Market Intelligence
& Analytics

CRISIL
An S&P Global Company

ACME Solar Holdings Limited

Strategic assessment of power and renewable energy sector in India

Final report

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Consulting

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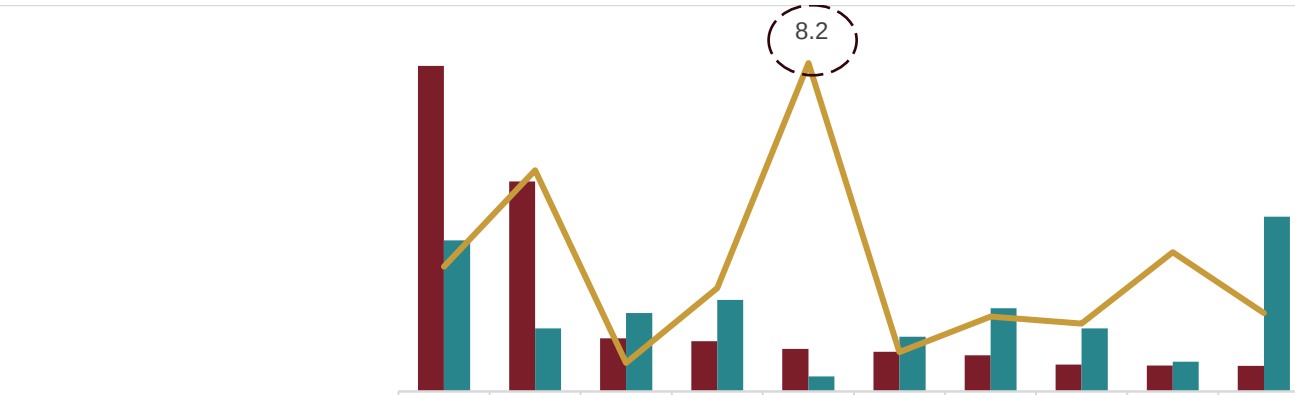
1 Macroeconomic overview

1.1 Economic indicators

India's gross domestic product (GDP) at constant (fiscal 2012) prices was Rs. 173.8 lakh crore (provisional estimates) for fiscal 2024 vis-à-vis the first revised estimate of Rs.160.7 lakh crore as per data released by the National Statistical Office (NSO) in May 2024. This translates into a growth of 8.2% over fiscal 2023.

India has become the fifth largest economy in the world in 2023, according to the International Monetary Fund's (IMF) World Economic Outlook (April 2024). As per IMF GDP Forecasts (July 2024), India's GDP growth is estimated at 6.5% in 2025, the highest amongst the top 10 economies.

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) FY23	27.36	17.66	4.46	4.21	3.57	3.34	3.03	2.26	2.17	2.14
Per capita ele. consumption CY22 (MWh)	12.7	5.3	6.6	7.7	1.3	4.6	7	5.3	2.5	14.7
Real GDP Growth CY23 (in %)	2.5	5.2	-0.2	1.9	8.2	0.1	1.1	0.9	2.9	1.2

**India Financial Year, Source: World Economic Outlook Database (April and July 2024) by IMF; IEA, CEA, CRISIL MI&A-Consulting*

The S&P Global's macro summary for the major regions and groups is summarised below:

- **The USA:** Second-quarter growth momentum is tracking above the (upwardly revised) potential rate of 2.2%. Growth in labor supply primarily drove the increase in estimated potential growth.
- **Europe**: Activity is on the rise, with the May composite purchasing managers' indices firmly above the expansion threshold. The eurozone has exited the recent manufacturing recession, putting it cyclically ahead of the U.S. Meanwhile, the labor market continues to slow although the unemployment rate remains near all-time lows.
- **China:** S&P Global raised its 2024 China GDP growth forecast to 4.8%, from 4.6%, but see a sequential slowdown in the second quarter as the combination of subdued consumption and robust manufacturing investment weighs on prices and profit margins.
- **Emerging markets:** First-quarter GDP data confirmed a recovery across most emerging markets. With a few exceptions, S&P Global expects this recovery to continue in the coming quarters. External demand dynamics are also improving, especially in emerging markets that are exposed to the nascent recovery in Europe, or those that are exposed to the improvement in the electronics trade cycle. Unexpected electoral outcomes, particularly in Mexico and South Africa, have increased uncertainty about upcoming policy paths.

Figure 2: GDP trajectory (% change)

At basic prices	FY19	FY20	FY21	FY22	FY 23E	FY24E	At market prices	FY19	FY20	FY21	FY22	FY23E	FY24E
							GDP	6.5%	3.9%	-5.8%	9.7%	7.0%	8.2%
Agriculture	2.1%	5.5%	3.3%	3.5%	4.7%	1.4%	Private consumption	7.1%	5.2%	-6.0%	11.1%	6.8%	4.0%
Industry	5.3%	-1.4%	-3.3%	14.8%	9.4%	7.5%	Govt. consumption	6.7%	3.4%	3.6%	6.6%	9.0%	2.5%
Manufacturing	5.4%	-2.9%	-0.6%	11.1%	-2.2%	9.9%	Fixed investment	11.2%	1.6%	-10.4%	14.6%	6.6%	9%
Mining and quarrying	-0.8%	-1.5%	-8.6%	7.1%	1.9%	7.1%	Exports	11.9%	-3.4%	-9.2%	29.3%	13.4%	2.6%
Services	7.2%	6.3%	-7.8%	9.7%	9.1%	8.4%	Imports	8.8%	-0.8%	-13.8%	21.8%	10.6%	10.9%

E: Estimated (Since FY23 are first revised estimates and FY24 are provisional estimates, shown as estimated))
Source: Central Statistics Office (CSO), CEIC, CRISIL MI&A-Consulting

CRISIL MI&A Consulting expects GDP growth to moderate to 6.8% this fiscal 2025 after a high growth of 8.2% last year, weighed down by high interest rates and low fiscal impulse. On a positive note, last year's laggards — agriculture and consumption — are poised to rise. Rural demand is expected to drive consumption. Monsoon is progressing well and is above normal as on September 10 (8% above long period average). Kharif sowing, too, is higher on-year. Along with increasing agricultural production, it will help ease food inflation this year, which is critical to raise discretionary spending.

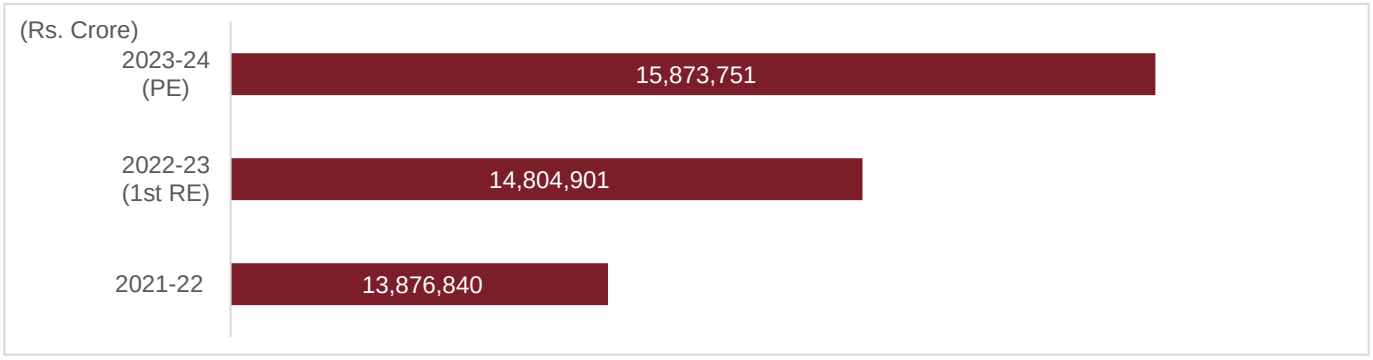
In addition, government spending on employment and asset generating schemes (PM *Awas Yojna* for urban and rural areas) should provide additional support to consumption growth. However, unlike last fiscal, rural consumption is expected to outpace urban consumption, as higher interest rates impact urban areas more. The signs of this are visible in the RBI's consumer confidence survey for urban areas released in August. Net-net, high rural demand and easing food inflation are expected to lift consumption over the anemic 4% growth seen last year.

Given growth expectation of 6.8%, CRISIL MI&A Consulting expects India to log the fastest growth among major economies and fare better than 6.7% growth seen in the decade preceding the pandemic.

1.2 GVA performance

Real gross value added (GVA), i.e., GVA at constant (fiscal 2012) basic prices, is estimated to increase 7.2% in fiscal 2024 as against 6.7% in fiscal 2023.

Figure 3: GVA at basic prices



PE: Provisional estimates; RE: revised estimates
Source: Ministry of Statistics and Programme Implementation, CRISIL MI&A-Consulting

1.3 India's GDP recovered with subsiding of the pandemic

In the past 11 years (from fiscal 2014 to 2024), India's GDP at constant (fiscal 2012) prices grew at a compounded growth of ~5.3% (CAGR).

GDP grew 6.7% on-year in the first quarter of fiscal 2025, in line with CRISIL's forecast of 6.8%. This was a deceleration vs the fourth quarter of fiscal 2024, which saw the economy expand 7.8%. And in the first quarter of fiscal 2024, the economy had grown 8.2%. On the supply side, GVA growth of 6.8% was slightly higher than 6.7% GDP growth.

From the demand side, decline in government consumption spending was a drag on GDP growth. And reducing growth in net taxes limited the rise in GDP over GVA growth. That being said, both private consumption and fixed investments picked up in the quarter. From the supply-side, despite healthy growth of 7.0%, manufacturing was slower than in the last quarter fiscal 2024, while agriculture and services improved. However, the improvement in agriculture was relatively modest, which capped the rise in GDP.

Overall, CRISIL MI&A-Consulting[1] expects India's real GDP to moderate to 6.8% in fiscal 2025, after a high growth of 8.2% last year, weighed down by high interest rates and low fiscal impulse. However, agriculture and consumption, which were both sluggish last fiscal 2024, are expected to see a revival this fiscal 2025.

Table 1: CRISIL's projections

	FY18	FY19	FY20	FY21	FY22	FY23	FY24E	FY25F
GDP growth (%)	6.8%	6.5%	3.9%	-5.8%	9.7%	7.0%	8.2%	6.8%
CPI (%, average)	3.6%	3.4%	4.8%	6.2%	5.5%	6.7%	5.4%	4.5%
CAD/GDP (%)	1.8%	2.1%	0.9%	-0.9%	1.2%	-2.0%	-0.7%	-1.0%
FAD/GDP (%)	3.5%	3.4%	4.6%	9.2%	6.7%	6.4%	5.6%	4.9%
Exchange rate (Rs/$ March-end)	65.0	69.5	74.4	72.8	76.2	82.3	83.0	84.0
10-year G-sec yield (%, March-end)	7.6%	7.5%	6.2%	6.2%	6.8%	7.4%	7.0%	6.8%

E: Estimated; F: Forecast; CPI: Consumer Price Index-linked; CAD: Current account deficit; G-sec: Government security; FAD: Fiscal account deficit
Source: CSO, Reserve Bank of India (RBI), CRISIL estimates

1.4 Aatmanirbhar Bharat Abhiyan

Production Linked Incentives (PLIs) in the 14 sectors for the *Aatmanirbhar Bharat* vision received an outstanding response, with a potential to create 60 lakh new jobs (as per government estimates).

Table 2: *Atmanirbhar Bharat* Vision for select sectors

Sector	Government spend	Key schemes
Renewable energy	~Rs 1,30,000 crore	• Rs 4,500 crore Production Linked Incentive Scheme 'National Programme on High Efficiency Solar PV Modules'. This was further increased by Rs 19,500 crore in the budget for fiscal 2023, taking it to Rs 24,000 crore; in Tranche I 8.7 GW and in Tranche II 39.6 GW capacity were allocated for domestic solar module manufacturing capacity under PLI.

[1] Based on CRISIL Centre for Economic Research (C-CER) projections
Projections in this Chapter are as per the C-CER

Sector	Government spend	Key schemes
		• PM Surya Ghar Muft Bijli Yojna: This scheme has a proposed outlay of Rs. 75,000 Crore and aims to light up 1 crore households (rooftop solar) by providing up to 300 units of free electricity every month. • Public procurement (Preference for 'Make in India') to provide for purchase preference (linked with local content) in respect of renewable energy (RE) sector • Implementation of Pradhan Mantri Kisan Urja Suraksha Utthan Mahabhiyan (PM KUSUM) scheme; MNRE, in November 2020, scaled up and expanded the PM KUSUM scheme to add 30.8 GW by 2022 with central financial support of Rs 34,422 crore. The scheme has been extended till March 31, 2026 • Approved Models & Manufacturers of Solar Photovoltaic Modules (Requirement for Compulsory Registration) Order, 2019 • List of manufacturers and models of solar PV modules recommended under ALMM Order • Scheme of grid connected wind-solar hybrid power projects • Basic customs duty (BCD) of 25% on solar cells and 40% on modules, respectively, effective April 1, 2022
Power distribution companies (discoms)	~Rs.97,000 Crore	• Rs 1.35 lakh crore liquidity infusion for discoms via Power Finance Corporation/ Rural Electrification Corporation (PFC/ REC) against receivables • Rebate for payment to be received by generation companies (gencos) to be passed on to industrial customers • Revamped distribution sector scheme (RDSS) to help discoms improve their operational efficiencies and financial sustainability by providing result-linked financial assistance; outlay of Rs 3,03,758 crore over 5 years i.e., fiscals 2022 to 2026. The outlay includes an estimated Government Budgetary Support (GBS) of Rs 97,631 crore.
New Energy	Rs. ~38,800 Crore	• Rs 18,100 crore under PLI scheme for Advanced Chemistry Cell (ACC) Battery Storage in India launched in October to achieve 50 GWh manufacturing capacity • Green Hydrogen Policy launched in February 2022 to facilitate production of green hydrogen/green ammonia • PLI scheme on green hydrogen manufacturing with an initial outlay of Rs 19,744 crore with an aim to boost domestic production of green hydrogen

Source: Official portal of the Government of India; various ministries, PIB press releases, CRISIL MI&A-Consulting

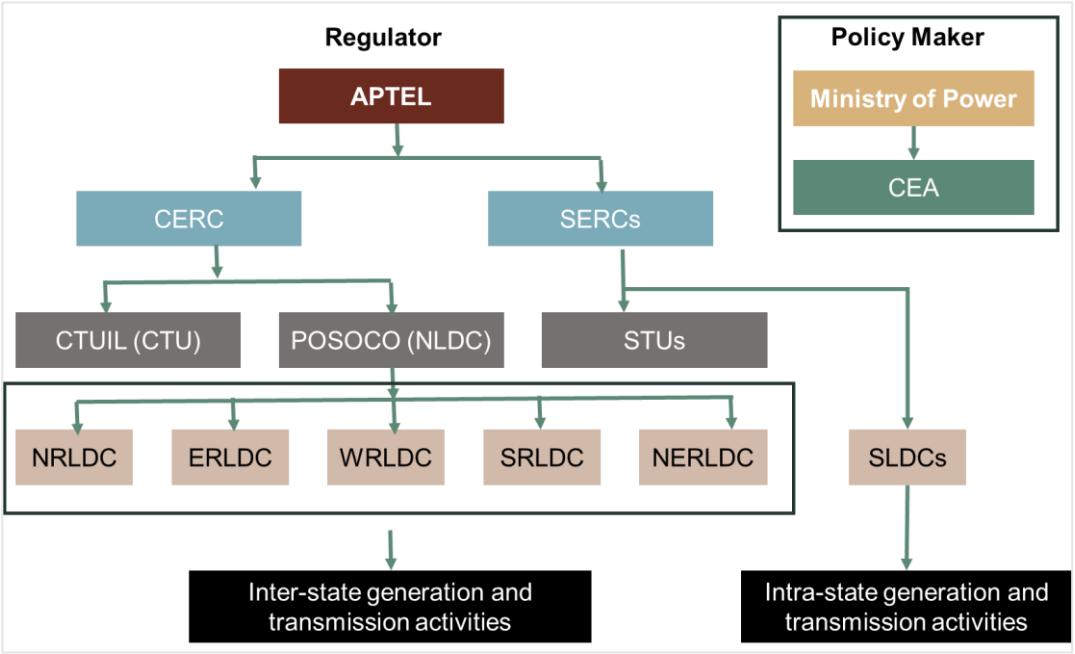
2 Overview of the Indian Power Sector

2.1 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

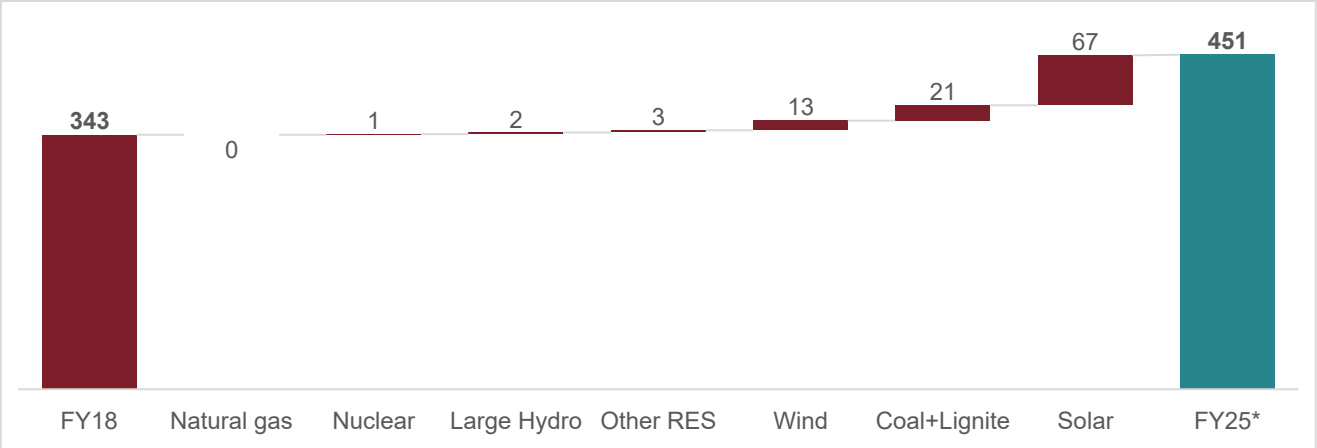


Note:
APTEL - The Appellate Tribunal for Electricity; CERC- Central Electricity Regulatory Commission; CEA- Central Electricity Authority; WRLDC- Western Regional Load Despatch Centre; ERLDC- Eastern Regional Load Despatch Centre; SRLDC- Southern Regional Load Despatch Centre; NLDC: National Load Despatch 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.
Source: CRISIL MI&A-Consulting

2.2 Power supply mix

The total installed generation capacity as of March 2024 was ~442 GW, of which ~98 GW of capacity was added over fiscal 2018-24. The overall installed generation capacity has grown at a CAGR of 4.3% over the same period. About 9 GW of capacity has been added during fiscal 2025 as of August 2024. The installed capacity has now reached 451 GW as of August 2024.

