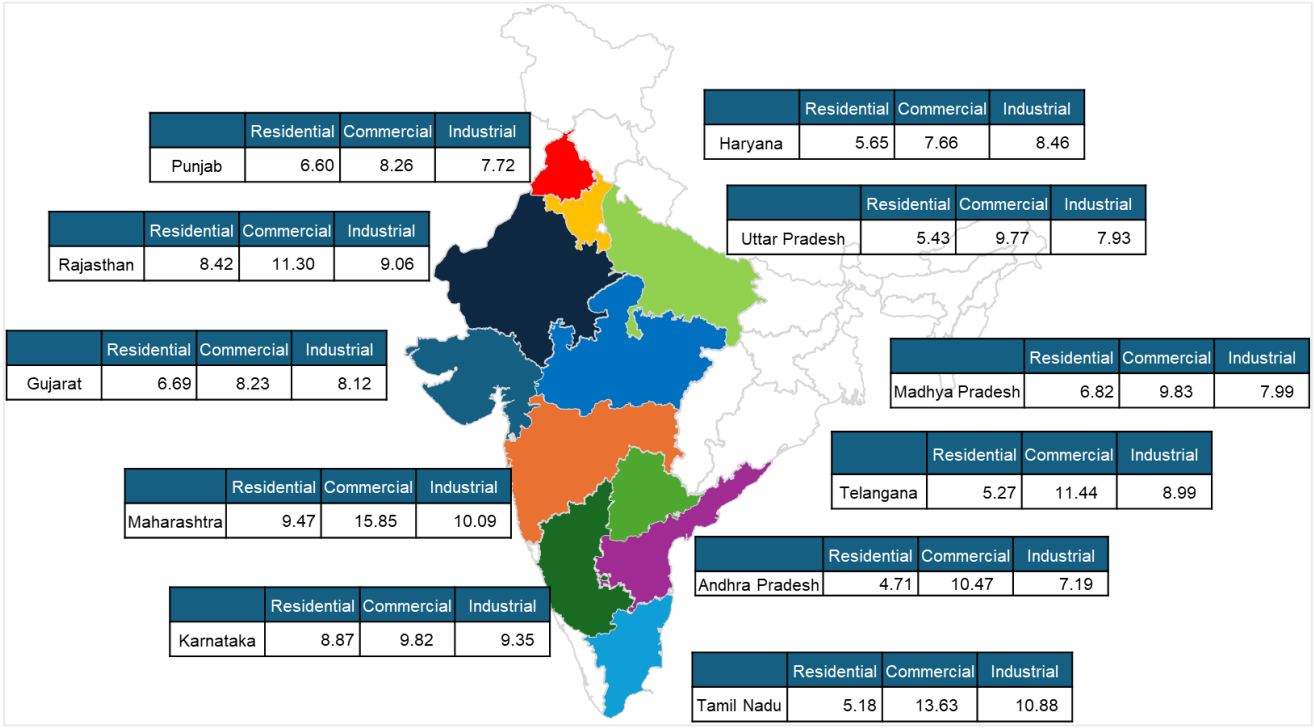

*RE includes solar, wind, small hydro, and other renewable sources*
*Source: CEA, Crisil Intelligence*

**Figure 13: Installed capacity breakup (GW, % share of total capacity)**




*P: Projected; Source: CEA, Crisil Intelligence*

**Figure 14: Due to cross subsidies C&I tariffs are higher than residential category (₹/kWh)**




*C&I: Commercial and industrial; Latest applicable average billing rates for respective category,*
*Source: Respective Tariff Orders of State Regulators, Crisil Intelligence*

## 2.5 Discom financial health

**Review of Aggregate technical and commercial (AT&C) loss and average cost of supply (ACS) - average revenue realised (ARR) gap of state Discoms**

Distribution is the final and critical link in the power sector value chain. However, the financial position of the distribution sector has significantly deteriorated over the past decade owing to irregular tariff hikes, high AT&C losses and delays in subsidy payments by state governments. This has adversely impacted power offtake by Discoms and led to delays in payments to generation companies. The Ujwal Discom Assurance Yojana ("UDAY") was launched by the Ministry of Power ("MoP") in November 2015 for improving the financial health and operational efficiency of state-owned Discoms across the country.

Outcomes of the operational improvements were measured through following indicators:

- Reduction of a AT&C losses to 15.00% in fiscal 2019 as per loss reduction trajectory to be finalized by the MoP and States
- Reduction in gap between average cost of supply and average revenue realized to zero by fiscal 2019 as finalized by the MoP and States.

States took over 75.00% of Discom debt as on 30 September 2015, over a period of two years, 50.00% in fiscal 2016 and 25.00% in fiscal 2017. The balance 25.00% (not taken over by the state) was to be converted by lenders into loans or bonds with an interest rate of not more than the banks' base rate plus 10 basis points ("**bps**"). Alternatively, this debt could be fully/partly issued by the Discoms as state guaranteed bonds at the prevailing market rates, which were to be equal to or less than the banks' base rate plus 10 bps. This is estimated to have aided in reduction of interest cost by 300 to 400 bps as the interest rate at which debt is

available to Discoms is 13-14%. As on the terminal year for the scheme, fiscal 2020, approximately ₹ 2.3 trillion worth of bonds had been issued (86.3% of target), which led to the debt and interest burden on Discoms being reduced, resulting in higher liquidity.

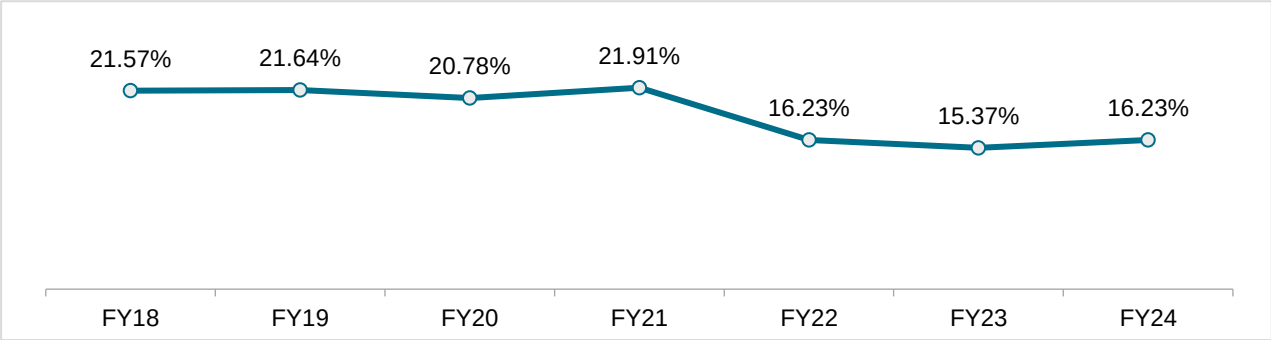
Both the financial and operational performance of Discoms started to improve post implementation of UDAY, but the situation reversed and worsened again once the scheme ended in March 2019.

The scheme envisaged reduction of the cost of power through measures such as additional supply of domestic coal (at notified prices), coal linkage rationalisation through swap agreements, supply of washed and crushed coal, and supply of cheaper power from NTPC and other central public sector units (as part of central allocation of power to states), if available through a higher plant load factor. Implementation was mixed with policy-level support but there was limited traction on the ground. While coal linkage rationalisation under the SHAKTI scheme did benefit several projects, and domestic supply also improved, the effect has been temporary or partial.

### 2.5.1 Improvements in Operational Efficiency

The AT&C losses for distribution utilities improved from 21.91% in fiscal 2021 to 16.23% in fiscal 2024. Billing efficiency improved marginally from 86.80% to 86.90% in fiscal 2024. However, the collection efficiency decreased by 1.2% from 97.27% in fiscal 2023 to 96.40% in fiscal 2024 which has led to an increase in AT&C loss in fiscal 2024 to 16.23%.

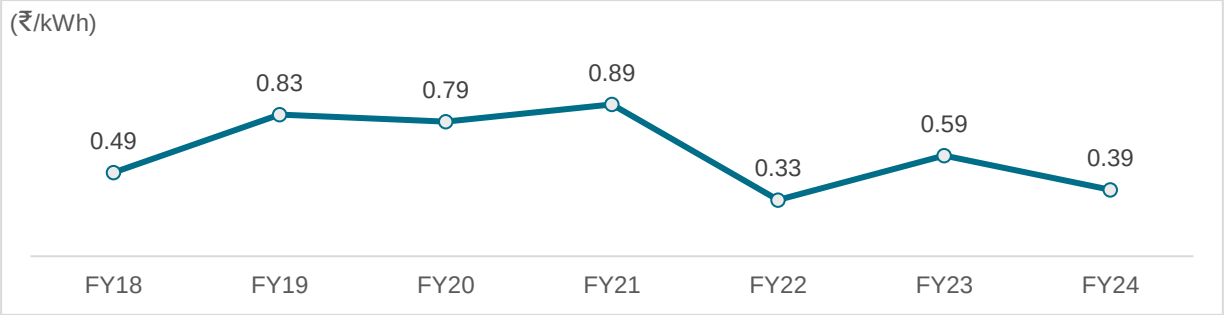
**Figure 15: AT&C loss trajectory (%)**




*Source: PFC, Crisil Intelligence*

The cash adjusted ACS and ARR gap narrowed to ₹ 0.33/kWh as of March 2022 driven by higher subsidies disbursement by state governments and better cash collections. In fiscal 2023, the gap again increased to ₹ 0.59/kWh due to an increase in power purchase cost. However, during fiscal 2024, the gap decreased by ₹ 0.20/kWh to ₹ 0.39/kWh.

**Figure 16: ACS-ARR gap**

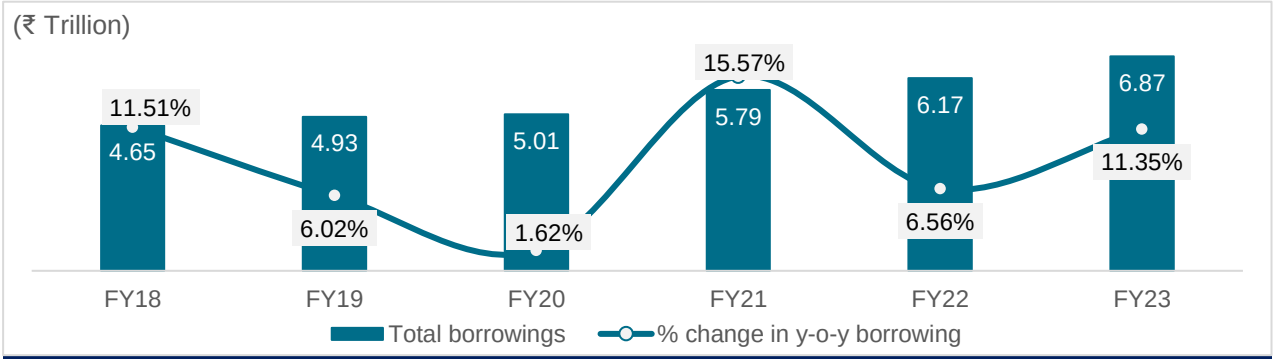


*Source: PFC, Crisil Intelligence*

## 2.5.2 Status of Discom borrowings

During fiscal 2023, the power purchase cost increased by ~15% from the previous year due to a surge in power demand by 9.72% from fiscal 2022 and other geopolitical challenges. To meet this demand, the government directed gencos to use imported coal. As a result, the coal imports in fiscal 2023 reached 56 million tonnes per annum (MTPA) (more than doubled from fiscal 2022) and due to Russia-Ukraine war the average cost of imported coal for India rose to over ₹ 12,500 per ton in fiscal 2023 from ₹ 8,300 per ton in fiscal 2022 and ₹ 4,300 per ton in fiscal 2021. Further, utilities were compelled to procure power from the exchanges at prices as high as ₹ 18-20/kWh to meet the growing demand. Such elevated cost of supply and subdued tariff hikes have kept operating losses elevated and led to an increase in borrowings to fund the losses.

**Figure 17: Total borrowings for Discoms**




*Source: MoP, PFC, Crisil Intelligence*

**Table 4: Credit rating of offtakers (State Discoms, Holding Companies, Central and Pvt. Agencies)**

| Offtakers | Date | Agency | Rating | Instrument |
|---|---|---|---|---|
| **GUVNL** | 18 March 2025 | CARE | AA+ Stable | **LT rating** |
| **MSEDCL** | 14 May 2024 | Acuite | A Stable | **LT rating** |
| **SECI** | 8 May 2024 | ICRA | AAA Stable | **LT rating** |
| **NTPC** | 25 March 2025 | ICRA | AAA Stable | **Long term loan** |
| **NHPC** | 17 January 2025 | CARE | AAA Stable | **Bonds** |
| **SJVN** | 9 September 2024 | CARE | AA+ Stable | **LT rating** |
| **PSPCL** | 7 January 2025 | Acuite | BBB- Stable | **LT rating** |
| **APSPDCL** | 18 March 2025 | CARE | C Stable | **LT rating** |
| **TSNPDCL** | 28 January 2025 | CRISIL | BB Stable | **LT rating** |
| **TSSPDCL** | 8 April 2025 | CARE | BB- Negative | **LT rating** |
| **MPPMCL** | 7 March 2025 | CARE | BB+ Stable | **LT rating** |
| **GRIDCO** | 16 December 2024 | India Ratings | BBB+ Stable | **Bank Loans** |
| **CSPDCL** | 19 February 2025 | India Ratings | A(CE) Stable | **Bonds** |

| Offtakers | Date | Agency | Rating | Instrument |
|---|---|---|---|---|
| **NBPDCL & SBPDCL** | **Not available** | | | |
| **UPPCL** | 21 June 2024 | India Ratings | AA(CE)/Stable | **NCD** |
| **BESCOM** | 23 July 2024 | CARE | BBB Negative | **Long term loans** |
| **The TATA Power CO. Ltd.** | 03 June 2025 | CRISIL | AA+/Stable | **Term Loan** |
| **Adani Electricity Mumbai Limited** | 21 Feb 2025 | CRISIL | AA+/Positive | **NCD** |
| **Torrent Power Ltd.** | 06 Feb 2025 | CRISIL | AA+/Stable | **Long Term** |

*Source: Credit Rating Agencies, Crisil Intelligence*

Following table summarises India's sovereign debt rating from various rating agencies.

**Table 5: India's sovereign debt rating**

| Name of Agency | Rating | Outlook | Date |
|---|---|---|---|
| Fitch | BBB- | Stable | 29 August 2024 |
| Moody's | Baa3 | Stable | 2 June 2025 |
| DBRS | BBB | Stable | 8 May 2025 |
| S&P | BBB- | Positive | 29 May 2024 |

*Source: Credit Rating Agencies, Crisil Intelligence*

Power Purchase Agreements (PPAs) and Merchant Sales are two common models used in the electricity industry for selling and purchasing electricity. A PPA is a long-term contract (typically 10-25 years) between a power generator (seller) and a buyer (usually a utility or a large consumer) to purchase electricity at a fixed price. In a Merchant Sale model, the power generator sells electricity directly to the wholesale market or to a third-party trader, without a long-term contract.

| Parameter | Long term PPA | Merchant Sale |
|---|---|---|
| Price certainty | Fixed price; energy costs can be managed effectively | Exposure to market price volatility; difficult to manage energy costs |
| Supply security | Assurance of stable supply | Supply uncertainty |
| Risk Management | Sellers are responsible | Generators |
| Long Term Planning | Improved long term planning | No certainty over long term |
| Operational Efficiencies | Generation as per contracted demand; improved operational efficiencies | Operations may be at varying levels; may lead to inefficiency |
| Flexibility and Scalability | Less chances of modifications since set for contracted demand | Can be expanded based on requirements |

Central sector PPAs have lower counterparty risk compared with PPAs directly with Discoms. The latter are known to delay payments to developers and have poor financial ratings, while SECI and other Central agencies are better rated and provide various payment security mechanisms (LCs, payment security fund and SECI, NTPC, NHPC, SJVN being party to the tripartite agreement).

Major payment security mechanisms (PSM) to de-risk investment in renewable energy inter- alia include Letter of Credit (LC); Payment Security Funds and Tripartite Agreement (TPA) between MoP, RBI and State Government (if applicable). These instruments are invoked in case of delays/default in payment to Renewable Energy Generating Companies and have been further strengthened by the notification of the Late Payment Surcharge Rules, 2022. Various initiatives such as stringent late payment surcharge rules, mandatory letter of credit by Discoms, regulation of power supply in case of non-maintenance of PSM, denial of open access in case of non-payment of dues beyond 75 days from due date etc. have tightened the payment security and brought in the much-required discipline in payments to RE generators by Discoms.

### 2.5.3 Distribution sector reforms

The government plans to implement several policies to resolve issues of the distribution segment, as it impacts the entire value chain. Key announcements pertaining to this are as follows:

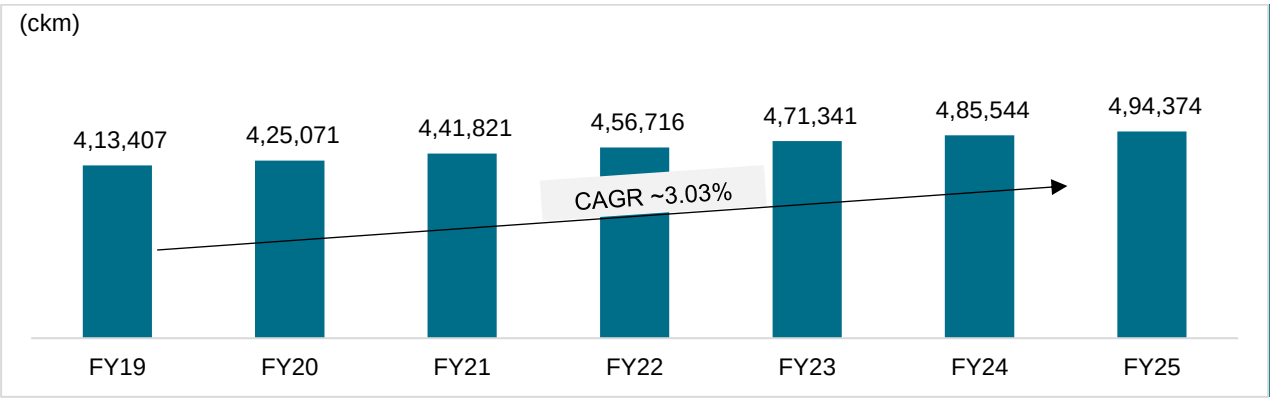
1) *₹ 3.00 trillion RDSS aiming to improve operational and financial parameters of Discoms* — In Union Budget 2022, the GoI announced the RDSS with an outlay of ₹ 3.04 trillion, partly funded by the GoI to the tune of ₹ 976 billion, aimed at reducing financial stress across Discoms. The package, slated to be distributed over the next five years, will subsume other schemes (Deen Dayal Upadhyaya Gram Jyoti Yojana and Integrated Power Development Scheme ) under its ambit. As has been the case with the *Aatmanirbhar Bharat* Discom liquidity package, PFC and REC will be the key nodal lenders for disbursal of funds to Discoms. The letter of credit ("LC") mechanism was also implemented in August 2019. This order mandated Discoms to issue LCs or provide payments upfront before purchase of power. However, the success of this scheme has been limited so far, due to various loopholes used by Discoms and the lower bargaining power of independent power producers ("IPPs").
2) MoP vide Gazette Notification dated 3 June 2022, notified "The Electricity (Late Payment Surcharge and Related Matters) Rules, 2022" ("LPS Rules") to address cash flow challenges faced mainly by gencos and transmission companies ("transcos") and to promote timely payments across the power sector. These rules provide a mechanism for settlement of outstanding dues of gencos, ISTS licensees and electricity trading licensees. The rules provisioned for converting Discoms' outstanding dues to these companies into equated monthly instalments (EMIs) for gradual liquidation of these dues. Further, to promote timely payment of current power bills, the power supply would be regulated for Discoms that fail to clear their bills one month after the due date of payment or two-and-a-half months after the presentation of the bill by the generating company.

   Since their notification, there has been significant progress in recovering outstanding dues, with most distribution companies now adhering to regular payment schedules. The total unpaid bills have reduced from around ₹ 1.4 trillion in June 2022 to around ₹ 480 billion in February 2024. As such the issue of nonpayment by Discoms is resolved to a great extent and provided much required regulatory certainty. The major driver for this trend has been LPS Rules, which converted legacy dues to EMIs. The LPS rule helped bring down days payable from 169 in fiscal 2022 to 132 in fiscal 2024.

## 2.6 Progress on T&D infrastructure, inter-regional transmission capacity

Robust generation capacity addition over the years and the government's focus on 100% rural electrification through last mile connectivity has led to the extensive expansion of the T&D system across the country. The total length of domestic transmission lines rose from 413,407 circuit kilometres (ckm) in fiscal 2019 to 494,374 ckm in fiscal 2025.

**Figure 18: Total transmission line network in the country (220 kV and above)**

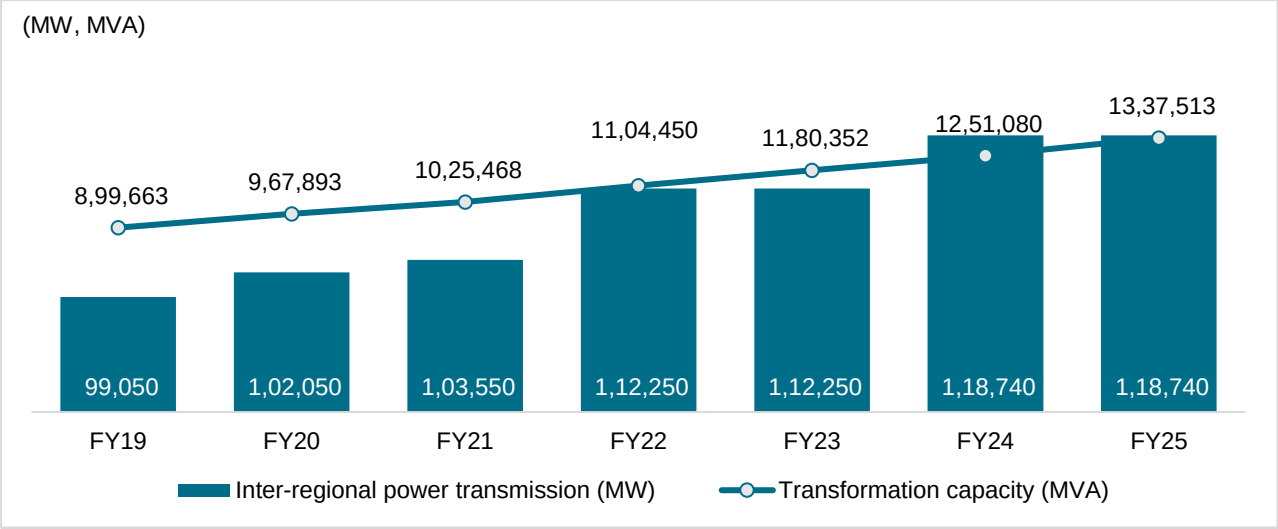



*Source: CEA, Crisil Intelligence*

The total transmission line length (above 220 kV) has increased at ~3.03% CAGR from fiscal 2019 to fiscal 2025. This increase can also be attributed to an increase in the commissioning of the 765-KV lines, growing at a CAGR of ~5.29% over the same period. 765 kV lines have higher transfer capacity and lower technical losses, thereby reducing the overall number of lines and rights of way required to deliver equivalent capacity. 800 kV lines have also shown a strong growth momentum, rising at 7.88% CAGR over the last 6 fiscals, majorly owing to strong investments by the central sector.

The inter-regional power transmission capacity of the National Grid has grown strongly from 99,050 MW in fiscal 2019 to 118,740 MW in fiscal 2025, at a CAGR of 3.07%. Subsequently, transformation capacity rose from 899,663 mega volt amperes (MVA) in fiscal 2019 to 1,337,513 MVA in fiscal 2025, growing at a CAGR of ~6.83%.

**Figure 19: Growth in transformation capacity and inter-regional power transmission capacity**




*Source: CEA, Crisil Intelligence*

## 2.6.1 Plans to increase grid infrastructure

Report on "National Electricity Plan Volume – II Transmission" published by CEA portrays the broad transmission system roadmap by 2032. The length of the transmission lines and sub-station capacity planned under ISTS by 2032 has been estimated to be 648,190 ckm and 2,345,135 MVA, respectively.

With the additional inter-regional transmission corridors under implementation/planned, the cumulative inter-regional transmission capacity is likely to be about 168 GW by 2032.

**Table 6: Planned Transmission capacity additions by CEA till 2032**

| Transmission system type/ voltage class | Unit | Capacity till 2032 |
|---|---|---|
| **(a) ± 800 kV / ± 500 kV / ± 320 kV** | ckm | 34,887 |
| **(b) 765 kV** | ckm | 114,719 |
| **(c) 400 kV** | ckm | 249,585 |
| **(d) 220 kV** | ckm | 248,999 |
| **Total transmission lines** | **ckm** | **648,190** |
| **(a) ± 800 kV / ± 500 kV / ± 320 kV** | MVA | 66,750 |
| **(b) 765 kV** | MVA | 920,200 |
| **(c) 400 kV** | MVA | 813,828 |
| **(d) 220 kV** | MVA | 611,107 |
| **Total substations** | **MVA** | **2,345,135** |

*Source: CEA, Crisil Intelligence*

**Table 7: Inter-regional capacity addition till 2032**

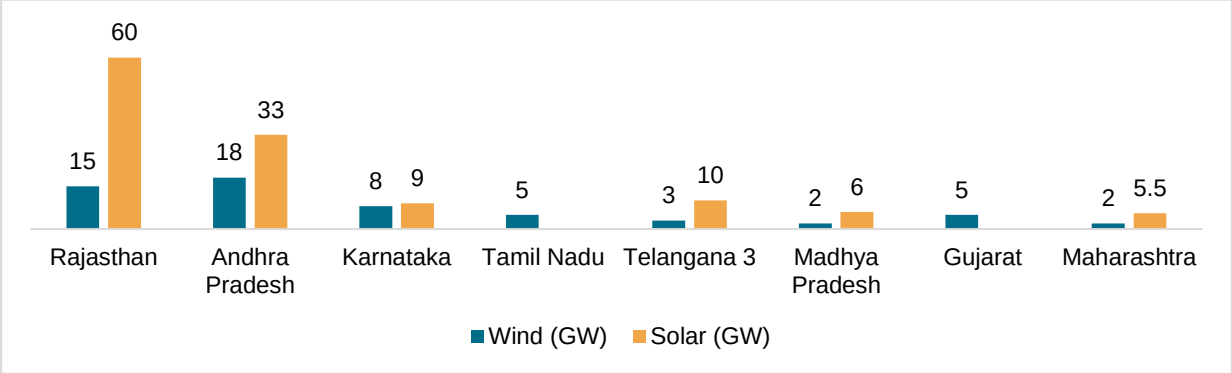
| Inter-regional capacity | Capacity till 2032 (MW) |
|---|---|
| **West – North** | 61,120 |
| **Northeast – North** | 3,000 |
| **East – North** | 28,530 |
| **East – West** | 22,790 |
| **East – South** | 12,030 |
| **West – South** | 36,520 |
| **East – Northeast** | 3,550 |
| **Total** | **167,540** |

*Source: CEA, Crisil Intelligence*

### 2.6.2 Strong renewable energy capacity additions to also drive transmission capacity

The central government has planned to achieve 500 GW capacity from non-fossil fuel-based energy sources by 2030. Solar and wind will play a main role in achieving the said target. The share of renewable energy (including hydro and energy storage) in the installed capacity mix is expected to reach ~62% in fiscal 2029 from ~43% in fiscal 2024. Such multi-fold expansion plans also require large scale development in the transmission sector. This is mainly because large scale grid-connected solar and wind plants are usually located in far-flung areas with limited existing transmission infrastructure. Moreover, renewable energy is not well-distributed across states and is intermittent in nature. Robust transmission planning is required to optimize the high costs, utilization levels and losses associated with the transmission system, ensuring efficient transmission of the power generated to load centres. For enabling growth of RE capacity, areas which have high solar and wind energy potential, need to be connected to ISTS, so that the power generated could be evacuated to the load centres. As the gestation period of wind and solar-based electricity generation projects is much less than the gestation period of the transmission system, it needs to be planned. MNRE/SECI have identified renewable energy zones (REZs) totaling 181.5 GW for likely benefits by 2030. These REZ's are in eight states as detailed below:

**Figure 20: Potential RE zones identified by MNRE/SECI (GW)**

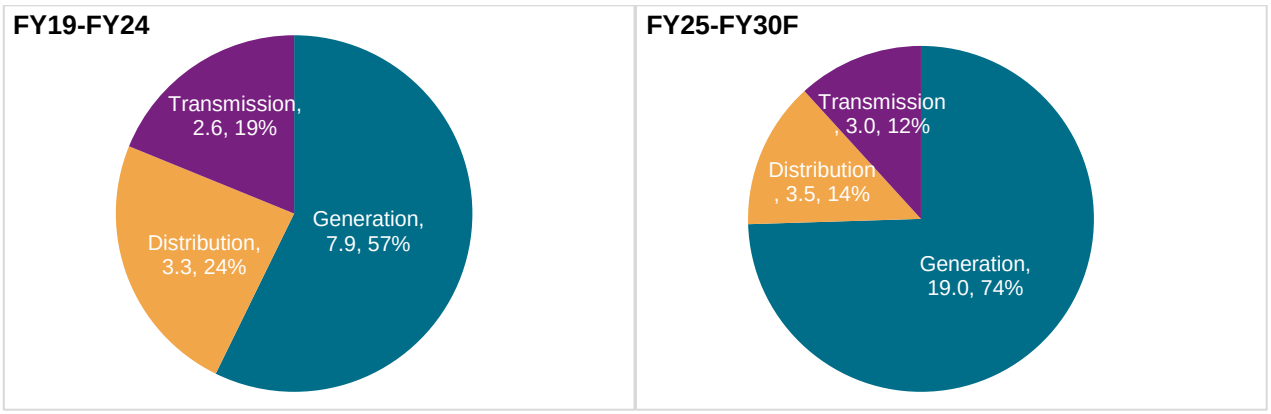



*Source: CEA: Transmission System for Integration of over 500 GW RE Capacity by 2030*

### 2.6.3 Investments in generation, transmission, and distribution infrastructure

The total investment in the power sector between fiscals 2019-24 was about ₹ 14.6 trillion. Crisil Intelligence expects investments of ₹ 25-26 trillion in the power sector over fiscals 2025-30 at a CAGR of 9-10%. Generation segment investments are being driven by capacity additions with robust growth in RE installations, followed by distribution investments led by the RDSS scheme.

**Figure 21: Segment-wise break-up of total investments (₹ trillion, % share of total)**




*Source: Crisil Intelligence*

Investments in the generation segment are expected to double from ₹ ~7.8 trillion to ~₹ 19.0-20.0 trillion over fiscals 2025-30. Capacity addition from RE sources is expected to be 220-225 GW from fiscal 2025 to 2030, and 25-27 GW from coal-based plant sources over the same period. Investments in RE capacity, which are expected to double over the next five years, in line with capacity additions, will constitute over 70% of overall generation investments.

To achieve the RE generation target, a strong transmission infrastructure is needed to integrate large scale RE capacities into the grid. This is expected to lead to transmission investments of ₹ 2.5-3.5 trillion between fiscals 2025-2030 from ~₹ 2.6 trillion between fiscals 2019-2024 led by upcoming ISTS projects. The distribution segment is expected to attract investments worth ₹ 3-4 trillion over fiscals 2025 to 2030 vis-vis ~₹ 3.3 trillion between fiscals 2019-2024. This is driven by the government's thrust on the RDSS scheme, entailing an outlay of ₹ 3.04 trillion for state Discoms, to be allocated until fiscal 2026. ₹ 2.77 trillion worth of DPRs have been sanctioned by nodal agencies (PFC and REC) as of December 2024.

# 3 Overview of Indian Renewable energy sector

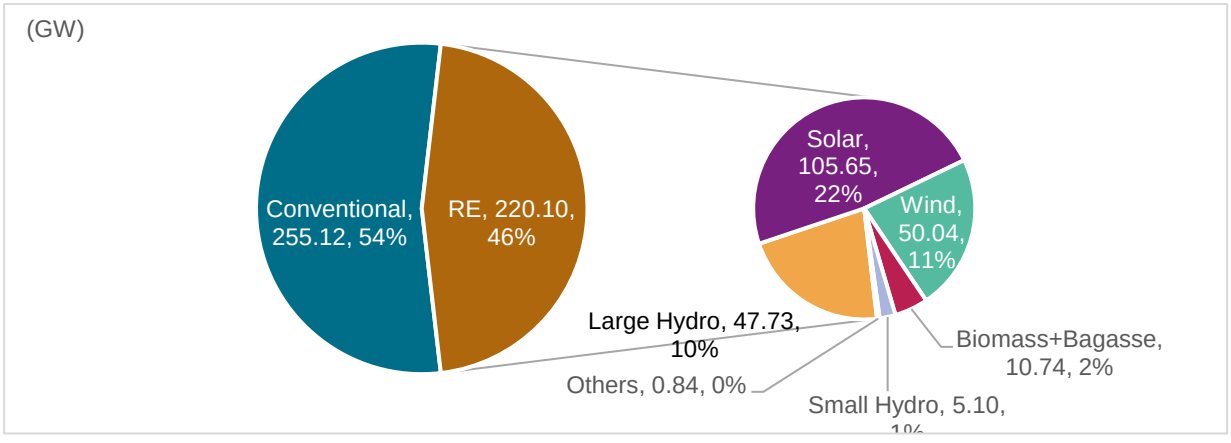
## 3.1 Renewable energy sector

The renewable energy sector in India stands as a cornerstone of the nation's commitment to sustainable development, harnessing clean energy sources that generate electricity without the deleterious emissions associated with fossil fuel combustion. By accelerating the adoption of renewable energy, India aims to significantly mitigate carbon emissions, thereby contributing to global efforts to combat climate change and preserve environmental integrity. In contrast to finite conventional resources, renewable source are abundant across India's diverse topography, from the solar-abundant regions of Rajasthan to the wind-rich coastal belts of Gujarat and Tamil Nadu, offering resilience against resource depletion. Supported by robust policy frameworks, such as the National Solar Mission and the Government of India's target of achieving 500 GW of non-fossil fuel-based capacity by CY2030, these renewable sources are instrumental in enhancing energy security, fostering economic progress, and advancing sustainable development.

'Must-run' status was provided to solar and wind power as per clause 5.2(u) of Central Electricity Regulatory Commission (Indian Electricity Grid Code) Regulations, 2010. Further, the Electricity (Promotion of Generation of Electricity from Must-Run Power Plant) Rules, 2021, extended must-run status to a wind, solar, wind-solar hybrid or hydro power plant (in case of excess water leading to spillage).

Renewable energy installations (including large hydro) have increased to ~220 GW as of March 2025, as compared with ~63 GW as of March 2012 (source: MNRE), led by various central and state-level incentives. As of March 2025, installed grid connected RE generation capacity (including large hydro) in India constituted ~46.32% of the total installed generation base in India. This growth has been led by solar power, which has grown to ~106 GW from merely ~0.09 GW over the discussed time period (i.e., from March 2012).

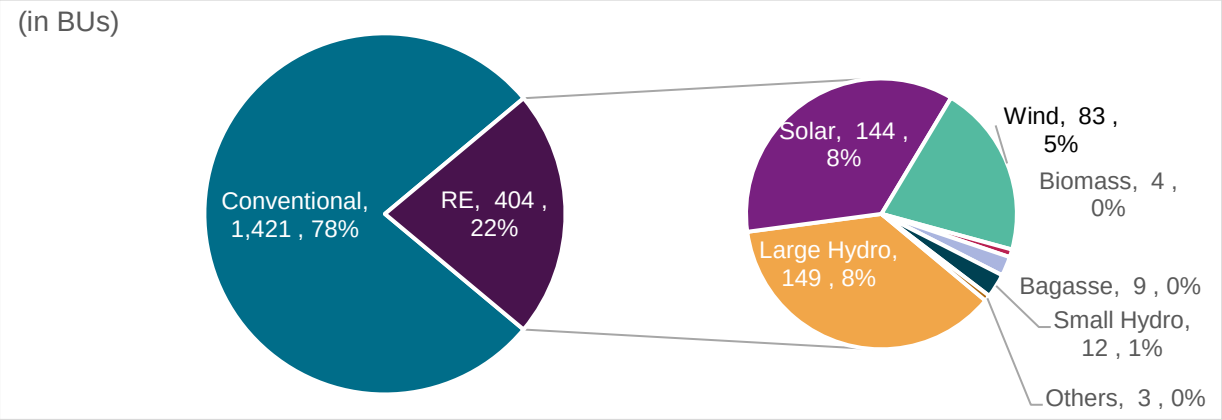
**Figure 22: India's RE (including large hydro) capacity was 45% at the end of March 2025**




*Conventional: Coal, Gas, Lignite, and Nuclear*
*Source: MNRE; CEA, Crisil Intelligence*

However, owing to lower capacity utilisation factors (CUF), the RE penetration (including large hydro) in terms of energy generation was at 22.13% for fiscal 2025 (as of March 2025).

**Figure 23: India's RE (including large hydro) penetration was about 22.12% at end of March 2025**

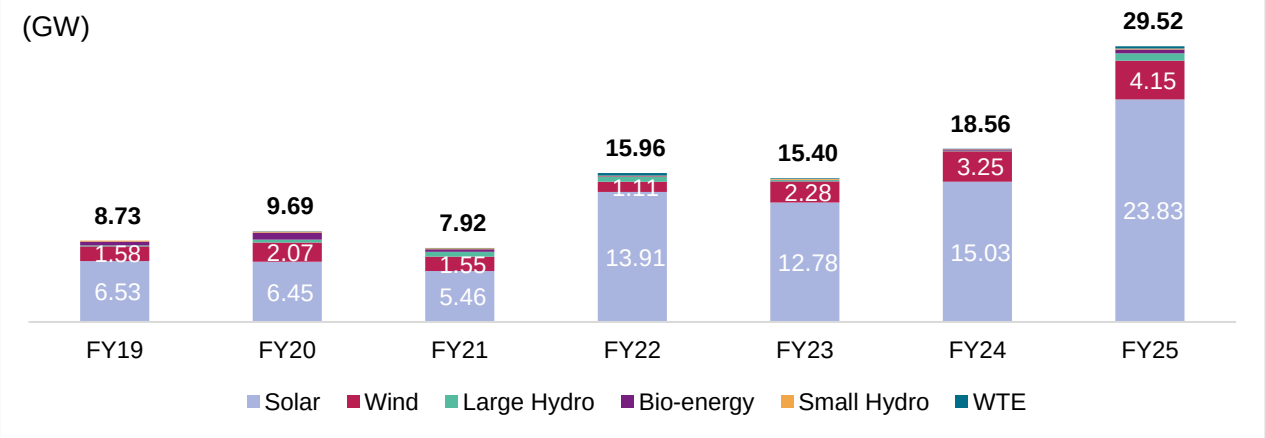



*Conventional: Coal, Gas, Lignite and Nuclear*
*Source: MNRE; CEA, Crisil Intelligence*

## 3.2 Overview of RE capacity additions

With the increased support of the Government and improved economics, the RE sector has become attractive from an investor's perspective. India's renewable energy market is led by solar and wind, which are already charting a significant growth trajectory. During fiscals 2019-24, India added around 71 GW of RE (including large hydro) capacities. The installed RE (including large hydro) capacity has grown from 114 GW in fiscal 2018 to 220 GW in fiscal 2025 at a CAGR of 9.81%. Solar segment led the capacity additions with cumulative additions of ~84 GW followed by wind ~16 GW during the same period. The other RE sources added ~4 GW during the same period.

**Figure 24: Historical annual RE Capacity additions in India**




*WTE: waste-to-energy*
*Source: CEA, MNRE, Crisil Intelligence*

## 3.3 Tendering activities in renewable energy

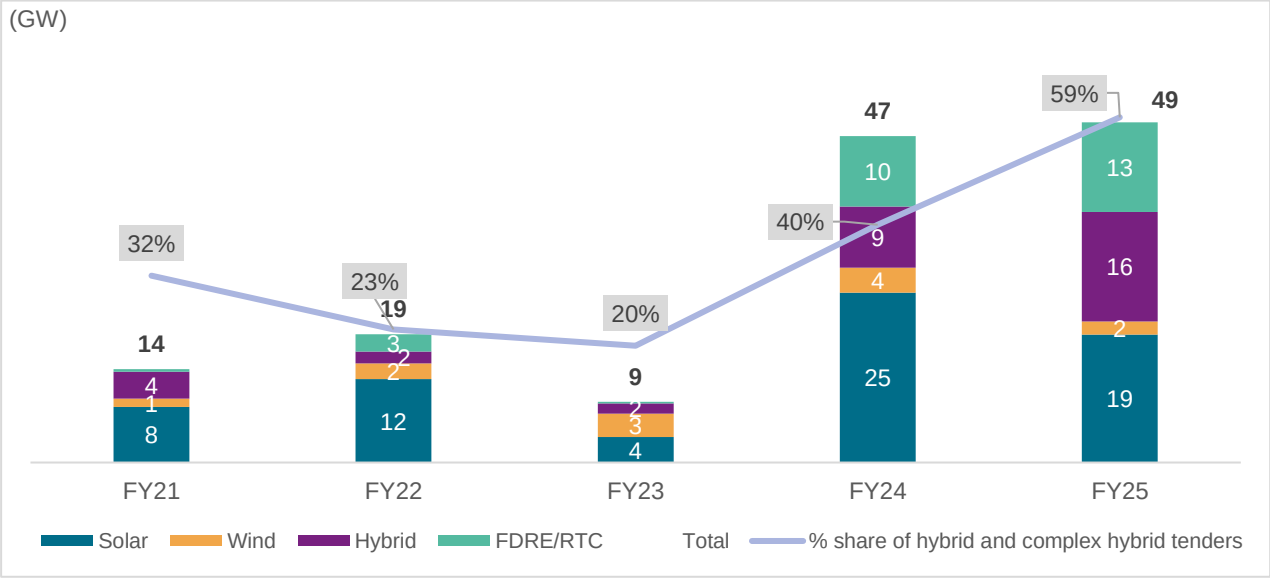
India issued over 135 GW of completed utility scale renewable energy tenders since fiscal 2021 across all technologies including complex WSH tenders with storage. The tendering activity increased about five-fold between fiscal 2023 and 2024 due to significant increase in government targets, innovative tendering solutions, Discom's shift to offtake more stable and firm power and increase in power sector investment.

The tendering activity for utility scale RE projects has outpaced the government's target of 50 GW for fiscal 2024. The government selected SECI, NTPC, SJVN and NHPC as RE implementing agencies (REIA).

Hybrid and Complex Hybrid RE tenders (including peak power tenders) have shown significant growth over the years. The share of Complex Hybrid RE tenders has increased from 32% in fiscal 2021 to 59% in fiscal 2025.

Apart from this, over 20 GW of standalone energy storage systems (ESS) tenders were also issued including pumped hydro storage. The average allocation of tenders has been above 85% of the tendered capacity in the last five years.

**Figure 25: RE tender auctioned capacity annually**




*Includes only utility scale tenders concluded during the year;*
*Source: Central and State nodal agencies, Crisil Intelligence*

## 3.4 Key policy and regulatory initiatives

**Central Government's Decarbonization Targets and Nationally Determined Contributions (NDCs) under the Paris Agreement**

In 2014, the government set a target to achieve 175 GW of renewable energy in India- 100 GW of solar energy by December 2022, 60 GW of wind energy by December 2022 and 15 GW via other sources, including small hydro projects, biomass projects and other renewable technologies, by December 2022. As on 31 December 2022, India had RE capacity (including large hydro) of 168 GW comprising 63 GW of solar, 42 GW wind and 47 GW of large hydro and 15 GW of other sources.

Further, under the Paris Agreement, the Indian government has committed to generating 40% of electricity from non-fossil fuels sources by 2030. India also has a target of setting up 450 GW of RE by 2030 and providing 1.7 million solar pumps to farmers under the Pradhan Mantri-Kusum Yojana.

The 2021 United Nations COP26 was the 26th United Nations Climate Change conference, held at Glasgow, Scotland during October-November 2021 and a draft agreement was circulated with respect to climate change action. The proposal aims at updating the timeframe for revised targets NDCs to next year — much

sooner than the requirement of every five years as laid out in the 2015 Paris Climate Accord. India updated its NDCs as follows:

- To reduce emissions intensity of its GDP by 45% by 2030, from 2005 level,
- To achieve about 50% cumulative electric power installed capacity from non-fossil fuel-based energy resources by 2030,
- By the year 2070, India will achieve the target of Net Zero.

These are more ambitious and are beyond the previous NDCs agreed under the Paris Agreement. These will provide a new thrust to the RE sector in India and will boost the already accelerating RE sector. These will also provide guidelines to the regulators as well as government authorities while setting the rules, regulations, and targets

**Renewable purchase obligations**

As per the Electricity Act, 2003, SERCs are required to fix the purchase of a minimum percentage of electricity from renewable energy sources out of total electricity consumption (excluding hydro) for obligated entities – Discoms, open access consumers and captive power users – in the state. The RPO could be met by purchase of renewable energy or through purchase of renewable energy certificates (RECs). In the event of default by an obligated entity in any fiscal, SERCs may direct the obligated entity to pay a penalty or to deposit an amount determined by the relevant SERC, into a fund to be utilised for, among others, the purchase of RECs.

To promote the installation of solar power systems across various Indian states, the government amended the National Tariff Policy in fiscal 2016, proposing an increase in RPO target to 21.00% by fiscal 2022. Consequently, several states set RPO targets based on their respective RE potential.

The MoP in July 2022 declared hydro power obligation (HPO) and energy storage obligation (ESO) trajectory till fiscal 2030 in addition to RPO. Later in October 2023, the MoP revised its RPO target from fiscal 2025 to 2030 and removed ESO from the RPO category. In this RPO notification, MoP added a category for distributed renewable energy which would be met only from the projects that are less than 10 MW.

**Table 8: RPO targets by the MoP notified in October 2023**

| Category | FY25 | FY26 | FY27 | FY28 | FY29 | FY30 |
|---|---|---|---|---|---|---|
| Wind RPO | 0.67% | 1.45% | 1.97% | 2.45% | 2.95% | 3.48% |
| HPO | 0.38% | 1.22% | 1.34% | 1.42% | 1.42% | 1.33% |
| Distributed RE | 1.50% | 2.10% | 2.70% | 3.30% | 3.90% | 4.50% |
| Other RPO | 27.35% | 28.24% | 29.94% | 31.64% | 33.10% | 34.02% |
| Total | **29.91%** | **33.01%** | **35.95%** | **38.81%** | **41.36%** | **43.33%** |

*Source: MoP, CRISIL Intelligence*

Wind RPO component is for the new wind projects commissioned after 31 March 2024 and hydro component shall be met only by energy produced from hydro power Projects (including pumped storage and small hydro projects), commissioned after 31 March 2024. The older wind projects, all solar projects and other RE projects would come under “Other RPO” component

**Implementation of Electricity (Promoting Renewable Energy Through Green Energy Open Access) Rules, 2022**

The Electricity (Promoting Renewable Energy Through Green Energy Open Access) Rules, 2022 give consumers an option to draw green energy through open access whose contract demand is 100 kW or above

and no limit for supply of power for captive consumers. Most of the large industrial and RE rich states have notified Green Energy Open Access Regulations, largely in line with the original rules.

Under open access, captive power projects are exempt from paying cross subsidy surcharge (CSS), as per Section 42(2) of the Electricity Act 2003. In its judgement dated 10 December 2021, the Supreme Court ruled that captive power consumers are not liable to pay an additional surcharge under Section 42 (4) of the Electricity Act, 2003.

**Implementation of ISTS charges waiver**

The MoP issued an order on 21 August 2020, waiving Inter-State Transmission System (ISTS) charges and losses for solar and wind power projects commissioned on or before 30 June 2023, to promote renewable energy adoption. This was followed by an amendment on 15 June 2021, extending the waiver of ISTS charges (but not losses) for solar and wind projects commissioned until 30 June 2025. Subsequently, an order dated 23 November 2021, clarified that projects commissioned after 30 June 2025, including solar, wind, PSP, and BESS, will face a phased reintroduction of ISTS charges. Starting 1 July 2025, ISTS charges will increase annually by 25% of the applicable rate, reaching 100% of ISTS charges from 1 July 2028.

Summary of ISTS Charges Waiver Policy For solar, wind, PSP, and BESS

- Commissioned till 30 June 2025: Waiver of 100% of applicable ISTS charges for 25 years from the date of commissioning
- Commissioned projects From 1 July 2025, till 30 June 2026: Waiver of 75% of applicable ISTS charges for 25 years from the date of commissioning
- Commissioned projects From 1 July 2026, till 30 June 2027: Waiver of 50% of applicable ISTS charges for 25 years from the date of commissioning
- Commissioned projects From 1 July 2027, till 30 June 2028: Waiver of 25% of applicable ISTS charges for 25 years from the date of commissioning
- 100% of applicable ISTS charges are applicable for projects commissioned post 1 July 2028 onwards.

The MoP, in August 2020, waived the ISTS charges and losses on all solar and wind projects commissioned before 30 June 2023. In June 2021, the waiver was extended up to 30 June 2025, only the ISTS charges were waived, and losses remained applicable. However, post June 2025, an annual increase of 25% in the ISTS charges will be applicable for solar, wind, PSP, and BESS sources, resulting in the applicability of 100% of ISTS charges from July 2028.

**Introduction of General network access**

In October 2021, the MoP launched the General Network Access (GNA) initiative, providing non-discriminatory access to the interstate transmission network nationwide for designated interstate customers. The Central Transmission Utility grants GNA for a specified period and maximum megawatt capacity, allowing for more flexible transmission planning and implementation. A key benefit of GNA is that it enables generators and drawees to plan their power requirements without needing to identify a specific source of purchase or sale, thereby streamlining the process for IPPs to access the transmission network without having to specify target beneficiaries.

**The Electricity (Late Payment Surcharge and Related Matters) Rules, 2022" ("LPS Rules")**

In June 2022, LPS Rules were introduced to address cash flow challenges faced mainly by gencos and transcos and to promote timely payments across the power sector. These rules provide a mechanism for settlement of outstanding dues of gencos, ISTS Licensees and Electricity Trading Licensees. The rules provisioned for converting Discoms' outstanding dues to these companies into EMIs for gradual liquidation of these dues. Further, to encourage timely settlement of power dues, short-term access for power procurement through exchanges shall be entirely regulated for distribution licensees that fail to clear their bills two and a half months from the date of bill presentation by the generating company. If the dues remain unpaid for an additional month after short-term access is regulated—or for a total period of three and a half months—long-term and medium-term access shall also be regulated by 10%. This reduction shall be progressively increased by 10% for each subsequent month of default, with the corresponding reduction applied to the approved drawl schedule of the defaulting entity.

In November 2024, Grid Controller of India released an implementation procedure for LPS Rules. It establishes that PSM can be a LC or LC backed by an escrow account. The Discoms have been provided a choice of making advance payment for the equivalent quantum of power to be scheduled from the gencos.

The provision of power is contingent upon the maintenance of a satisfactory PSM or, in its absence, the receipt of advance payment. Failure to comply with this requirement may result in the genco forfeiting its right to impose LPS on the Discom. In the event of non-payment of outstanding dues by the specified deadline, the genco's obligation to supply power will be reduced to 75% of the contracted amount, with the remaining 25% being eligible for sale through power exchanges. Furthermore, if the Discom fails to establish a PSM or defaults on payment for a period of 30 days, the genco will be entitled to sell 100% of the contracted power through power exchanges, thereby mitigating potential losses due to non-payment.

Since their notification, there has been significant progress in recovering outstanding dues, with most distribution companies now adhering to regular payment schedules. The total unpaid bills have reduced from around ₹ 1.4 trillion in June 2022 to around ₹ 480billion in February 2024. As such the issue of nonpayment by Discoms is resolved to a great extent and provided much required regulatory certainty. The major driver for this trend has been LPS Rules, which converted legacy dues to EMI instalments. The LPS rule helped bring down days payable from 169 in fiscal 2022 to 132 in fiscal 2024.

**Renewable energy certificates**

REC is a market-based instrument that facilitates RPO compliance by obligated entities which include Discoms, captive power plants and open access consumers. One REC is equivalent to one MWh of electricity generated from RE sources. The RE generators can issuance REC whose tariff is neither determined under the provisions of the Electricity Act nor selling power through power exchanges / traders and has not availed any waiver / concession on open access charges. The registration of RECs is valid for 15 years from the project commissioning date and 25 years for the existing RE project. The REC have no expiration date and no floor and forbearance price. The price of REC is discovered through power exchanges / traders and the certificates are issued basis technology multiplier. Over the last 2 years, about ~75 million RECs have been issued, of which over 30 million RECs remained unsold. The total unsold RECs are about 46 million since inception. The average prices have fallen from ₹ 1,000 per REC in April 2023 to below ₹ 250 per REC in fiscal 2024. However, considering the surge in demand, the REC price in fiscal 2025 reached ₹ 350 per REC.

Further, the International Renewable Energy Certificate (I-REC) is also an instrument which is a globally recognized standard. I-RECs represent a significant tool for industries aiming to reduce their carbon emissions and meet sustainability goals such as RE100 (a global initiative, bringing together the world's most

influential businesses committed to 100% renewable electricity), or those looking to claim their products are manufactured using renewable energy.

## 3.5 Voluntary Emission Reduction

Voluntary Emission Reductions (VERs) refer to reductions in emissions that are made voluntarily, without being required by law or regulation. These reductions are typically driven by an organization's desire to take proactive steps to address climate change.

The voluntary carbon market operates independently of the compliance market, allowing businesses, organizations, and individuals to offset their emissions voluntarily, without being mandated to do so. The carbon credits generated through VERs cannot be used to meet government-imposed emissions targets, as outlined in the Kyoto Protocol, and are instead used for voluntary offsetting purposes.

The Gold Standard (GS) is a widely recognized and established voluntary emission trading scheme, globally acknowledged for its credibility. To ensure integrity, GS projects adhere to the technical requirements set by the United Nations Framework Convention on Climate Change (UNFCCC). In order to issue Voluntary Emission Reduction Units (VERs), each project must undergo a rigorous validation and verification process, which is conducted by a UNFCCC-accredited entity, guaranteeing the project's authenticity and environmental integrity. It ensures the highest levels of environmental integrity and social impact by certifying projects that go beyond carbon reduction to deliver measurable contributions to sustainable development and the United Nations Sustainable Development Goals (SDGs).

### 3.5.1 Eligibility and process for VER issuance

- Eligibility and Project Categorization

Projects must align with Gold Standard’s eligibility criteria and fall under approved sectors such as:

  - Renewable energy (e.g., solar, wind, biomass)
  - Energy efficiency
  - Waste management and biofuels
  - Clean cooking and household energy solutions etc.

Each project must demonstrate measurable greenhouse gas (GHG) emission reductions and positive contributions to sustainable development. In the case of Juniper, all Gold Standard projects are solar-based renewable energy initiatives.

- **Methodology Selection**

Projects must adopt an approved Gold Standard methodology, which provides defined procedures for baseline determination, emission reduction calculation, and monitoring. All of Juniper's Renewable projects use the ACM0002 methodology, applicable to grid-connected renewable electricity generation, ensuring standardization and accuracy in emissions accounting.

- **Project Design Document (PDD) and SDG Impact**

Each project requires the preparation of a comprehensive Project Design Document (PDD) that includes:

  - Baseline and project emissions assessment
  - Monitoring plan and data collection procedures
  - Demonstration of additionality and financial need for carbon finance

- Identification and substantiation of contributions to a minimum of three SDGs

- **Stakeholder Consultation and Safeguarding Principles**

A mandatory Local Stakeholder Consultation is conducted to ensure community engagement, transparency, and local acceptance. Additionally, the project must comply with Gold Standard's Safeguarding Principles, which are designed to prevent any adverse impacts on local populations or ecosystems.

- **Third-party Validation and Registration**

The PDD and supporting documentation undergo third-party validation by an accredited Validation and Verification Body (VVB) to ensure compliance with Gold Standard rules and methodologies. Upon successful validation, the project is officially registered under the Gold Standard registry.

- **Monitoring, Verification, and Issuance**

Post-registration, projects enter the monitoring phase, during which real-time emission reductions are tracked. These are then independently verified by the VVB. Once verified, Gold Standard Verified Emission Reductions (VERs) are issued, serialized, and published on the Gold Standard public registry. Each issuance is fully traceable and meets the highest standards of environmental credibility.

- **Review process by Gold Standard**

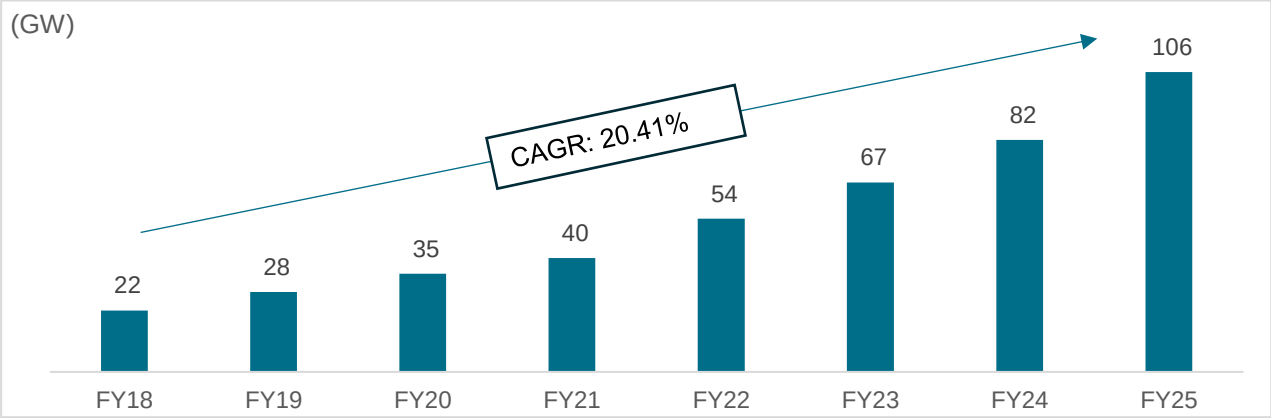
In addition to third-party validation and verification, Gold Standard conducts an independent review of each project to ensure full compliance with its guidelines and principles. This internal review ensures the overall integrity, transparency, and effectiveness of the certification process, and confirms that the project contributes meaningfully to climate and sustainable development objectives.

# 4 Overview of Indian solar energy sector

## 4.1 Evolution of Solar Power in India

Growth in the solar power sector over the last five years has been robust. About 54 GW of solar capacity was added in the segment over fiscals 2019-24, registering a CAGR of ~24.80%, although starting from a low base. Despite the second wave of COVID-19 pandemic, fiscal 2022 witnessed solar capacity additions of ~14 GW. In a relief to developers, the MNRE provided a total extension of seven-and-a-half months for the projects affected by the first and second waves of the pandemic. This has delayed commissioning in fiscal 2022, leading to a spillover into fiscals 2023 and 2024. In fiscal 2023, solar capacity additions stood at ~13 GW, with ~2.2 GW coming from rooftop solar projects. Similarly, in fiscal 2024, solar capacity additions stood at ~15 GW, with ~3 GW coming from grid connected rooftop solar projects. During fiscal 2025, ~23.83 GW solar capacity was added leading to 106 GW of installed capacity as of March 2025.