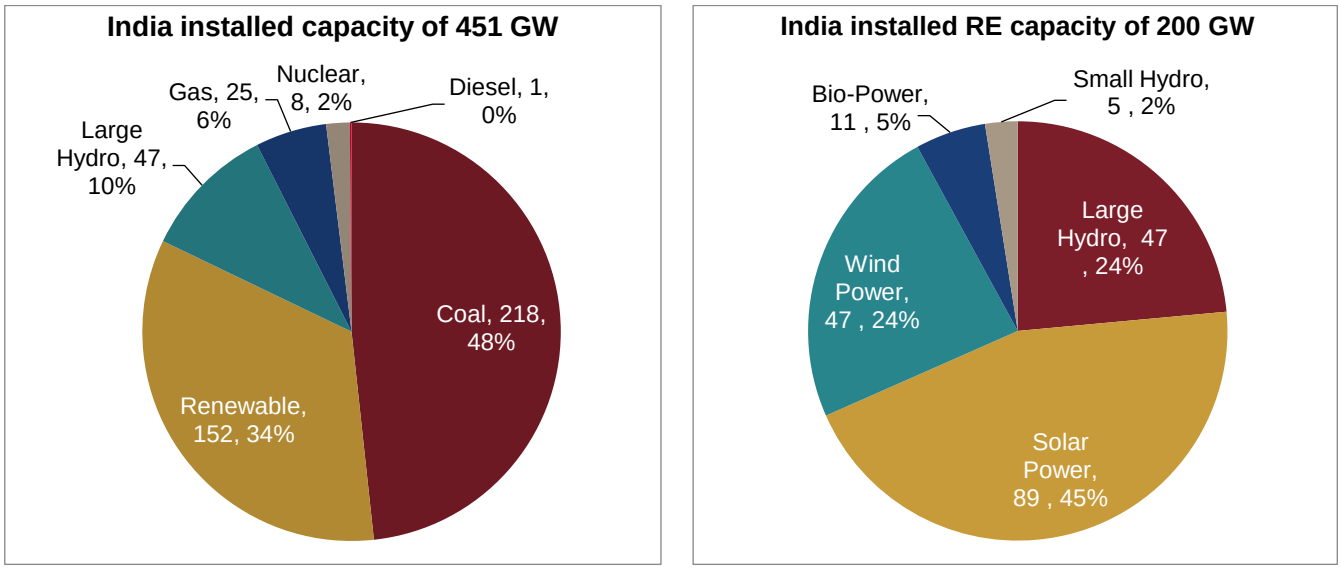
Figure 5: India Annual capacity additions and installed capacity (GW)



FY25 data as of August 2024; Source: CEA, CRISIL MI&A-Consulting

Coal and lignite-based installed power generation capacity has maintained its dominant position over the years and accounts for ~48% as of August 2024. However, RE installations (including large hydroelectric projects), have reached ~200 GW capacity as of August 2024, compared with 114 GW as of March 2018, constituting about 44% of total installed generation capacity. This growth has been led by solar power, which rapidly rose to ~67 GW from 22 GW over the same period.

Figure 6: Breakup of installed capacity as of August 2024 (GW, % share)

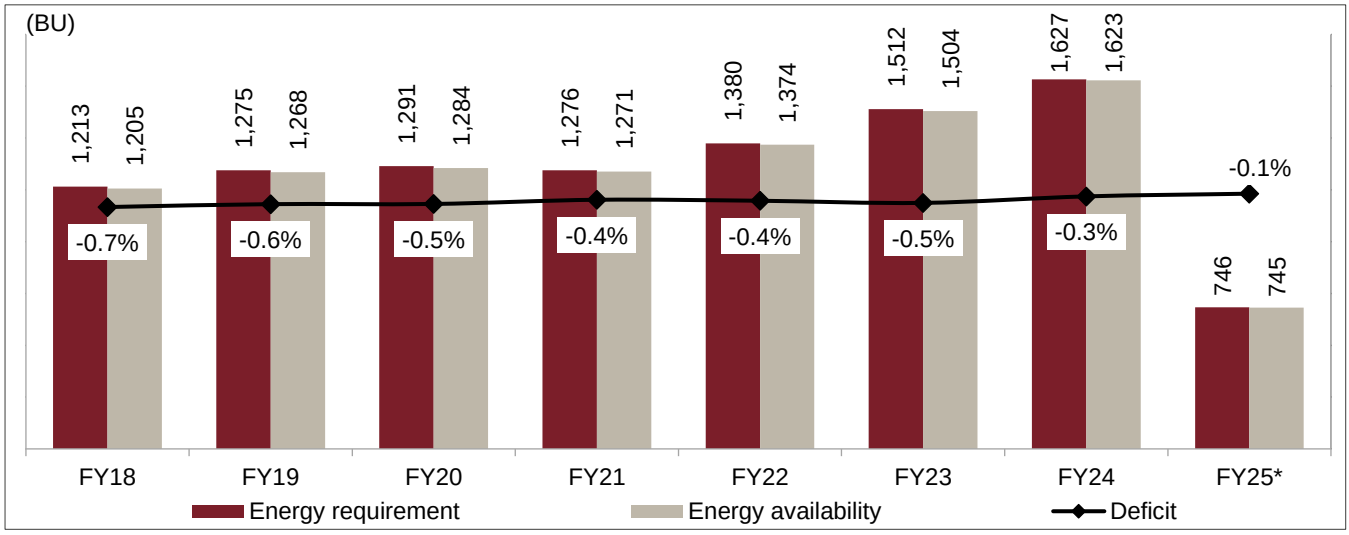


Source: CEA, CRISIL MI&A-Consulting

2.3 Demand-supply scenario

India's electricity requirement has risen at a CAGR of ~5.0% between fiscals 2018 and 2024, while power availability rose at ~5.1% CAGR on the back of strong capacity additions, both in the generation and transmission segments. As a result, the energy deficit declined to 0.5% in fiscal 2023 and further reduced to 0.3% in fiscal 2024 from 0.7% in fiscal 2018. Also, strengthening of inter-regional power transmission capacity over the past five years has further supported the fall in deficit levels as it reduced supply constraints on account of congestion and lower transmission corridor availability. During fiscal 2025, the deficit has reduced to 0.1% as of August 2024.

Figure 7: Aggregate power demand supply (in billion units, or BUs)

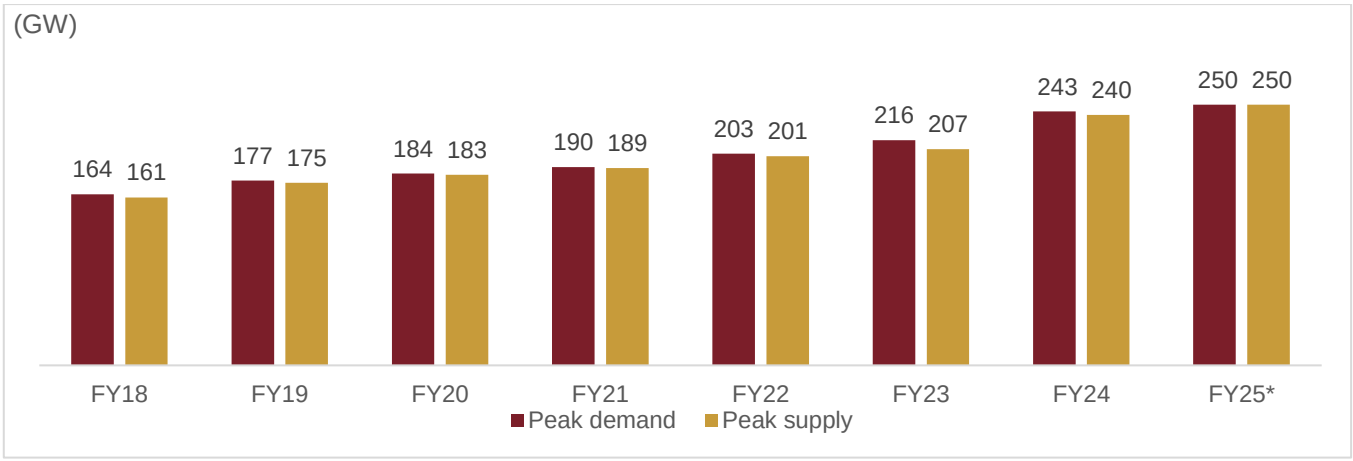


FY25 data as of August 2024; Source: CEA, CRISIL MI&A-Consulting

Peak electricity demand in India has grown from 164 GW in fiscal 2018 to 243 GW in fiscal 2024 clocking an average growth rate of 6.8% in the past six years. In fiscal 2025 (as of August 2024) the peak demand further increased to 250 GW during the month of May 2024. Prior to the pandemic, electricity demand in India usually peaked in August-September, mostly covering the monsoon season. This spike in peak demand was primarily due to an increase in domestic and commercial load, mainly space cooling load due to high humidity conditions. However, during post pandemic years, annual peak demand occurred in the summer season (April-July), due to extreme heatwave conditions.

Peak demand touched record high levels of 250 GW in fiscal 2025 during May 2024, attributed to an increase in cooling demand as intense summers scorched several regions of the country. During fiscal 2023, the generation has struggled to keep up with the rise in demand, resulting in an increase in peak deficit to 4.2% as compared with 1.2% for the same period in fiscal 2022. However, during fiscal 2024, the peak deficit reduced to 1.4% with a deficit of only 3 GW with jump in supply. The peak supply position further improved in fiscal 2025 with no deficit witnessed during the period.

Figure 8: Peak power demand and supply



FY25 data as of August 2024; *Source: CEA, CRISIL MI&A-Consulting*

2.4 Distribution sector reforms

Despite various measures, consumers did not get reliable 24x7 electricity in many parts of the country. Aggregate Technical and Commercial (AT&C) losses and the Average Cost of Supply-Average Revenue Realized (ACS-ARR) gap continued to be high. This sub-optimal performance of the Distribution Sector was due to structural and management deficiencies and some remaining weaknesses in the infrastructure. The distribution companies (DISCOMs) are required to focus on improving their operational efficiencies & financial sustainability; and improve consumer services to be able to meet the desired consumer service standards. This required large-scale reforms in the Distribution Sector and schemes that would enable the DISCOMs to reduce losses to make them financially sustainable and operationally efficient.

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:

- *Rs 3 trillion RDSS aiming to improve operational and financial parameters of discoms* — In Union Budget 2021-22, the GoI announced the RDSS with an outlay of Rs 3.04 trillion, partly funded by the GoI to the tune of Rs 976 billion, aimed at reducing financial stress across discoms. The package, slated to be distributed over the next five years, will subsume other schemes (DDUJY and IPDS) 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).

- MoP vide Gazette Notification dated 3rd June' 2022, notified "The Electricity (Late Payment Surcharge and Related Matters) Rules, 2022" (LPS Rules) to address cash flow challenges faced mainly by generation companies (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 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 Rs. 1.4 lakh crores in June 2022 to around Rs. 48,000 crores 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 166 in fiscal 2022 to 126 in fiscal 2023.

2.5 Discom financial health

Review of AT&C loss and ACS-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 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% in 2018-19 as per loss reduction trajectory to be finalized by Minister of Power and States
- Reduction in gap between average cost of supply and average revenue realized to ZERO by 2018-19 as finalized by MP and States.

States took over 75% of discom debt as on September 30, 2015, over a period of two years, 50% in fiscal 2016 and 25% in fiscal 2017. The balance 25% (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 300-400 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, Rs ~2.3 trillion worth 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 Ujwal DISCOM Assurance Yojana (UDAY), but the situation reversed and worsened again once the scheme ended in March 2019.

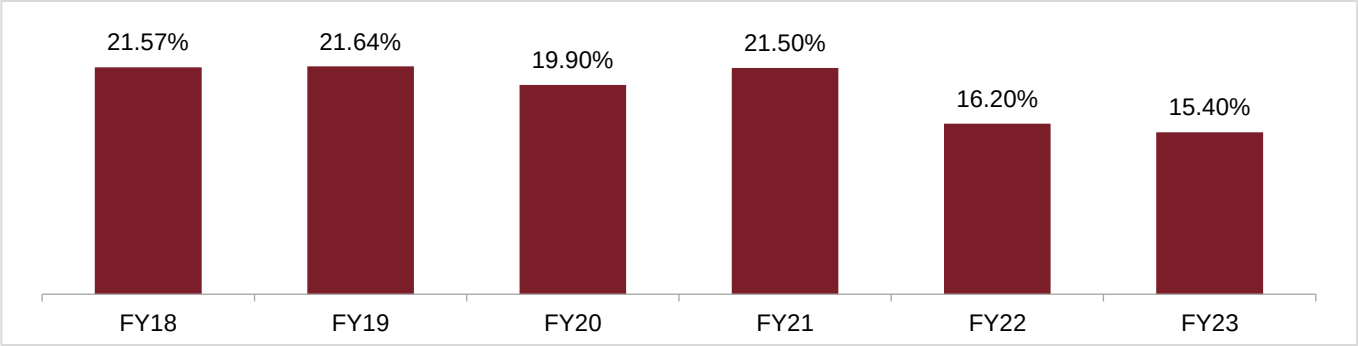
The scheme envisaged reduction of the cost of power through measures such as additional supply of domestic coal (at notified prices), coal linkage rationalisation through swap agreements, supply of washed and crushed coal, and supply of cheaper power from NTPC and other central public sector units (as 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.

Improvements in operational efficiency

AT&C losses reduced to 15.4% in fiscal 2023, significantly lower than 21.5% in fiscal 2021. AT&C losses were considerably high in fiscal 2021, as COVID-19 adversely impacted both billing and collection efficiencies. However, AT&C losses reduced by ~4.5% in fiscal 2023 even when compared with the pre-pandemic level (fiscal 2020).

The AT&C loss trend indicates that the improvement was driven by collection efficiency, which improved from 93.1% in fiscal 2020 to 97.3% in fiscal 2023. On the other hand, billing efficiency improved marginally to 87.0% in fiscal 2023 from 85.9% in fiscal 2020.

Figure 9: AT&C loss trajectory (%)

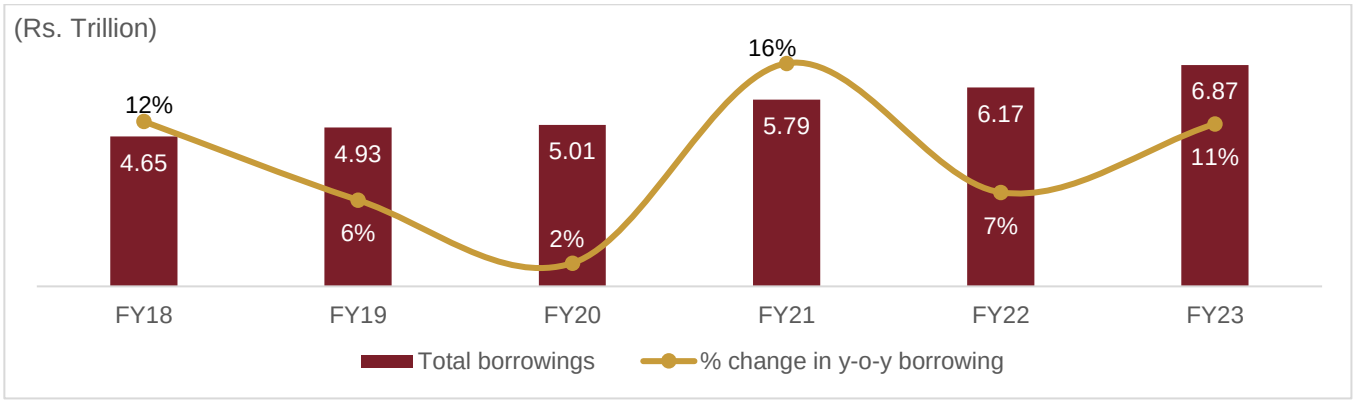


Source: PFC, CRISIL MI&A-Consulting

The cash ACS and ARR gap at the national level narrowed to Rs 0.49 per kWh in fiscal 2018 from Rs 0.58 per kWh in fiscal 2017 but expanded to Rs 0.83 per kWh at the end of fiscal 2019. The cash-adjusted ACS-ARR gap stood at Rs 0.79/kWh as of March 2020 and widened further to Rs 0.89/kWh as of March 2021, indicating further deterioration in discoms' financial profiles. However, the gap narrowed to Rs 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 Rs 0.55/kWh due to an increase in power purchase cost.

The power distribution sector suffers from high trade payables averaging 126 days nationally, as opposed to the benchmark of 45 days specified in LPS Rules, 2022. With the sector making losses and facing liquidity crunch, reducing trade payables remains challenging.

Figure 10: Total borrowings for discoms



Source: MoP, PFC, CRISIL MI&A-Consulting

CRISIL MI&A-Consulting has bucketed states based on their operational performance, infrastructure growth, and the respective state government's ability and willingness to support them. The details are as of March 2023.

Figure 11: Most state entities within moderate-to-weak band

Bucketing of state utilities

	State	AT&C loss (%)	ACS-ARR gap (₹/kWh)	Fiscal deficit (% of GSDP)
Strong	Gujarat	9.66%	0.02	1.51%
	Andhra Pradesh	8.48%	0.01	3.60%
	Haryana	11.74%	-0.04	3.30%
Moderate	Karnataka	13.76%	0.61	2.84%
	Punjab	11.30%	0.18	5.20%
	Tamil Nadu	10.30%	0.96	3.00%
	Rajasthan	15.60%	0.15	4.30%
	Chhattisgarh	16.10%	0.11	3.20%
	Maharashtra	19.00%	1.56	2.79%
	Telangana	19.69%	1.11	3.20%
	Madhya Pradesh	20.97%	-0.46	3.60%
Weak	Uttar Pradesh	20.81%	1.64	4.00%
	Jharkhand	30.30%	2.47	2.30%
	Bihar	24.59%	0.18	8.80%

AT&C loss (%)
- Less than 15%
- Between 15% and 21%
- Above 21%

ACS-ARR gap (₹/kWh)
- Less than ₹ 0.05/kWh
- Between ₹ 0.05 and ₹ 0.35/kWh
- Above ₹ 0.35/kWh

Fiscal deficit (% of GSDP)
- Less than 3%
- Between 3% and 4.5%
- Above 4.5%

Source: PFC, CRISIL MI&A-Consulting

Strong states have performed better in operational parameters

Gujarat, Andhra Pradesh, and Haryana have been classified as strong states, as they have AT&C losses significantly lower than 15%, which is all India target under RDSS. Also, the state profile is preferable with lower fiscal deficit.