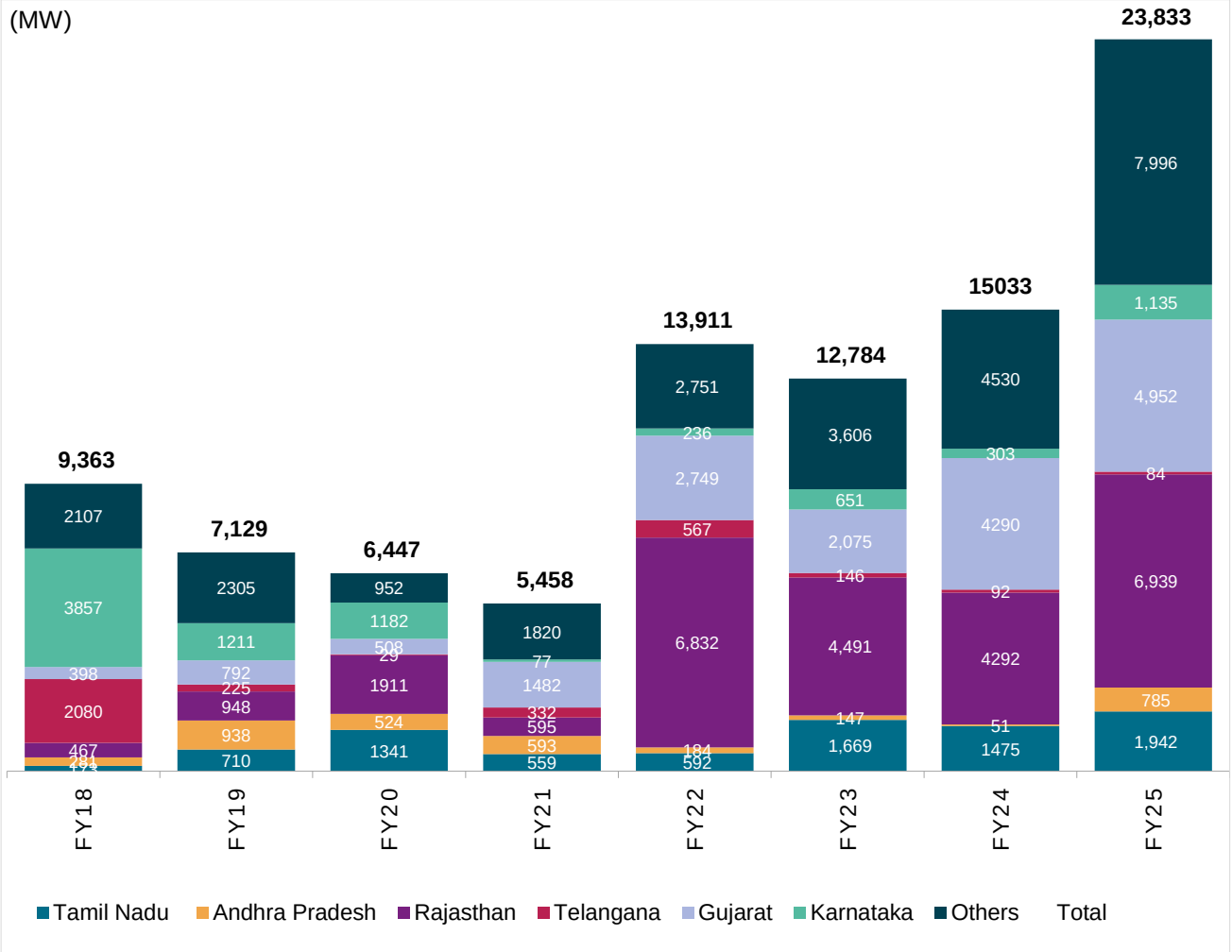
**Figure 26: Trend in cumulative solar capacity installation in India**




*Source: MNRE, CEA, Crisil Intelligence*

The imposing of solar RPOs across Indian states in 2011 by GoI, coupled with the sharp drop in capital costs, led most states to release solar polices. This resulted in a spur in solar sector investments. Until fiscal 2012, only Gujarat and Rajasthan had state solar policies. Following the success of Gujarat's solar policy, other states such as Andhra Pradesh, Tamil Nadu, Karnataka, Madhya Pradesh, and Telangana introduced their respective solar polices.

**Figure 27: States that helped drive solar capacity addition in India**




*Source: MNRE, Crisil Intelligence*

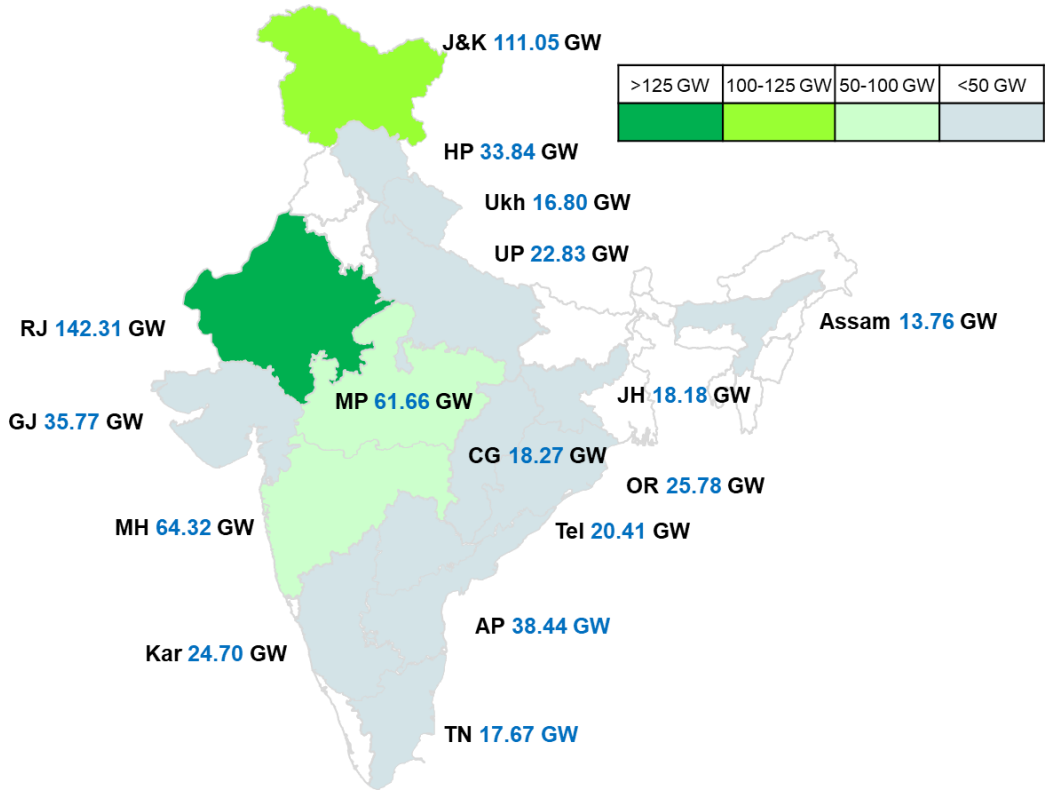
Commissioning activity has been concentrated in the key states of Rajasthan, Gujarat, Maharashtra and Tamil Nadu, which accounted for two-thirds of total capacity added in fiscal 2025. The installation trend was driven by the same states in the previous fiscal year as well.

## 4.2 State wise potential of solar power across India

The National Institute of Solar Energy (NISE) estimated the country's solar potential at 748.99 GW, assuming solar PV modules cover 3% of the geographical surface. India is a perfect location for solar energy because of its location. It has 300 days of sunshine each year, with daily peak electricity use being in the evenings and a seasonal peak in the summer.

The daily average Global Horizontal Irradiance (GHI) in India is around 5 kWh/m$^2$ in north-eastern and hilly areas to about 7 kWh/m$^2$ in western region and cold desert areas. The annual GHI varies from 1600 – 2200 kWh/m$^2$. States like Gujarat, Rajasthan, Madhya Pradesh, Andhra Pradesh, Karnataka, and Tamil Nadu offer more solar irradiance as compared to other parts of India, which makes them desirable for installing solar projects.

**Figure 28: State wise solar potential**




*Others: ~83.20 GW; Source: NISE: MNRE, Crisil Intelligence*

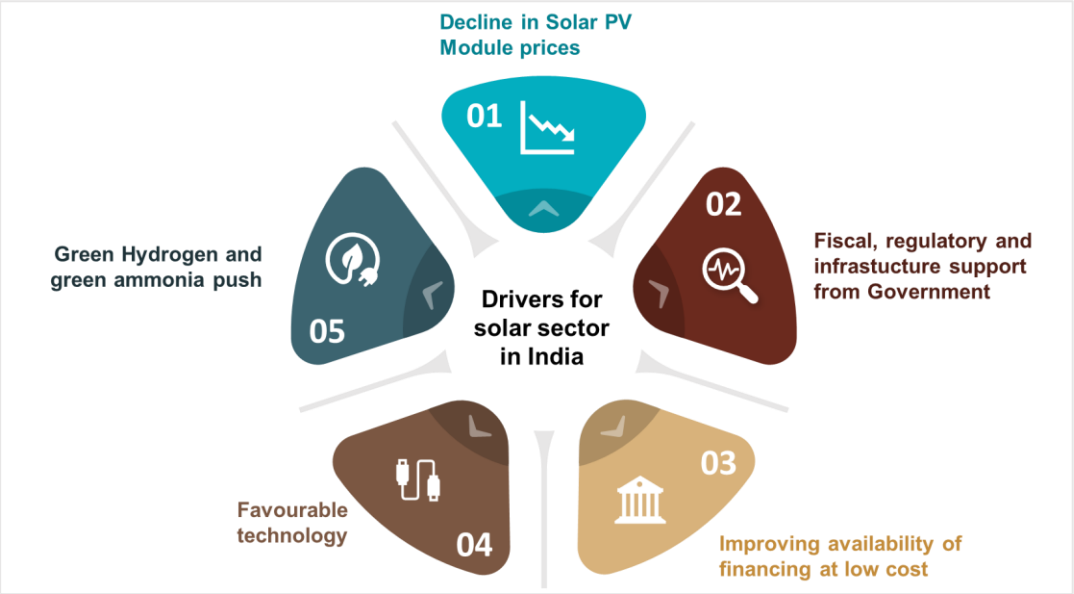
**Table 9: State wise solar energy potential and installed capacity for key states (as of March 2025)**

| Sr. No. | State | Potential (GW) | Installed capacity (GW) |
|---|---|---|---|
| 1. | Rajasthan | 142.31 | 28.29 |
| 2. | Jammu & Kashmir | 111.05 | 0.07 |
| 3. | Maharashtra | 64.32 | 10.69 |
| 4. | Madhya Pradesh | 61.66 | 5.12 |
| 5. | Andhra Pradesh | 38.44 | 5.37 |
| 6. | Gujarat | 35.77 | 18.50 |
| 7. | Himachal Pradesh | 33.84 | 2.06 |
| 8. | Odisha | 25.78 | 0.62 |
| 9. | Karnataka | 24.70 | 9.68 |
| 10. | Uttar Pradesh | 22.83 | 3.36 |
| 11. | Telangana | 20.41 | 4.84 |
| 12. | Chhattisgarh | 18.27 | 1.35 |
| 13. | Jharkhand | 18.18 | 0.20 |
| 14. | Tamil Nadu | 17.67 | 10.15 |
| 15. | Others | 113.76 | 5.34 |

*Source: MNRE, NISE, Crisil Intelligence*

## 4.3 Key drivers for solar energy capacity additions

**Figure 29: Growth drivers for solar sector in India**




*Source: Crisil Intelligence*

Some of these are discussed in detail in the following sections:

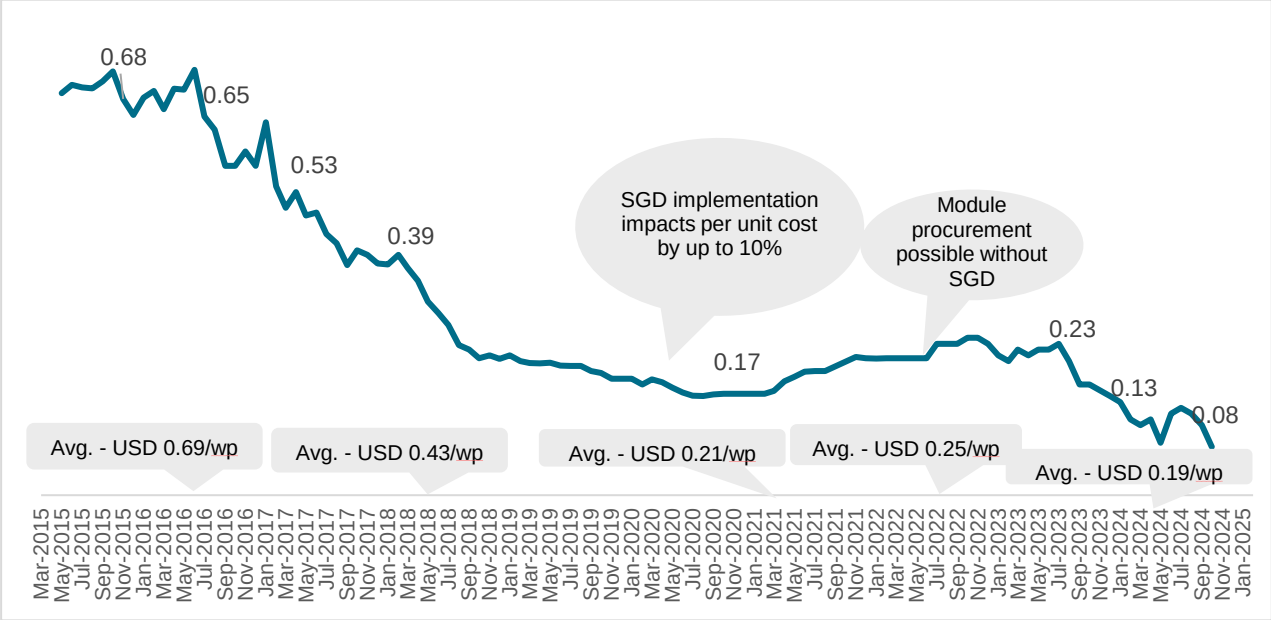
### 4.3.1 Declining module prices and tariffs

The global average solar module price, which constitutes 55-60% of the total system cost, crashed by 73.60% to USD0.47/Wp in 2016 (average for January-December) from USD1.78/Wp in 2010. In fact, prices continued to decline to USD0.22/Wp by August 2019, owing to technological improvement, scale benefits, and a demand-supply gap in the global solar module manufacturing industry. Further, declining inverter prices (6-7% of the capital cost), which fell to USD0.2/Wp by March 2020, reduced system costs. In fiscal 2021, module prices reached USD0.20/Wp.

Module prices started to fall in fiscal 2023, owing to the ramp-up in the production of upstream components. Prices of modules fell to USD0.15-0.20/Wp in April-November 2023 from USD0.23/Wp in January 2023. This has eased some pressure on the capital costs in fiscal 2024. Prices of Monofacial module had touched USD0.20/Wp by Q4 of fiscal 2024.

As India largely relies on imported cells for module manufacturing, a steep fall in upstream component prices has also resulted in fall in module prices. Thus, the average price for fiscal 2025 is expected to remain 24-26% below compared to last fiscal, owing to low cell prices on year. Crisil Intelligence expects prices to be in the range of USD0.15-0.18/Wp for imported mono-crystalline modules and USD0.17-0.19/Wp for domestic mono-crystalline modules (assembled using imported cells) in fiscal 2026, owing to limited room for discounts at the manufacturing level.

**Figure 30: Module prices declined over 80-85% from fiscal 2015 to 2025 (USD/Wp)**




*Source: Crisil Intelligence*

**Table 10: Safeguard and customs duty trajectory**

| Year of imposition | 30 July 2018 to 29 July 2019 | 30 July 2019 to 29 January 2020 | 30 January 2020 to 29 July 2020 | 30 July 2020 to 29 January 2021 | 30 January 2021 to 29 July 2021 | From 1 April 2022 (BCD) | From 2 February 2025 (BCD)* |
|---|---|---|---|---|---|---|---|
| Duty rate | 25% | 20% | 15% | 14.9% | 14.5% | Module – 40%<br>Cell – 25% | Module- 20%<br>Cell- 20% |

** Additional agricultural and infrastructure development cess of 20% on modules and 7.5% on cells*

*Source: Crisil Intelligence*

Various players from the Indian solar component manufacturing industry filed additional duty petitions against imports. The key in this regard was a safeguard duty investigation filed by the Indian Solar Manufacturer's Association (ISMA) to the Directorate General of Trade Remedies (DGTR).

After initiating a probe to decide on the continuation of the Safeguard Duty (SGD) on solar import and receiving applications from domestic companies, the DGTR extended the imposition of the SGD for another year, with the duty being levied at 14.90% from 30 July 2020, to 29 January 2021, followed by 14.50% from 30 January 2021, to 29 July 2021. Declining duty had led to eased cost pressures, and tariffs began to lower. The Ministry of Finance imposed a BCD of 25% and 40% on solar cells and modules, respectively, effective 1 April 2022. The imposition of the BCD led to an increase in capital costs for projects based on imported modules by 20-25%, and an increase in tariffs by ₹ 0.20-0.50/kWh (with the tariffs ranging from ₹ 2.60-2.80/kWh).

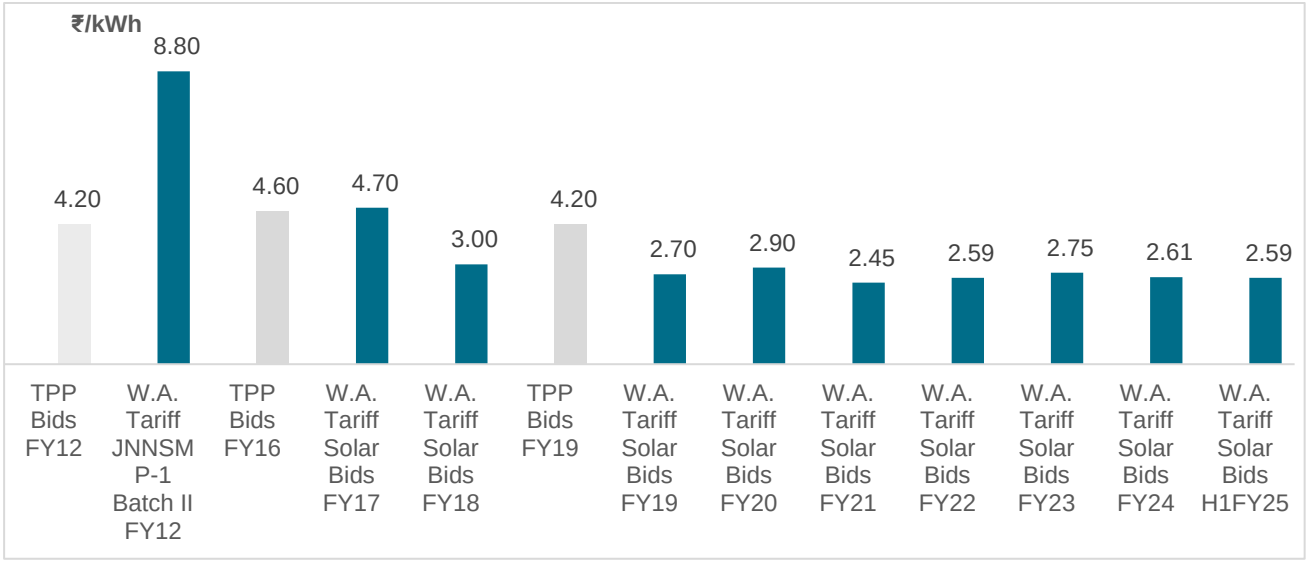
In the Budget for fiscal 2026, the government has reduced the import duties on solar cells to 20% from 25% and solar modules to 20% from 40%, effective 2 February 2025. However, the Agricultural and Infrastructure Development Cess (AIDC) of 20% on modules and 7.5% on cells keep the effective BCD rate of solar modules at 40% and for cells 27.50%.

### 4.3.2 Solar power tariffs have been lower than coal-based power tariffs

On the pricing front, solar tariffs showed a rapid decline from fiscal 2016 to fiscal 2020, with a rapid fall in component pricing, technological improvements in efficiency and the government's policy push. While declining module prices contributed to a reduction in tariffs over fiscals 2017-2019, access to low-cost financing was the primary driver for the decline in tariffs over fiscals 2020-2022. Over the said period, global investments in the Indian renewable energy segment picked up via green bond issuance and external commercial borrowings, helping the lower cost of debt for the space. The participation of global players and entities with strong credit profiles like Central public sector undertakings (CPSUs) has helped tariffs remain in the ₹ 2.40 - 2.60 /kWh range even until fiscal 2022 when supply-side disruptions started to emerge. Tariffs recorded a 16% uptick in fiscal 2023, when it rose to ₹ 2.80 /kWh before declining to ₹ 2.61 /kWh in fiscal 2024, a drop of close to 7%. Tariff drop in fiscal 2024 was majorly on account of price decline in upstream components, mainly solar cells, where prices fell by ~47% in fiscal 2024. In H1 fiscal 2025, the tariffs remained consistent as last year with a weighted average tariff of ₹ 2.59 /kWh.

In recent years, there has not been any major development in the case of thermal power bidding. However, considering the previously bid prices of thermal power, solar power tariffs have been on the lower side.

**Figure 31: Competitively bid solar power tariffs are much lower than coal-based power tariffs**




*Note: TPP – Thermal power plant; JNNSM – Jawaharlal Nehru National Solar Mission; W.A. – Weighted average levelized tariffs*

*Source: Details of Case I bids, Bidding of power from stressed assets, CEA; Crisil Intelligence*

However, while looking at solar tariffs, one will have to increasingly factor in grid integration costs as the penetration level of renewable energy increases. This is expected to increase the procurement cost of solar power plants and hence an incremental focus on WSH and more firm power (FDRE/RTC).

### 4.3.3 Fiscal and regulatory incentives

The Indian government has been offering a variety of incentives to encourage the development of solar power plants.

**PM *Surya Ghar Muft Bijli Yojna*:** For further sustainable development and people's well-being, the Central Government in February 2024 launched the PM *Surya Ghar: Muft Bijli Yojna*. This scheme has a proposed

outlay of ₹ 750 billion and aims to light up 10 million households by providing up to 300 units of free electricity every month.

**Subsidy for residential households:**

₹ 30,000/- per kW up to 2 kW
₹ 18,000/- per kW for additional capacity up to 3 kW
Total Subsidy for systems larger than 3 kW capped at ₹ 78,000

The MNRE on 20 February 2024, has declared that only applications received after 13 February 2024, will be considered for Central Financial Assistance (CFA) under PM Surya Ghar Muft Bijli Yojana. Further, it was also clarified that this is a whole new scheme, and all previous schemes have been lapsed.

**Annual Bidding Trajectory**

MNRE has prescribed an annual bidding trajectory for RE power bids to be issued by the Renewable Energy Implementation Agencies (REIAs). Bids for 50 GW per annum RE capacity, with at least 10 GW per annum Wind power capacity, are to be issued each year from fiscal 2024 to fiscal 2028. This is expected to help in achieving the targets specified for 2030. Bids of 53.32 GW have been issued by four REIAs (SECI, NTPC, NHPC and SJVN) in fiscal 2024. REIAs issued RE procurement tenders aggregating 44 GW in fiscal 2025.

**Operational support to execute solar projects**

Apart from providing incentives, the government has lent significant support to the solar power sector for the execution of projects.

**Solar parks and ultra mega solar power projects**: One of the most important initiatives by the GoI has been the establishment of solar parks in the country. To overcome the land, approvals and transmission-related challenges, the scheme for "Development of Solar Parks and Ultra-Mega Solar Power Projects" was rolled out in December 2014 with the objective to facilitate the solar project developers to set up projects expeditiously.

Solar parks/ ultra mega renewable energy power parks (UMREPPs) of aggregate capacity of 40,763 MW have been envisaged for development in the country as on 31 December 2024. Of these, the capacity of 12,306 MW has already been commissioned while 13,280 MW capacity is under construction and 15,177 MW is under award/tendering process. The State-wise details are given below.

**Table 11: State wise solar park approved capacity (GW) as of December 2024**

| Name of the State in which Solar Parks/UMREPPs are located | Total Capacity of Solar Park/ UMREPP (MW) | Capacity Under Award / Tendering (MW) | Capacity Awarded (MW) | Capacity Under construction (MW) | Capacity Commissioned (MW) |
|---|---|---|---|---|---|
| Andhra Pradesh | 4,300 | - | 4,300 | 1,250 | 3,050 |
| Chhattisgarh | 100 | - | 100 | - | 100 |
| Gujarat | 12,150 | 3,770 | 8,380 | 7,380 | 1,000 |
| Himachal Pradesh | 53 | 21 | 32 | - | 32 |
| Jharkhand | 1,089 | 679 | 410 | 410 | - |
| Karnataka | 2,500 | 500 | 2,000 | - | 2,000 |
| Kerala | 255 | 100 | 155 | 50 | 105 |
| Madhya Pradesh | 4,780 | 2,002 | 2,778 | 515 | 2,263 |
| Maharashtra | 1,105 | 605 | 500 | 250 | - |

| Name of the State in which Solar Parks/UMREPPs are located | Total Capacity of Solar Park/ UMREPP (MW) | Capacity Under Award / Tendering (MW) | Capacity Awarded (MW) | Capacity Under construction (MW) | Capacity Commissioned (MW) |
|---|---|---|---|---|---|
| Mizoram | 20 | - | 20 | - | 20 |
| Odisha | 340 | 200 | 140 | 140 | - |
| Rajasthan | 10,341 | 6,000 | 4,341 | 1,035 | 3,306 |
| Uttar Pradesh | 3,730 | 1,300 | 2,430 | 2,000 | 430 |
| **Total** | 40,763 | 15,177 | 25,586 | 13,030 | 12,306 |

*Source: CEA, MNRE, Crisil Intelligence*

### 4.3.4 Key schemes driving solar capacity additions

| Sr. No. | Scheme | Incentives |
|---|---|---|
| 1. | Grid Connected Rooftop Solar PV Power Projects **PM Surya Scheme** | **Subsidy for residential households**<br>• ₹ 30,000/- per kW up to 2 kW<br>• ₹ 18,000/- per kW for additional capacity up to 3 kW<br>• Total Subsidy for systems larger than 3 kW capped at ₹78,000 |
| 2. | Central Public Sector Undertaking (CPSU) Scheme Phase-II | Viability Gap Funding (VGF) support up to ₹ 5.5 million per MW to the CPSUs/Govt. Organizations entities selected through competitive bidding process. |
| 3. | PLI Scheme 'National Programme on High Efficiency Solar PV Modules' | The beneficiaries are eligible for Production Linked Incentive (PLI) on production and sale of solar PV modules. The quantum of PLI eligible for disbursal depends upon: (i) quantum of sales of solar PV modules; (ii) performance parameters (efficiency and temperature coefficient of maximum power) of solar PV modules sold; and (iii) percentage of local value addition in modules sold. |
| 4. | Solar Park Scheme | Up to ₹ 2.5 million per Solar Park, for the preparation of Detailed Project Report (DPR).<br>₹ 2.0 million per MW or 30% of the project cost, whichever is lower, for development of infrastructure. |
| 5. | PM-KUSUM scheme | **Component A**: Setting up of 10,000 MW of Decentralized Ground/Stilt Mounted Solar Power Plants<br>Benefit available: Procurement Based Incentive (PBI) to the DISCOMs @ 40 paise/kWh or ₹0.66 million/MW/year, whichever is lower, for buying solar power under this scheme. The PBI is given to the DISCOMs for a period of five years from the Commercial Operation Date of the plant. Therefore, the total PBI payable to DISCOMs is up to ₹ 3.3 million per MW.<br>**Component B**: Installation of 2.0 million Stand-alone Solar Pumps<br>Benefit available: CFA of 30% of the benchmark cost or the tender cost, whichever is lower, of the stand-alone solar agriculture pump is provided.<br>However, in Northeastern States, Sikkim, Jammu & Kashmir, Ladakh, Himachal Pradesh and Uttarakhand, Lakshadweep and A&N Islands, CFA of 50% of the benchmark cost or the tender cost, whichever is lower, of the stand-alone solar pump is provided.<br>**Component C:** Solarisation of 1.5 million Grid Connected Agriculture Pumps including through feeder level solarisation |

| Sr. No. | Scheme | Incentives |
|---|---|---|
| | | Benefit available:<br>a. Individual Pump Solarization: CFA of 30% of the benchmark cost or the tender cost, whichever is lower, of the solar PV component will be provided. However, in Northeastern States, Sikkim, Jammu & Kashmir, Ladakh, Himachal Pradesh and Uttarakhand, Lakshadweep and A&N Islands, CFA of 50% of the benchmark cost or the tender cost, whichever is lower, of the solar PV component is provided.<br>b. Feeder Level Solarization: Agriculture feeders can be solarized by the State Government in CAPEX or RESCO mode with CFA of ₹ 10.5 million per MW as provided by MNRE. However, in Northeastern States, Sikkim, Jammu & Kashmir, Ladakh, Himachal Pradesh, Uttarakhand, Lakshadweep and Andaman & Nicobar Island, CFA of ₹ 17.5 million per MW is provided. |
| 6. | Green Energy Corridor Scheme (for development of intra-state transmission system for RE projects) | GEC Phase-I: CFA of 40 % of DPR cost or awarded cost, whichever is lower.<br>GEC Phase-II: CFA of 33 % of DPR cost or awarded cost, whichever is lower. |
| 7. | R&D programme | MNRE encourages research and technology development proposals in collaboration with the industry and provides up to 100% financial support to Government/non-profit research organizations and up to 50- 70% to Industry, Start-ups, Private Institutes, Entrepreneurs and Manufacturing units. |
| 8. | National Green Hydrogen Mission | SIGHT programme for Electrolyser manufacturing: allocation of ₹ 44.4 billion by 2029-30; incentives start from ₹ 4440 per kW in the first year and end at ₹ 1480 per kW in the fifth year.<br>SIGHT programme for Green Hydrogen production (Mode-I): incentives for Green Hydrogen production, which are capped at ₹ 50/kg ₹ 40/kg and ₹ 30/kg for the first, second and third year, respectively. |
| 9. | Other Tax benefits | Income tax exemption for solar power projects like Section 80-IA of the Income Tax Act, 1961, Accelerated Depreciation (AD), and GST exemptions. |

*Source: MNRE, Crisil Intelligence*

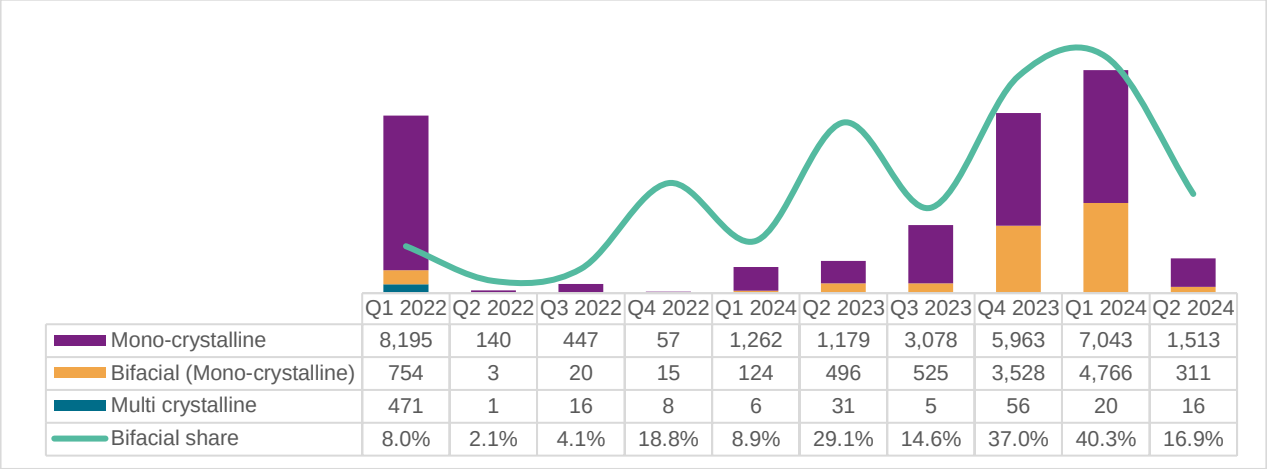
### 4.3.5 Favourable technology

Solar power is becoming increasingly attractive due to falling module prices and improving efficiency resulting from excess manufacturing capacity in China and technological advancements, respectively.