Moderate states have few promising operational parameters, but are stretched on certain counts

Madhya Pradesh despite high AT&C loss, has ACS-ARR gap relatively under control with moderate fiscal profile of state. Karnataka, Punjab and Tamil Nady with high ACS-ARR gap and relatively good fiscal profile except Punjab is considered moderate as its AT&C losses are lower than 15%.

Other discoms have reported higher AT&C losses and ACS-ARR gap

AT&C loss and ACS-ARR gap in states such as Bihar, Jharkhand, Uttar Pradesh are higher than national average on account of weak distribution infrastructure, higher power purchase costs, and lower billing and collection efficiency.

As a result of operational inefficiencies and financial losses incurred over the years, state discoms have accumulated a significant debt burden. After completion of UDAY scheme, discoms' debt rose over fiscals 2020 and 2021 as revenues fell on account of weak power demand. As of fiscal 2023, total outstanding debt is Rs 6.87 trillion. Going forward, the debt burden is expected to increase over fiscals 2024-28 despite power demand recovery as operational inefficiencies persist and losses pile up, requiring discoms to borrow to fund the accumulated losses and debt servicing.

Table 3 :Credit Ratings of offtakers (State Discoms, Holding Companies, Central Agencies)

Offtakers	Date	Agency	Rating	Instrument
SECI	8-May -24	ICRA	AAA Stable	LT rating
MSEDCL	14-May-24	Acuite	A Stable	LT rating
PSPCL	10-Oct-23	Acuite	BBB- Stable	LT rating
APSPDCL	5-Apr-24	CARE	C Stable	LT rating
TSNPDCL	16-Apr-24	CRISIL	BB/Negative	LT rating
TSSPDCL	2-Apr-24	CARE	BB- Negative	LT rating
GUVNL	9-Apr-24	ICRA	AA-Stable	LT rating
MPPMCL	22-Feb-24	CARE	BBB-Stable	LT rating
GRIDCO	28-June-24	India Ratings	BBB+/Stable	Bank Loans
CSPDCL	20-Feb-24	India Ratings	A(CE)/Stable	Bonds
NBPDCL & SBPDCL	Not available			
UPPCL	21-Jun-24	India Ratings	AA(CE)/Stable	NCD
NTPC	5-Apr-24	India Ratings	AAA/Stable	Long term loan
NHPC	1-Aug-24	India Ratings	AAA/Stable	Term Loans
SJVN	5-Sept-24	India Ratings	AA+/Stable	NCD
BESCOM	23-July-24	CARE	BBB -ve	Long term loans

Source: Credit Rating Agencies, CRISIL MI&A Consulting

2.6 Capacity addition outlook

India's installed generation capacity, which stood at 356 GW at the end of fiscal 2019 has reached 442 GW as of fiscal 2024 and ~451 GW in fiscal 2025 (as of August 2024) on the back of healthy renewable capacity additions (including solar, wind, hybrid, and other renewable sources) even as additions in coal and other fuels have declined. In fiscal 2024, renewables (excl. large hydro) accounted for ~33% of the installed capacity, up from ~22% in fiscal 2019, whereas coal-based capacity tapered to ~49% over the same period.

Capacity additions in the conventional power generation segment of about 32-35 GW are expected over fiscals 2025 to 2029 driven by higher than decadal average power demand. Fresh project announcements are limited as players are opting for the inorganic route for expansion given the availability of assets at reasonable valuations. In fact, 4.8 GW of stressed power assets awaiting debt resolution. However, the need for generation capacity equipped for flexible operations to ramp up-down quickly is critical to meet peak demand as generation from renewable capacities is infirm in nature. CRISIL MI&A-Consulting expects 25-27 GW of coal-based power to be commissioned over fiscals 2025-29. Coal capacity additions are expected to be driven entirely by central and state sectors, as major private gencos continue to focus on adding RE capacity.

Nuclear power capacity additions of 5-6 GW are expected during the period as ongoing projects at Kakrapara, Kalpakkam, and Rajasthan is nearing completion. As of January 2024, Unit 1 of KAPP has been commissioned with Unit 2 expected by end of fiscal 2024.

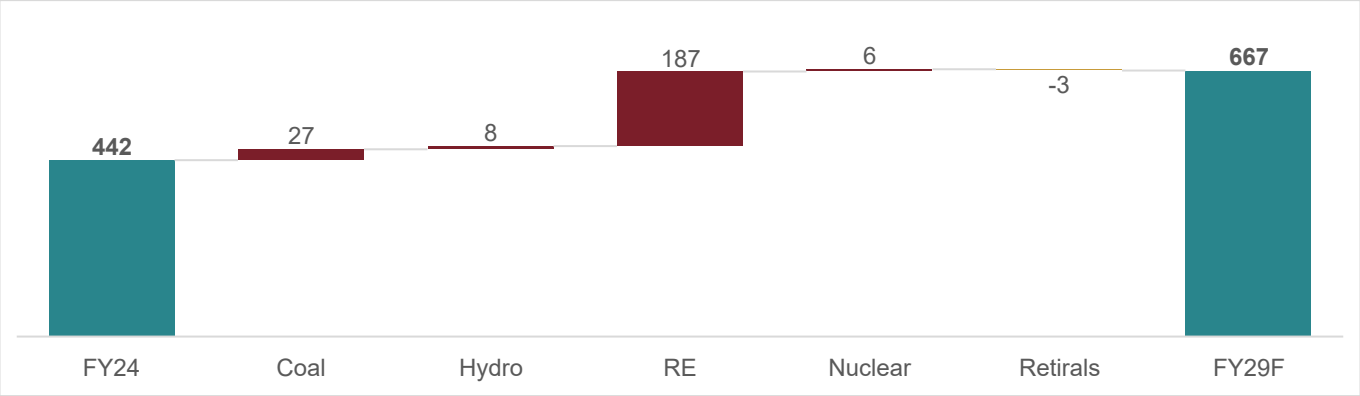
CRISIL MI&A-Consulting expects 15-16 GW of hydro power installations including 6.5-7.5 GW pumped hydro storage projects (PSP) capacity additions over fiscals 2024-2029.

Old and inefficient coal plants to the tune of 14-15 GW (mainly state-owned) were to be retired. However, as per CEA notification issued on January 20, 2023, power utilities have been advised to not retire any thermal units until 2030 and carry out renovation and maintenance (R&M) for life extension and improve the flexibility and reliability of thermal units.

By fiscal 2029, RE capacity (excl. large hydro) of over 320 GW is expected, driven by 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 660-670 GW by fiscal 2029.

Battery energy storage system (BESS) capacity additions, aimed at storing renewable energy during off-peak hours of power demand to support peak supply, are expected to commission starting fiscal 2025, with 23-24 GW of BESS capacity likely to be added through fiscal 2029.

Figure 12: All India installed estimated capacity addition by fiscal 2029 (in GW)



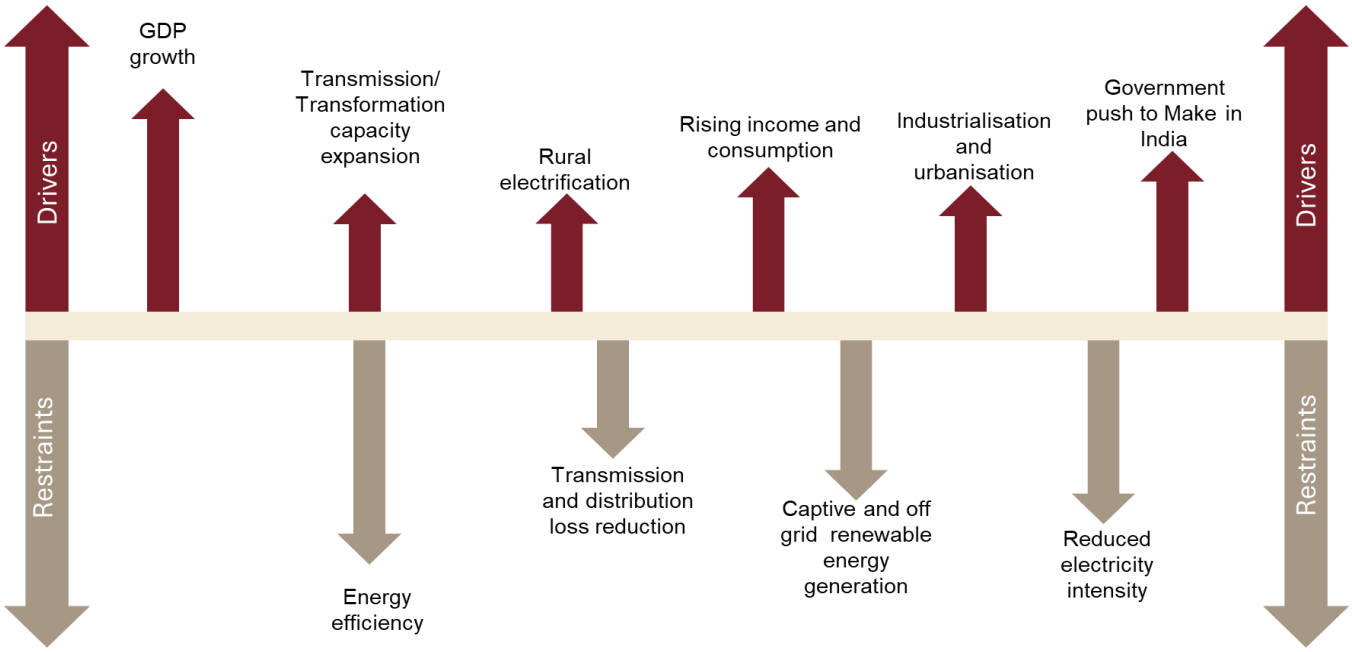
RE includes solar, wind, small hydro, and other renewable sources
Source: CEA, CRISIL MI&A-Consulting

2.7 Demand-supply scenario

2.7.1 Demand drivers and constraints

Power demand is closely associated with a country's GDP. Healthy economic growth leads to growth in power demand. India is already the fastest-growing economy in the world, with average GDP growth of 5.5% over the past decade. The trickle-down effect of government spending on infrastructure through the National Infrastructure Pipeline, expansion of the services industry, rapid urbanisation, and increased farm income from agriculture-related reforms are key macroeconomic factors that are expected to foster power demand. Significant policy initiatives such as 24x7 power for all, Sahaj Bijli Har Ghar Yojana (SAUBHAGYA) scheme to provide electricity connections to all households, green energy corridor to facilitate evacuation of RE power, green city scheme to promote the development of sustainable and eco-friendly cities, PLI scheme and low corporate tax rates among others are expected to further support power demand in the country.

Figure 13: Factors influencing power demand



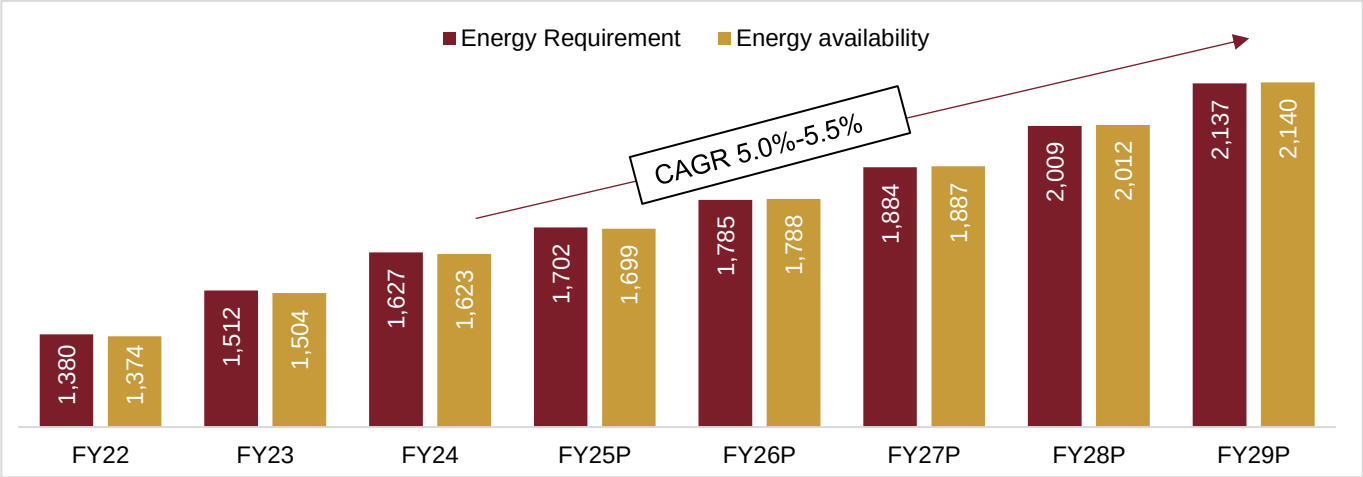
Source: CRISIL MI&A-Consulting

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, higher demand from key infrastructure and manufacturing sectors. 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.

2.7.2 Power demand-supply forecast

Power demand maintained a strong growth momentum in fiscal 2023 logging a double-digit growth of ~10% albeit a moderate base of fiscal 2022 due to extreme seasonal vagaries, sustained buoyancy in economic activities along with robust industries activities accelerated power demand. GDP is expected to grow at 7.3% in fiscal 2024 supporting power demand despite a higher base of 7.2% in fiscal 2023. Despite the high base of preceding three years, CRISIL MI&A-Consulting expects power demand to grow by 5.5-6.0% 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, 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 14: Energy demand outlook (fiscals 2022-29) in BUs

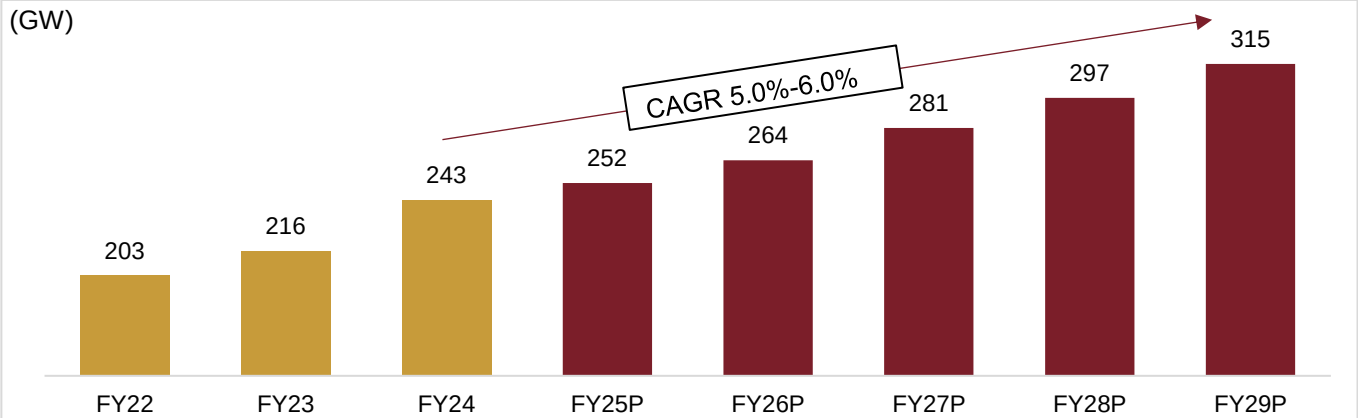


P: Projected, Source: CEA, CRISIL MI&A-Consulting

Peak electricity demand in India has grown from 184 GW in fiscal 2020 to 243 GW in fiscal 2024 clocking an average growth rate of 7.3% in the past five years.

Peak demand is expected to grow at annual average 5-6% over fiscal 2024-29 to reach nearly 315 GW by fiscal 2029 with expected persistent high temperatures, rising urbanization, economic growth and infrastructure push leading to higher power consumption.

Figure 15: Peak demand to increase by 95-100 GW between fiscals 2023 and 2029 to cross 300 GW



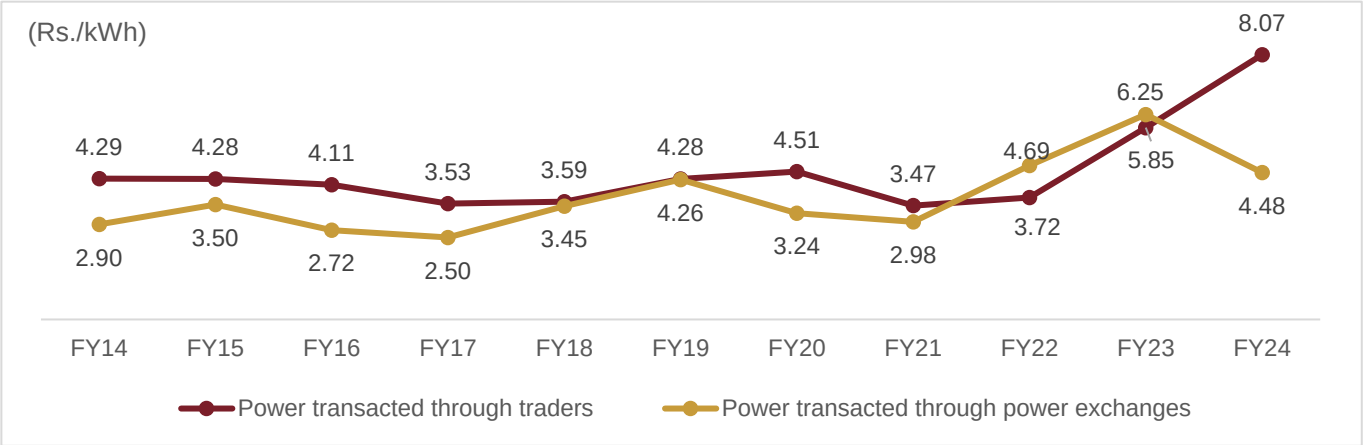
P: Projected, Source: CEA, CRISIL MI&A-Consulting

2.8 Short term market

2.8.1 Trading prices

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 factors such as rise in demand after economy opened (post COVID-19 lock downs), precarious coal stock position at various plants, reduced RE generation (especially during August and September 2021) coupled with increasing coal prices.