On the project development front, developers are exhibiting a heightened preference for bifacial modules that are compatible with tracker technology and typically have higher efficiency relative to mono-facial modules. In fiscal 2023, the share of bifacial variants in module imports increased from 8% in Q1 2022 to 40% in Q1 2024. On the other hand, multi-crystalline modules are being phased out due to lower efficiency and higher degradation rates. The share of import volume was negligible in fiscal 2023.

The share of monocrystalline technology is now about 84% (compared with 66% in 2019) of total crystalline silicon (c-Si) production. The performance ratio has also been improved in the 80-90% range. The c-Si segment is expected to grow substantially due to c-Si's long life and light weight.

**Figure 32: Historic module imports, MW**



| | Q1 2022 | Q2 2022 | Q3 2022 | Q4 2022 | Q1 2024 | Q2 2023 | Q3 2023 | Q4 2023 | Q1 2024 | Q2 2024 |
|---|---|---|---|---|---|---|---|---|---|---|
| Mono-crystalline | 8,195 | 140 | 447 | 57 | 1,262 | 1,179 | 3,078 | 5,963 | 7,043 | 1,513 |
| Bifacial (Mono-crystalline) | 754 | 3 | 20 | 15 | 124 | 496 | 525 | 3,528 | 4,766 | 311 |
| Multi crystalline | 471 | 1 | 16 | 8 | 6 | 31 | 5 | 56 | 20 | 16 |
| Bifacial share | 8.0% | 2.1% | 4.1% | 18.8% | 8.9% | 29.1% | 14.6% | 37.0% | 40.3% | 16.9% |

*Source: Ministry of Commerce, Crisil Intelligence*

Currently, the solar PV market is dominated by monocrystalline silicon technology. TOPCon technology has also made inroads in India's solar module manufacturing sector with adoption and switching existing manufacturing lines to TOPCon. Within monocrystalline technology, Mono PERC is an advanced version that employs dielectric passivation film on the rear surface of the cells which increases the efficiency levels. These cells are currently leading the market due to higher efficiency, less space covered, higher output in low light conditions and are available at competitive pricing. However, ongoing technological innovation in the manufacturing processes is crucial to reduce material intensity, especially for critical minerals like silver and copper. These efforts aim to minimize vulnerabilities in the supply chain.

**Table 12: Solar PV module technologies**

| Parameters | Thin film | Mono PERC | TOPCon | HJT |
|---|---|---|---|---|
| Cell Efficiency | 18.9%-20.6% | 23.2% - 23.7% | 24.5% - 25.2% | 24.5% - 25.2% |
| Module Efficiency | 18.1%-19.7% | 20.0% – 21.5% | 22.0% - 23.0% | 22.0% - 23.0% |
| Bi-faciality | NA | 70% - 75% | 80% - 85% | 80% - 90% |
| Complexity | Moderate | Moderately complex | Less than HJT. Existing Mono PERC production facility can be upgraded to TOPCon | Most complex |
| Temperature Co-efficient of Power (Pmax Temperature Co-efficient) | • -0.32% / °C.<br>• Power decline less than PERC cells at elevated temperatures | • -0.35% / °C.<br>• PERC cells experience a more noticeable power decline at elevated temperatures | • -0.29% / °C.<br>• Offers a significant power improvement over PERC cell at elevated temperatures | • -0.24% to -0.26% / °C.<br>• Lowest temperature coefficient - HJT cells experience minimal power loss even at high temperatures. |
| Losses and Damages | 0.3% degradation rate; not prone to LID losses | p-type Mono PERC cells are prone to LID and PID losses. Such | PID and LID losses in TOPCon are lower compared to Mono PERC, | Not prone to PID and LID losses, since general cell |

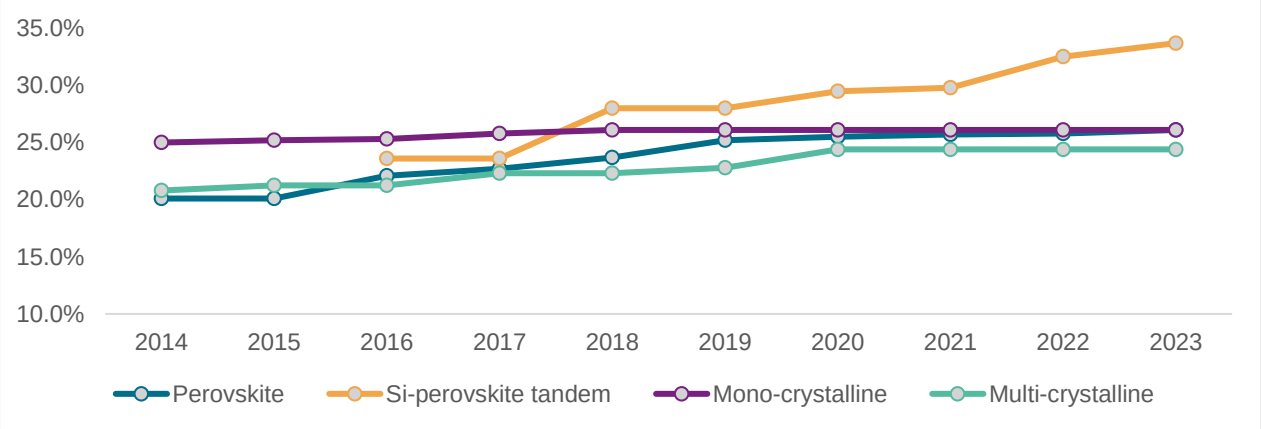
| Parameters | Thin film | Mono PERC | TOPCon | HJT |
|---|---|---|---|---|
| | | losses are high compared to peers | | construction is n-type |

*Note: Initial capex for module manufacturing lines pertains to Chinese set-ups.*
*Potential Induced Degradation (PID) and Light Induced Degradation (LID)*
*Source: Crisil Intelligence*

In addition to process improvements, the development of new solar cell designs is essential for achieving further efficiency gains while simultaneously reducing material intensity and manufacturing costs. The p-type to n-type migration is currently underway and paving the way for new technologies – by the end of CY 2023, n-type technologies including TOPCon, heterojunction (HJT) and back contact represented 42% of China's total module manufacturing capacity (7% in CY 2022). These designs hold the potential for achieving additional efficiency gains in solar panels. Based on pilot tests conducted by leading global manufacturers, it is estimated that the TOPCon cell could provide an additional efficiency gain of up to 2-2.5% gain over mono PERC modules. Even though TOPCon is expected to be the dominant n-type technology over the next couple of years due to its lower cost over other new technologies, HJT modules' higher efficiency, and lower temperature sensitivity make it a better alternative to TOPCon modules in selected locations. Additionally, China's market share of HJT modules is expected to increase from an estimated 2% in CY2023 to around 16% in CY2027 due to decreasing production cost differential with TOPCon technology.

In addition, there are ongoing considerations for mass manufacturing of multilayer and tandem silicon-perovskite or silicon-CdTe hybrid solar panels. These innovative solutions have the potential to significantly increase cell efficiency, surpassing the 30% mark, while maintaining competitive production costs and promise to make solar power an even more compelling and sustainable energy solution in the years to come.

**Figure 33: Cell efficiency comparison**

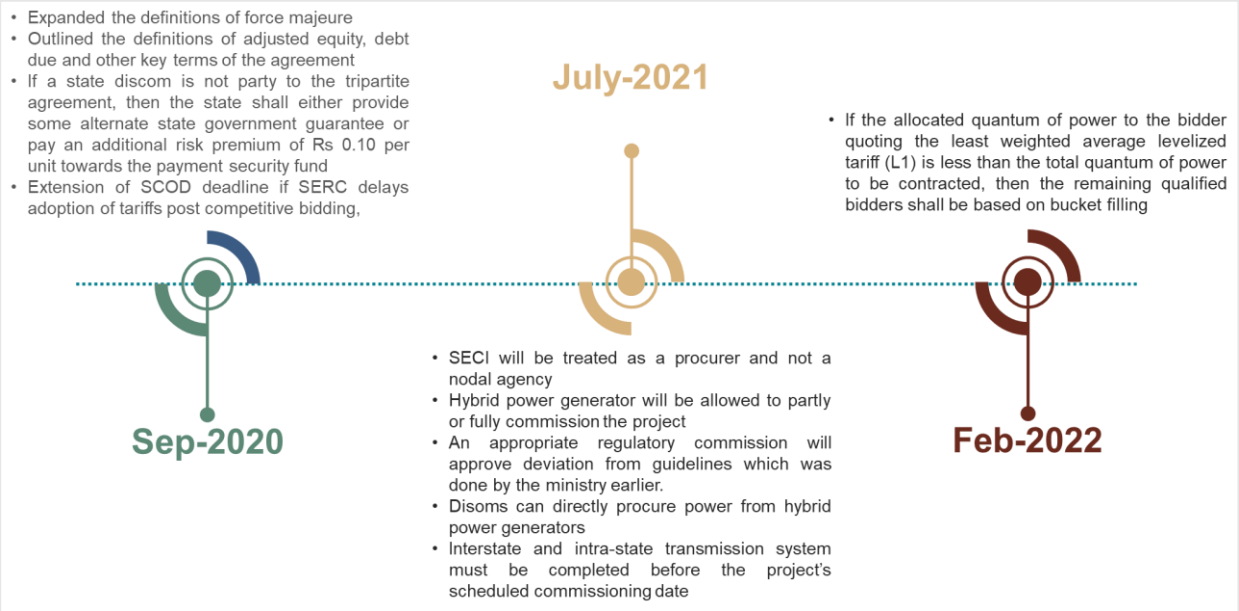



*Source: NREL, Crisil Intelligence*

## 4.4 Review of competitive bidding

For solar projects over 2009-2013, most states signed PPAs at Feed-in Tariff (FiTs) determined by the state commission on a fixed regulated equity return of ~16%. For wind energy projects, states followed the FiT mechanism until March 2017. However, from fiscal 2018 onwards, the sector veered towards competitive bidding.

**Figure 34: Positive changes to bidding guidelines undertaken to support bidder interest**



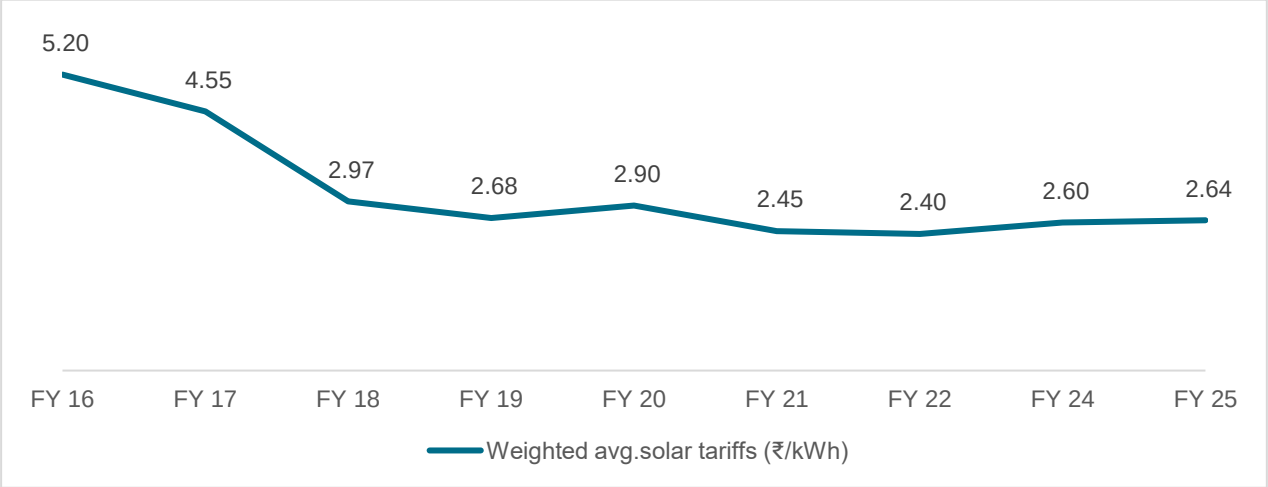

*Source: MNRE, Crisil Intelligence*

Overall, the above amendments are a positive sign for the developers, as they grant extension in SCOD for events that have been hampering commissioning, stipulate some form of state government guarantee, and ease liquidity in the sector by way of introducing alternative payment security mechanisms. These changes provide a positive boost to the open access market as well and simplify procedures or provide provisions to stimulate bidder interest. However, the sector requires consistent positive regulatory support to spur capacity additions, despite a healthy pipeline.

In February 2025, the MNRE issued revised guidelines for solar, wind, and WSH projects and introduced several key changes. Procurers can now specify the sub-station for project connectivity. Generators that fail to maintain the minimum CUF for two consecutive years will be liable to pay damages. The guidelines also clarify the definition of "Change in Law" which now refers to any event related to the project that occurs from 7 days prior to the last date of Bid Submission. Additionally, the period for signing PPAs and power sale agreements can be extended to 12 months after receiving LoA, and tariffs discovered through bidding must be adopted by the appropriate Commission within 30 days. Other changes include the introduction of Insurance Surety Bonds, revised rules for Performance Bank Guarantees, and a requirement for procurers to seek approval from the appropriate Commission for any deviations from the guidelines.

After registering the lowest tariff of ₹ 1.99/kWh in December 2020, the solar tariffs have bounced back and witnessed a more than 25% increase. This increase can be attributed to increased project cost, implementation of BCD, requirement of ALMM and domestic content requirement, as well as regulatory and policy risks. Crisil Intelligence believes that a tariff of ₹ 2.5-2.75/kWh will be required for a 10-15% equity IRR, owing to a sharp decline in module prices year-on-year in fiscal 2025, despite a basic customs duty in place.

**Figure 35: Weighted average solar tariff trend (₹/kWh)**




*Note: The above tariffs are for ground-mounted solar only;*

*Source: Press Releases by respective Companies. Investors Presentations as available on stock exchanges etc., Crisil Intelligence*

## 4.5 Project Capex, EPC and O&M costs movement

Solar project CAPEX trend has largely followed global module price trends – between fiscal 2011 and fiscal 2021, EPC cost for utility-scale projects reduced by around 65% to ₹ ~39 million/MWp due to falling module prices. While landed module cost increased temporarily in Q2 CY 2022 due to the imposition of BCD on China modules, over H2 of CY 2022 and CY2023, led by a massive supply glut in China, prices across the solar value chain declined sharply – China module prices decreased by around 57% in the two-year period ended December 2023 to USD 0.12/Wp. As a result, EPC costs for utility-scale projects declined by around 33% in the two-year period ended in December 2023 to ₹ 27 million/ MWp. On the BoS front, while prices of commodities like copper and aluminium (used for building mounting structures and other key components) are volatile, the effect on overall EPC cost is marginal due to a low share in CAPEX.

Going forward, while China module prices are expected to remain soft due to excess manufacturing capacity coupled with subdued international demand (mainly due to US aversion to China imports and high inventory levels in EU), domestic prices are expected to hover around USD 0.18-0.21/Wp in CY2025 due to inadequate, albeit growing, domestic supply and ALMM's implementation from April 2024 onwards.

MNRE issued Office Memorandum No. 283/2/2024-GRID SOLAR on 9 December 2024, amending the ALMM Order of 2019 to mandate that, starting 1 June 2026, all solar PV projects—including government-backed schemes, net-metering projects, and open-access projects—must use solar cells listed in ALMM List-II for module manufacturing. This applies to all projects under the ALMM framework, ensuring modules listed in ALMM List-I are manufactured using domestically produced solar cells from List-II, except for specific exemptions as given below:

- Projects with **bid submission deadlines on or before 9 December 2024**, are exempt from the requirement to use ALMM List-II solar cells, regardless of their commissioning date. This means these projects can use **imported solar cells** even if commissioned after 1 June 2026, provided they use modules from ALMM List-I.

Modules that use domestic cells are expected to be even more expensive, with prices at least 50% higher than those using imported cells. Therefore, until sufficient domestic manufacturing capacity is established, the use of domestic modules with domestic cells could lead to a significant increase in domestic tariffs by around ₹ 0.30 - 0.75 /kWh.

## 4.6 Outlook of overall grid-connected solar energy capacity additions

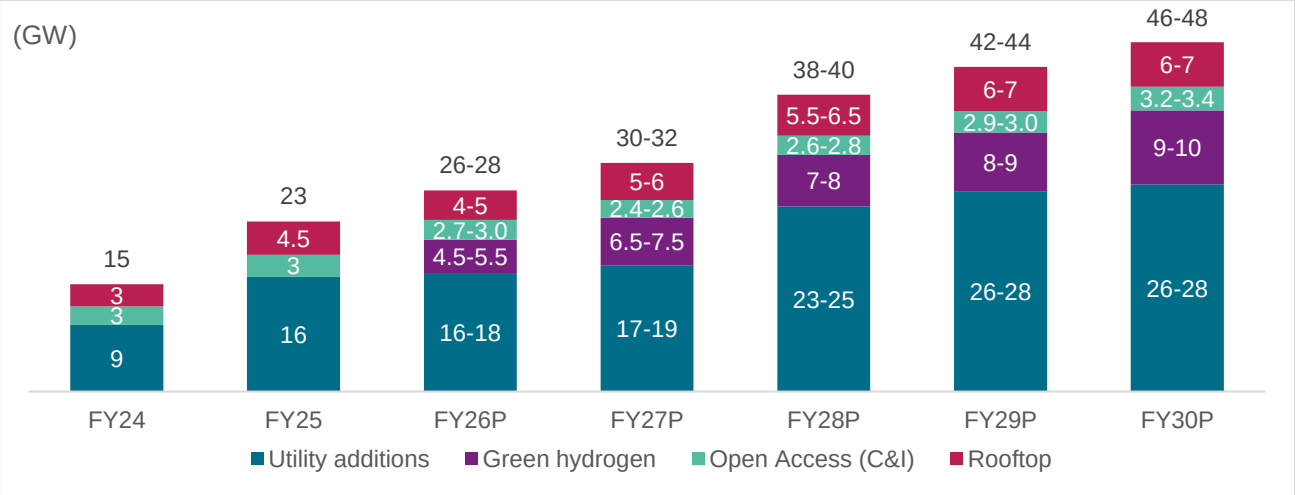
The demand for renewable energy in India is rapidly growing, fueled by environmental considerations and regulatory support. Solar sector growth in India primarily spurred by robust government backing, demonstrated through an aggressive tendering strategy. Some of the key catalysts include technological advancements, affordable financing, supportive policies, thrust on go-green initiatives/sustainability targets, cost optimisation due to increased grid electricity tariffs, subsidy initiatives (especially in rooftop solar) and various incentives such as ISTS charge waiver.

Crisil Intelligence expects 175-180 GW of solar capacity additions over fiscal 2025-2030. This will be driven by the additions under:

- **National Solar Mission (NSM)**: The entire NSM Phase II Batch II Tranche I of 3,000 MW has been commissioned. Under NSM Phase II, Batch III, and Batch IV, SECI through its state specific VGF has tendered out ~7 GW of capacities, most of which has been completed.
- **Other central schemes**: SECI has also started tendering projects outside the JNNSM Batch programme. It has initiated the ISTS scheme, wherein projects are planned for connection with the ISTS grid directly. Under this, SECI has already tendered and allocated ~35 GW (including WSH).
- **State solar policies**: ~25-27 GW of projects are under construction and are expected to be commissioned over the fiscal 2025-2030. Based on tendered capacities by states at the end of June 2024, a further ~24 GW capacity of solar projects is expected to be up for bidding over the same duration.
- **Public sector undertakings (PSUs)**: The CPSU programme under JNNSM has been extended to 12 GW in February 2019. The government is also encouraging cash-rich PSUs to set up renewable energy projects. NTPC has already commissioned a total of over ~3.7 GW of capacities at the end of September 2024. It has a target of installing ~35 GW of renewable energy capacities by fiscal 2028. Similarly, NHPC had allocated 2 GW of projects in 2020, while the Indian Railways has committed to 20 GW of solar power by 2030. Other PSUs such as NLC, defence organizations, and governmental establishments are also expected to contribute to this addition.
- **Rooftop solar projects**: Crisil Intelligence expects 27-29 GW of rooftop solar projects (under the capex and opex mode) to be commissioned by fiscal 2030, led by PM Surya Ghar Yojana and industrial and commercial consumers under net/gross metering schemes of various states.
- **Open-access solar projects**: Crisil Intelligence expects 18-19 GW of open-access solar projects (under the capex and opex mode) to be commissioned by fiscal 2030, led by Green Energy Open Access Rules 2022, sustainability initiatives/RE 100 targets of the corporate consumers, better tariff structures and policies of states such as Uttar Pradesh and Karnataka, which are more long term in nature.
- **Push for Green hydrogen**: Production for green hydrogen is expected to start from fiscal 2026 with production of 0.5-1 million tonnes. The government has set the target production of 5 million tonnes of

green hydrogen by 2030. As per the announcement, Crisil Intelligence expects 2.0-3.0 MTPA of green hydrogen to commission, which can lead to the further upside of the solar capacity of 30-32 GW, by fiscal 2030. However, since developers may tie-up via grid or open access rather than the captive route, generation under this segment will remain monitorable.

**Figure 36:Year wise expected solar capacity addition**




*Source: Crisil Intelligence*

Also, global conglomerates such as Amazon, and Microsoft have set their sustainability goals and procured more and more renewable energy in India to set off their global GHG emission. This also provides a lucrative opportunity for IPPs to sign PPAs for RE capacity. A 100 MW solar plant enables a reduction of 177,100 $tCO_2e$ (with 22% CUF and a combined margin of 0.919) which is equivalent to planting approximately 0.71 million trees (with an average carbon sequestration of 25 kg per tree).

The European Unions' (EU) Carbon Border Adjustment Mechanism (CBAM) is the EU's tool to put a fair price on the carbon emitted during the production of carbon-intensive goods that are entering the EU, and to encourage cleaner industrial production in non-EU countries. The CBAM is expected to have a significant impact on solar capacity additions in non-EU countries. With the increasing adoption of solar energy, CBAM is expected to contribute to the overall growth of the market. The CBAM is expected to drive the renewable energy demand for energy-intensive industries export their products to the European markets to follow their norms regarding carbon emission and avoid imposition of penalties for non-adherence to such rules and regulations.

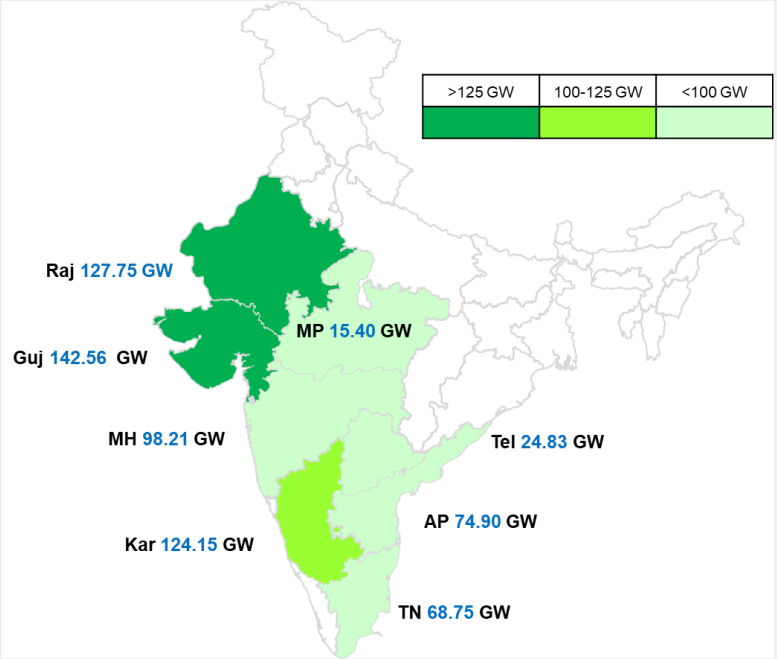
Crisil Intelligence's outlook factors in the prevailing market dynamics, where regulatory/policy support is key. The renewable energy domain is highly dependent on policy support, and any uncertainty surrounding this could restrict capacity additions.

# 5 Overview of Indian wind energy sector

## 5.1 Review of wind capacity additions in India

India has a vast wind energy potential, estimated at 695.50 GW at 120 meters above ground level (AGL) as per estimates by the National Institute of Wind Energy.

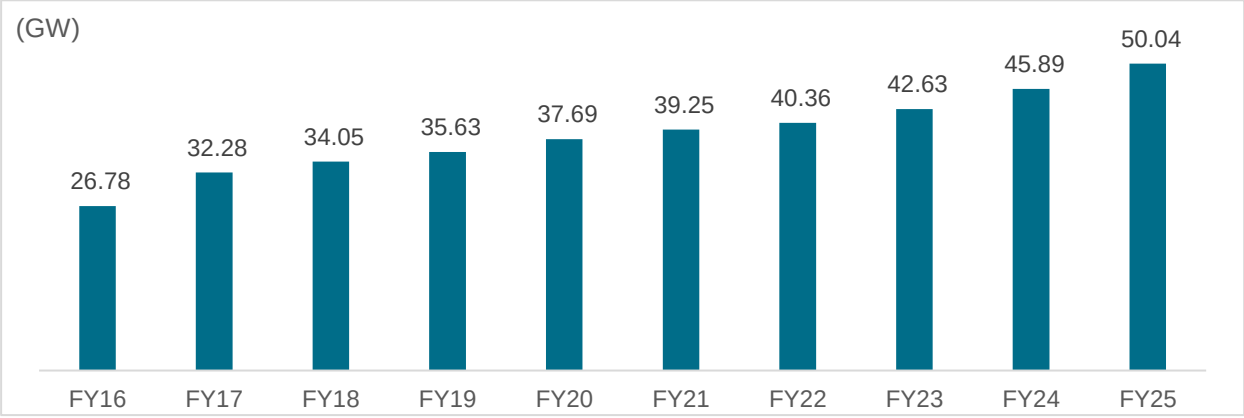
**Figure 37: India-Wind Energy Potential**




*Note: Others 18.95 GW; Source: National Institute of Wind Energy (NIWE), MNRE, Crisil Intelligence*

India has the fourth largest installed wind power capacity in the world, with ~50.04 GW as of 31 March 2025. Wind power accounted for nearly 10.53% of India's total installed utility power generation capacity. Wind power capacity is mainly spread across the southern, western, and northwestern states of India. Leading states in wind power installations include Tamil Nadu, Gujarat, Maharashtra, Rajasthan, and Karnataka. Over the last five years, the installed wind power capacity in India has grown at ~5.83% (CAGR).

**Figure 38: India-Wind power installed capacity**



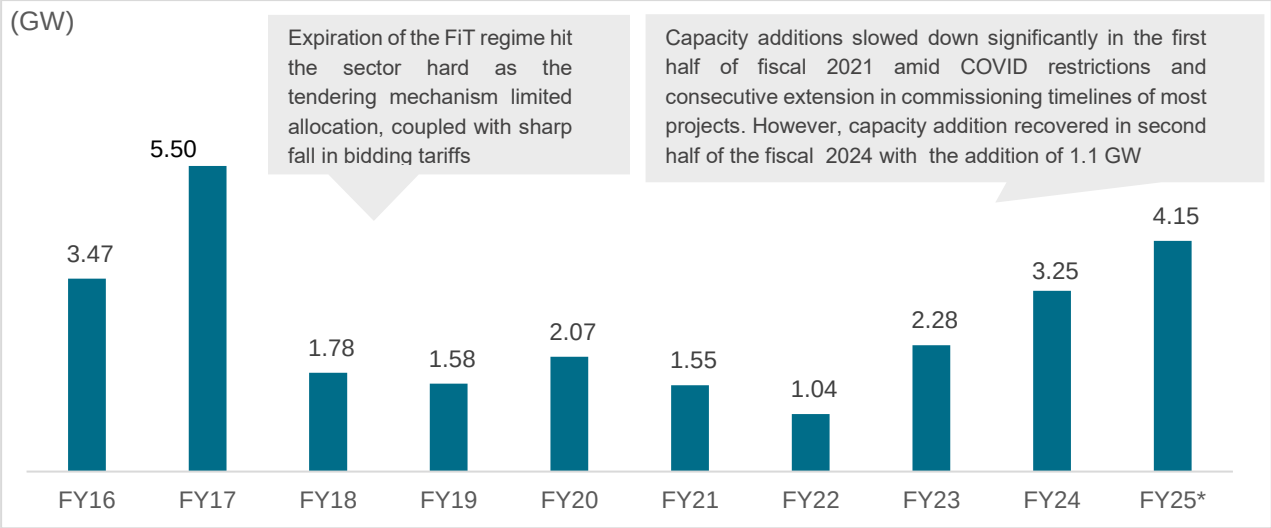

*Source: MNRE, CEA, Crisil Intelligence*

In fiscal 2025, India added 4.15 GW of wind power capacity, continuing the upward trend from 3.25 GW in fiscal 2024. This growth was driven by the rising adoption of WSH projects, which enhanced project viability, and the stabilization of key commodity prices, reducing project costs. In fiscal 2023, a capacity of 2.28 GW was installed, supported by the commissioning of long-pending projects under SECI Tranches IV, V, and VI, alongside favorable WSH project momentum and moderated commodity prices.

Contrastingly, fiscal 2022 saw a 33.24% year-on-year decline in capacity additions, primarily due to a surge in commodity prices that escalated project costs and hampered economic viability. Additionally, challenges in securing sites in key windy regions and delays in establishing associated connectivity infrastructure further constrained progress.

In fiscal 2020, capacity additions rebounded after subdued performance in fiscals 2018 and 2019, largely due to a shift in the Feed-in-Tariff (FiT) regime to incorporate competitive bidding, which improved project economics. The increase was also fuelled by the commissioning of delayed projects under SECI Tranches I, II, and III, as well as state-led auctions in Tamil Nadu, Maharashtra, and Gujarat, which boosted implementation.

**Figure 39: Annual wind capacity additions**




*Source: MNRE, CEA, Crisil Intelligence*

That said, the sector continues to face delays on account of execution challenges, grid connectivity issues, regulatory approvals and limited availability of key wind sites and OEM suppliers.

**Key States with leading capacity addition**

Wind power capacity additions in India have been concentrated in select states. In fiscal 2024, Gujarat led with 1,744 MW of new wind capacity, followed by Karnataka with 725 MW, Tamil Nadu with 586 MW, and Maharashtra with 195 MW. In fiscal 2023, Rajasthan topped the list with 867 MW, followed by Gujarat (770 MW), Madhya Pradesh (324 MW), and Karnataka (164 MW). These variations reflect regional advantages in wind resources, supportive state policies, and project execution capabilities

## 5.1.1 High-wind-density zones to drive wind energy capacity additions

The top five states (Gujarat, Tamil Nadu, Karnataka, Rajasthan, Maharashtra) make up ~84.46% of the installed wind capacity (as of 31 March 2025), with some regions within these states accounting for most

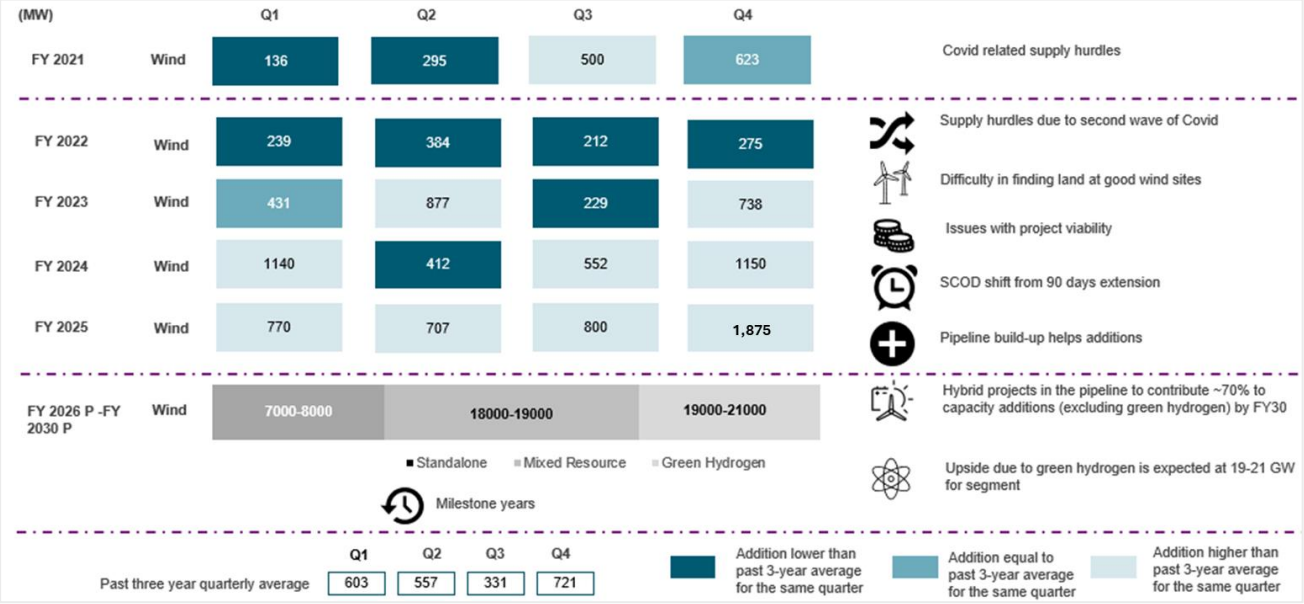
wind power projects. Since April 2021, ~82.97% the new capacity additions have happened in 3 states – Gujarat, Tamil Nadu, and Karnataka.

Gujarat, with the highest installed wind capacity of 12,677 MW, sees concentration of projects in or near the Rann of Kutch region, apart from coastal sites and select locations of Jamnagar, Porbandar, Morbi and Bhavnagar. Similarly, for Tamil Nadu with an installed wind base of 11,740 MW, most projects are located in districts of Tirunelveli, Nilgiris, Erode, Tuticorin, Coimbatore and Tiruppur. Likewise, for Karnataka (7,351 MW), Chitradurga, Bellary, Davengere and Tumkur, for Rajasthan (5,209 MW), Barmer and Jaisalmer; and for Andhra Pradesh (4,377 MW), Ananthapur, Nellore and Kurnool are the key regions where projects are concentrated.

**Review of overall grid connected wind energy capacity additions**

Capacity addition in fiscal 2025 stood at 4,152 MW, building on the back of an uptick recorded in fiscal 2024, with quarterly additions at 1,140 MW, 412 MW, 552 MW and 1,150 MW in the first, second, third and fourth quarters, respectively. Quarterly additions in fiscal 2025 stood at 770 MW in Q1, 707 MW in Q2, 800 MW in Q3 and 1,875 MW in Q4. Additions were weak in fiscal 2022 and fiscal 2021, compared with long-term historical trends, with only 1,111 MW and 1,553 MW, respectively.

**Figure 40: Wind capacity addition analysis (FY21 – FY25)**




*Note: FY 2021 quarterly additions are as per CEA reports, while FY 2022, FY 2023 and FY 2024 are as per MNRE;*

*Past three years quarterly average is calculated for FY22-FY24*

*Source: Solar Energy Corporation of India Ltd, MNRE, CRISIL Intelligence*

Wind capacity additions have primarily been concentrated in Gujarat, Karnataka and Tamil Nadu, accounting for 43.44%, 21.13% and 18.41%, respectively. Similarly, of the total capacity added between fiscal 2021 to fiscal 2025, these states added 5,331 MW, 2,593 MW and 2,259 MW, respectively.

**Review of competitive bidding**

The discovered tariffs for competitively bid projects reached as low as at ₹ 2.43 /kWh in 2017. However, post December 2017, when this low benchmark was reached, tariffs started to increase again. For instance, the weighted average tariff of allocations in fiscal 2023, have averaged at ₹ 3.0/kWh, providing an indication that

developers are factoring in increased tariffs to adequately manage risks. Weighted average tariffs rose further during the fiscal 2024, with ₹ 3.63/kWh being quoted under SECI auction. Overall, weighted average tariff during fiscal 2024 stood at ₹ 3.39/kWh. Fiscal 2025 followed similar trend with weighted average tariff continued at ₹ 3.80/unit.

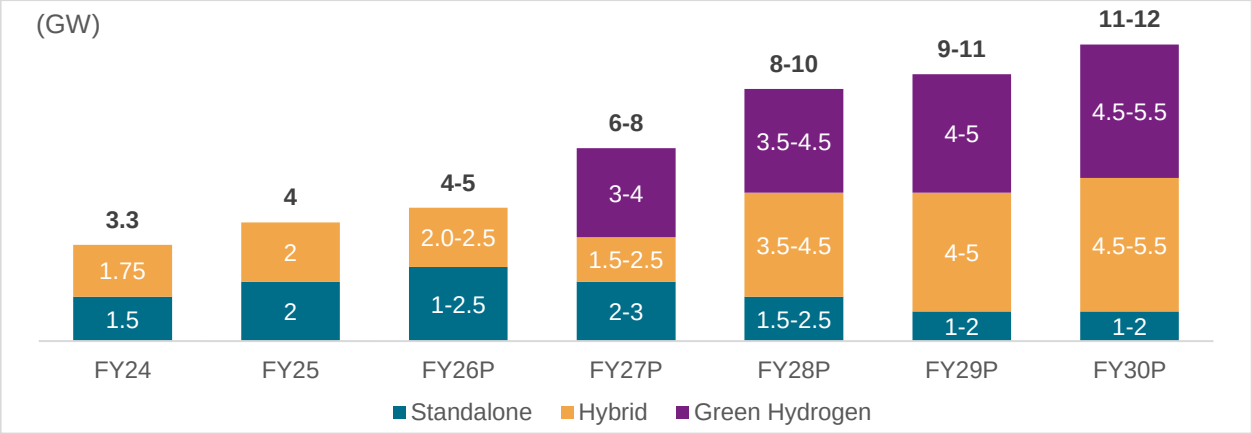
Crisil Intelligence believes that previously projects were aggressively bid even when availability of developed land banks (availability of wind micro siting data and proximity to the transmission) with high wind density sites were not tied up prior or finalised before bidding. This has caused execution challenges for several projects in the sector, for e.g. the SECI ISTS III projects were previously not able to acquire required wind sites in the preferred region of Gujarat. This has deterred further interest/ developer response. Additionally, authorities had set pricing expectations near the ₹ 2.8 /kWh mark, making it difficult for capacities to be auctioned at higher tariff ranges. However, the tariff cap removal in March 2020, provided an opportunity to developers to factor in the added execution challenges along with concerns over project viability, leading to higher bid tariffs in successive auctions.

MNRE had also announced closed bidding process with the option to carry e-reverse auction process to improve bidder interest and activity in the wind sector. This move was expected to ease aggression in bidding, providing a mechanism to provide cost reflective tariffs for the segment, boosting viability for the segment. However, with the concerns over undersubscription of wind projects after the implementation, MNRE revised the guideline giving the option to continue reverse bidding process for wind energy tenders. This is again expected to bring down the high tariffs we witnessed last fiscal year. Crisil Intelligence expects the tariff to remain nearer to ₹ 3.6-3.85/unit for sustainability of the projects.

## 5.2 Outlook for capacity additions in the next 5 years

Crisil Intelligence expects capacity additions of 23-25 GW over fiscals 2025-2030, with further upside of 15-17 GW from green hydrogen entailing investments of ₹ 1.6-1.8 trillion over the period and another ₹ 1.1-1.2 trillion from green hydrogen. Crisil Intelligence expects additions of 9.5-10.5 GW from standalone wind and 14-15 GW from mixed resources wind component to be commissioned by fiscal 2030, factoring in delays due to evacuation infrastructure, etc. Newer business models additions such as WSH, round-the-clock and firm RE to account for 14-15 GW.

**Figure 41: Expected annual wind power capacity additions**




*Source: Crisil Intelligence*

## 5.3 Key factors to drive wind energy capacity additions

**New tender opportunities**

New opportunities have emerged in the wind sector in India with SECI tendering projects including WSH, round-the-clock, peak power supply and firm RE projects. Although the exact split of wind vs solar for WSH projects is based on developer choice and technical design, they tend to have a higher share of solar energy, due to lower capital costs and ease of installation. However, since WSH projects have a floor cap on capacity contribution from solar and wind (power capacity of one resource is at least 33% of the rated power capacity of the other resource), they contribute to capacity additions for wind. Similarly, round-the-clock, peak power supply and firm RE projects also generate substantial demand for wind capacity addition as developers require a good mix of sources (solar, wind and/or energy storage) to get the maximum possible efficiency. Furthermore, WSH and newer model tenders will lead to 14-15 GW capacity additions of wind over the next five years with existing schemes. With fresh WSH tenders in the industry, the additions will further increase gradually over the long term.

**Improved technology**

Newer wind turbines are being launched that have higher rated capacity and higher hub height (130 -140 m), which can be set up at low-quality wind sites, otherwise considered economically unattractive. However, plant load factors and subsequent viability would vary. Technological advancements have allowed players to set up windmills in states/sites with lower wind density. Around 70-80% indigenisation has been achieved with strong domestic manufacturing in the wind sector. All the major global players in this field have their presence in the country with the total existing annual production capacity of ~18 GW. The unit size of WTG has gone up to 5.2 MW.

Based on our estimates, for every 100-bps change in PLFs, equity IRRs improve by 100-150 bps. As per industry interactions, increased capital costs factor-in the improvement in turbine technology, and 3.5 MW and above wind turbine technology have already started installations. Innovations in blade technology with lower weight which allows for building longer blades with lower mass. These improvements in technology will enable lower levelised cost, capacity additions outside the windy region, thereby driving capacity additions.

**Large-scale central allocations**

Post competitive bidding of 1 GW by SECI in February 2017, SECI further allocated ~15 GW (excluding cancelled contracts) of capacities over March 2017-June 2024 through wind only schemes. This bodes well as central sector PPAs have lower counterparty risk compared with PPAs directly with Discoms. The latter are known to delay payments to developers and have poor financial ratings, while SECI and PTC are better rated and provide various payment security mechanisms (LCs, payment security fund and SECI being party to the tripartite agreement).

**Table 13: Competitive auctions over fiscals 2021, 2022, 2023, 2024 and 2025**

| Fiscal | Capacity allocated (GW) | Wt. Avg. Tariff (₹/kWh) |
|---|---|---|
| **2021** | 2.2 | 2.88 |
| **2022** | 1.2 | 2.69 |
| **2023** | 1.7 | 2.97 |

| Fiscal | Capacity allocated (GW) | Wt. Avg. Tariff (₹/kWh) |
|---|---|---|
| **2024** | 1.8 | 3.39 |
| **2025*** | 0.4 | 3.83 |

**April 2024- January 2025, Source: Crisil Intelligence*

**Accelerated depreciation**

Historically, particularly in fiscals 2015 and 2016, accelerated depreciation (AD) had been a key driver for capacity additions. However, going forward, CRISIL expects capacity additions under this mode to be restricted only to large conglomerates in other unrelated businesses seeking tax breaks. While AD was halved to 40% from April 2017 onwards, it will continue to support additions in open-access segment.

**High industrial tariffs in select states**

In states such as Maharashtra, Karnataka, Tamil Nadu, and West Bengal, where industrial tariffs are high (₹ 6-6.5/unit), wind power is an attractive option since generation cost is about ₹ 3.0-4.0/kWh. Capacity can be set up via the open-access mode, i.e., bilateral agreements directly with consumers such as commercial/industrial entities.

**National Green Hydrogen Mission**

The National green Hydrogen Mission with an objective to make India leading producer and supplier of Green Hydrogen by developing 5 MTPA of Green hydrogen per annum, as per target set by the Government by 2030. But production of green hydrogen is expected to start from fiscal 2026 itself, necessitating installation of renewable from fiscal 2024. As per Crisil Intelligence estimates, based on announcements made, 2-3 MTPA green hydrogen capacity could come online by fiscal 2029. From this green hydrogen capacity addition, wind capacity addition is expected to be 15-17 GW between fiscals 2025 and 2030 but green hydrogen capacity addition will remain a key monitorable.

# 6 Wind solar hybrid (WSH) and Firm and Dispatchable RE (FDRE)

## 6.1 Overview

India's commitment to a net-zero future has driven transformational policy shifts across the power sector. MNRE has proactively promoted hybrid and dispatchable renewable solutions to address intermittency challenges and integrate higher shares of renewables in the grid. Key initiatives include:

- **National Wind-Solar Hybrid Policy (2018)** – Enables co-located or remotely located hybrid plants to optimize transmission and land, while enhancing grid stability.
- **FDRE and RTC tenders by SECI and NTPC** – Launched to procure energy with assured supply windows, simulating the dispatchability of thermal power.

Traditional standalone solar (CUFs ~20–22%) and wind projects (CUFs ~30–35%) offer variable output that limits their utility for Discoms managing peak demand and grid balancing. In contrast:

- **Hybrid projects** deliver CUFs of 40%+ through complementary generation patterns of wind and solar.
- **FDRE/RTC projects** (with storage or overcapacity + blending) can ensure 50–80% annual availability in specified time blocks—mirroring thermal power's reliability profile.

This evolution addresses the core concern of renewables: firmness of supply, enabling their role beyond energy substitution into base-load and peak-load roles.

MNRE has been instrumental in shaping India's renewable energy landscape. The National Wind-Solar Hybrid Policy, adopted on 14 May 2018, provides a framework for promoting large-scale, grid-connected WSH systems to optimize transmission infrastructure and land use while reducing the intermittency of renewable energy. The policy encourages both new hybrid projects and the hybridization of existing wind or solar plants, allowing the power generated to meet both solar and non-solar Renewable Purchase Obligations (RPOs). It also mandates regulatory authorities, such as the Central Electricity Regulatory Commission (CERC), to formulate standards for WSH systems, including tariff determination and financial incentives like waivers on transmission charges.

In October 2020, MNRE introduced tariff-based competitive bidding guidelines for WSH projects, ensuring transparency through a reverse auction process. These guidelines stipulate a minimum project size of 50 MW and an annual CUF of at least 30%, fostering investment and scalability. Amendments in August 2021 further streamlined processes by allowing DISCOMs to directly procure power from WSH projects, reducing costs by bypassing intermediaries like the Solar Energy Corporation of India (SECI).

For FDRE, MNRE and SECI have pioneered tenders since June 2023 to ensure firmness and dispatchability, aligning with Discoms' demand profiles. These tenders integrate renewable energy with storage solutions like BESS or PSP to provide RTC or peak power. MNRE's vision includes a 50 GW annual bidding trajectory from FY2024 to FY2028, with at least 10 GW reserved for wind projects, emphasizing the complementary nature of wind and solar.

The Indian Renewable Energy Development Agency (IREDA) and SECI play critical roles in implementation, with IREDA providing financial assistance and SECI acting as an intermediary for PPAs. Additionally, state

governments in Gujarat, Rajasthan, and Andhra Pradesh have introduced their own WSH policies, offering incentives like land allocation and transmission waivers to align with national goals.

MNRE's broader vision aligns with India's net-zero target by CY2070 and 50% non-fossil fuel energy by CY2030. WSH and FDRE projects are pivotal in reducing reliance on thermal power, enhancing grid reliability, and supporting economic growth through green jobs and domestic manufacturing.

**Grid Stability and Reliability**: The complementary nature of wind (stronger at night and during monsoons) and solar (peak during daytime) reduces variability in power generation, enhancing grid stability. FDRE projects further improve reliability by integrating storage to ensure dispatchable power.

**Environmental Benefits**: By reducing reliance on thermal power, WSH and FDRE projects lower greenhouse gas emissions, aligning with India's climate commitments.

WSH is increasingly gaining traction over plain vanilla RE projects in India. Although MNRE has not yet set a generation target, the nascent sector has received strong support from SECI and several state governments. There are two types of WSH projects — pure-play ones and those with storage. There are also projects that may come up under the government's FDRE power scheme.

India has introduced FDRE generation tenders, including WSH tenders to strengthen clean generation combining solar, wind and storage technologies. The MNRE introduced the National WSH Policy on 14 May 2018. The main objective of the policy is to provide a framework for promoting large grid connected WSH systems and efficient utilisation of transmission infrastructure and land. It also aims to reduce the variability in RE generation and achieve better grid stability. As on 31 December 2024, WSH projects of aggregate capacity 35,787 MW are under construction in the country.

## 6.2 Advantages of WSH and FDRE projects

Some of the key advantages of WSH and FDRE projects include improved land and transmission infrastructure utilisation, reduced generation variability and complimentary generation profiles. Standalone solar and wind projects exhibit relatively low CUF. However, the amalgamation of these two technologies leads to a higher CUF, resulting in enhanced overall efficiency of the WSH plant. Moreover, the cost of co-located solar and wind projects is lower compared to that of their respective standalone counterparts, making them economically attractive. Consequently, tenders conducted for such WSH projects have yielded competitive tariffs, with prices ranging from ₹ 3.0 - 3.5/kWh. These factors contribute to the growing allure and widespread adoption of WSH projects.

WSH projects are well suited for a time-of-day tariff regime wherein during the morning/evening peak hours additional tariffs are charged and during night (off peak) hours, rebate in tariff is provided. Since generation patterns of wind and solar are usually complementary, with wind power generation picking up after sunset and reaching peak generation late night. Thereby, the wind project can generate more revenue by selling power during evening peak hours when the tariff would be 10-20% higher than the normal tariff.

Further, WSH in conjunction with firm and dispatchable RE (FDRE) can provide a reliable and stable power supply to meet the demands of utilities. FDRE projects (assured peak, load following, RTC, and specific peak power supply) offer firm power supply as per demand given by utilities and a higher CUF compared to pure-play solar and wind projects. Furthermore, the expected tariff ranges have resulted in being higher than the norm of ₹ 2.5 - 2.6/kWh (for standalone solar with imported cell based modules), approaching the range of ₹ 3 - 5/kWh(for WSH and FDRE).

FDRE tenders have emerged as a promising alternative to newly constructed/under-construction thermal projects. The cost of under construction thermal projects ranges from ₹ 90-120 million per MW (depending on technology and size) and are often plagued by time and cost overruns, delays in commissioning. The tariffs of new thermal projects is around ₹ 4.50-5.50/kWh and the variable cost would keep on increasing due to rising cost of coal. In contrast, FDRE projects can be developed at a lower cost per MW and can be commissioned in a shorter period (24-30 months). Furthermore, FDRE projects offer different power supply options (peak power supply, time-block basis dispatch of power, RTC power), which can be tailored to meet specific demand requirements, depending on the technology configuration and battery storage capacity. This makes FDRE projects an increasingly appealing choice for power generation, providing a reliable, efficient, and cost-effective solution for meeting India's growing energy needs.

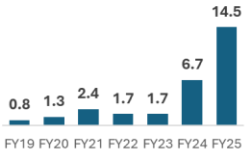
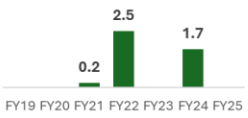
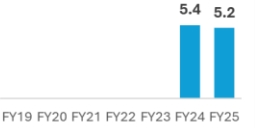
## 6.3 New business models warrant higher tariffs

With a large quantum of the pipeline already in place for solar/wind-only projects, nodal authorities are now turning to issue tenders that aim to improve the quality of power supplied to off-takers. Some key changes have been made to tender structures concerning the quantum of generation available from RE sources and the ability to match peak demand.

While there are multiple combinations now issued in the market some key distinctive features are as follows:

- Plain vanilla WSH tenders require simple blending of solar and wind resources to achieve higher PLFs compared to those achieved on standalone basis and inject power for more hours during the day, compared to either source on standalone basis.
- Peak power tenders demand injection of renewable energy during peak periods of power demand in the day, typically four hours per day. The peak power tenders ensure energy availability during peak periods (2 to 4 hours of morning or evening period) as per Discoms requirements. The buying entities need to specify daily peak hours (2-4 hours) to draw power. Peak power tenders require capacity utilisation factor of 40% along with 90% availability of 90% during peak period.
- Round the clock (RTC) tenders are designed to enable injection of renewable power asking for higher availability from the power sources. RTC tenders ensure a stable and reliable power supply throughout the day, meeting both peak and off-peak demand. These tenders require generators to supply power 24X7, with a guaranteed minimum capacity factor. RTC tenders typically require annual availability of 75-85% with time block-wise availability of 50%.
- FDRE/RTC tenders require availability of firm and dispatchable of renewable power (FDRE) with multiple requirements across availability, peak timing supply and / or following of a particular load profile. FDRE tenders ensure grid stability and reliability To provide firm power, developers are required to install mandatory energy storage system (either battery energy storage system or pumped hydro storage system) which are charged through renewable energy and discharged as per power requirement of buying entities. Further, To meet the energy obligations under PPAs developers generally install higher renewable energy capacity than the contracted capacity. FDRE tenders require to maintain monthly demand fulfilment ratio (DFR) of at least 80% for each time block of 15 minutes on monthly basis.

**Table 14: Tariff range of ₹3-5 /kWh to provide high returns compared to plain vanilla projects**

| | Plain Hybrid | Peak Power | RTC | Firm Power |
|---|---|---|---|---|
| Weighted avg. tariff | ₹ 3.25 per unit | ₹ 4.86 per unit | ₹ 3.58 per unit | ₹ 4.61 per unit |
| Year of first allocation under structure | | | | |
| (GW) |  |  |  |  |
| Total allocation | 23 GW | 3 GW | 4.4 GW | 10.5 GW |
| Key Players | Juniper, Adani, JSW, Avaada | Renew, Avaada, ACME | Greenko, Renew, NTPC | Juniper, Renew, JSW |
| Key distinctive features | Plain vanilla hybrid tenders require simple blending of solar and wind resources to achieve higher PLFs compared to those achieved on standalone basis | Peak power tenders demand injection of renewable energy during peak periods of power demand in the day, typically 4 hours per day | Round the clock tenders are designed to enable injection of renewable energy asking for higher availability from the energy sources | Firm power tenders require availability of firm and dispatchable renewable power with multiple requirements across availability, peak timing supply and/ or following of a particular load profile with battery |

*Note: Weighted average is calculated across all projects allocated under respective models for the period Apr 2024 -Feb 2025.*

*Source: Crisil Intelligence*

So far, all these tender models have seen successful allocations, with FDRE at 10.5 GW and RTC at 4.4 GW, mainly driven by central entities.

Consequently, while the newer implementation models improve the dispatchability of power for off-takers, in the current scenario, they would still require a higher tariff to be executed. However, considering the tariffs being lower than thermal power, offtakers are showing interest in signing PPAs for these new tenders.

Since these projects are still relatively new and have been allocated recently, execution dynamics are yet to be clearly observed. Crisil Intelligence expects new business models i.e. all forms of WSH and FDRE to add 30-35 GW between fiscal 2025 and 2030. Furthermore, technological improvements, especially on the storage side, may further reduce cost requirements over the longer term, making implementation more feasible.

## 6.4 WSH and FDRE Auction trends

Due to their inherent complexity and additional requirements, FDRE, RTC and WSH Auctions have shown a wide range of tariffs. However, compared to plain vanilla solar or wind, these tenders have discovered attractive tariffs indicating a premium is required to be paid for uninterrupted reliable power supply.