Figure 16: Weighted average tariff of short-term transactions



Note: Annual Report for FY 2023-24 not yet available with CERC, hence the prices for FY24 have been estimated by consolidated based on monthly reports published by CERC
Source: CERC, CRISIL MI&A-Consulting

Peak demand in Indian power system reaches during pre and post monsoon as cooling load picks up with rising temperatures. IMD has indicated that during 2024 hot weather season (April to June), above-normal maximum temperatures are likely over most parts of the country. As a result of heat wave and increase in ambient temperature, there is increase in peak demand, higher demand for relatively longer duration, increased energy consumption, and higher electricity market prices due to increased demand. The weighted average price of electricity transacted through power exchanges during fiscal 2023 was on higher side at Rs. 6.25/kWh as against Rs. 4.69/kWh in fiscal 2022. Rise in temperatures, increased demand and soaring imported coal prices lead to an increase in short term prices in fiscal 2023. Short term prices have recovered to some extent in fiscal 2024 due to correction of the elevated imported coal prices. Considering the historical trend as well as increased instances of heat wave, the weighted average short-term electricity prices are expected to be in the range of Rs. 4.0 to 4.50/kWh on medium term basis (fiscal 2025 and 2026). Such higher short term electricity prices provide an opportunity for power generator mitigating the offtake risks specially for firm and dispatchable renewable energy (FDRE) projects wherein sale of excess of contracted capacity is allowed in exchanges on daily basis. Higher power exchange tariffs would also help the developers to get better returns.

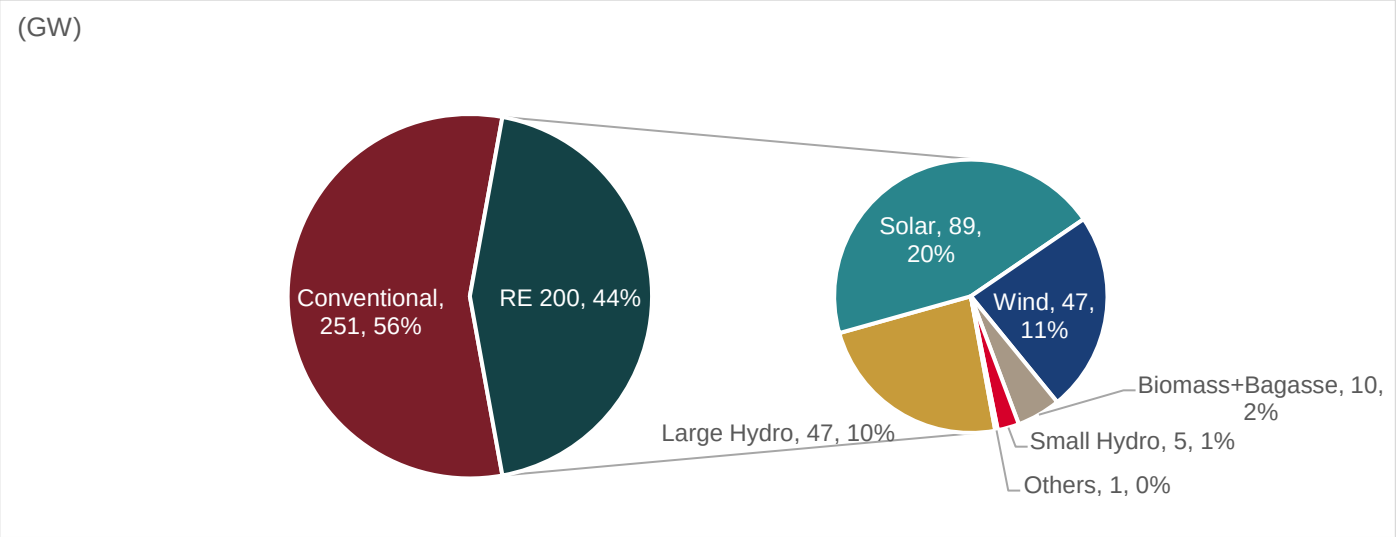
3 Renewable Energy Sector

3.1 Overview of renewable energy sector

Renewable sources are a clean source of energy as they do not burn like fossil fuels, preventing the release of pollutants into the air. Increasing use of RE would help avoid carbon emissions, and thereby, restrict global warming. Further, the wide availability of these resources makes them less susceptible to depletion unlike conventional sources of energy. While there are multiple renewable sources that can be utilised, including solar, wind, small hydro, biomass, and bagasse remain key sources.

Renewable energy installations (incl. large hydro) have increased fivefold to ~200 GW as of August 2024, as compared with ~63 GW as of March 2012 (*source: MNRE*), led by various central and state-level incentives. As of March-2024, installed grid connected RE generation capacity (incl. large hydro) in India constituted ~44% of the total installed generation base in India. This growth has been led by solar power, which has grown to ~89 GW from merely ~0.09 GW over the discussed time period (i.e. from March 2012).

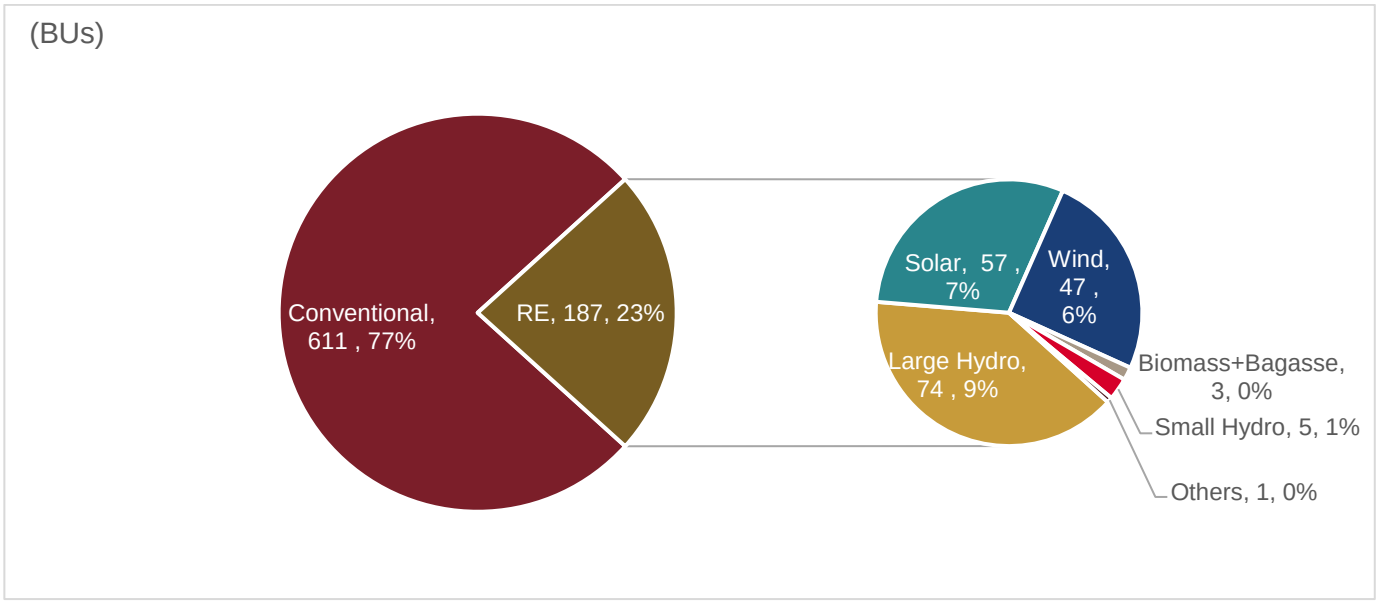
Figure 17: India's RE (incl. large hydro) capacity was ~44% at the end of August-2024



Conventional: Coal, Gas, Lignite, and Nuclear; Large Hydro (including pumped hydro storage)
Source: MNRE; CEA, CRISIL MI&A-Consulting

However, owing to lower capacity utilisation factors, the RE penetration (incl. large hydro) in terms of energy generation was at ~187 BUs in fiscal 2025, as of August 2024.

Figure 18: India's RE (incl. large hydro) penetration was about 23% between Apr-2024 to August-2024



Generation from Apr-2024 to Aug -2024
Conventional: Coal, Gas, Lignite and Nuclear
Source: MNRE; CEA, CRISIL MI&A-Consulting

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.

Further, under the Paris Agreement, the Indian government has committed to generating 40% of electricity from non-fossil fuels sources by 2030. The country also has a target of setting up 450 GW of RE by 2030 and providing 17 lakh 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 Oct-Nov 2021 and a draft agreement was circulated with respect to climate change action. The proposal aims at updating the time frame 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.

Various incentives available for renewable energy sector in India

- **Central Public Sector Undertaking** (CPSU) Scheme Phase-II (Government Producer Scheme) for setting up 12 GW grid-connected Solar Photovoltaic (PV) Power Projects by Government Producers, using domestically manufactured solar PV cells and modules, with Viability Gap Funding (VGF) support, for self-use or use by Government/ Government entities, either directly or through Distribution Companies (DISCOMS). Viability Gap Funding (VGF) support is provided up to Rs 5.5 Mn/MW to the CPSUs/Govt. Organizations entities selected through competitive bidding process.

- **Production Linked Incentive scheme** 'National Programme on High Efficiency Solar PV Modules' for achieving manufacturing capacity of Giga Watt (GW) scale in High Efficiency Solar PV modules (Tranche- I & II). 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.
- **Rooftop Solar Programme Phase II** for grid connected solar rooftop power plants. Under this Programme, subsidy is provided for residential sector and performance linked incentives to DISCOMs for achieving capacity addition in rooftop solar above baseline.
- Subsidies under Grid Connected Rooftop Solar PV Power Projects **PM Surya Scheme:**
    - Rs. 30,000/- per kW up to 2 kW
    - Rs. 18,000/- per kW for additional capacity up to 3 kW
    - Total Subsidy for systems larger than 3 kW capped at Rs 78,000
- **Green Energy Corridors (GEC):** to create intra-state transmission system for renewable energy projects. Central Financial Assistance (CFA) is provided to set up transmission infrastructure for evacuation of Power from Renewable Energy projects in total ten States (considering both the phases of GEC).
    - GEC Phase-I: CFA of 40 % of DPR cost or awarded cost whichever is lower.
    - GEC Phase-II: CFA of 33 % of DPR cost or awarded cost whichever is lower.
- **National Green Hydrogen Mission** launched with an outlay of Rs. 197.44 billion with aim to make India a Global Hub for production, utilization and export of Green Hydrogen and its derivatives.
- **Viability gap funding** for 4,000 MWh battery energy storage systems and formulation of a detailed framework for pump storage projects.

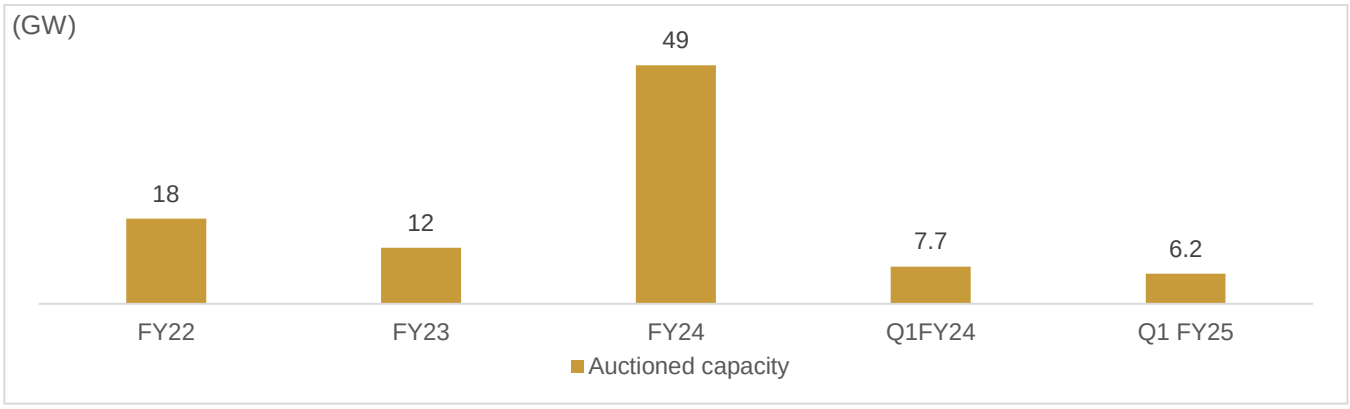
3.1.1 Tendering activity in renewable energy

In the last three fiscals, India issued over 150 GW of utility scale renewable energy tenders across all technologies including ESS. However, the auction has been about half of the tendering capacity over the same period whereas the allocation has been at around 44% of the tendering capacity and 86% of auctioned capacity. The tendering activity increased about three-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). However, there was a shortfall of about 6 GW in the cumulative target set for these REIAs due to non-issuance of wind tenders. The tender issuance in Q1 of fiscal 2024 was a bit slow but it picked up in the subsequent quarters to surpass the overall target of 50 GW due to participation from other state nodal agencies and state discoms. Apart from this, over 20 GW of standalone ESS tenders were also issued including pumped hydro storage. The average allocation of tenders has been above 85% of the auctioned capacity in the last three years.

During the first five months of fiscal 2025, the total auctioned capacity has been 12 GW, of which 6.2 GW was auctioned in Q1 of fiscal 2025.

Figure 19: Auctioned capacity of utility scale RE projects



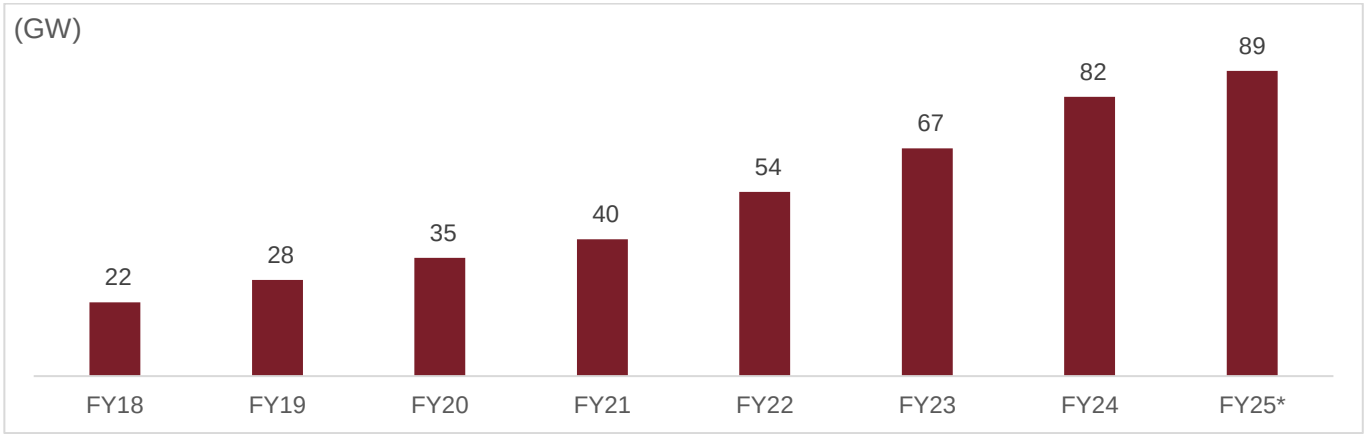
Source: Industry, REIAs, CRISIL MI&A Consulting

From fiscal 2017 to fiscal 2021, more than 110 GW of utility-scale project development renewable energy tenders were issued.

3.2 Solar sector

In the renewable energy basket (including large hydro) as of August 2024, solar energy accounted for a share of ~44%. Growth in the solar power sector over the last five years has been robust. As much as ~70 GW capacity was added in the segment over fiscals 2018-24, registering a CAGR of ~24.8%, although on a low base. Despite the second wave of COVID-19 infections, fiscal 2022 witnessed solar capacity additions of ~14 GW. In a relief to developers, the MNRE provided total extension of seven-and-a-half months for the projects affected by the first and second waves of pandemic. This is estimated to have 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. The first five months of fiscal 2025 saw a capacity addition of ~7.6 GW.

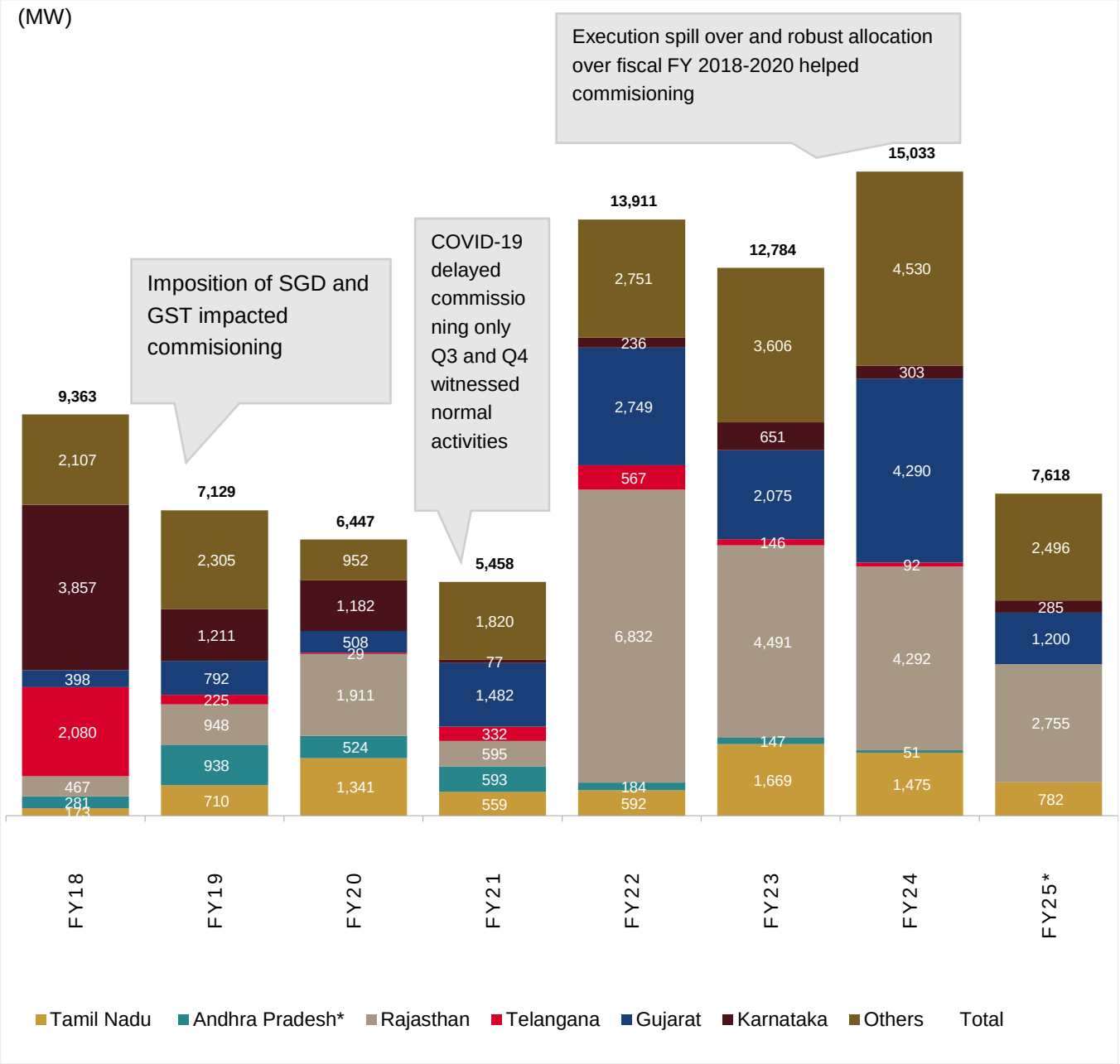
Figure 20: Trend in solar capacity installation in India



**As of August 2024, Source: MNRE, CEA, CRISIL MI&A-Consulting*

During fiscals 2018-2024, ~70 GW of solar capacity has been commissioned. Despite the second pandemic wave, ~14 GW of solar capacity was added in fiscal 2022. The momentum continued in fiscal 2023 and 2024, with robust solar capacity additions of ~13 GW and ~15 GW respectively. The first five months of fiscal 2025 saw a capacity addition of ~7.6 GW.

Figure 21: States that helped drive solar capacity addition in India

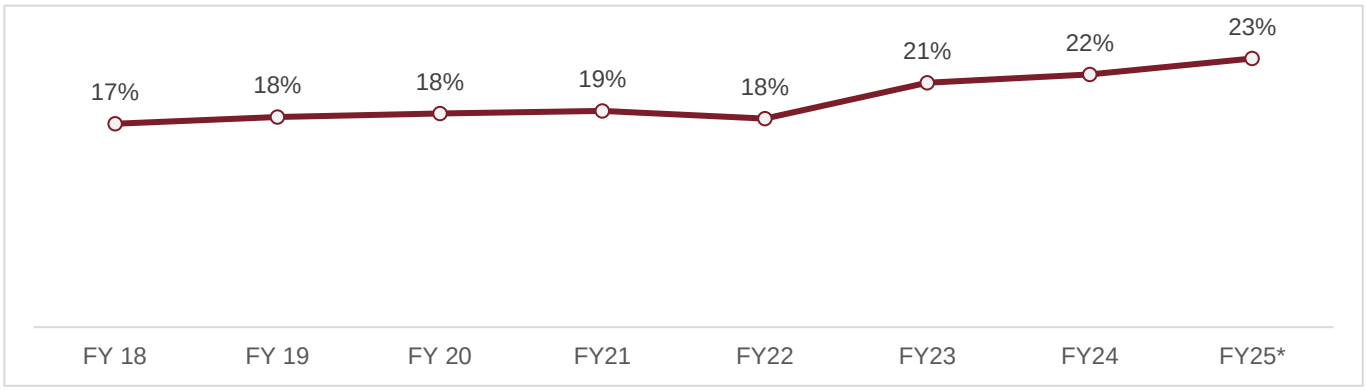


**FY25 as on August 2024, Source: MNRE, CRISIL MI&A-Consulting*

Commissioning activity has been concentrated in the key states of Rajasthan, Gujarat, and Tamil Nadu, which accounted for two-third of total capacity added in fiscal 2023. In the previous fiscal as well, the installation trend was driven by the same states.

Over the past five years, the average annual CUFs of solar capacities have seen improvements, mainly driven by technological advancements, DC over-loading, improvement in inverter efficiencies for solar, better tracking and weather forecasting technologies as well as improvement in O&M practices to reduce downtime.

Figure 22: PLF Trends for Solar power projects



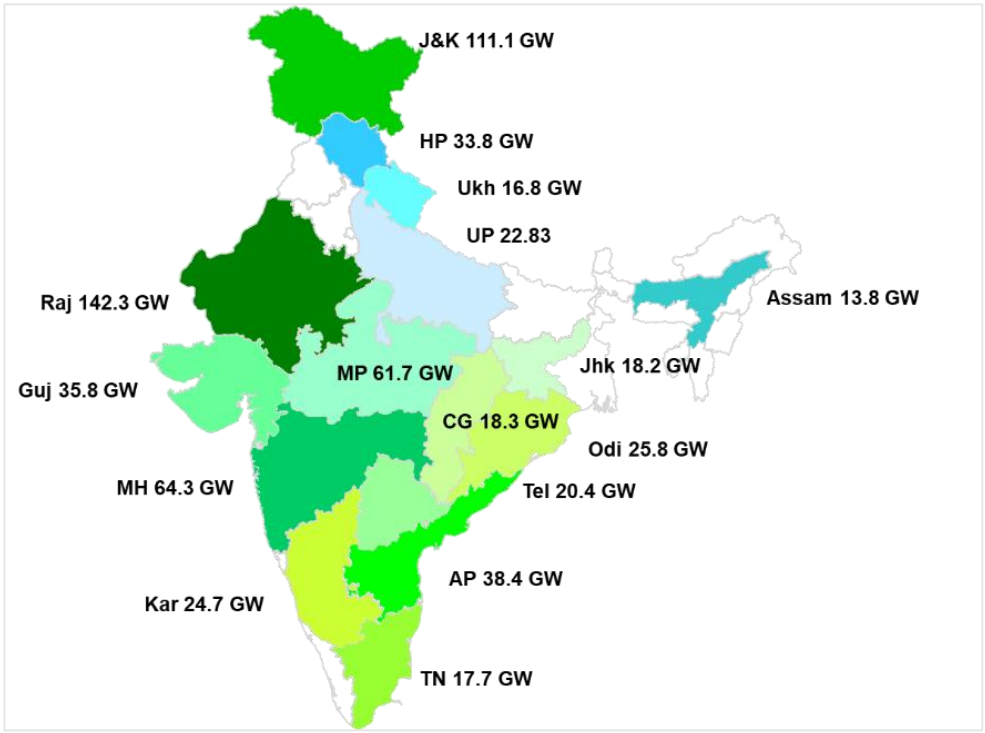
**FY25 data as on July 2024; Source: CEA; CRISIL Analysis*

The National Institute of Solar Energy estimated the country's solar potential at 748 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, Tamil Nadu offers more solar irradiance as compared to other parts of India which makes them desirable for installing solar projects.

Further, during the summer months India experiences southwest monsoon winds and northeast monsoons during the winters. The Indian summer monsoon typically lasts from June-September in large areas of western and central India, whereas certain regions in South India gets rain during winter months due to northeast monsoon. Consequently, the solar projects located in Southern part of India may get affected during October-December. Additionally, unseasonal rainfall also impacts solar generation adversely.

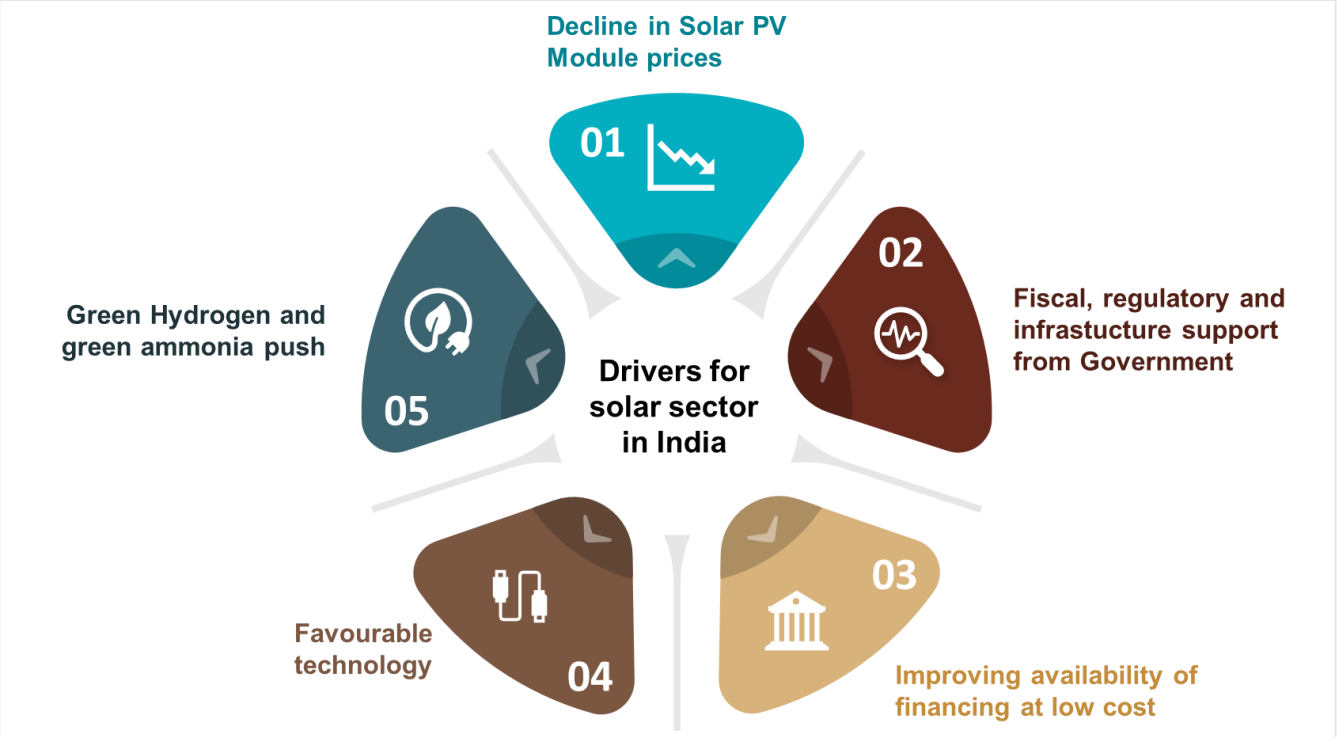
Figure 23: State wise solar potential



Others: ~83 GW; Source: NISE: MNRE, CRISIL MI&A Consulting

3.2.1 Growth drivers for Solar sector in India

Figure 24: Growth drivers for solar sector in India



Source: CRISIL MI&A-Consulting

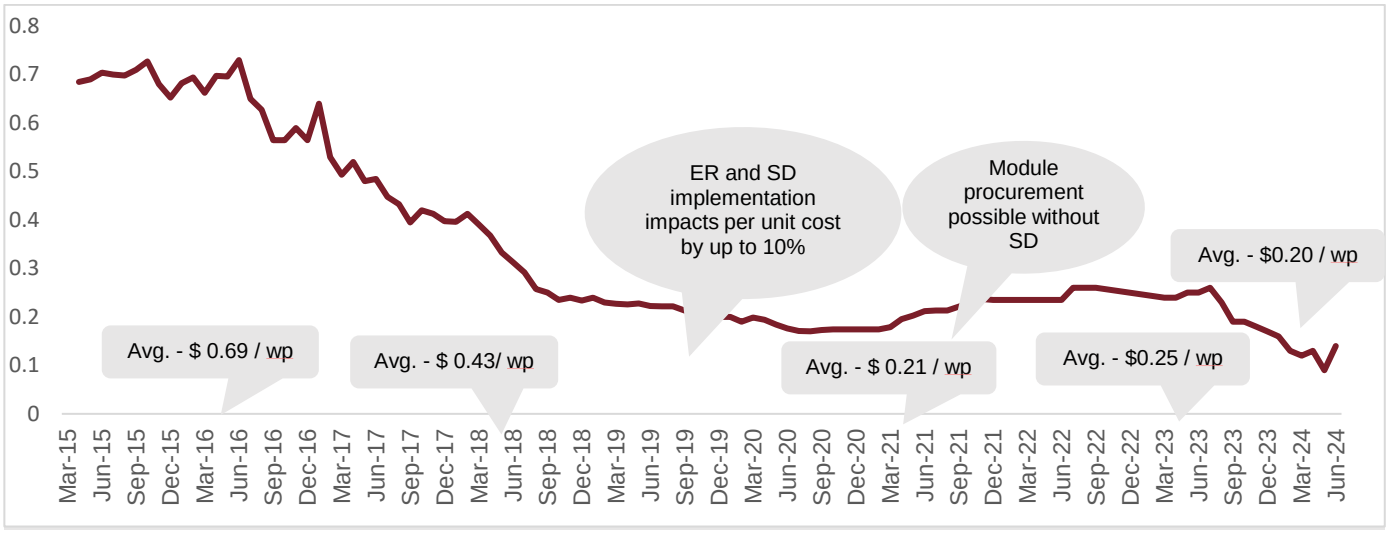
Each growth driver for solar energy in India is detailed below:

3.2.1.1 Declining module prices and tariffs

The global average solar module price, which constitutes 55-60% of the total system cost, crashed 73% to $0.47 per watt-peak in 2016 (average for January-December) from $1.78 per watt-peak in 2010. In fact, prices continued to decline to $0.22 per watt-peak by end-August 2019, owing to technology 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 $0.2 per watt-peak by March 2020 (which has now been reduced to $0.016-0.018 per Wp), reduced system costs. Module prices reached $0.22 per watt-peak level in fiscal 2021.

Module prices started to fall in 2023 owing to the ramp-up in the production of upstream components. Prices of modules fell to $0.15-0.20 per watt-peak in April-November 2023 from $0.23 per watt-peak in January 2023. This has eased some pressure on capital costs in fiscal 2024. Global solar module prices have reached a historic low, standing at just $0.09 per watt-peak in June 2024, which is expected to stimulate growth in solar power capacity. Prices are expected to remain stable over the medium term due to supply glut and relatively weak demand internationally. In line with this trend domestic prices too fell to $ 0.14 per watt-peak maintaining a steady premium over landed cost of imported modules.

Figure 25: Module prices declined over 200% from fiscal 2015 to 2024 (USD/Wp)



Source: Industry, CRISIL MI&A-Consulting

Table 4: Safeguard and customs duty trajectory

Year of imposition	July 30, 2018, to July 29, 2019	July 30, 2019, to January 29, 2020	January 30, 2020, to July 29, 2020	July 30, 2020, to January 29, 2021	January 30, 2021, to July 29, 2021	From April 1, 2022 (BCD)
Duty rate	25%	20%	15%	14.9%	14.5%	Module – 40% Cell – 25%

Source: CRISIL MI&A-Consulting

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 further to applications invited from domestic companies for the same, DGTR extended the imposition of the safeguard duty for another year, with the duty being levied at 14.9% from July 30, 2020, to January 29, 2021, followed by 14.5% from January 30, 2021, to July 29, 2021. Declining duty had led to easing cost pressures, and tariffs had also started lowering. The Ministry of Finance imposed BCD of 25% and 40% on solar cells and modules, respectively, effective April 1, 2022. The imposition of BCD led to an increase in capital costs for projects based on imported modules by 20-25%, and an increase in tariffs by Rs 0.2-0.5/kWh (with the tariffs ranging from Rs 2.6-2.8/kWh).

3.2.1.2 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 Rs. 75,000 crore and aims to light up 1 crore households by providing up to 300 units of free electricity every month.

Subsidy for residential households

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

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

There was a similar scheme in place for encouraging solar rooftop installations. However, due to lack of awareness and clarity on savings, higher capital cost, delay in subsidy reimbursements, approvals and bureaucracy, subsidized tariff for lower slabs of electricity consumption, the scheme did not see the success as expected. Lower residential tariffs and higher investments may hinder the progress of the scheme. Further, Central Public Sector Undertakings (CPSUs) have been entrusted the residential solar installation under the scheme. The Central government introduced the CPSU scheme Phase I in 2015 to promote the set-up of 1,000 MW grid-connected solar PV power projects by CPSUs and government organisations with Viability Gap Funding (VGF). Further, the Central Government in March 2019, approved implementation of CPSU Scheme Phase-II for setting up grid-connected Solar PV Power Projects by Central and State PSUs, Government Organisations, with VGF support of Rs 8,580 crore, for self-use or use by Government/ Government entities, either directly or through Distribution Companies (DISCOMs). The maximum permissible VGF was initially two tranches and was kept at Rs 0.70 Cr/MW which was subsequently reduced to Rs 0.55 Cr/MW for third tranche. Under this Scheme, the Government has so far sanctioned about 8.2 GW capacity of solar PV power plants to various entities. Ability of CPSUs to execute the scheme at ground level and consumer awareness will play key roles in success of the Scheme.

Annual Bidding Trajectory:

MNRE has prescribed an annual bidding trajectory for RE power bids to be issued by 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 2023-24 to 2027-28. This is expected to help in achieving the targets specified for 2030. Bids of 35.51 GW have been issued by four REIAs (SECI, NTPC, NHPC & SJVN) in fiscal 2024 till December 2023.

The GoI has laid significant emphasis on climate change, for which it provided a framework, NAPCC, in 2008, where it proposed an eight-pronged strategy — NSM, energy efficiency, sustainable habitat, water planning, Himalayan ecosystem, afforestation, sustainable agriculture, and strategic knowledge on climate change. As can be seen, the GoI has laid significant emphasis on solar power. This is also evident from the 100 GW out of 175 GW target set out by the GoI. Government support to the solar sector in India is reflected by the following:

National Solar Mission

Central-level allocations under NVVN Batch II, JNNSM Phase II Batch III and IV have been almost entirely commissioned.

Operational support to execute solar projects

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

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

This is critical given the land-intensive nature (~5 acres required per MW of solar PV) of solar projects, coupled with low average holding (1.16 hectare) per person in India. Under the Solar Park Policy released in September 2014, the government planned to prepare land banks for 20,000 MW of solar projects across 25 states (including Andhra Pradesh, Madhya Pradesh, Gujarat, Rajasthan, Uttar Pradesh, Karnataka, Telangana, West Bengal, Chhattisgarh,

Tamil Nadu, Jammu and Kashmir, and a few north-eastern states). These states have started preparing land banks for solar parks, either through their own implementing agencies or through joint ventures with SECI.

The capacity of the scheme was doubled from 20,000 MW to 40,000 MW on March 2017, to set up at least 50 solar parks by fiscal 2022. Such parks significantly reduce construction/ execution risk as they include a contiguous parcel of land, evacuation infrastructure (HV/EHV substation evacuating to state grid substation), and other ancillary infrastructure and utilities such as road, water, and drainage.

As per the available information on CEA, 50 Nos. Solar Parks / UMREPPs of aggregate capacity of 39,785 MW have been envisaged for development in the country as of June 2024. Out of 39,785 MW, 22,489 MW is awarded (Of these, the capacity of 11,416 MW has already been commissioned while 11,073 MW capacity is under construction) and 17,296 MW is under award/tendering process.