**Table 15: List of WSH tenders concluded between April 2021 – December 2024**

| Sr No | Bidding scheme | Result month | Winning tariffs discovered (₹/unit) | | Capacity (MW) | | Winners |
|---|---|---|---|---|---|---|---|
| | | | Lowest | Highest | Tendered | Allotted | |
| 1. | MSEDCL Pan India | Jul 2021 | 2.62 | 2.62 | 500 | 500 | • Tata Power<br>• Azure Power |

| Sr No | Bidding scheme | Result month | Winning tariffs discovered (₹/unit) | | Capacity (MW) | | Winners |
|---|---|---|---|---|---|---|---|
| | | | Lowest | Highest | Tendered | Allotted | |
| 2. | SECI Pan India Tranche IV | Aug 2021 | 2.34 | 2.35 | 1,200 | 1,200 | • NTPC Ltd.<br>• NLC India Ltd.<br>• Project Ten Renewable Power (Ayana Renewable Power)<br>• Azure Power India |
| 3. | SECI Pan India Tranche V | May 2022 | 2.53 | 2.53 | 1,200 | 1,170 | • TO Surya (Tata Power)<br>• Amp Energy Green<br>• NTPC REL |
| 4. | TPDDL Pan India | Dec 2022 | 3.00 | 3.00 | 255 | 510 | • Tata Power REL |
| 5. | CESC Pan India | May 2023 | 3.07 | 3.07 | 150 | 150 | • AMP Energy India |
| 6. | TPC-D Pan India | Sep 2023 | 3.27 | 3.28 | 225 | 225 | • Juniper Green Energy Ltd.<br>• Tata Power REL |
| 7. | NTPC Pan India | Dec 2023 | 3.35 | 3.37 | 1,500 | 1,104 | • O2 Power<br>• Sprng Energy<br>• ACME Cleantech Solutions<br>• Juniper Green Energy Ltd.<br>• Avaada Energy |
| 8. | SECI Multiple States WSH Tranche-VII | Jan 2024 | 3.15 | 3.21 | 2,000 | 900 | • NTPC REL<br>• Juniper Green Energy Ltd.<br>• Green Infra Wind Energy |
| 9. | GUVNL Tranche I | Jan 2024 | 2.99 | 3.04 | 500 | 200 | • KPI Green Energy<br>• Juniper Green Energy Ltd. |
| 10. | SJVN Pan India WSH Tranche I | Feb 2024 | 3.43 | 3.49 | 1,500 | 1,500 | • Juniper Green Energy Ltd.<br>• Datta Power Infra<br>• Green Infra Wind Energy (Sembcorp)<br>• Energizent Power (O2 power)<br>• Green Prairie Energy (EverGreen Power)<br>• Avaada Energy |
| 11. | NTPC Pan India WSH Tranche II | Mar 2024 | 3.27 | 3.32 | 1,500 | 1,500 | • ABC Cleantech (Axis Energy)<br>• Juniper Green Energy Ltd.<br>• ACME Cleantech Solutions<br>• ReNew Solar Power |
| 12. | NTPC Pan India -Tranche V | Apr 2024 | 3.41 | 3.47 | 1,000 | 1,000 | • Sprng Energy<br>• AmpIn Energy Transition<br>• Juniper Green Energy Ltd.<br>• Renew Power<br>• Avaada Energy |

| Sr No | Bidding scheme | Result month | Winning tariffs discovered (₹/unit) | | Capacity (MW) | | Winners |
|---|---|---|---|---|---|---|---|
| | | | Lowest | Highest | Tendered | Allotted | |
| 13. | GUVNL Pan India - Tranche II | June 2024 | 3.33 | 3,39 | 500 | 560 | • KPI Green Energy<br>• Juniper Green Energy Ltd.<br>• JSW Neo<br>• Hinduja Renewables |
| 14. | SJVN Pan India - Tranche II | June 2024 | 3.41 | 3.42 | 1,500 | 1,500 | • AmpIn Energy Transition<br>• Ganeko Solar (Solarpack)<br>• Juniper Green Energy Ltd.<br>• Datta power Infra<br>• Inaayu Renewables (Evergreen)<br>• JSW Neo<br>• Avaada Energy |
| 15. | SECI Pan India -Tranche VIII | Jun 2024 | 3.43 | 3.46 | 1,200 | 1,200 | • Juniper Green Energy Ltd.<br>• UPC Renewables<br>• JSW Energy<br>• AmpIn Energy<br>• Adyant Enersol (Datta power Infra)<br>• Avaada Energy |
| 16. | MSEDCL Pan India - Tranche III | Jul 2024 | 3.60 | 3.69 | 500 | 426 | • JSW Energy<br>• Juniper Green Energy Ltd.<br>• BN Peak Power (BrightNight)<br>• Avaada Energy |
| 17. | SECI Pan India - Tranche VII | Jul 2024 | 3.41 | 3.42 | 1,200 | 1,200 | • Pace Digitek<br>• JSW Neo Eenrgy<br>• Hero Solar Energy<br>• ACME Solar Holdings |
| 18. | NTPC Pan India -Tranche VI | Jul 2024 | 3.43 | 3.46 | 1,000 | 1,000 | • Juniper Green Energy Ltd.<br>• JSW Neo<br>• TEQ Green power (O2 power)<br>• Adyant Enersol (Datta Infra)<br>• Avaada Energy |
| 19. | MSEDCL Pan India | Aug 2024 | 3.60 | 3.60 | 1,650 | 488 | • JSW Neo<br>• Juniper Green Energy Ltd.<br>• Tata Power REL |
| 20. | SECI Pan India – Tranche IX | Oct 2024 | 3.25 | 3.26 | 600 | 600 | • Juniper Green Energy Ltd.<br>• ACME Solar Holdings<br>• Sembcorp Green Infra |
| 21. | NTPC - Tranche VII | Oct 2024 | 3.28 | 3.29 | 1,200 | 1,200 | • Green Prairie Energy (Evergreen)<br>• Adyant Enersol (Datta Power Infra)<br>• Sembcorp Green Infra<br>• Adani Renewable<br>• ReNew Solar Power |

| Sr No | Bidding scheme | Result month | Winning tariffs discovered (₹/unit) | | Capacity (MW) | | Winners |
|---|---|---|---|---|---|---|---|
| | | | Lowest | Highest | Tendered | Allotted | |
| 22. | SJVN Pan India – Tranche III | Nov 2024 | 3.19 | 3.19 | 1,200 | 1,200 | • Adyant Enersol (Datta Infra)<br>• Gentari Renewables India<br>• Juniper Green Energy Ltd.<br>• Enfinity Global<br>• Sunsure Solarpark RJ 1 |
| 23. | NTPC Pan India – Tranche VIII | Dec 2024 | 3.38 | 3.44 | 1,200 | 1,200 | • JSP Green (Jindal Renewables)<br>• Adyant Enersol (Datta Infra)<br>• Green Prairie Energy IV (Evergreen)<br>• AmpIn Eenrgy Utility<br>• Adani Green Energy |

*Source: Press Releases by respective Companies, SECI, SJVN, NTPC etc. Crisil Intelligence*

**Table 16: List of FDRE/RTC tenders concluded between April 2021 – December 2024**

| Sr No | Bidding scheme | Result month | Winning tariffs discovered (₹/unit) | | Capacity (MW) | | Winners |
|---|---|---|---|---|---|---|---|
| | | | Lowest | Highest | Tendered | Allotted | |
| 1. | REMCL Pan India RTC | Apr 2023 | 3.99 | 4.27 | 1,000 | 960 | • Sprng Akshay Urja<br>• NTPC RE Ltd.<br>• Ayana Power<br>• O2 Power |
| 2. | SECI Multiple States Tranche VI (Peak Power) | Apr 2023 | 4.64 | 4.73 | 1,200 | 1,200 | • AMP Energy Green<br>• ReNew Vikram Shakti<br>• Hero Solar Energy<br>• ACME Cleantech |
| 3. | SJVN, Storage Hybrid Tranche i (Peak Power) | Nov 2023 | 4.38 | 4.39 | 1,500 | 2,368 | • Juniper Green Energy Ltd.,<br>• Tata Power Renewable Energy,<br>• ACME Cleantech Solutions,<br>• Solarcraft Power India<br>• Hero Solar Energy;<br>• TEQ Green Power XVI;<br>• Renew Solar power |
| 4. | REMCL RTC | Jan 2024 | 4.25 | 4.43 | 750 | 650 | • ACME Cleantech Solutions<br>• ReNew Solar Power<br>• Tata Power Renewable<br>• O2 Power<br>• NTPC REL<br>• Torrent Power |
| 5. | NHPC Pan India WSH Storage (Firm power) Tranche II | Feb 2024 | 4.55 | 4.64 | 1,500 | 1,400 | • BN Hybrid power 1<br>• Hero Solar Energy<br>• Solarcraft Power India 20<br>• Juniper Green Energy Ltd.<br>• Renew Solar Power |

| Sr No | Bidding scheme | Result month | Winning tariffs discovered (₹/unit) | | Capacity (MW) | | Winners |
|---|---|---|---|---|---|---|---|
| | | | Lowest | Highest | Tendered | Allotted | |
| | | | | | | | • ACME Cleantech Solutions |
| 6. | NTPC Pan India WSH Storage Tranche I (Firm power) | Mar 2024 | 4.64 | 4.73 | 3,000 | 1,584 | • ABC Cleantech (Axis Energy)<br>• ACME Cleantech Solutions<br>• Juniper Green Energy Ltd.<br>• Hero Solar Energy<br>• Serentica Renewables India 11<br>• Tata Power REL |
| 7. | SECI Pan India (firm power) Tranche IV | Jul 2024 | 4.98 | 4.99 | 630 | 630 | • Vena Energy<br>• Hero Solar Energy<br>• JSW Neo Energy<br>• Hexa Climate Solutions<br>• Serentica Renewables India 11 |
| 8. | NHPC Pan India Tranche II | Sep 2024 | 4.37 | 4.38 | 1,200 | 1,200 | • Essar Renewables<br>• Juniper Green Energy Ltd.<br>• Serentica Renewables<br>• Hexa Climate Solutions<br>• Avaada Energy |
| 9. | SJVN Pan India Tranche II | Oct 2024 | 4.25 | 4.26 | 1,200 | 1,200 | • Hero Solar Energy<br>• Solarpack<br>• Juniper Green Energy Ltd.<br>• ReNew<br>• Avaada Energy |
| 10. | NTPC Pan India Tranche II | Nov 2024 | 4.69 | 4.70 | 1,200 | 760 | • Hexa Climate Solutions<br>• Avaada Energy<br>• Acme Solar Holdings |
| 11. | NHPC Pan India Tranche III | Dec 2024 | 4.48 | 4.56 | 1,200 | 1,200 | • Rays Power Infra<br>• Avaada Energy<br>• Acme Solar Holdings<br>• Juniper Green Energy Ltd. |

*Source: Press Releases by respective Companies, SECI, SJVN, NTPC etc. Crisil Intelligence*

Some of the key players such as Juniper Green Energy, Avaada, Acme, ReNew, Adani, have been actively participating in the complex RE tenders. Juniper Green Energy has successfully achieved 100% bidding to winning conversion rate from April 2021 to December 2024, while the majority of other key players have achieved conversion rate of over 60%.

Following table summarises the total bid submitted, and capacity won by key players:

**Table 17: Total bid submitted vs capacity won by key players (Apr 2021 – Dec 2024)**

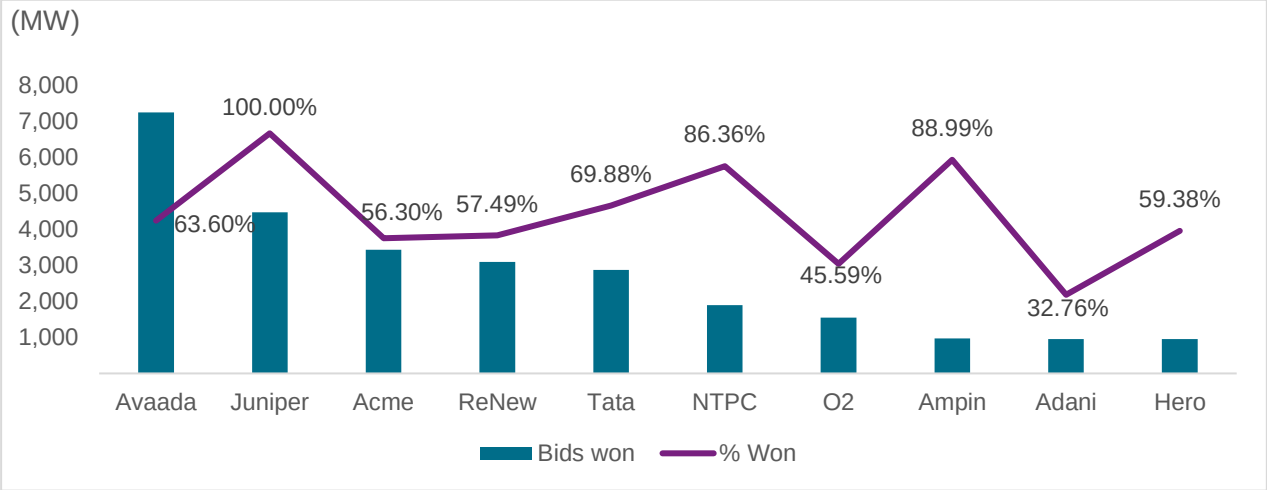
| Player | Bid submitted (MW) | Capacity Won (MW) | % Winning |
|---|---|---|---|
| **Avaada** | 11,390 | 7,244 | 63.60% |
| **Juniper** | 4,470 | 4,470 | 100.00% |

| Player | Bid submitted (MW) | Capacity Won (MW) | % Winning |
|---|---|---|---|
| **Acme** | 6,100 | 3,434 | 56.30% |
| **ReNew** | 5,389 | 3,098 | 57.49% |
| **Tata** | 4,107 | 2,870 | 69.88% |
| **NTPC** | 2,200 | 1,900 | 86.36% |
| **Adani** | 3,900 | 950 | 32.76% |
| **O2** | 3,400 | 1,550 | 45.59% |
| **Ampin** | 1,090 | 970 | 88.99% |
| **Hero** | 1,600 | 950 | 59.38% |

*Note: Including green shoe options; for WSH and FDRE tenders*

*Source: Press releases by respective companies, Crisil Intelligence*

**Figure 42: Bids won and winning percentage of key players for period between Apr 2021 – Dec 2024**




*Includes only WSH and FDRE tenders*

*Source: Press Releases by respective Companies, Crisil Intelligence*

## 6.5 Key growth drivers

WSH and FDRE segment in India is experiencing rapid growth, driven by several key factors:

- **Potential:** India has around 696 GW (120 m hub height) wind potential and around 750 GW of solar potential. Currently only around 10% of the potential is developed and balance 90% of the potential yet to be exploited. This provides huge opportunities for wind and solar energy development.
- **Geographical advantages:** India's coastline provides high wind speed as well as excellent solar potential. State such as Gujarat, Maharashtra, Karnataka, Tamil Nadu, Andhra Pradesh have excellent wind as well solar potential. Such an advantage provides a great opportunity for supply of WSH power. Depending on the project requirements, the WSH projects can be co-located or located in different locations, making it more flexible even if natural resources are located in different places.
- **Complementary resources:** Wind and solar sources complement each other. Due to their inherent characteristics, they generate power during different times of the day as well as seasons. Therefore, for 24X7 supply, they complement each other and hence WSH projects provide more reliable power and can be used for RTC supply (especially with energy storage).

- **Resource optimisation:** Co-located WSH plants can help with resource optimisation. With optimum land utilisation and infrastructure sharing, the wind and solar resources can be optimally utilised leading to better CUF as well as cost optimisation. With energy storage facilities, the WSH plants help in better grid management and higher penetration of RE into existing power systems.
- **Policy push:** Government of India's policy push has also helped the WSH segment. A confluence of increased RPO targets, VGF funding, ISTS waiver, PLI and solar park schemes, have helped both the resources to thrive.

**Draft amendments to CERC (Connectivity and General Network Access to the inter-State Transmission System) Regulations, 2022.**

Further, CERC has issued draft amendments to GNA regulations, 2025 by introducing significant changes aimed at improving transmission system efficiency, optimizing RE integration and ensuring stricter compliance mechanism. A key focus is the introduction of "Restricted access" entities which applies to RE generating stations and ESS with limited injection scheduling rights based on solar and non-solar hours. The RE generators with Wind/ESS would get a preference for non-solar hours. Solar based generators have restricted scheduling during non-solar hours. NLDC would declare the solar/non-solar hours on a weekly basis for each state in advance. Post enactment of this Regulation, the generators would need to align projects with the new scheduling rules.

## 6.6 State level policies

Based on the MNRE's WSH policy, governments of RE-rich states have also introduced their own WSH policies. Gujarat was the first to come up with such a policy in 2018. Other states such as Rajasthan, Andhra Pradesh, and Karnataka followed. This has helped set up open access WSH projects and encouraged corporates to procure RTC power from such projects. These policies provide clarity in terms of various provisions, such as RPO, banking, settlement period, various waivers and incentives, applicability of transmission and wheeling charges and waiver in electricity duty etc.

**Table 18: WSH policy comparison for select states**

| Parameter | MNRE | Gujarat* | Andhra Pradesh | Rajasthan | Karnataka |
|---|---|---|---|---|---|
| Issued in | May 2018 | October 2023 | January 2019 | December 2019 | April 2022 |
| Capacity targets | - | - | 5,000 MW | 3,500 MW by fiscal 2025 | - |
| RPO | RPO can be fulfilled separately for solar and non-solar | RPO can be fulfilled<br>Separately as well as commonly depending on the project type | RPO can be fulfilled separately for solar and non-solar | Mandatory for Discoms to purchase power equivalent to 5% of their RPO targets under this policy | RPO can be fulfilled separately for solar and non-solar |
| Banking | - | - | 5% banking charges | 10% banking charges | 2% banking charges |
| CSS | - | Captive: 100% exemption Third-party sale: 25% concession | 50% waived for third-party sales for projects set up within the state | - | - |
| Additional surcharge | - | Captive: 100% exemption<br>Third-party sale: 25% concession | - | - | 75% exemption |

| Parameter | MNRE | Gujarat* | Andhra Pradesh | Rajasthan | Karnataka |
|---|---|---|---|---|---|
| Transmission and wheeling charges | 100% exemption for already existing plants | No waivers /concession for captive as well as for third-party sale | 50% exemption in transmission and wheeling charges for new projects developed within the state | **WSH:** 50% concession for captive/ third party sale for 7 years from project commissioning. **WSH + storage:** 75% concession for captive/ third party for 7 years from the year of commissioning | Charges will be applicable for additional transmission capacity |
| Electricity duty | - | 100% exemption for intrastate consumption | 50% exemption for intrastate consumption | 100% exemption for intrastate captive consumption | 100% exemption for intrastate consumption<br>applicable for third parties |

**Gujarat has issued a new RE policy in 2023 which includes WSH projects. Thereafter a Tariff Order for procurement of WSH power was issued in March 2024. The aforementioned provisions are as per Gujarat Electricity Regulatory Commission's WSH Tariff Order*

*Source: MNRE, respective state policy documents, Crisil Intelligence*

## 6.7 Constraints in setting up WSH power plants

**Lack of good sites**

This means the ideal locations for WSH should have good irradiation and experience high wind speeds. However, such locations are hard to find, especially as major windy areas with strong grid evacuation facilities have been saturated. The preferred locations for WSH projects are usually Gujarat and Rajasthan for pan India tenders. Due to lack of good sites, sites having good solar irradiance and good wind speeds are in demand leading to fierce competition for these sites.

**Grid balancing requirement poses implementation risks**

Developers are required to balance the grid before injecting electricity generated from a co-located WSH plant. This means they need to simulate the ideal wind and solar generation mix from the plant to optimize the WSH curve. This may lead to additional implementation risks for a developer.

**Delay in development of transmission evacuation infrastructure**

There is a limited margin available at existing/under implementation 220 kV and 400 kV bays of ISTS substations which creates bottlenecks for connecting new RE projects. The transmission projects face multiple challenges such as right of way issues, forest clearances, and supply chain constraints. Due to such challenges, the government has estimated that transmission connectivity for only about 60 GW of RE capacity is expected by fiscal 2027. Furthermore, if a developer applies for connectivity today in Rajasthan/Gujarat (RE rich States), the connectivity may not be available till FY2030.

**Optimal sizing**

The size of the WSH plant differs from state to state depending on the resource availability. Optimal sizing of storage is also critical. Overloading or oversizing may lead to under utilisation during the peak generation period (daytime in summer or night-time in monsoons) resulting in storage capacity remaining unutilised or idle.

# 7 Overview of energy storage segment

## 7.1 Overview of energy storage technologies

Energy storage technologies can be broadly divided into four segments – mechanical, electromechanical, chemical, and thermal storage. However, only a few technologies are available on a commercial scale worldwide. Technologies such as PSP, lithium, and sodium batteries are available commercially and are being used for different applications. Other technologies such as compressed air, flywheel, thermal and hydrogen storage, have yet to demonstrate their commercial viability at scale.

PSP is the most widely used and commercially available means of energy storage technology in India. However, the total installed capacity of PSP is minuscule (~4% of the exploitable potential) in the country. Considering the intermittent and unpredictable nature of RE technologies, such as solar and wind technologies, efficient and economical grid operation is increasingly becoming one of the critical challenges for India's power system. This challenge calls for solutions such as spinning reserves, flexible generation, ancillary services, transmission system augmentation and frequency control, etc.

### 7.1.1 Overview of PS projects in India

The identified potential of PSP in the country is about 189.03 GW (comprising 168 PSPs). However, the operational capacity of PSP is merely 4.7 GW, which indicates the large potential growth in this segment. Maharashtra, Andhra Pradesh and Tamil Nadu cumulatively comprise of 49.11% of total PSP potential of India.

As of March 2025, India has an installed capacity of 4.75 GW of on-river pumped storage projects in operation. Further, as per CEA, as of February 2025, 7.97 GW is under construction and is largely expected to be commissioned by fiscal 2030. Also, 4.6 GW projects have been cleared by CEA and will shortly commence construction and about 66.01 GW of PSP projects (including on-river and off-river) are under survey and investigation stage for which different states have already allocated these projects to various agencies.

PSPs with aggregate capacity of 78,580 MW, which are at different stages of development, are distributed among 12 States. Of these 12 States, over 50% of capacity is expected to be installed in two states, namely, Andhra Pradesh and Maharashtra.

### 7.1.2 Battery energy storage

BESS is another form of storage technology which has gained traction in the last few years. It has a very high energy density, making it appropriate to offer ancillary services. More importantly, BESS can be installed easily, requires less time for setup, and can be used for a wide range of grid support activities, such as energy time shift, distribution deferral, and energy arbitrage etc. The technology is yet to achieve its full potential to provide grid support services, and comes with high investment cost and changing technology, and therefore has associated risks. Further, batteries would require replacement or disposal after 12-15 years, depending upon usage.

### 7.1.3 Comparison of PSP vs BESS

A comparative analysis of PSP and BESS technology is mentioned below:

**Table 19: Comparison of PSP and BESS**

| Parameters | PSP | BESS |
|---|---|---|
| **Capital cost** | Total capital cost for a closed loop PSP ranges around ~₹ 50-60 Mn/ MW* | Lithium-ion battery storage can range from USD 550-700/kW (for a four-hour storage solution) |
| **Efficiency** | 75-80% | 80-85% |
| **Land requirement** | ~2,000 $m^2$/MW | ~100 $m^2$/MW |
| **Ideal storage duration** | 6 – 12 hours | Upto 4 hours |
| **Response time** | 30-90 seconds | In milliseconds |
| **Project life** | 40 – 50 years (life of dam/reservoir is over 80 years) | 12-15 years |
| **Construction period** | 4 – 5 years, it also depends upon other external and socio-political factors | 1 year |
| **Operating cost** | Lower | Higher since batteries need to be replaced after certain period |
| **Estimated levelised tariff** | ₹ 4 – 6 per kWh | ₹ 5 – 7 per kWh |
| **Environmental impact** | Need substantial reservoirs which may cause environmental consequences, such as habitat destruction and changes in water flow downstream | Disposal of batteries is a major concern. If not taken care properly, may end up in landfills, posing risks of corrosion, flammability, and environmental contamination |
| **Execution and operational risk** | • Long approval process for land, environmental and forest clearances<br>• Rehabilitation and resettlement issues<br>• Limited naturally suitable sites<br>• Long gestation period with high construction risk<br>• Managing water requirement, especially in case of any adverse events | • Shortage of rare minerals and metals<br>• Limited manufacturing capacity<br>• Cost volatility<br>• Performance deterioration and fire risk in extreme ambient conditions<br>• Constant degradation and self-discharge |

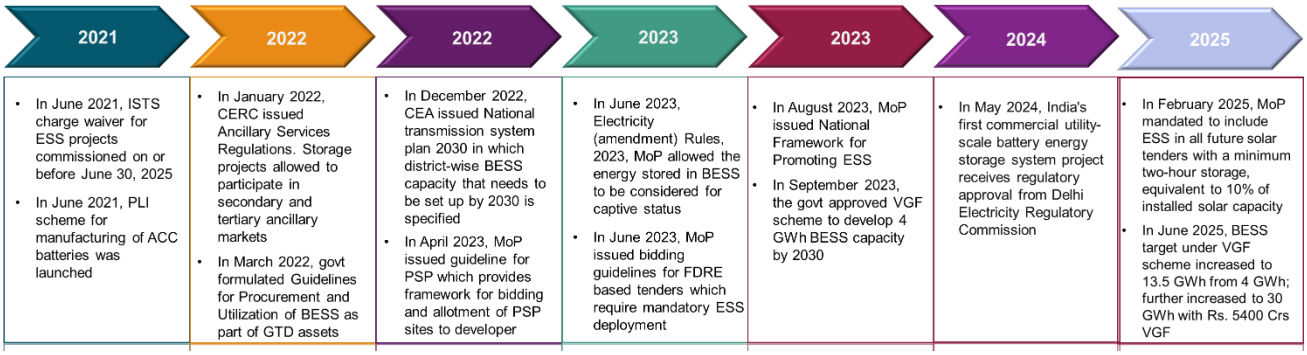
**Capex may vary based on no. of reservoirs to be built, topography/ region, etc.*

*Source: Environmental Impact Assessment Reports for some PSPs, CEA, Crisil Intelligence*

### 7.1.4 Policies and key driving factors for storage projects

Over the last 2-3 years, the government has taken several initiatives to promote energy storage through standardisation of the policy and regulatory framework by issuing guidelines, regulations, changes in bidding mechanisms, etc. The summary of key policy measures is listed below.

**Figure 43: Key policy measures for storage projects**




*Source: MoP, MNRE, Crisil Intelligence*

The GoI has taken several measures such as providing legal status to storage, energy storage obligation, waiver in ISTS charges, captive status for energy stored in BESS. These measures are expected to expedite the deployment of storage systems and thereby accelerating the growth of India's RE capacity. The guidelines released by the MoP in April 2023 address many issues. However, traction in PSPs will depend on steps to make tariffs attractive to Discoms and mitigate implementation risk to fuel private sector participation. MNRE in its RE bidding guidelines provided the option to the RE developer to tie up with energy storage system developers to meet the project parameters to provide firm and dispatchable RE power.

In February 2025, the MoP issued an advisory requiring new solar power projects to incorporate energy storage systems to enhance grid stability and reduce power costs. The advisory, sent to state governments, central generating stations, and renewable energy agencies, mandates that all future solar tenders include co-located ESS with a minimum of two-hour storage, equivalent to 10% of the installed solar capacity. By implementing this requirement, the MoP expects to add about 14 GW/28 GWh storage capacity by 2030.

**Pumped hydro projects**

Unlike other storage technologies, the performance of PSP is quite reliable on long term basis. PSP offers energy storage for 6 to 12 hours which is well suited for energy-shifting applications, wherein excess RE generation can be shifted to peak demand periods of late evenings. The long project life of PSP has the potential to provide a stable and consistent cash inflow for about 40 years.

Several provisions are proposed to facilitate the allocation and development of PSP under the guidelines such as no upfront premium for project allocation, monetization of ancillary services, and participation in all market segments. Financial institutions are expected to provide long-term loans with competitive rates, and tax and duty incentives are provided to encourage development. States may reimburse State Goods and Services Tax (SGST) on hydropower project components, provide exemptions in stamp duty and registration fees for land, and offer land on an annual lease rent basis. The guidelines also mandated using green finance like sovereign bonds or concessional climate finance for funding such projects.

To speed up the clearance process, CEA has also established a Single Window Clearance Cell for fast track approval of PSPs. Additionally, the MoP has provided budgetary support of ₹ 10 Mn/MW (for projects above 200 MW) and ₹ 15 Mn/MW (for projects below 200 MW and up to 25 MW) for the construction of roads and bridges for hydropower projects (including PSPs) whose construction started after March 2019.

**Battery energy storage projects**

BESS can be used for multiple applications such as voltage and frequency regulation, spinning reserves, peak shaving. For batteries, a special consideration is degradation. Batteries degrade as they age, decreasing the amount of capacity they can store. The expected life of the batteries is about 10 to 12 years (depending on the technology and how the batteries are operated). By the end of that time, the batteries' capacity is expected to be reduced to less than 70% of their original capacity.

In September 2023, the government approved the VGF scheme for development of 4,000 MWh of BESS capacity by fiscal 2031. An initial outlay of ₹94 billion including budgetary support of ₹37.60 billion has been provided under the scheme. The VGF would be provided from fiscal 2024 to 2026 and will be capped at 40% of the capital cost. Prior to VGF scheme, the Ministry of Heavy Industries in June 2021 launched a PLI scheme for Advance Chemistry Cell battery storage of 50 GWh capacity with an outlay of ₹ 181 billion, which includes more than 10 GWh grid-scale battery storage. The Scheme expects direct investment of around ₹ 450 billion in ACC battery storage manufacturing projects. As of December 2023, out of 50 GWh capacity, 30 GWh capacity has already been allotted through competitive bidding process.

The National Renewable Energy Laboratory has forecasted a fall in the price of storage solutions, especially lithium-ion technology. Lithium-ion battery prices have reduced USD160-170 per kWh in CY 2020 to USD110-120 per kWh in CY 2024, registering a decline of about 30% in the last four years due to advancement in battery technology, reduction in cost of raw materials such as lithium, cobalt, nickel and faster growth in production capacity addition. With the greater adoption of lithium-ion battery storage, improvement in battery efficiency, and large-scale manufacturing, Crisil Intelligence expects the four-hour utility-scale lithium-ion battery costs is expected to stable at USD90-100 per kWh in 2030 from the current levels. According to the CEA's National Electricity Plan (Volume II – Transmission), India's generation capacity will need around 47 GW of BESS, and 31 GW Pumped Storage Projects by fiscal 2032.

## 7.2 Large scale ESS tenders

As RE penetration scales up, ESS is expected to play a critical role. In the recent past, there have been several grid scale ESS tenders including RTC, peak power supply, standalone ESS, and FDRE tenders. SECI issued its first 1200 MW RE+storage tender with guaranteed peak power supply of 6 hours per day which concluded in 2020. The two bidders, Greenko (900 MW at peak tariff of ~ ₹ 6.12/kWh) with pumped hydro storage and ReNew Power (300 MW at peak tariff of ₹ 6.85/kWh) with BESS were awarded the project.

A few large-scale standalone ESS tenders were also issued by SECI, NTPC, GUVNL, MSEDCL in fiscal 2024. In terms of ESS technology, SECI's tender was for BESS. However, NTPC's tender was technology agnostic with the requirement of six hours of energy supply. JSW Energy won 500 MW in SECI's tender. Moreover, MSEDCL has also awarded 2 GW of PSP each to Torrent Power and JSW in September 2024 which would supply power for 8 hours per day with a maximum of 5 continuous hours. As of January 2025, ~23 GW of standalone grid-scale ESS capacity has been tendered, of which ~19 GW has been awarded and are under different phases of execution. A confluence of these initiatives indicates the large potential and keen interest from project developers in the ESS segment. Moreover, the results of these tenders also indicate the commercial competitiveness of ESS and RE+ESS as compared to electricity sources. There were other small scale solar-cum-storage tenders issued by SECI, NLC for regions such as Leh, Andaman and Nicobar Islands and Lakshadweep of capacities less than 50 MW, which have also been successfully awarded by the bidding agencies. While PSP is primarily useful for long duration energy storage requirement (i.e., for 6–10-hour storage) while BESS is typically useful for shorter duration storage requirement (2-4 hours). Hence, both the technologies have their unique requirements and use cases.