Table 5: State wise solar park capacity (GW) as of June 2024

Sr. No.	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)
1	Andhra Pradesh	4,200	1,150	3,050	0	3,050
2	Chhattisgarh	100	0	100	0	100
3	Gujarat	12,150	2,770	9,380	8,405	975
4	Himachal Pradesh	53	53	0	0	0
5	Jharkhand	1,089	859	230	230	0
6	Karnataka	2,500	500	2,000	0	2,000
7	Kerala	155	50	105	5	100
8	Madhya Pradesh	4,780	2,172	2,608	958	1,650
9	Maharashtra	1,100	850	250	250	0
10	Mizoram	20	0	20	0	20
11	Odisha	340	300	40	40	0
12	Rajasthan	9,568	5,292	4,276	1,185	3,091
13	Uttar Pradesh	3,730	3,300	430	0	430
	Total	**39,785**	**17,296**	**22,489**	**11,073**	**11,416**

Source: CEA, MNRE, CRISIL MI&A-Consulting

Other Policy/Regulatory initiatives

- Implementation of Electricity (Promoting Renewable Energy Through Green Energy Open Access) Rules, 2022
- The MoP, in August 2020, waived the ISTS charges and losses on all solar and wind projects commissioned before June 30, 2023. In June 2021, the waiver was extended up to June 30, 2025. However, this time, only the ISTS charges were waived off, and losses remained applicable. Waivers are available for projects commissioned by June 30, 2025. Hoverer, post June 2025, an annual increase of 25% in the ISTS charges will be applicable for solar, wind, hydro PSP, and BESS sources, resulting in the applicability of 100% of ISTS charges from July 2028. Subsequently, in February 2023, it was clarified that green hydrogen and green ammonia projects would get a waiver of ISTS charges for 25 years if the projects are commissioned before June 30, 2025.
- The MoP further decided to extend the waiver of ISTS charges on the transmission of power from new hydro power projects, for which, construction work is awarded and PPAs are signed on or before June 30, 2025.

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

Although the potential of solar energy is high, there exist a few challenges, which are critical to achieving rapid growth of solar power.

Availability of contiguous parcels of land — With rapid capacity additions and stiff competition, it becomes imperative for developers to acquire land at competitive costs and in areas with high levels of solar irradiance. The 40 GW solar park scheme is facilitative in this aspect; however, beyond that capital costs and, hence, tariffs do fluctuate state to state depending on land prices and irradiance quality.

Adequacy of evacuation infrastructure — Grid integration of renewables is key to the growth of the sector. Instances of delay in readiness of transmission infrastructure at solar parks have caused concern amongst developers. However, an aggressive roadmap to add an incremental ~100 GW via new schemes and existing available capacity to the grid should be adequate for the expected additions. However, timely execution is critical.

Availability of low-cost capital — With the emergence of several large players in the sector, scale and experience have aided fundraising to an extent, especially with the backing of several foreign investors. However, a weak rupee, conservative risk appetite of lenders (especially for weaker counterparties and part merchant power capacities) and policy flip-flops make it imperative for developers to maintain prudent capital management to sustain over the long term. To mitigate this, developers have been tapping alternative/ new routes such as Infrastructure Trusts, Green bonds etc. to raise financing from time to time.

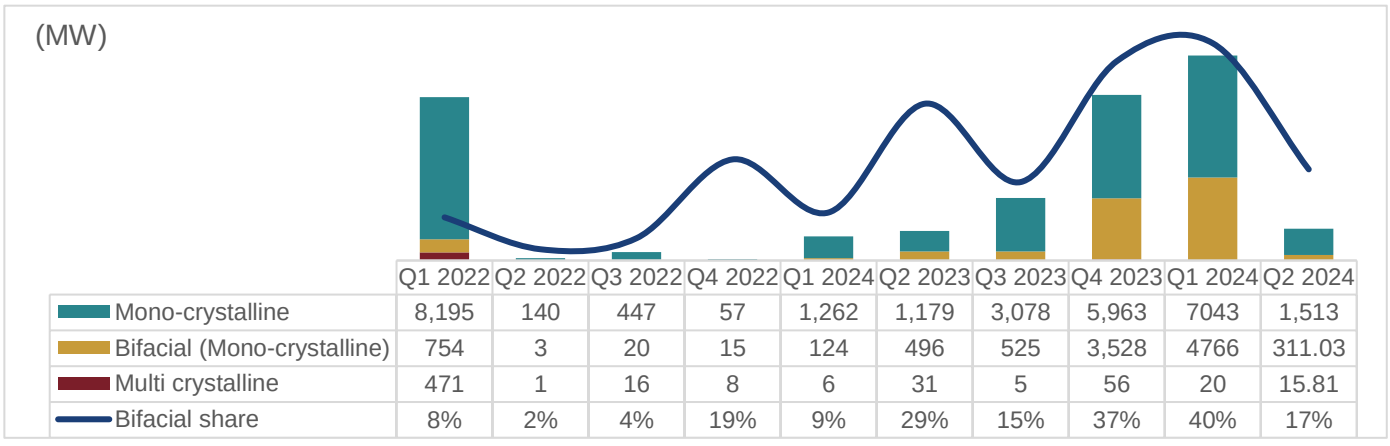
3.2.1.3 Favourable technology

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

On the project development front, developers are exhibiting heightened preference for bifacial modules that typically have higher efficiency relative to mono-facial modules and are compatible with tracker technology. In 2023, the share of bifacial variant 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 rate – share of import volume was negligible in 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 26: 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	7043	1,513
Bifacial (Mono-crystalline)	754	3	20	15	124	496	525	3,528	4766	311.03
Multi crystalline	471	1	16	8	6	31	5	56	20	15.81
Bifacial share	8%	2%	4%	19%	9%	29%	15%	37%	40%	17%

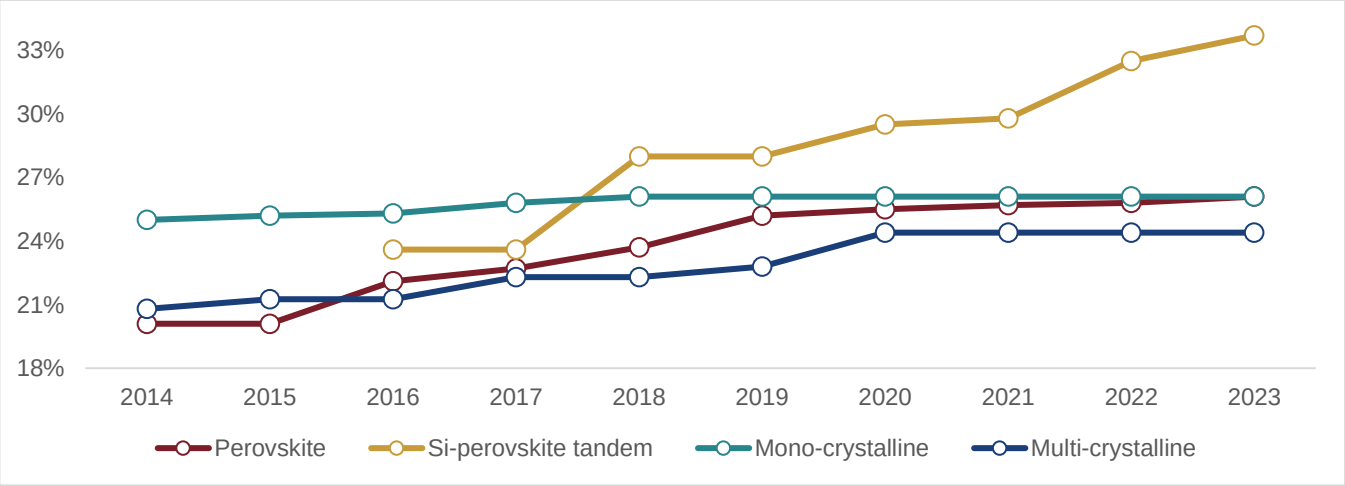
Source: Ministry of Commerce, Industry, CRISIL MI&A Consulting

Currently, the solar PV market is dominated by monocrystalline silicon technology. 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, cover less space, higher output in low light conditions and are available at competitive pricing. However, ongoing technology innovation in 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.

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 end of 2023, n-type technologies including TOPCon, heterojunction (HJT) and back contact represented 42% of China's total module manufacturing capacity (7% in 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 upto 2-2.5% gain over mono PERC modules. While TOPCon is expected to be the dominant n-type technology over next couple of years due to its lower cost over other new technologies, higher efficiency, and lower temperature sensitivity of HJT modules make it a better alternative to TOPCon modules in select locations. Additionally, China market share of HJT modules is expected to increase from an estimated 2% in 2023 to around 16% in 2027 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 27: Cell efficiency comparison

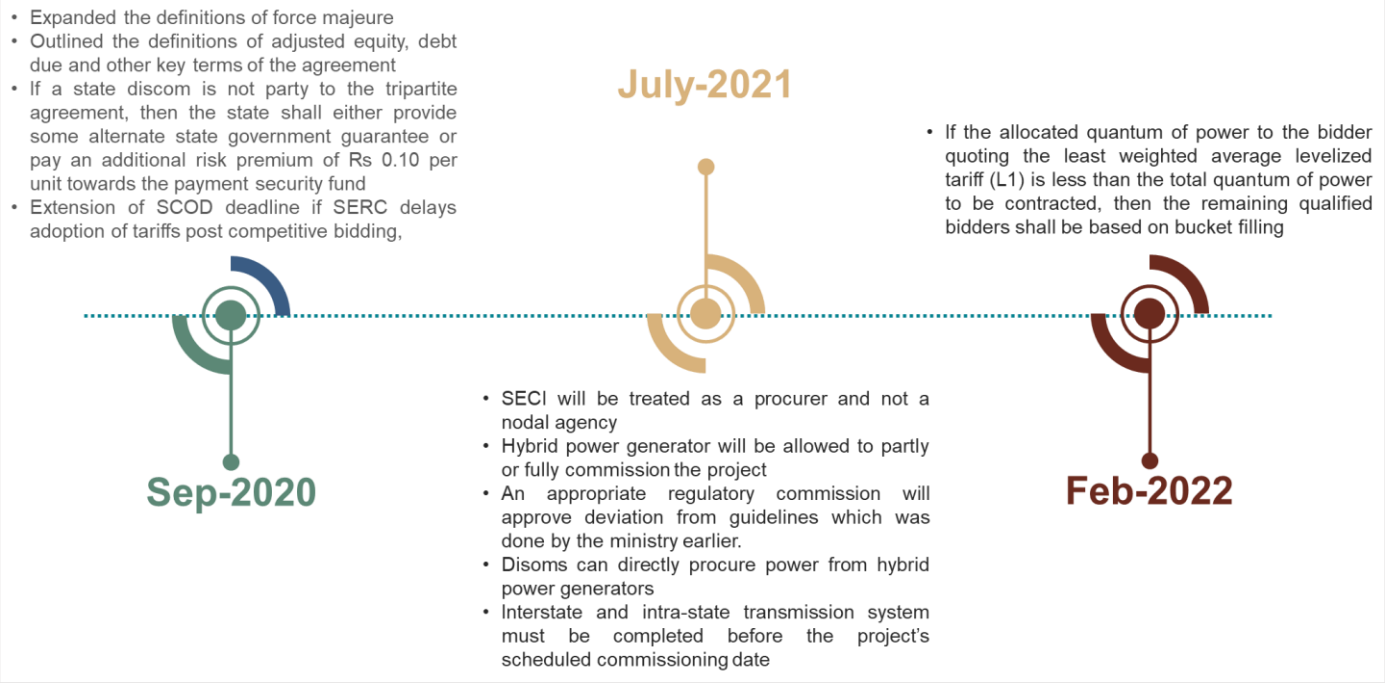


***Source**: NREL, CRISIL MI&A Consulting*

3.2.2 Review of competitive bidding

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

Figure 28: Positive changes to bidding guidelines undertaken to support bidder interest



Source: MNRE, CRISIL Consulting

Overall, the above amendments are a positive for the developers as these amendments 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, provide positive boost to the open access market 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.

Table 6: **Bid tariffs quoted over fiscal 2022 to August 2024**

Sr no	Bidding scheme/Tender	Month of bidding	Lowest tariffs discovered (Rs/unit)
1.	500 MW MSEDCL	Sep 2022	2.82
2.	750 MW GUVNL	Sep 2022	2.49
3.	750* MW RUMS	Sep 2022	3.03
4.	105# MW MSPGCL	Oct 2022	3.93
5.	300# MW RUMS	Nov 2022	3.89
6.	255* MW TPDDL	Dec 2022	3.00
7.	500 MW MSEDCL	Dec 2022	2.90
8.	250** MW MSEDCL	Dec 2022	9
9.	500 MW GUVNL	Jan 2023	2.51
10.	1250 MW RECPDCL	Apr 2023	2.55
11.	500 MW RECPDCL	Apr 2023	2.69
12.	1000 MW* RUMSL	Apr 2023	3.99
13.	200 MW* SECI	Apr 2023	4.64
14.	500 MW MSEDCL	Apr 2023	2.87
15.	500 MW GUVNL	Apr 2023	2.71

Sr no	Bidding scheme/Tender	Month of bidding	Lowest tariffs discovered (Rs/unit)
16.	600 MW GUVNL	May 2023	2.73
17.	1000 MW RUVNL	May 2023	2.61
18.	150 MW CESC*	May 2023	3.07
19.	40 MW AVVNL Rajasthan (KUSUM-C)	May 2023	3.33
20.	31 MW JVVNL Rajasthan (KUSUM-C)	May 2023	3.43
21.	27 MW JdVVNL Rajasthan (KUSUM-C)	May 2023	3.55
22.	800 MW GUVNL Tranche XX	July 2023	2.70
23.	200 MW SECI Tranche XI	July 2023	2.60
24.	200 MW PSPCL	Jull 2023	2.53
25.	300 MW RUMSL#	Aug 2023	3.79
26.	1,200 MW RUVNL (Storage hybrid peak power)	Aug 2023	6.68
27.	50 MW APDCL	Aug 2023	3.90
28.	70 MW APDCL	Aug 2023	3.92
29.	225 MW TPC-D Hybrid	Sep 2023	3.27
30.	18 MW PEDA	Sep 2023	2.63
31.	810 MW RUVNL	Oct 2023	2.64
32.	3,000 MW NHPC	Nov 2023	2.52
33.	1,500 MW Hybrid peak power	Nov 2023	4.38
34.	420 MW TANGEDCO (KUSUM A)	Nov 2023	3.28
35.	1000 MW SECI Tranche XII	Dec 2023	2.52
36.	500 MW GUVNL Tranche XXII	Dec 2023	2.63
37.	500 MW NTPC*	Dec 2023	3.35
38.	2000 MW SECI Tranche VII	Jan 2024	3.15
39.	500 MW# GUVNL, Hybrid Tranche I	Jan 2024	2.99
40.	600 MW GUVNL Tranche XXI	Jan 2024	2.54
41.	750 MW REMCL WSH with storage RTC	Jan 2024	4.25
42.	1500 MW SJVN	Feb 2024	2.52
43.	1500 MW* NHPC WSH Tranche I	Feb 2024	3.48
44.	1500 MW* SJVN WSH Tranche I	Feb 2024	3.49
45.	1500 MW* NHPC (Storage Firm power) Tranche I	Feb 2024	4.55
46.	1125 MW GUVNL Solar Tranche XXIII	Mar 2024	2.62
47.	1500 MW SECI Tranche XIII	Mar 2024	2.56
48.	1500 MW SECI Tranche XIV	Mar 2024	2,57
49.	1500 MW NTPC Tranche II	Mar 2024	2,59
50.	1500 MW, NTPC Pan India Solar Tranche III	May 2024	2.68
51.	500 MW, GUVNL Pan India Solar Tranche XXIV	Jun-2024	2.67
52.	1200 MW, SJVN Pan India Solar Tranche II	Aug-2024	2.52
53.	500 MW SECI Pan India Solar Tranche XVI	Aug-2024	2.48

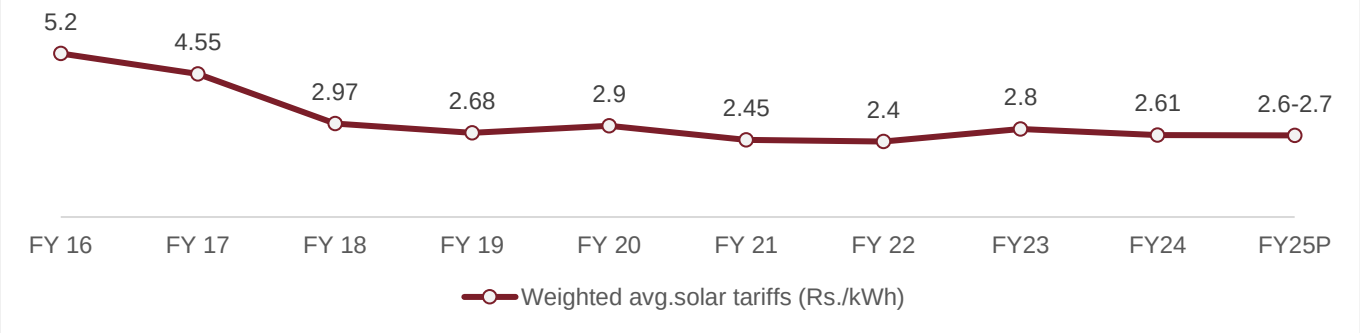
Sr no	Bidding scheme/Tender	Month of bidding	Lowest tariffs discovered (Rs/unit)
54.	1200 MW NHPC Pan India Solar	Sep 2024	2.56

*Note: *WSH capacity, **RTC- solar-wind-conventional-storage hybrid, #Floating solar*

Source: Industry, CRISIL MI&A-Consulting

After registering the lowest tariff of Rs. 1.99/kWh in December 2020, the solar tariffs have bounced back and witnessed 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 MI&A Consulting believes that tariff of Rs 2.5-2.6/kWh will be required for a 12-14% equity IRR owing to a sharp decline in module prices on year in fiscal 2025, despite rising BoS cost.

Figure 29: Tariffs to remain flat in fiscal 2025 owing to fall in upstream component prices



Note: The above tariffs are for ground mounted solar only; Source: Industry, CRISIL MI&A Consulting

3.2.3 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 resorting to issue tenders, which improve the quality of power supplied to off-takers. Some key changes were made to tender structures with respect to the generation profile available from RE plant and the ability to match demand requirements of the off-taker.

Three new tender structures have been issued so far to solve the above aspects – assured peak power supply (PPS), RTC, and the relatively newer FDRE. A key feature across these tenders is the increase in the quantum of generation, which was required to be supplied and the PPS tender for stipulating the power to be provided during peak hours. The PPS tender also mandated the use of storage, as that would be essential to supply power during peak hours. The government agencies have released FDRE tenders of over 14 GW in fiscal 2024 and Q1 of fiscal 2025 cumulatively.

Wind-Solar Hybrid Projects: In May 2018, the MoP issued the Wind-Solar Hybrid policy with an objective to provide a framework for promotion of large grid connected wind-solar PV hybrid system for optimal and efficient utilization of transmission infrastructure and land, reducing the variability in renewable power generation and achieving better grid stability. The Policy also aimed to encourage new technologies, methods and way-outs involving combined operation of wind and solar PV plants. Hybrid projects typically provide higher CUF than standalone solar or wind projects. This is due to the fact that the wind projects operate optimally during morning and night and thus complement solar projects which peak during daytime

As per the revised bidding guidelines, the rated power capacity of one resource (wind or solar) in such projects should be at least 33% of the total contracted capacity. The guidelines also allowed the setting up of the solar and wind projects at the same or different locations. To meet the energy obligations under the power purchase agreements, developers generally install higher renewable energy capacity than the contracted capacity under the Hybrid Scheme.

Firm and dispatchable renewable energy projects: In June 2023, the MoP issues guidelines for procurement of firm and dispatchable power from grid connected renewable energy projects with energy storage systems. The

guidelines explained the term 'firm and dispatchable power' as the power profile configuration that is defined in the request for selection that is sought to be met by RE power sources and will include configurations like assured peak power, Round-the-Clock RE with firm delivery of power at rated capacity at any hour of the day as per demand or load following power delivery as specified by DISCOM, RE projects with firm delivery of power for fixed hours of requirement by DISCOMs etc.

The guidelines also broadened the renewable energy to include solar power generating systems, wind power generating systems, wind solar hybrid; or any other renewable energy resource based generating system or a combination thereof, with energy storage system. Energy from solar and wind projects is intermittent and infirm in nature resulting in lower capacity utilization. However, FDRE addresses these challenges by providing following solutions.

- Firm power supply as per demand given by utilities; and
- Higher capacity utilization factor

Under FDRE, the project developer is required to supply RE power in a Firm and Dispatchable manner, matching the demand profile(s) provided by the Buying Entity. 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 the power purchase agreements developers generally install higher renewable energy capacity than the contracted capacity.

Modelling the above three tender structures with assumptions, coupled with industry interactions, we believe that the higher generation quantum mandated by these newer tenders could either be met using storage components or scaling up the plant capacity, i.e., setting up the plant of capacity larger than its rated capacity.

This has resulted in the expected tariff ranges required to maintain the equity IRRs of 12-14%, which are currently seen in regular tenders, to be higher than the norm of Rs 2.5-2.6 per unit, approaching the range of Rs 3-5 per unit. This increase will mainly be driven by higher capital and operating costs resulting from either the inclusion of a storage element or the need for higher capacity. Some moderation was observed only in the RTC tender, where the stipulated escalation in tariff will lead to higher tariffs.

Table 7: Higher tariff range at Rs.3-5 /kWh to maintain returns similar to regular trend

	Plain hybrid	FDRE	Round the clock	Peak power supply
Weighted average tariff	Rs 3.05/unit	Rs 4.59/unit	Rs 4.21/unit	Rs 4.70/unit
Capacity allocated till 1QFY25	15 GW	4.2 GW	1.7 GW	1.2 GW
Key player participation	Many developers	Acme, Juniper, Tata, ReNew, O2, Hero and 9 players	NTPC, Ayana, Shell, Torrent, O2, ReNew, Acme and Tata	Hero, ReNew, Acme and Amp

Note: Weighted average is calculated across all projects allocated under respective models till Q1FY25.
Source: CRISIL MI&A-Consulting

So far, all these tender models have seen successful allocations, with FDRE at 4168 MW and the RTC at 1710 MW driven by central entities. In the third type of tender, bundled, thermal energy can be sourced either from existing plants or from a new setup, each with its own set of challenges. While in existing plants, power may already be tied up, funding would be a key hurdle if power is sourced from a stranded asset or a new setup.

The lowest tariff discovered in the FDRE tender is Rs. 4.38/kWh which is lower than that of many thermal plants and in fact below the APPC of many of the state utilities. The bid tariffs in the FDRE tenders are impacted by the tender conditions such as high availability requirement, supplying power during specific hours of the day, demand fulfilment ratio, etc. Hence, tenders with different conditions and complexities result in different tariffs. However, most of the good resource locations are already taken up for project development and limited availability of good resource

locations may put upward pressure on tariffs. FDRE bids of total capacity of around 8.25 GW were auctioned in India during fiscal 2024. Acme, ReNew, Juniper, Avaada, Tata, Hero are some of the leading players in such FDRE tenders.

3.2.4 Outlook on Solar capacity additions in India

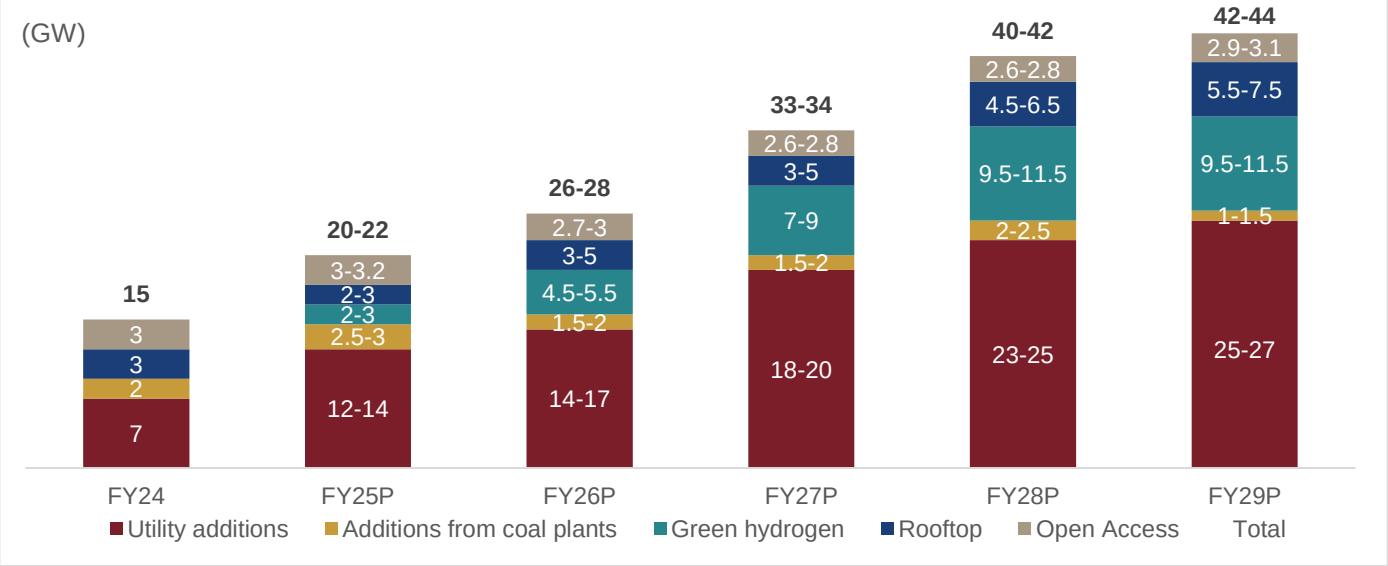
Solar sector growth in India primarily spurred by robust government backing, demonstrated through an aggressive tendering strategy. Some of the key catalysts include technological advancements, affordable financing, supportive policies, thrust on go-green initiatives/sustainability targets, cost optimisation due to increased grid electricity tariffs, subsidy initiative (specially in rooftop solar) and various incentives such as ISTS charge waiver.

CRISIL MI&A-Consulting expects 137-142 GW of solar capacity additions over fiscal 2025-2029. This will be driven by additions under:

- **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 more than 35 GW (including hybrid).
- **State solar policies**: ~24 GW of projects are under construction and are expected to be commissioned over the fiscal 2025-2029. 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.
- **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 ~2,120 MW of capacities, allocated ~5 GW, and tendered a further ~1 GW, under various schemes. 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 MI&A-Consulting expects 20-22 GW of rooftop solar projects (under the capex and opex mode) to be commissioned by fiscal 2029, led by PM Surya Ghar Yojana and industrial and commercial consumers under net/gross metering schemes of various states.
- **Open-access solar projects**: CRISIL MI&A-Consulting expects 13-15 GW of open-access solar projects (under the capex and opex mode) to be commissioned by fiscal 2029, 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.

  Data centers also emerging as an attractive infrastructure asset class in India. The Data Centers primarily focus on an omptimisation of grid energy and renewable energy due to the nature of energy requirements (continuous/uninterrupted supply) and about 40-50% of operating expenses come from electricity consumption. Due to rising demand for data, the energy requirement for data centers is expected to increase to ~1500-1700 MW in 2026 from an estimated 700-750 MW in 2023.
- **Push for Green hydrogen**: Production for green hydrogen is expected to start from fiscal 2026 with expected production of 0.5-1 million tonnes of production which will see solar capacities coming from fiscal 2024. As the government pushes towards the target production of 5 million tonnes of green hydrogen by 2030 more solar capacities are expected to commission totaling 34-38 GW by fiscal 2029 to cater to the demand of producing 2-2.5 million tonnes of green hydrogen. However, since developers may tie-up via grid / open access and not go to the captive route generation under this segment will remain a monitorable.

Figure 30:Year wise expected solar capacity addition



Source: CRISIL MI&A-Consulting

Also, the global conglomerate such as Amazon, Microsoft has set their sustainability goals and procuring 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.

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 increasing adoption of solar energy, CBAM is expected to contribute to overall growth of the market. The CBAM is expected to drive the renewable energy demand for energy intensive industries who export their products in European markets in order to follow their norms regarding carbon emission and avoid imposition of penalties for non-adherence to such rules & regulations.

CRISIL MI&A-Consulting'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.

3.2.5 Outlook on domestic Solar module manufacturing capacity additions

The nameplate module manufacturing capacity in India is expected to grow 50-55% in fiscal 2025 on year to reach 84-88 GW from 63 GW in fiscal 2024. The increased technological progressive module capacity (500 Wp and above) will provide comfort to the increasing average solar demand of 38-42 GW per annum till fiscal 2029. Further, capacity across the supply chain is expected to witness commissioning from fiscal 2025 to meet PLI scheme timelines. Nearly 18-22 GW of cells, 2-5 GW of wafers are also expected to become operational in fiscal 2025 reducing need for imports. Overall, the domestic manufacturing nameplate module capacity is expected to touch 125 GW by fiscal 2029, with 25% being backward integrated till the polysilicon stage. Increased domestic module manufacturing capacity is expected to provide a boost to capacity additions, comfort in module prices, decline in import reliance and ease in supply related challenges. However, utilisation of the installed capacities will be a key monitorable.

Project developers such as ReNew, Avaada, Adani Green, ACME, AMP Energy etc. have entered into solar module manufacturing business and announced various plans for capacity addition. Modules being the most expensive component, such backward integration is expected to provide better cost control to project developers and manage the supply chain related issues with an all-year-round module supply.

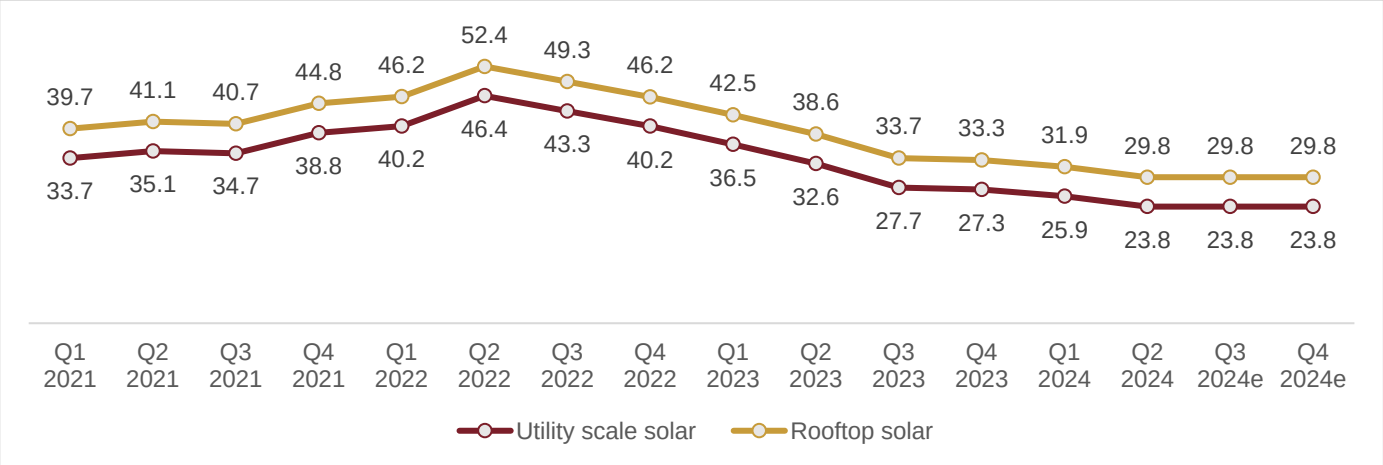
The price of domestic make modules is marginally lower in fiscal 2024 at $0.26 per watt-peak compared to $0.27 per watt-peak of international modules owing to steeper fall in cell prices. While the module prices are expected to fall 35-40% on year in fiscal 2025, the prices in Q4 of fiscal 2024 of $0.20 per watt-peak and $0.21 per watt-peak of international and domestic modules, respectively, are believed to have bottomed out with limited room for discount left at manufacturing ends. The industry is expected to take cognizance of the situation and limit additions to avoid further bloodbath of prices. Nearly 42 GW of global ingot and wafer and 40 GW of polysilicon plants to be commissioned in fiscal 2024 and 2025 have been postponed indefinitely. Further, ~20 GW of global cell manufacturing expected to commission in fiscal 2024-25 has been cancelled. Additionally, MNRE has reinstated the applicability of ALMM. As a result, only ALMM enlisted manufacturers can supply cells and modules to government and government-assisted projects. Projects under open access and rooftop solar by private parties are also brought into the ambit of ALMM. Therefore, the fall in prices across the value chain is expected to be arrested in fiscal 2025.

Global solar module prices have reached a historic low, standing at just $0.09 per watt-peak in June 2024, which is expected to stimulate growth in solar power capacity. Prices are expected to remain stable over the medium term due to supply glut and relatively weak demand internationally. In line with this trend domestic prices too fell to $ 0.14 per watt-peak maintaining a steady premium over landed cost of imported modules.

3.2.6 Project capex and O&M cost movements

Solar project CAPEX trend has largely followed global module price trends – between 2011 and 2021, EPC cost for utility-scale projects reduced by around 65% to Rs ~39 million/MWp due to falling module prices. While landed module cost increased temporarily in Q2 2022 due imposition of BCD on China modules, over H2 of 2022 and 2023, led by a massive supply glut in China, prices across the solar value chain declined sharply – China module prices decreased by around 57% in two-year period ended December 2023 to USD 0.12/Wp. As a result, EPC cost for utility-scale projects declined by around 33% in the two-year period ended December 2023 to Rs 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 low share in CAPEX.

Figure 31: EPC cost, Rs million/ MWp



Source: Industry, CRISIL MI&A Consulting
Note: EPC cost for utility scale projects is estimated using imported mono-crystalline modules in a fixed tilt layout and central inverters. EPC cost for rooftop solar systems is estimated for a typical industrial installation on a metal roof.

Global solar module prices have reached a historic low, standing at just $0.09 per watt-peak in June 2024, which is expected to stimulate growth in solar power capacity. Prices are expected to remain stable over the medium term due to supply glut and relatively weak demand internationally. In line with this trend domestic prices too fell to $ 0.14 per watt-peak maintaining a steady premium over landed cost of imported modules.

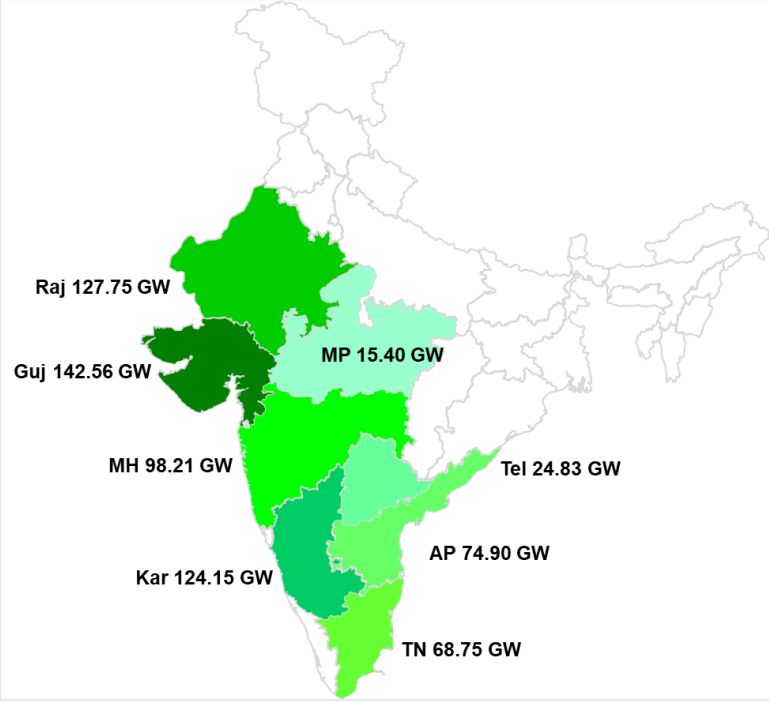
On the O&M front, costs have decreased by around 30% in the last 3-4 years to around Rs 0.18-0.25 Mn/MW/annum due to experience gained by service providers coupled with technology adoption including robotic cleaning. Robotic cleaning not only helps in achieving better efficiency but also are more environmentally friendly since they use less water and no chemical cleaners

3.3 Review of wind sector in India

3.3.1 Review of wind capacity additions in India

India has a vast wind energy potential, estimated at 695.5 GW at 120 meters above ground level (AGL) as per estimates by the National Institute of Wind Energy.

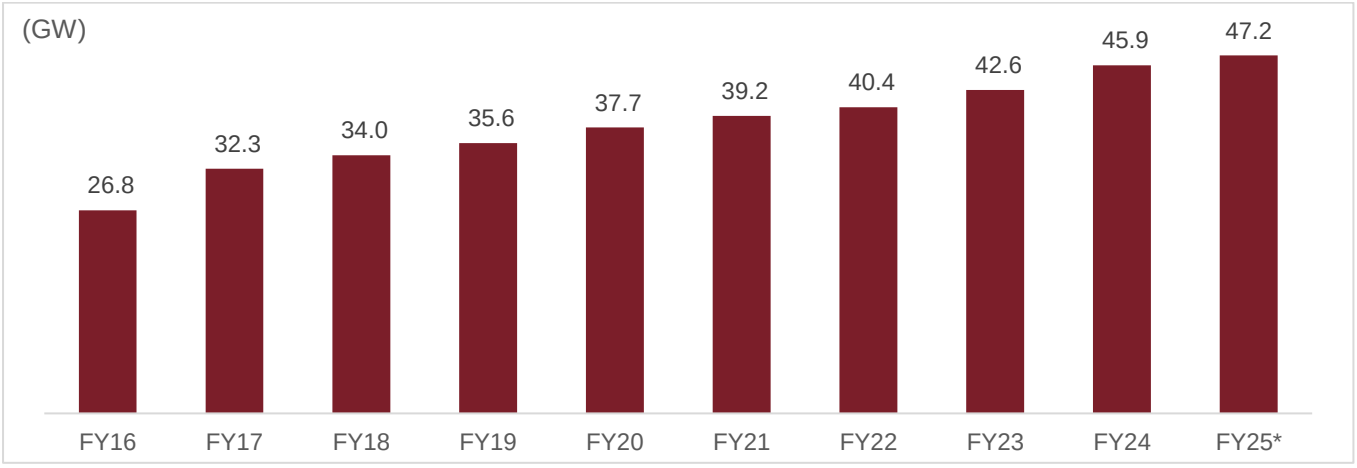
Figure 32: India-Wind Energy Potential



Note: Others 18.95 GW; Source: NIWE, MNRE, CRISIL MI&A Consulting

India has the fourth largest installed wind power capacity in the world, with ~47 GW as of 31st July 2024. Wind power accounted for nearly 10.5% 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 7-8 years, the installed wind power capacity in India has grown at ~7% (CAGR).