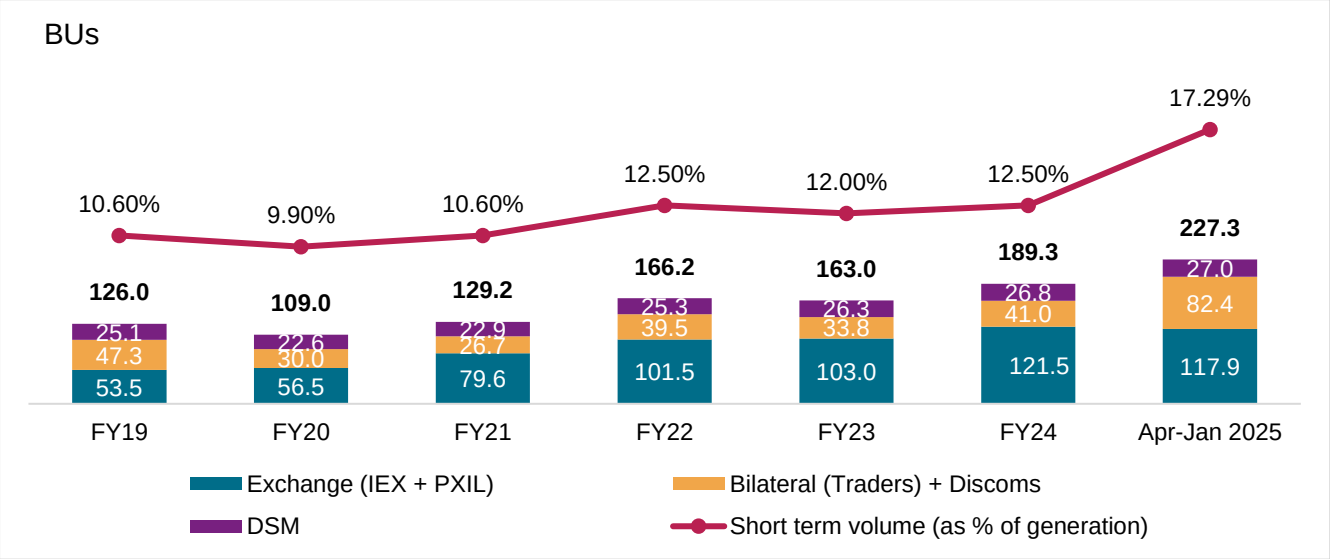
# 8 Overview of merchant market and cross border trading

## 8.1 Trend in short-term power transactions

### 8.1.1 Short-term power market in India

Total volume of short-term transactions of electricity increased from 65.90 BUs in fiscal 2010 to its all-time high of 218 BUs in fiscal 2024. Over the period (fiscal 2019-24), volume of short-term transactions of electricity increased at a higher rate (CAGR of 8.49%) than total electricity generation (CAGR of 4.80%). The volume of short-term transactions of electricity as a percentage of total electricity generation varied from ~10.60% to 12.50% between fiscals 2019 and 2024. The share of transactions through power exchanges has increased from ~54 BU in fiscal 2019 to ~122 BU in fiscal 2024, indicating a CAGR of 17.82%. Transactions through power exchanges occupies a share of 64.18% in the total short-term transactions followed by bilateral transactions which have a share of 21.67% as of fiscal 2024. DSM transactions have remained at a stable level attributing to a share of 14.15% as of fiscal 2024.

**Figure 44: Volume of short-term transactions**

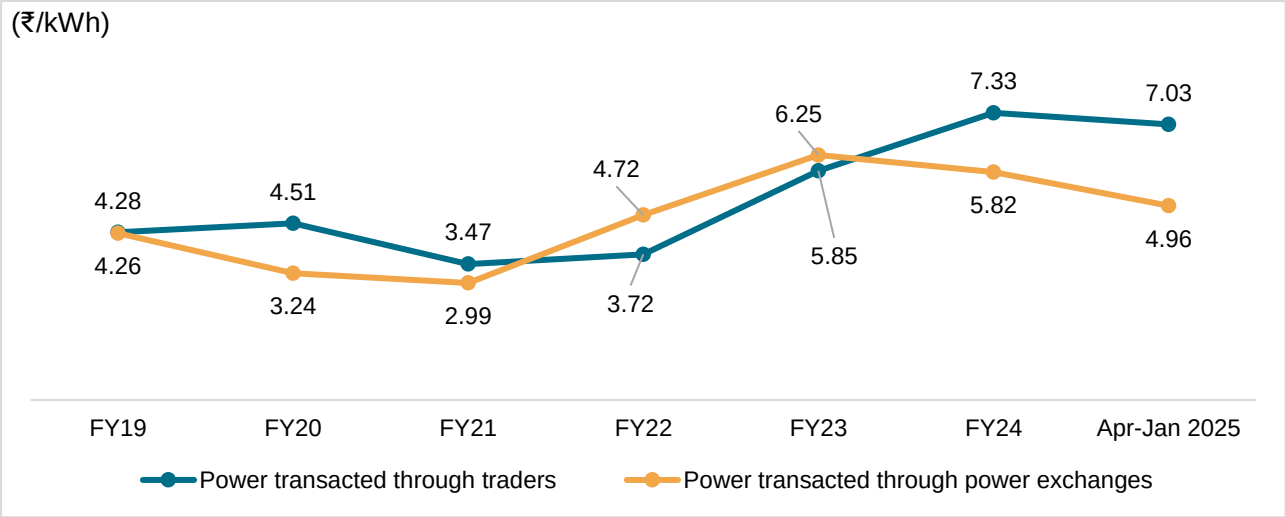



*Source: CERC Market Monitoring Report, Crisil Intelligence*

### 8.1.2 Average price of electricity transacted

Over the years, the weighted average price of electricity transacted through traders was higher than the price of electricity transacted through power exchanges, except in fiscal 2022 when the price at power exchanges was comparatively high due to various domestic and global factors.

**Figure 45: Weighted average tariff of short-term transactions**




*Note: The prices for the period April to January 2025 have been estimated by consolidated based on monthly reports published by CERC*

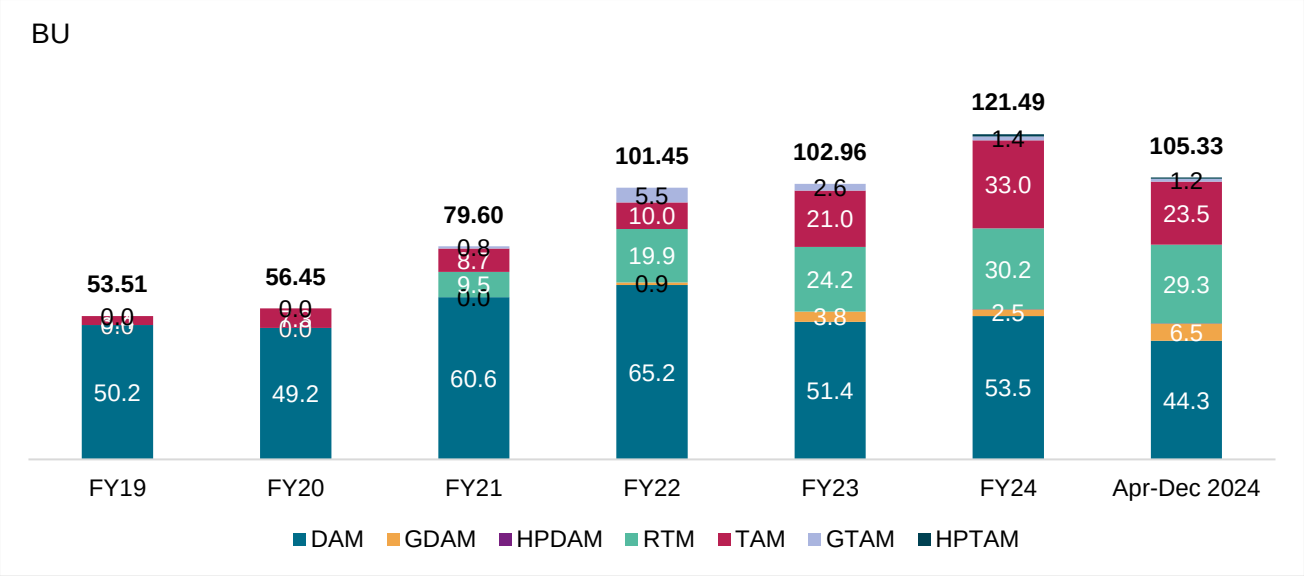
*Source: CERC Market Monitoring Report, Crisil Intelligence*

## 8.2 Share of various trade modes

Transactions through power exchanges are undertaken in different markets in 3 exchanges in India - Indian Energy Exchange (IEX), Power Exchange India Limited (PXIL) and Hindustan Power Exchange (HPX). IEX is the first and largest power exchange in India with coverage of 83.72% of the total transactions on the power exchange as of fiscal 2024. PXIL is the second largest power exchange with a share of 7.56% as of fiscal 2024. HPX is the newest power exchange promoted by PTC India Limited, BSE Investments Limited and ICICI Bank Limited having a share of 8.72% as of fiscal 2024.

Power exchanges in India commenced operations in 2008 offering various products such as Day Ahead Market (DAM), Real Time Market (RTM), Term-Ahead Market (TAM). Day Ahead Market (DAM) had the highest share of 93.72% in fiscal 2019. However, with the introduction of newer products such as Green Day Ahead Market (GDAM), Green Term Ahead Market (GTAM), High Price Day Ahead Market (HPDAM), High Price Term Ahead Market (HPTAM), as well as development of RTM and TAM, the share of DAM has fallen to 44.08% as of fiscal 2024. Share of RTM has grown from 11.90% in fiscal 2021 to 24.84% in fiscal 2024. Similarly, the share of TAM has increased from 6.28% in fiscal 2019 to 27.14% in fiscal 2024.

**Figure 46: Share of various trade modes in the power exchange**




*Source: CERC Market Monitoring Report, Crisil Intelligence*

## 8.3 Major buyers and sellers in short term market

The major sellers of electricity are generally independent power producers/merchants power plants (IPPs/MPPs) and state utilities, while the major buyers of electricity are state utilities, private distribution licensees and open access consumers.

Major buyers and sellers of electricity through traders (bilateral) and through power exchanges for fiscal 2024 are given below

**Table 20: Major Sellers of Electricity through Traders in fiscal 2024**

| Sr No | Seller | State | Volume (MU) | % total volume through traders | Weighted average price (₹/kWh) |
|---|---|---|---|---|---|
| 1. | Jindal Power Ltd. | Chhattisgarh | 3,594 | 14.67% | 7.40 |
| 2. | IL&FS Tamil Nadu Power Company Ltd. | Tamil Nadu | 2,615 | 10.67% | 7.82 |
| 3. | Jaypee Nigrie STPP | Madhya Pradesh | 2,255 | 9.20% | 6.93 |
| 4. | Raipur Energen Ltd. | Chhattisgarh | 1,490 | 6.08% | 8.57 |
| 5. | Simhapuri Energy Ltd. | Andhra Pradesh | 1,454 | 5.93% | 7.85 |
| 6. | JITPL | Odisha | 1,057 | 4.31% | 5.68 |
| 7. | Mahan Energen Ltd. | Madhya Pradesh | 933 | 3.81% | 8.72 |
| 8. | OPG Power Generation Pvt. Ltd. | Tamil Nadu | 893 | 3.64% | 8.01 |
| 9. | Jhabua Power Ltd. | Madhya Pradesh | 807 | 3.30% | 5.56 |
| 10. | Coastal Energen Pvt. Ltd. | Tamil Nadu | 677 | 2.76% | 8.33 |

*Source: CERC Market Monitoring Report, Crisil Intelligence*

**Table 21: Major Buyers of Electricity through Traders in fiscal 2024**

| Sr No | Buyer | State | Volume (MU) | % total volume through traders | Weighted average price (₹/kWh) |
|---|---|---|---|---|---|
| 1. | APPCC | Andhra Pradesh | 4,231 | 17.27% | 8.38 |
| 2. | HPPC | Haryana | 4,122 | 16.82% | 7.14 |
| 3. | TANGEDCO | Tamil Nadu | 2,458 | 10.03% | 8.40 |
| 4. | GUVNL | Gujarat | 1,936 | 7.90% | 6.85 |
| 5. | BRPL | Delhi | 1,301 | 5.31% | 7.50 |
| 6. | RUVNL | Rajasthan | 1,292 | 5.27% | 6.73 |
| 7. | UPPCL | Uttar Pradesh | 1,245 | 5.08% | 10.04 |
| 8. | KSEB | Kerala | 1,167 | 4.76% | 5.65 |
| 9. | Torrent Power Limited – Distribution | Gujarat | 1,083 | 4.42% | 7.57 |
| 10. | MSEDCL | Maharashtra | 1,025 | 4.18% | 7.63 |

*Source: CERC Market Monitoring Report, Crisil Intelligence*

**Table 22: Major Sellers of Electricity in the Day Ahead Market of IEX, in fiscal 2024**

| Sr No | Seller | State | Volume (MU) | % total volume transacted in IEX | Weighted average price (₹/kWh) |
|---|---|---|---|---|---|
| 1. | UPPCL | Uttar Pradesh | 5,223 | 9.78% | 4.24 |
| 2. | CSPDCL | Chhattisgarh | 3,935 | 7.37% | 3.87 |
| 3. | Mahan Energen Ltd. | Madhya Pradesh | 2,106 | 3.94% | 5.24 |
| 4. | BSPHCL | Bihar | 2,085 | 3.91% | 4.20 |
| 5. | DB Power Ltd. | Chhattisgarh | 1,955 | 3.66% | 5.25 |
| 6. | Jindal Power Ltd Stage II | Chhattisgarh | 1,896 | 3.55% | 5.38 |
| 7. | Adani Raipur TPP | Chhattisgarh | 1,874 | 3.51% | 5.51 |
| 8. | JITPL | Odisha | 1,673 | 3.13% | 5.22 |
| 9. | Jaypee Nigrie STPP | Madhya Pradesh | 1,471 | 2.76% | 5.77 |
| 10. | HPPC | Haryana | 1,264 | 2.37% | 4.21 |

*Source: CERC Market Monitoring Report, Crisil Intelligence*

**Table 23: Major Buyers of Electricity in the Day Ahead Market of IEX, in fiscal 2024**

| Sr No | Buyer | State | Volume (MU) | % total volume transacted in IEX | Weighted average price (₹/kWh) |
|---|---|---|---|---|---|
| 1. | APSPDCL | Telangana | 6,745 | 12.63% | 5.06 |
| 2. | GUVNL | Gujarat | 4,807 | 9.00% | 5.90 |
| 3. | MSEDCL | Maharashtra | 3,686 | 6.90% | 5.51 |
| 4. | WBSEDCL | West Bengal | 3,391 | 6.35% | 5.62 |
| 5. | APCPDCL | Andhra Pradesh | 3,297 | 6.18% | 6.39 |
| 6. | PSPCL | Punjab | 3,090 | 5.79% | 4.79 |
| 7. | JKPCL | Jammu & Kashmir | 2,363 | 4.43% | 4.33 |
| 8. | RUVNL | Rajasthan | 1,624 | 3.04% | 6.27 |
| 9. | UKPCL | Uttarakhand | 1,580 | 2.96% | 4.40 |
| 10. | Torrent Ahmedabad | Gujarat | 1,333 | 2.50% | 4.45 |

*Source: CERC Market Monitoring Report, Crisil Intelligence*

## 8.4 Different options available on the power exchange

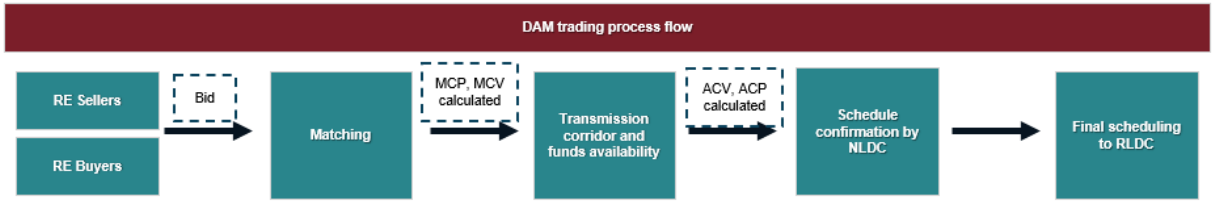
### 8.4.1 Day ahead market

DAM serves as a physical electricity trading market for trading 15-minute contracts

Key features include:

- It allows deliveries for 15-minute time-blocks in 24 hours of the next day
- Prices and quantum of electricity to be traded are determined through an anonymous double-sided auction bidding process
- SLDC gives clearance to buyers and sellers subject to network availability and ABT (Availability Based Tariff) meters

**DAM trading process flow**




*Source: CERC, IEX, Crisil Intelligence*

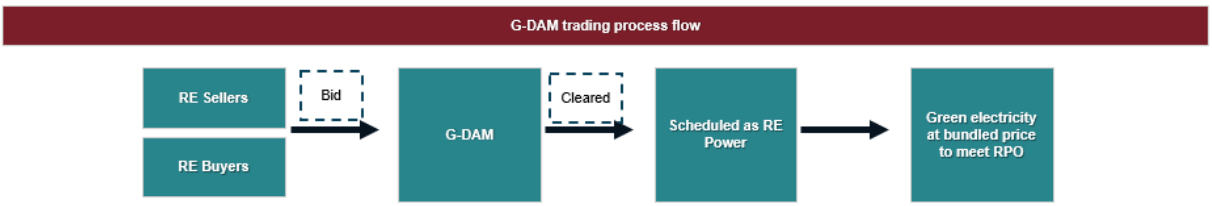
### 8.4.2 Green day-ahead market

GDAM is a marketplace for trading renewable power on a day-ahead basis

**Eligibility for GDAM:**

- Sellers: RE generators, Discoms subject to issuance of NoC/Standing clearance by RLDC/SLDCs containing type of RE source along with other details viz maximum quantum in accordance with the applicable regulations
- RE Generators registered under REC mechanism are not eligible
- Buyers: Entities which are eligible to procure power through Open Access shall be eligible to participate in GDAM as buyer.

**GDAM trading process flow**




*Source: CERC, IEX, Crisil Intelligence*

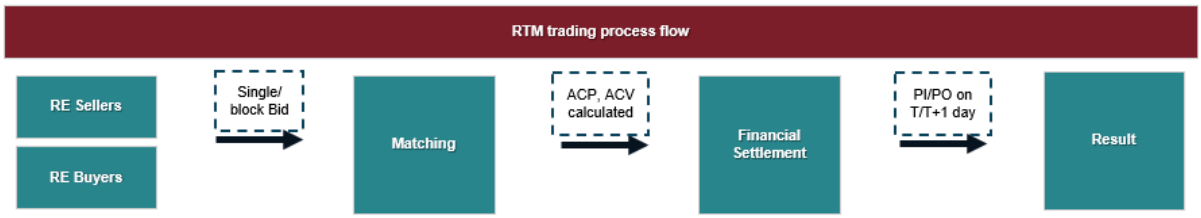
### 8.4.3 Real time market

Real Time Market (RTM) is a newly launched market, commenced operations in FY21.

Key features include:

- New auction session every 30 minutes (48 times a day) and power to be delivered after 4-time blocks (or 1 hour after gate closure of the auction)
- Price and quantum of electricity traded is determined via double-sided closed auction bidding
- Single bids: 15-minute bids for different prices and quantity pairs. Partial execution of bids is possible
- Block bids: Any 15-min block or series of 15-min blocks during the same day. Partial execution is not possible

**RTM trading process flow**




*ACP: Area clearing price ACV: Area clearing volume*

*Source: CERC, IEX, Crisil Intelligence*

The expected introduction of Market-Based Economic Dispatch (MBED) alongside an increasingly renewable energy-driven merchant market presents opportunities to engage strategically in the real-time balancing of supply and demand.

## 8.5 Overview of cross border trading though power exchange

India is actively strengthening cross-border electricity trade with its neighboring countries—Nepal, Bangladesh, Bhutan, and Myanmar—through both synchronous and asynchronous transmission systems. Transmission links at 33 kV, 132 kV, and 400 kV levels have been established between Indian border states (Bihar, Uttar Pradesh, Uttarakhand, Tripura, West Bengal, and Assam) and these countries. While some interconnections are still under construction, several new cross-border links are planned. Currently, around 4,100 MW of power is exchanged through these connections, and this is expected to rise to approximately 7,000 MW by fiscal 2027. Cross Border Electricity Trade (CBET) aims at integrating the South Asian power market. CBET regulations were launched by CERC to facilitate cross-border trade, followed by CBET Rules launched by CEA in February 2021. It enables countries to participate in India's DAM, TAM and RTM markets. The countries involved in CBET are India, Nepal, Bangladesh, and Bhutan.

Key advantages of CBET include:

- Transparent and efficient procurement of power
- Integrated power markets across nations
- Competitive power prices
- Optimum use of resources
- Improved energy access and security

Presently, India is a net exporter of electricity to Nepal, Bangladesh, and Myanmar, and a net importer of electricity from Bhutan.

**Table 24: Cross Border Trade of Electricity between India and its neighboring countries (MU)**

| Year | Bhutan (+) | Nepal (-) | Bangladesh (-) | Myanmar (-) | Net Export/Import by India |
|---|---|---|---|---|---|
| FY19 | 4,657.07 | 2,798.84 | 5,690.31 | 6.67 | -3,838.75 |
| FY20 | 6,310.73 | 2,373.06 | 6,987.94 | 8.61 | -3,058.88 |
| FY21 | 9,318.17 | 1,865.05 | 7,551.99 | 9.24 | -108.11 |
| FY22 | 7,670.34 | 1,921.09 | 7,301.74 | 8.80 | -1,561.29 |
| FY23 | 6,379.95 | 158.05 | 8,622.14 | 9.80 | -2,410.04 |
| FY24 | 3,862.78 | 154.08 | 8,413.52 | 8.47 | -4,713.29 |

*Source: CERC Market Monitoring Report, Crisil Intelligence*

The Cross-Border Trade of Electricity was commenced in the Day Ahead Market of IEX in fiscal 2022. The trade with Nepal commenced on 17 April 2021, whereas the trade with Bhutan commenced on 1 January 2022. Cross-Border Trade in Real Time Market commenced from October 2023.

**Table 25: Cross Border Trade of Electricity at IEX (MU)**

| Year | Nepal | | Bhutan | |
|---|---|---|---|---|
| | Buy | Sell | Buy | Sell |
| FY22 | 785.84 | 32.04 | 240.11 | - |
| FY23 | 1,035.69 | 1,357.77 | 318.84 | - |
| FY24 | 1,310.81 | 1,556.33 | 1,299.42 | 40.28 |
| Apr-Dec 2024 | 579.45 | 1,601.76 | 464.30 | 238.36 |

*Note: The volume traded represents the volume traded in both DAM and RTM*

*Source: CERC Market Monitoring Report, Crisil Intelligence*

To meet its power demand, Bhutan mainly relies on hydroelectric power generating stations which provide less generation during winter months. Although Bhutan is a net exporter of electricity to India, it faces a deficit in winter due to low hydro generation. Bhutan's electricity consumption has increased in recent years, and to meet this increased demand, Bhutan, through its electricity department Druk Green Power Corporation Ltd. (DGPC), has entered a contract with Tata Power Trading Company Ltd. (TPTCL) to off-take Juniper Green Cosmic power for three years during winter months (Jan to April and Nov and Dec,). The supply period can be extended upon mutual agreement. The total power to be supplied under the contract is approximately 64 MUs per year for the next three years, which is around 25% of the annual generation from the 100 MW Cosmic plant. The nodal agency has granted approval for 3 years. The supply does not include the green component, which is being retained by Juniper Green Cosmic for further sale.

Such merchant RE projects that are commissioned prior to June 2025 will be eligible for ISTS waiver. As a result, IPPs will have a competitive advantage, as they will be exempt from paying ISTS charges for the entire 25-year lifespan of the project, thereby enhancing their financial viability and market competitiveness.

# 9 Overview of green hydrogen

## 9.1 Green Hydrogen Policy

### 9.1.1 Key highlights of green hydrogen policy

Some of the key highlights of green hydrogen policy are as follows:

- The waiver of inter-state transmission charges shall be granted for a period of 25 years for green hydrogen and green ammonia projects commissioned before 31 December 2030.
- Developers can manufacture green hydrogen/green ammonia using RE from co-located or remotely located plants, or from the Power Exchange. They will be granted open access within 15 days of a complete application. Open access charges will be in accordance with the Green Energy Open Access Rules 2022.
- Banking permitted for a period of 30 days for RE used for making green hydrogen /green ammonia.
- RE projects set up to manufacture green hydrogen/green ammonia will be granted priority for ISTS connectivity.
- Land in renewable energy parks can be allotted for the manufacture of green hydrogen / green ammonia.
- Manufacturers of green hydrogen/green ammonia can set up bunkers near ports to store green ammonia for export or use by shipping. Port authorities will provide land for storage at applicable charges.
- RE used to produce green hydrogen /ammonia counts towards RPO compliance for consumer and the Discom in whose area the project is located.
- Distribution licensees may also procure and supply RE to the manufacturers of green hydrogen / green ammonia in their States. In such cases, the Distribution licensee shall only charge the cost of procurement as well as the wheeling charges and a small margin as determined by the SERC.
- MNRE to create a single portal for all green hydrogen/ammonia clearances. All clearances will be provided within a period of 30 days from date of application.

The Strategic Interventions for Green Hydrogen Transition (SIGHT) programme is a major financial measure under the National Green Hydrogen Mission, with an outlay of ₹ 174.90 billion. Under the provision of the central government, the SIGHT programme allocates ₹ 44.40 billion for domestic manufacturing of electrolysers (Component-1) and ₹ 130.50 billion for green hydrogen production (Component-2).

## 9.2 Expected investments in green hydrogen production segment in India

The Central Government has approved the Green Hydrogen Mission. The Mission will have wide ranging benefits- creation of export opportunities for Green Hydrogen and its derivatives; Decarbonisation of industrial, mobility and energy sectors; reduction in dependence on imported fossil fuels and feedstock; development of indigenous manufacturing capabilities; creation of employment opportunities; and development of cutting-edge technologies. India's Green Hydrogen production capacity is likely to reach at least 5 MTPA, with an associated renewable energy capacity addition of about 125 GW. As per the Central Government, the targets by 2030 are likely to bring in over ₹ 8 trillion investments.

## 9.3 Overview of current market size and outlook

After China and USA, as of March 2024, India is the third largest consumer and producer of hydrogen in the world. In 2020, India's hydrogen demand stood at 6 million tonnes (MT) per year. ~48% hydrogen is used in fertilizers to produce ammonia/urea and ~46% in refineries for hydrodesulfurization. India's grey hydrogen market is estimated to be ~ USD 9-10 billion considering production costs of ~USD 1.5-1.8 per kg. Additionally, India's annual ammonia consumption for fertilizer production is about 15 MTPA, roughly 15% of this demand (over 2 MTPA) is currently met from imports. Driven by captive consumption by refineries, fertilisers and ammonia, the hydrogen demand is expected to reach ~11-12 MTPA by 2030 making it ~USD 22-25 billion market. Out of this ~4-4.5 MTPA is expected from refineries and ~6-6.5 MTPA from fertilisers. Very small quantum (~0.5 to 0.75 MTPA) will be from Petrochemicals and other industries. Considering ~8-10% of hydrogen demand from fertilisers and 22-24% of hydrogen demand from refineries can be met through green hydrogen in 2030, ~1.4-1.8 MTPA will be from green hydrogen. Considering a production cost of ~USD 2 to 2.5 per kg, the green hydrogen market is expected to be ~USD 3-4 billion in fiscal 2030.

# 10 Competition analysis of companies with similar offerings

Juniper Green Energy Ltd. is a renewable energy independent power producer in India with an experience in building, and developing renewable energy assets including solar, wind, WSH and FDRE projects. As of 31 March 2025, Juniper Green Energy Ltd. has an operational utility scale solar power portfolio of 894.88 MWp and 69.30 MW of wind power capacity and also owns two Merchant Solar Power Projects of 210 MWp capacity. The following table provides details of commissioning date of operational projects of Juniper Green Energy along with the other bidders participated in the tenders.

**Table 26: Details of COD of operational projects of Juniper Green Energy Ltd. along with the other bidders**

| Tender | Participants | Capacity (MW) | Tariff (₹/kWh) | SCOD | COD* |
|---|---|---|---|---|---|
| GUVNL / 500 MW / Solar (Phase-IV) | Paryapt Solar Energy Private Limited (Part of UPC-AC Energy Solar, a joint venture of UPC Solar and AC Energy) | 50 | 2.55 | 24 Apr 2021 | 12 Aug 2021 |
| | Gujarat State Energy Corporation Limited | 75 | 2.67 | 24 Apr 2021 | 15 Apr 2021 |
| | Juniper Green Energy Limited | 120 | 2.67 | 21 Apr 2021 | 16 Nov 2020 |
| | Adani Renewable Energy Park (Gujarat) Limited | 150 | 2.67 | 21 Apr 2021 | 20 Jan 2021 |
| | Renew Solar Power Private Limited | 105 | 2.68 | 21 Apr 2021 | 21 Apr 2021 |
| GUVNL /500MW/ Solar (Phase VIII) | Vena Energy | 40 | 2.61 | NA | NA |
| | Juniper Green Energy Limited | 190 | 2.63 | 24 Mar 2022 | 23 Mar 2022 |
| | TATA power Company Ltd. | 120 | 2.64 | 24 Mar 2022 | 04 May 2022 |
| MSEDCL ISTS Phase IV Solar | Juniper Green Energy Limited | 150 | 2.89 | 01 Aug 2022 | 03 Jul 2022 |
| | MSPGCL | 350 | 2.90 | NA | NA |
| MSEDCL Phase VII Solar | SJVN | 200 | 2.90 | NA | NA |
| | Juniper Green Energy Limited | 75 | 2.90 | 04 Oct 2024 | 14 Mar 2024 |
| | TATA power | 150 | 2.91 | NA | NA |
| | SAEL | 50 | 2.91 | NA | NA |
| | Avaada | 25 | 2.91 | NA | NA |
| GUVNL/500MW/ Wind (Phase V) | Juniper Green Energy Limited | 70 | 2.90 | 13 Dec 2024 | 05 May 2024 |
| | SJVN Green Energy Limited | 100 | 3.17 | NA | NA |

| Tender | Participants | Capacity (MW) | Tariff (₹/kWh) | SCOD | COD* |
|---|---|---|---|---|---|
| | Solarcraft Power India 14 Private Limited | 40 | 3.17 | NA | NA |
| | Evergreen Renewables Private Limited | 30 | 3.17 | NA | NA |
| Mukhyamantri Saur Krushi Vahini Yojana (MSKVY 1.0) | Juniper Green Energy Limited | 30 | 3.15 | 27 Jan 2020 | 31 Jan 2020 |
| | Nisagra Renewable Energy Pvt. Ltd (A Juniper Green Energy Subsidiary) | 70 | 3.15 | | |
| | Atnu Solar Power Ltd | 70 | 3.09 - 3.15 | 27 Jan 2020 | 28 Jan 2021 |
| | Aurinko Energy Pvt. Ltd | 10 | 3.11 | 27 Jan 2020 | 22 Jan 2020 |

*Notes: SCOD: Scheduled Commercial Operation Date, COD: Commercial Operation Date; NA: Not available*

**Weighted average COD*

*Source: Press Releases by respective Companies, Crisil Intelligence*

From the above table, it is evident that Juniper Green Energy has successful track record of commissioning most of its operational projects as of 31 March 2025 ahead of schedule and ahead of other IPPs in the respective bids thereby showcasing its expertise in timely project execution.

Competitive mapping covers the details of companies, their products and services within a given market to understand competitive intensity. Some of the key players include ACME Solar Holdings Limited (ACME), NTPC Green Energy Limited (NTPC Green), ReNew Energy Global PLC (ReNew), JSW Neo Energy Limited (JSW Neo), Tata Power Renewable Energy Limited (TATA Power RE), Torrent Power Limited (Torrent Power), Avaada Energy, Hero Future Energies (Hero Future), Continuum Green Energy Limited (Continuum Green). These players also have a sizeable quantum of capacity under consideration/development.

**Table 27: Key players with similar offerings**

| Parameter | Juniper Green Energy | ACME | NTPC Green @ | Renew | Adani Green | JSW Neo |
|---|---|---|---|---|---|---|
| *Operational Capacity (MW) as on 31 December 2024* **(MW)** | 804.30 | 2,540.00 | 5,902.00 | 10,432.30 | 11,609.00 | 4,724.00 |
| *Under Construction/ Development Capacity (MW) as on 31 December 2024* **(MW)** | 4,180.00 | 4,430.00 | 26,357.70 | 6,638.90 | NA | 16,116.00 |
| **Total (MW) (Operational +Under Construction/ Development Capacity )** | **4,984.30** | **6,970.00** | **32,259.70** | **17,071.20** | **11,609.00** | **20,840.00** |
| Key Offtakers for Total Capacity | SECI , NTPC, NHPC, SJVN , The Tata Power Company Limited GUVNL MSEDCL etc. | SECI, NTPC, GUVNL, CSPDCL, MSEDCL, UPPCL, MPPMCL, PSPCL, TSNPDCL, TSSPDCL, APSPDCL, NBPDCL & SBPDCL etc. | SECI, GUVNL, RUMSL, IREDA, NVVNL, REC/NTPC MPPMCL Raj. Discoms AP Discoms UPPCL Telangana Discoms etc. | SECI, MSEDCL, APSPDCL, GUVNL, MPPMCL, TSNPDCL, NTPC, PTC, Corporates etc. | TANGEDCO, Karnataka ESCOMS, UPPCL, PSPCL, NTPC, SECI, MSEDCL, GUVNL, NPCL, TSSPDCL, MPPMCL, PTC India, AEML etc. | MSEDCL SECI PCKL Corporates etc. |

| Parameter | TATA Power RE | Torrent Power | Avaada Energy | Hero Future | Continuum Green |
|---|---|---|---|---|---|
| *Operational Capacity (MW) as on 31 December 2024* **(MW)** | 5,384.00 | 1,662.00 | 4,600.00 | 2,159.00 | 2,216.64 |
| *Under Construction/ Development Capacity (MW) as on 31 December 2024* **(MW)** | 5,517.00 | 2,965.00 | 17,000.00 | 5,222.00 | 1,308.37 |
| **Total (MW) (Operational + Under Construction/ Development Capacity)** | **10,901.00** | **4,627.00** | **21,600.00** | **7,381.00** | **3,525.01** |
| Key Offtakers for Total Capacity | SECI, SJVN TANGEDCO | Corporates, MSEDCL, SECI | Corporates, Gujarat, Haryana, | MSEDCL HESCOM | MSEDCL GUVNL |

| Parameter | TATA Power RE | Torrent Power | Avaada Energy | Hero Future | Continuum Green |
|---|---|---|---|---|---|
| | APDISCOMs<br>GUVNL, BESCOM<br>UPPCL, NPCL<br>MSEDCL, TPCD<br>KSEB, MPPCL<br>JVVNL, JdVVNL etc. | REMCL, TPDL<br>(Own Discom) etc. | Karnataka,<br>Maharashtra,<br>NHPC,<br>SECI, UP etc. | SECI<br>MPPMCL<br>Corporates etc. | SECI<br>MPPCL<br>Corporates etc. |

*S: Solar, W: Wind, H: WSH, FDRE: Firm and despatchable RE, WSH: Wind Solar Hybrid; @Since Dec 2024 operational details are not available, considered as of 31 March 2025;*

*Source: Press releases by respective Companies, Investor Presentations as available on stock exchanges, Company websites etc., Crisil Intelligence*

**Table 28: Key Parameters**

| Metric | Units | Juniper | | | | ACME Solar | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 9M FY25 | FY24 (A) | FY23 (A) | FY22 (A) | 9M FY25 | FY24 (A) | FY23 (A) | FY22 (A) |
| **Installed capacity/ Operational Portfolio** | **MWac** | **804.30** | **660.20** | **560.00** | **410.00** | **2,540.00** | **1,320.00** | **1,459.00** | **1,159.00** |
| Solar | MWac | 735.00[1] | 635.00 | 560.00 | 410.00 | 2,540.00 | 1,320.00 | 1,459.00 | 1,159.00 |
| Wind | MWac | 69.30 | 25.20 | - | - | - | - | - | - |
| WSH | MWac | - | - | - | - | - | - | - | - |
| FDRE | MWac | - | - | - | - | - | - | - | - |
| **Under Construction Contracted Capacity** | MWac | **1,730.00** | **339.10** | **69.30** | **150.00** | **2,340.00** | **1,650.00** | **1,800.00** | **1,750.00** |
| Solar | MWac | 50.00[2] | 100.00[1] | - | 150.00 | 300.00 | 1,500.00 | 1,750.00 | 1,750.00 |
| Wind | MWac | 210.00 | 164.10 | 69.30 | - | 150.00 | 150.00 | 50.00 | - |
| WSH | MWac | 950.00 | 75.00 | - | - | 300.00 | - | - | - |
| FDRE | MWac | 520.00 | - | - | - | 1,590.00 | - | - | - |
| **Under Construction Awarded Capacity** | MWac | **2,450.00** | **1,440.00** | **75.00** | **-** | **2,090.00** | **2,380.00** | **-** | **-** |
| Solar | MWac | 150.00 | - | 75.00 | - | 600.00 | 300.00 | - | - |
| Wind | MWac | - | 90.00 | - | - | - | - | - | - |
| Hybrid | MWac | 1,650.00 | 830.00 | - | - | 450.00 | 830.00 | - | - |
| FDRE | MWac | 650.00 | 520.00 | - | - | 1,040.00 | 1,250.00 | - | - |

| Metric | Units | Juniper | | | | ACME Solar | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 9M FY25 | FY24 (A) | FY23 (A) | FY22 (A) | 9M FY25 | FY24 (A) | FY23 (A) | FY22 (A) |
| **Average CUF for the assets held as on the last date of the financial year/period** | **%** | **24.40** | **25.83** | **25.36** | **26.07** | **23.70** | **24.59** | **22.08** | **21.93** |
| Solar | % | 23.65 | 25.83 | 25.36 | 26.07 | 23.70 | 24.59 | 22.08 | 21.93 |
| Wind | % | 32.34 | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| Average Grid Availability for the assets held as on last date of the financial year/period | % | 99.30 | 99.12 | 99.09 | 98.09 | 99.40 | 99.40 | 99.37 | 99.30 |
| Average Plant Availability for the assets held as on the last date of the financial year/period (%) | % | 98.63 | 98.57 | 99.21 | 99.74 | 99.60 | 99.41 | 99.23 | 99.69 |
| Average tariff for Total portfolio (Operational + Contracted + Awarded)[$] | ₹/kWh | 3.51 | 3.41 | 2.82 | 2.80 | 3.70 | NA | NA | NA |
| Revenue from operations | ₹ Mn | 3,515.94 | 3,915.50 | 3,313.07 | 1,705.30 | 9,184.44 | 13,192.50 | 12,949.04 | 14,879.02 |
| Revenue Growth | % | NC | 18.18 | 94.28 | 71.17 | NC | 1.88 | (12.97) | (12.05) |
| Total Income | ₹ Mn | 3,863.99 | 4,244.47 | 3,624.86 | 1,891.70 | 10,361.86 | 14,662.67 | 13,613.73 | 18,922.89 |
| EBITDA | ₹ Mn | 3,291.68 | 3,708.43 | 2,982.87 | 1,649.86 | 9,174.25 | 12,362.12 | 12,390.62 | 16,447.09 |
| EBITDA Margin | % | 85.19 | 87.37 | 82.29 | 87.22 | 88.54 | 84.31 | 91.02 | 86.92 |
| Operating EBITDA | ₹ Mn | 2,943.63 | 3,379.46 | 2,671.08 | 1,463.46 | 7,996.83 | 10,891.95 | 11,725.93 | 12,403.22 |
| Operating EBITDA Margin | % | 83.72 | 86.31 | 80.62 | 85.82 | 87.07 | 82.56 | 90.55 | 83.36 |
| Profit for the period / year after tax ("PAT") | ₹ Mn | 78.19 | 400.64 | (120.58) | 272.28 | 1,287.46 | 6,982.27 | (31.74) | 620.10 |
| Net Debt to Equity | Times | 0.78 | 1.00 | 2.47 | 1.72 | NA | 2.66 | 3.85 | 3.56 |
| Days of Receivable Outstanding | Days | 16.70 | 23.06 | 19.89 | 15.46 | NA | 84.97 | 166.11 | 199.91 |
| Interest Coverage | Times | 1.72 | 1.94 | 1.50 | 1.96 | 1.66 | 1.61 | 1.53 | 1.65 |
| Operating EBITDA ROCE | % | 9.75 | 12.12 | 29.58 | 28.64 | 10.77 | 13.65 | 16.03 | 12.22 |
| Operating EBIT ROCE | % | 5.71 | 7.74 | 17.39 | 20.05 | 8.28 | 9.79 | 9.40 | 6.84 |

| Metric | Units | ReNew | | | | Adani Green | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 9M FY25 | FY24 (A) | FY23 (A) | FY22 (A) | 9M FY25 | FY24 (A) | FY23 (A) | FY22 (A) |
| **Installed Capacity/ Operational Portfolio** | **MWac** | **10,432.40** | **8,230.00** | **7,663.00** | **7,468.00** | **11,609.00** | **10,934.00** | **8,086.00** | **5,410.00** |
| Solar | MWac | 5,178.10 | 4,159.00 | 3,765.00 | 3,688.00 | 7,756.00 | 7,393.00 | 4,975.00 | 4,763.00 |
| Wind | MWac | 4,081.30 | 4,071.00 | 3,898.00 | 3,780.00 | 1,714.00 | 1,401.00 | 971.00 | 647.00 |
| WSH | MWac | NA | NA | NA | NA | 2,140.00 | 2,140.00 | 2,140.00 | 0.00 |
| FDRE | MWac | 1,173.00 | 650.00 | NA | NA | NA | NA | NA | NA |
| **Under Construction Contracted Capacity** | **MWac** | **6,638.90** | **7,063.00** | **5,713.00** | **5,242.00** | **NA** | **11,019.00** | **10,449.00** | **NA** |
| Solar | MWac | 2,457.80 | 3,405.00 | 2,807.00 | 2,615.00 | NA | 9,409.00 | 8,669.00 | NA |
| Wind | MWac | 913.80 | 1,004.00 | 1,202.00 | 923.00 | NA | 1,010.00 | 1,180.00 | NA |
| WSH | MWac | - | - | - | - | NA | 600.00 | 600.00 | NA |
| FDRE | MWac | 3,267.30 | 2,654.00 | 1,704.00 | 1,704.00 | NA | NA | NA | NA |
| **Under Construction Awarded Capacity** | **MWac** | **NA** | **NA** | **NA** | **NA** | **NA** | **NA** | **NA** | **NA** |
| Solar | MWac | NA | NA | NA | NA | NA | NA | NA | NA |
| Wind | MWac | NA | NA | NA | NA | NA | NA | NA | NA |
| Hybrid | MWac | NA | NA | NA | NA | NA | NA | NA | NA |
| FDRE | MWac | NA | NA | NA | NA | NA | NA | NA | NA |
| **Average CUF for the assets held as on the last date of the financial year/period** | **%** | **NA** | **NA** | **NA** | **NA** | **NA** | **NA** | **NA** | **NA** |
| Solar | % | 23.00 | 25.00 | 25.00 | 23.30 | 23.50 | 24.50 | 24.70 | 23.80 |
| Wind | % | 28.00 | 28.00 | 27.00 | 26.40 | 29.20 | 29.40 | 25.20 | 30.80 |
| Average Grid Availability for the assets held as on last date of the financial year/period | % | NA | NA | NA | NA | 99.80 (S)<br>99.70 (W)<br>100/00 (H) | 99.50 (S)<br>99.30 (W)<br>99.80 (H) | 99.40 (S)<br>92.10 (W)<br>99.20 (H) | 98.90 (S)<br>99.70 (W) |
| Average Plant Availability for the assets held as on the last date of the financial year/period (%) | % | NA | NA | NA | NA | 99.40 (S)<br>95.00 (W)<br>99.70 (H) | 99.70 (S)<br>95.50 (W)<br>99.50 (H) | 99.60 (S)<br>94.30 (W)<br>99.10 (H) | 99.60 (S)<br>96.50 (W) |

| Metric | Units | ReNew | | | | Adani Green | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 9M FY25 | FY24 (A) | FY23 (A) | FY22 (A) | 9M FY25 | FY24 (A) | FY23 (A) | FY22 (A) |
| Average tariff for Total portfolio (Operational + Contracted + Awarded)[$] | ₹/kWh | NA | NA | NA | NA | 3.09* | 2.96 | 2.99 | 2.99 |
| Revenue from operations | ₹ Mn | 68,555.00 | 83,399.00 | 80,462.00 | 62,043.00 | 82,540.00 | 92,200.00 | 77,760.00 | 51,330.00 |
| Revenue Growth | % | NC | 3.65 | 29.69 | 28.54 | NC | 18.57 | 51.49 | 64.31 |
| Total Income | ₹ Mn | 75,911.00 | 96,531.00 | 89,309.00 | 69,195.00 | 91,060.00 | 104,600.00 | 86,170.00 | 55,770.00 |
| EBITDA | ₹ Mn | 60,158.00 | 73,386.00 | 64,304.00 | 43,243.00 | 71,000.00 | 85,370.00 | 57,720.00 | 39,540.00 |
| EBITDA Margin | % | 79.25 | 76.02 | 72.00 | 62.49 | 77.97 | 81.62 | 66.98 | 70.90 |
| Operating EBITDA | ₹ Mn | 52,802.00 | 60,254.00 | 55,457.00 | 36,091.00 | 62,480.00 | 72,970.00 | 49,310.00 | 35,100.00 |
| Operating EBITDA Margin | % | 77.02 | 72.25 | 68.92 | 58.17 | 75.70 | 79.14 | 63.41 | 68.38 |
| Profit for the period / year after tax ("PAT") | ₹ Mn | 1,454.00 | 4,147.00 | (5,029.00) | (16,128.00) | 16,180.00 | 12,600.00 | 9,730.00 | 4,890.00 |
| Net Debt to Equity | Ratio | 5.96 | 5.41 | 4.25 | 2.61 | NA | 5.52 | 6.96 | 19.36 |
| Days of Receivable Outstanding | Days | NA | 67.57 | 113.61 | 260.85 | NA | 27.37 | 76.10 | 91.08 |
| Interest Coverage | Ratio | 1.60 | 1.54 | 1.26 | 1.04 | 1.89 | 1.71 | 1.98 | 1.51 |
| Operating EBITDA ROCE | % | 7.71 | 10.58 | 12.20 | 9.54 | 9.53 | 13.67 | 15.00 | 18.27 |
| Operating EBIT ROCE | % | 5.47 | 7.50 | 8.70 | 5.90 | 6.75 | 10.11 | 11.04 | 13.85 |

| Metric | Units | NTPC Green Energy | | | |
|---|---|---|---|---|---|
| | | 9M FY25[@] (UA) | FY24 (A) | FY23 (A) | FY22 (A) |
| **Installed Capacity/Operational Portfolio** | **MWac** | **5,902.00** | **2,925.00** | **2,611.00** | **1,445.00** |
| Solar | MWac | 5,419.00 | 2,825.00 | 2,561.00 | 1,395.00 |
| Wind | MWac | 483.00 | 100.00 | 50.00 | 50.00 |
| WSH | MWac | - | - | - | - |
| FDRE | MWac | - | - | - | - |
| **Under Construction Contracted and Awarded Capacity** | MWac | **17,277.70** | **11,571.00** | **6,250.00** | **4,766.00** |
| Solar | MWac | 13,525.50 | 9,571.00 | 5,750.00 | 4616.00 |
| Wind | MWac | 3,752.20 | 2,000.00 | 500.00 | 150.00 |
| WSH | MWac | - | - | - | - |

| Metric | Units | NTPC Green Energy | | | |
|---|---|---|---|---|---|
| | | 9M FY25@ (UA) | FY24 (A) | FY23 (A) | FY22 (A) |
| FDRE | MWac | - | - | - | - |
| **Under Construction Awarded Capacity** | MWac | **9,080.00** | - | - | - |
| Solar | MWac | 6,830.00 | - | - | - |
| Wind | MWac | 2,250.00 | - | - | - |
| Hybrid | MWac | - | - | - | - |
| FDRE | MWac | - | - | - | - |
| **Average CUF for the assets held as on the last date of the financial year/period** | **%** | **24.07** | **23.86** | **NA** | **NA** |
| Solar | % | 24.17 | 23.97 | 27.17 | 19.21 |
| Wind | % | 21.01 | 19.78 | 16.48 | 23.66 |
| Average Grid Availability for the assets held as on last date of the financial year/period | % | NA | NA | NA | NA |
| Average Plant Availability for the assets held as on the last date of the financial year/period (%) | % | NA | NA | NA | NA |
| Average tariff for Total portfolio (Operational + Contracted + Awarded) $ | ₹/kWh | NA | NA | NA | NA |
| Revenue from operations | ₹ Mn | 15,873.70 | 19,625.98 | 14,497.09 | 9,104.21 |
| Revenue Growth | % | NC | 35.38 | 59.24 | NC |
| Total Income | ₹ Mn | 17,142.00 | 20,376.57 | 14,575.27 | 9,182.43 |
| EBITDA | ₹ Mn | 14,832.90 | 18,190.30 | 13,174.34 | 8,027.10 |
| EBITDA Margin | % | 86.53 | 89.27 | 90.39 | 87.42 |
| Operating EBITDA | ₹ Mn | 13,564.60 | 17,439.70 | 13,096.16 | 7,948.88 |
| Operating EBITDA Margin | % | 85.45 | 88.86 | 90.34 | 87.31 |
| Profit for the period / year after tax (“PAT”) | ₹ Mn | 2,409.10 | 3,447.21 | 4,564.88 | 947.42 |
| Net Debt to Equity | Ratio | NA | 1.98 | 1.09 | 4.41 |
| Days of Receivable Outstanding | Days | NA | 99.51 | 56.60 | 34.94 |
| Interest Coverage | Ratio | 2.54 | 2.63 | 2.80 | 3.17 |
| Operating EBITDA ROCE | % | 12.64 | 18.05 | 30.55 | NA |
| Operating EBIT ROCE | % | 7.49 | 11.40 | 19.90 | NA |

*(W): Wind; (S): Solar and (H): WSH (A): Audited; NC: Not computed; NA: Not available; Parameters to the extent reported by peers have been populated and/or calculated else classified as not available N/A: Not applicable; $Wt. Avg. Tariff computed using MW Capacity for competitors; @Since Dec 2024 operational details are not available, considered as of 31 March 2025; * Wt. avg. tariff for Adani Green for 9MFY25 is for Operational Portfolio as reported, tariff for under construction portfolio is not reported.*

*(1): Includes 100 MW of solar merchant project; (2) Includes 50 MW of solar merchant project.*

*Source: Consolidated financial information for Juniper Green Energy Limited has been derived from restated consolidated financial statements as of and for the nine months ended 31 December 2024 and as of and for the financial years ended 31 March 2024, 31 March 2023 and 31 March 2022, Company websites, Investors Presentations as available on stock exchanges, RHP Filings, Crisil Intelligence*

Formulae used:

i. *Installed Capacity/Operational Portfolio represents the aggregate megawatt rated capacity of renewable power plants that are commissioned and operational as at the reporting date.*
ii. *Under Construction Contracted Capacity represents projects for which power purchase agreement has been signed but the project has not achieved its commercial operation date.*
iii. *Under Construction Awarded Capacity represents projects for which a letter of award has been received from the off-taker but have not signed a PPA and the contracted capacity details for such projects are as per the letter of award*
iv. *Average CUF for the assets held as on last date of the financial year/period (%)refers to the weighted average of CUF of Installed Capacity in the portfolio as a given financial year/period . In case where any project is commissioned in multiple phases/during the month, the period considered for CUF calculation for such project is taken from the full month following the full commissioning of such project*
v. *Average Grid Availability for the assets held as on last date of the financial year (%) refers to the weighted average of Grid Availability of Installed Capacity in the portfolio as on the given financial year/period. In case where any project is commissioned in multiple phases/during the month, the period considered for Grid Availability calculation for such project is taken from the full month following the full commissioning of such project.*
vi. *Average Plant Availability for the assets held as on the last date of the financial year (%) refers to the weighted average of Plant Availability of Installed Capacity in the portfolio as on given financial year/period. In case where any project is commissioned in multiple phases/during the month, the period considered for Plant Availability calculation for such project is taken from the full month following the full commissioning of such project.*
vii. *Average tariff for total portfolio as on last date of financial year/period is calculated as the tariff rates for each project as per the LOA, weighted by the respective contracted capacity as per LOA. Total portfolio does not include merchant projects.*
viii. *Revenue from operations: Revenue is the income earned in the usual course of business of the entity through sale of electricity (net off rebate and reactive charges) & Sale of Voluntary Emission Reductions*
ix. *Revenue growth: Revenue growth is calculated as revenue from operations for the current year less revenue from operations for the previous year divided by revenue from operations for the previous year*
x. *Total Income: Total Income is calculated as sum of Revenue from operations and other income*
xi. *EBITDA: EBITDA is calculated as earnings before interest, taxes, depreciation and amortisation*
xii. *EBITDA Margin (%): EBITDA Margin is calculated as EBITDA divided by Total Income*
xiii. *Operating EBITDA: Operating EBITDA is calculated as EBITDA minus other income*
xiv. *Operating EBITDA Margin (%): Operating EBITDA Margins is calculated as Operating EBITDA divided by Revenue from Operations.*
xv. *Profit for the period / year after tax ("PAT"): Profit or loss after tax for the given period.*
xvi. *Net Debt to Equity: Net Debt to Equity is calculated by dividing Net Debt by total equity. Net Debt is calculated by subtracting a company's total cash and cash equivalents, other bank balances and current investments from its total borrowing*

*xvii. Days of Receivable Outstanding: Days of Receivables Outstanding is calculated as closing trade receivables (excluding unbilled revenue) divided by billed revenue (revenue from operations plus opening unbilled revenue minus closing unbilled revenue for the period) multiplied by 365 for yearly or 275 for the nine months period ended December 31, 2024. Trade Receivables includes both current and non-current trade receivables.*

*xviii. Interest Coverage: Interest Coverage is calculated as EBITDA/finance costs*

*xix. Operating EBITDA ROCE: Operating EBITDA ROCE is operating EBITDA divided by opening capital employed less opening capital work in progress less opening capital advances less opening cash and cash equivalents less current and non-current other bank balances less current and non-current investments*

*xx. Operating EBIT ROCE: Operating EBIT ROCE is operating EBIT divided by opening capital employed less opening capital work-in-progress less opening capital advances less opening cash and cash equivalents less current and non-current other bank balances less current and non-current investments. Operating EBIT is calculated as Operating EBITDA less depreciation and amortization*

Juniper Green Energy ranks among the top 10 largest renewable IPPs in India in terms of total capacity as of 31 December 2024, where total capacity includes operational, under construction contracted and awarded projects.

Juniper Green Energy holds a share of 11.48%, ranking as the second largest bidder in terms of total capacity won in WSH and FDRE tenders concluded between 1 April 2021 to 31 December 2024 and had a 100% conversion rate for WSH and FDRE tenders won between 1 April 2021, to 31 December 2024.

Juniper Green Energy has the shortest receivable days in each of the preceding three financial years i.e. FY22, FY23 and FY24 as well as 9MFY25 compared to other listed industry peers

Juniper Green Energy's projects are present across Gujarat, Maharashtra, Rajasthan and Madhya Pradesh which are key states/regions for RE development. These states account for around 41% of India’s solar energy potential with more than 59% of India’s installed solar capacity; and around 55% of India’s wind energy potential with more than 59% of India’s installed wind capacity as of January 2025.

Juniper Green Energy has entered into an agreement with First Solar for the procurement and supply of 1 GW of its advanced Series 7 FT1 cadmium telluride (CdTe) thin film PV modules. This agreement marked a major milestone in the Indian solar industry given that it is one of India’s largest agreements for domestically produced modules. First Solar has 3.3 GW vertically integrated solar manufacturing plant in Tamil Nadu. This will reduce its dependence on China given that these modules are truly domestic with no reliance on China’s crystalline silicon supply chains. The Series 7 FT1 modules are ALMM enlisted, DCR eligible, BIS compliant and have been created specifically for India’s ground-mount PV market to optimize balance of system costs and reduce the levelized cost of energy (“LCOE”) for India’s PV projects. First Solar is America's leading solar PV technology and manufacturing company with expected nameplate capacity of over 25 GW by 2026, including 14 GW in US.

Juniper Green Energy has signed a contract with Envison for the supply of 1 GW of their 5 MW WTGs. These WTGs are larger in comparison to older 2.00–2.50 MW WTGs and help achieve economies of scale, lower the carbon footprint by reducing reliance on fossil fuels and may potentially generate more renewable energy credits.

Juniper Green Energy's participation in the Gold Standard (GS) framework reaffirms its commitment to climate action, transparency, and sustainable development. By adhering to GS' rigorous guidelines, Juniper Green projects generate high-integrity, verifiable carbon credits that deliver not only environmental benefits but also tangible social and economic value—making them attractive in both carbon and ESG markets.

# 11 Challenges and threats for the sector

**Threats**

- Any adverse shift in government policies, including reductions in incentives or changes in energy regulations, can significantly impact renewable player's revenue and profitability. However, considering the COP commitment, climate change ambitions and government push for RE, the chances of drastic changes in regulatory regime are less likely. This can also be ascertained from the fact that as against capacity addition of ~97 GW of RE, only ~23 GW of conventional capacity has been added over the last 6 years (FY2019-FY25).

- There were some delays in signing PSAs having higher tariffs by Discoms due to declining tariffs in subsequent tenders. However, with the government's plan for stricter adherence to renewable purchase obligations (RPOs), higher penalties in case of non-compliance, and revision of tariff in manufacturing-linked tenders, PSA signing activity improved during fiscal 2022 onwards.

- There are only a few states which are complying with the RPO obligations fully and there has been limited enforcement on obligated entities - Discoms and open access and captive power users - to meet RPO targets. The proposed amendment to the Electricity Act 2003 has stipulated a penalty on RPO non-compliance and uniform imposition of penalties and strict enforcement would be critical for significant improvement and fair distribution of RPO compliance across states.

- The solar power industry is currently facing cost pressures on account of volatility in module prices, exchange rates, freight, and commodity prices. This may impact on the EPC margin of renewable players as they may not be able to pass on the cost increase to project developing SPVs.

- The RE sector is highly competitive, with numerous players vying for market share. Established competitors along with capable new entrants can pose challenges. Climate change and extreme weather events can affect the performance and reliability of renewable energy systems, potentially leading to disruptions or damage to infrastructure. Further, economic downturns and financial instability can reduce capital available and increase costs for renewable energy investments, affecting the renewable player's expansion plans.

- Recently Government of India has imposed anti-dumping duty on solar glass imports from China and Vietnam for 5 years, effective Dec 4, 2024. The duty rates range from USD570 to USD664 per metric ton, varying by producer and country. This will have an adverse impact on the prices of modules manufactured by domestic companies. Furthermore, safeguard duty on import on steel (applicable for 200 days from 21 April 2025) may have an impact on the prices of wind turbine generators.

**Challenges:**

- There is counterparty credit risk due to the depleted financial position of most Discoms. Due to legacy issues, higher T&D losses, lack of adequate tariff revisions, lack of timely subsidy support, operational challenges, financial position in most of the State Discoms is weak. However, implementation of Late Payment Surcharge Rules 2022 (LPS Rules) has helped developers to reduce receivables to a large extent. Further, the Rules also debar Discoms from short term access

for sale and purchase of electricity in case of default or non-payment by Discoms (nonpayment for a period of 75 days from the date of presentation of bills or 30 days from the due date, whichever is later).

- Further, execution risk in under construction projects may impact profitability and in turn liquidity. However, major renewable players having in-house EPC expertise and experience in execution of large-scale projects should mitigate this risk.
- Furthermore, the availability of contiguous land and acquisition challenges associated with land parcels are some of the key challenges that developers are facing. To acquire large tracts of land in a single resourceful location, many stakeholders have to be involved, which slows down the pace of project execution. The 40-GW solar park scheme, which provides land to successful bidders for setting up the projects, is facilitative in this aspect.
- Availability of timely transmission connectivity is another challenge. To optimize costs, utilization levels, and losses associated with the transmission system, it is crucial to have robust transmission planning. Concerns about connectivity for renewable projects have been raised by the various stakeholders at the appropriate levels. Nodal agencies (PGCIL and SECI) have planned various schemes to reduce grid congestion and enhance connectivity, taking this into account.
- Green Energy Corridor Scheme and Renewable Energy Zones expected to add ~80 GW of transmission grid capacity taking it to more than 100 GW for RE projects. This will give comfort against the planned capacity additions in renewable energy segment.

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