Figure 33: India-Wind power installed capacity.



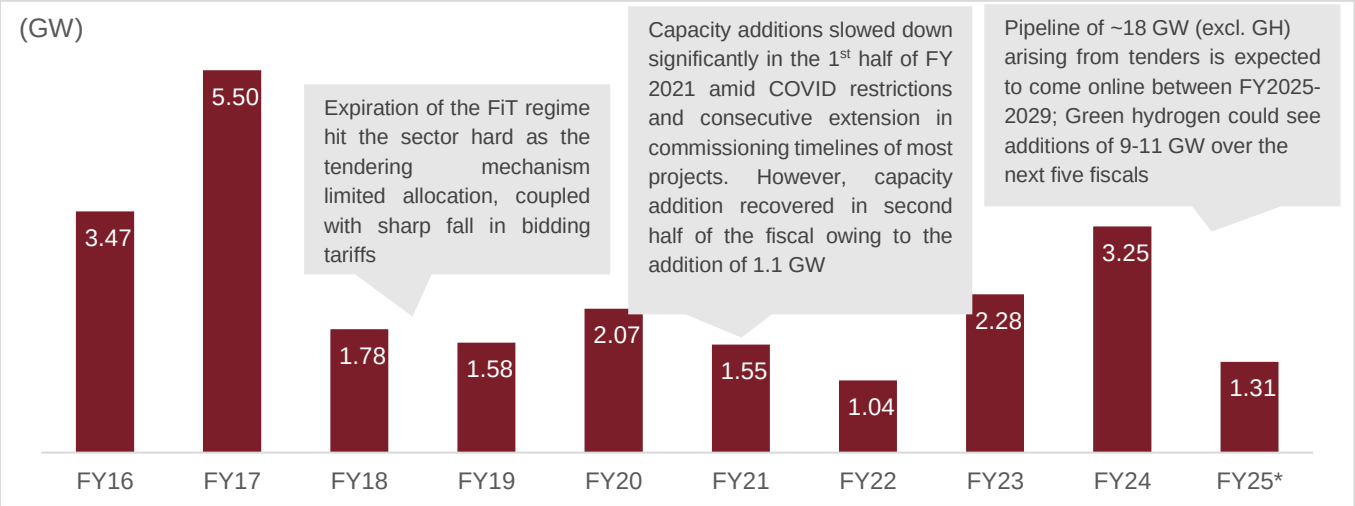
**FY25 as of August 2024; Source: MNRE, CEA, CRISIL MI&A-Consulting*

Fiscal 2024 has witnessed, healthy capacity addition of ~3.25 GW whereas fiscal 2025 witnessed a capacity addition of 1.31 GW in the first 5 months of the fiscal. In fiscal 2023, ~2.28 GW wind power capacity was installed on the back of commissioning under several schemes that have been pending - SECI Tranche IV, V and VI. The rising trend of hybrid power (solar plus wind) projects coupled with moderation and stabilisation in key commodity prices has also supported growth.

Capacity additions had declined ~33% y-o-y in fiscal 2022, primarily on account of a surge in commodity prices impacting project costs and viability. This was coupled with continued challenges in acquiring sites in key windy regions along with associated connectivity, causing further delays.

The capacity additions in fiscal 2020 following subdued fiscals 2019 and 2018 took place after a change in the FiT regime to factor in competitive bidding. The increase in fiscal 2020 was largely attributed to the commissioning of delayed projects under SECI Tranche I, II, and III, as well as state auctions in Tamil Nadu, Maharashtra, and Gujarat.

Figure 34: Annual wind capacity additions



GH: Green Hydrogen
Source: MNRE, CEA, CRISIL MI&A-Consulting

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

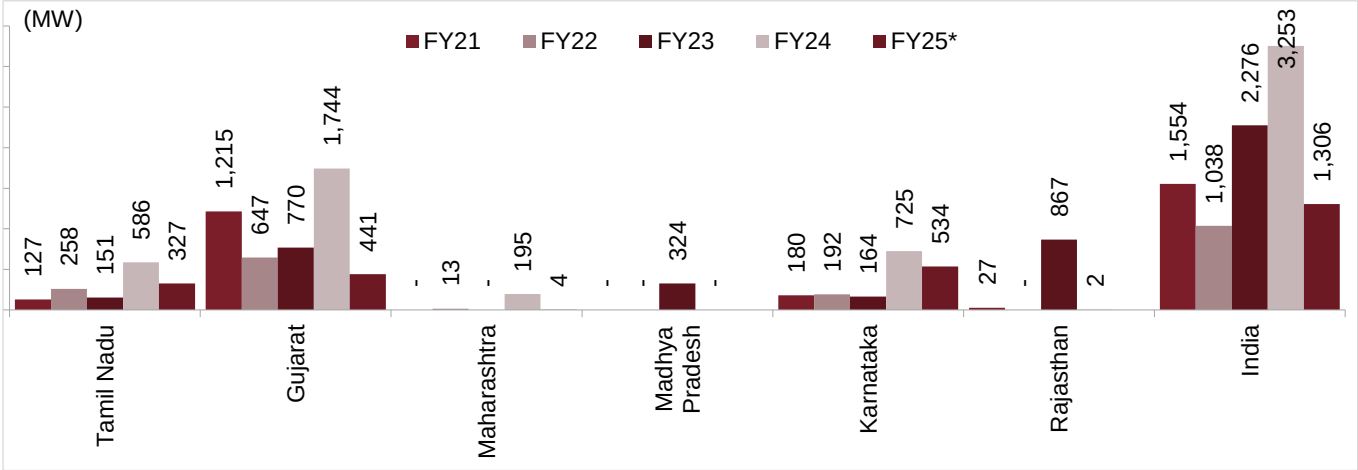
Wind power capacities have remained concentrated in certain states.

In the five months of fiscal 2025, Karnataka added 534 MW, Gujarat 441 MW and Tamil Nadu added 327 MW.

In fiscal 2024, Gujarat added 1,744 MW, Karnataka added 725 MW, Tamil Nadu added 586 MW, and Maharashtra added 195 MW of wind capacity.

In fiscal 2023, Rajasthan added the highest wind capacity of 867 MW, followed by Gujarat (770 MW), Madhya Pradesh (324 MW), and Karnataka (164 MW).

Figure 35: State-wise wind capacity additions (MW)



**FY 25 as of August 2024; Source: MNRE, CEA, CRISIL MI&A-Consulting*

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

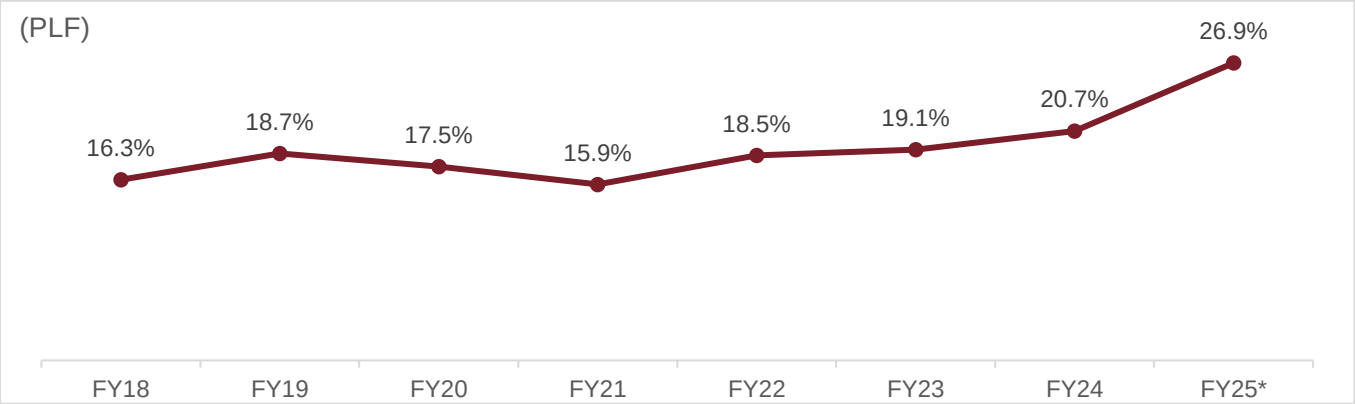
The top five states (Gujarat, Tamil Nadu, Karnataka, Rajasthan, Maharashtra) make up ~85% of the installed wind capacity (as of 31 August 2024), with some regions within these states accounting for most wind power projects. Since April 2021 (till Aug-2024), ~85% the new capacity additions have happened in 3 states – Gujarat, Tamil Nadu, and Karnataka.

Gujarat, with the highest installed wind capacity of 12,163 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 10,930 MW, most projects are located in districts of Tirunelveli, Nilgiris, Erode, Tuticorin, Coimbatore and Tiruppur. Likewise, for Karnataka (6,554 MW), Chitradurga, Bellary, Davengere and Tumkur, for Rajasthan (5,196 MW), Barmer and Jaisalmer; and for Andhra Pradesh (4,097 MW), Ananthapur, Nellore and Kurnool are the key regions where projects are concentrated.

PLF trends of operational projects

The Plant Load Factor (PLF) of operational wind projects in India has seen fluctuations over the past few years. PLF is a project/site specific variable, which primarily depends on available wind speed, turbine capacity (power curve) and hub height. Auxiliary consumption, transmission availability, curtailment, and down time due to O&M issues can impact the overall PLF of wind project. In India, the overall low PLF can be attributed to low-capacity wind turbines (25 GW, <2 MW turbine) in Class-1 wind sites, inadequate maintenance, low hub-heights of 80–100-meters as well as adverse changes in wind patterns.

Figure 36: PLF of wind projects in India over FY18-24



FY 25: As of 31 July, 2024, Source: MNRE, CEA, CRISIL MI&A-Consulting*

Review of competitive bidding

The weighted average discovered tariffs for allocated capacity of competitively bid projects for FY24 is Rs 3.4/kWh as against Rs. 3.1-3.3/kWh tariff required for earning 10-13% equity IRRs. The weighted average tariff of allocations in FY 2023, have averaged at Rs 3.0/kWh, providing an indication that developers are factoring in increased commodity costs and other execution related risks. The recent SECI auction held in July 2024 witnessed the highest tariff of Rs 3.70 per unit in Tranche-XVI, while the latest auction held by state agency was GUVNL Phase VI saw weighted average tariff of Rs. 3.43 per unit.

CRISIL MI&A-Consulting believes 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 instance, the SECI ISTS-III projects were previously not able to acquire required wind sites in the preferred region of Gujarat. Removal of the tariff cap in March 2020 provided an opportunity to developers to factor in the added execution challenges, leading to higher bid tariffs in successive auctions. Removal of e-reverse auction process also boosted bidder interest and activity in the wind sector. The move was to provide a mechanism to provide cost reflective tariffs for the segment, boosting viability for the segment.

The Ministry has indicated that it is willing to bring back reverse auction bidding for wind capacity allocation. Currently, wind capacity is auctioned based on single stage, two envelope closed bidding process. The bidding method is being reviewed in view of undersubscription and higher tariff discovery in recent wind bids. CRISIL MI&A-Consulting expects the tariff to remain nearer to Rs 3.4-3.6/kWh for sustainability of the projects.

Table 8: Tariffs discovered in competitive bidding in last 3-4 years

Sr No	Bidding scheme	Month of bidding	Winning tariffs discovered (Rs /unit)		Capacity (MW)		Sector
			Lowest	Highest	Tendered	Allotted	
1.	500 MW#, MSEDCL Pan India WSH	Jul 2021	2.62	2.62	500	500	State
2.	1200 MW# SECI Pan India WSH Tranche-IV	Aug 2021	2.34	2.35	1200	1200	Central
3.	1200 MW SECI Multiple States Tranche-XI	Sep 2021	2.69	2.70	1200	1200	Central
4.	2500 MW SECI Pan India Solar Wind Storage Hybrid RTC Tranche-II	Oct 2021	3.01	3.45	2500	2500	Central
5.	300 MW, MSEDCL Pan India	Oct 2021	3.43	3.44	300	300	State
6.	100 MW, KSEB Kerala	Apr 2022	3.96	4.09	100	35	State
7.	1200 MW# SECI Pan India WSH Tranche-V	May 2022	2.53	2.54	1200	1200	Central
8.	1200 MW SECI Multiple States Tranche-XII	May 2022	2.89	2.94	1200	1100	Central
9.	500 MW, GUVNL Wind Tranche III	Jul 2022	2.84	3.27	500	500	State
10.	750 MW#, RUMS MP WSH	Sep 2022	3.03	3.04	750	750	State
11.	255 MW#, TPDDL Pan India WSH	Dec 2022	3.00	3.00	355	255	State
12.	250 MW#, MSEDCL Pan India WSH Storage	Dec 2022	9.00	9.00	250	250	State
13.	1200 MW SECI Pan India Wind Tranche-XIII	Dec 2022	2.90	2.95	1200	600	Central
14.	300 MW, GUVNL Wind Tranche IV	Jan 2023	2.96	3.01	300	300	State
15.	1000 MW#, REMCL Pan India WSH Storage	Apr 2023	3.99	4.27	1000	900	Central
16.	1200 MW# SECI Multiple States WSH Tranche-VI	Apr 2023	4.64	4.73	1200	1200	Central
17.	500 MW GUVNL Pan India Tranche V	May 2023	3.11	3.17	500	200	State
18.	150 MW# WSH CESC Pan India	May 2023	2.92	2.92	150	150	Private
19.	1200 MW, SECI Pan India Tranche XIV	Jul 2023	3.18	3.24	1200	690	Central
20.	225 MW#, WSH TPC-D Pan India	Sep 2023	3.27	3.28	225	225	Private
21.	1500 MW, SJVN, Storage Hybrid (Peak Power)	Nov 2023	4.38	4.39	1500	1,184	Central
22.	100 MW RECPDCL	Dec 2023	3.58	3.59	100	100	Central

Sr No	Bidding scheme	Month of bidding	Winning tariffs discovered (Rs /unit)		Capacity (MW)		Sector
			Lowest	Highest	Tendered	Allotted	
23.	1500 MW# WSH NTPC Pan India	Dec 2023	3.35	3.37	150	1,104	Central
24.	500 MW GUVNL Pan India Tranche VI	Jan 2024	3.42	3.45	500	164	State
25.	2000 MW# SECI Multiple States WSH Tranche-VII	Jan 2024	3.15	3.21	2000	900	Central
26.	500 MW# WSH Tranche I	Jan 2024	2.99	3.04	500	200	State
27.	1350 MW# SECI Multiple States Wind Tranche-XVI	Feb 2024	3.60	3.70	1350	650	Central

#Hybrid, WSH: Wind Solar Hybrid

Source: Industry, CRISIL MI&A-Consulting

CRISIL MI&A-Consulting believes sub-Rs 3.40/kWh projects are viable only at high PLFs, above 32%, which is provided by improved technology, and hub heights situated in Type I wind sites or good quality type II sites. The lower availability of type I wind sites in preferred locations and congested transmission infrastructure may force developers to move to lower quality wind sites, which have a lower PLF range sub 30%.

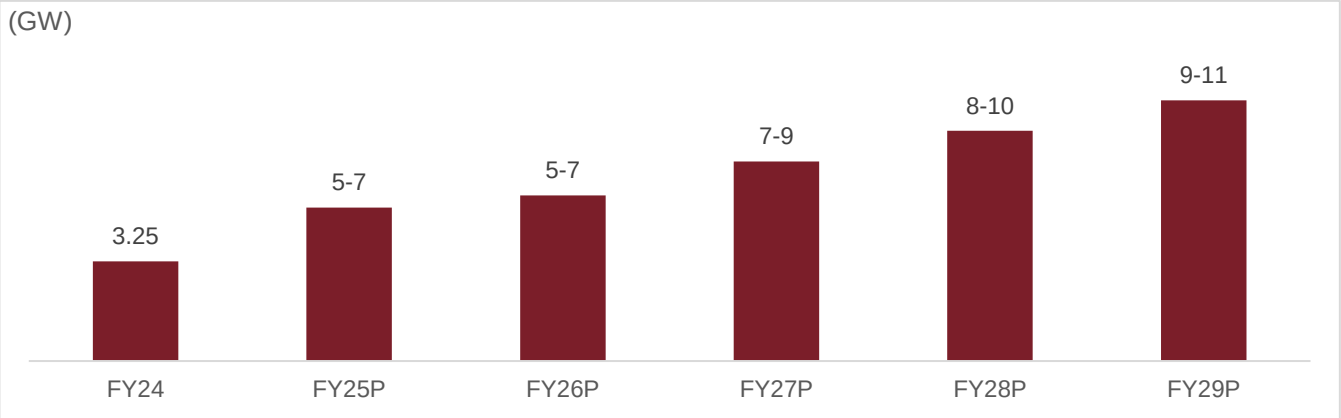
3.3.2 Outlook for capacity additions in next 5 years

CRISIL MI&A-Consulting expects capacity additions to grow over the next five years led by pipeline build-up under existing schemes and new tendering schemes, improvement in technology, thrust on green hydrogen, renewable generation obligation and mixed resource models (RTC, hybrid, FDRE etc.). However, incremental challenges pertaining to wind-site/land availability, grid connectivity, and viability at low tariffs due to elevated capital cost pose challenges for the sector.

Led by India's ambitious clean energy targets declared under NDC, focus on clean segments such as wind is expected to continue coupled with a healthy pipeline existing in the segment. The government policy to tender 10 GW wind capacity annually till fiscal 2028 will further boost the capacity additions. The Central Government is also contemplating for renewable generation obligation (RGO) mandating thermal power generators to generate certain % of their additional capacity from renewable energy. Capacity additions over the long term will also be driven by increased hybrid tenders, storage, and new business model-based tenders. Central government allocations under relatively strong off-takers such as SECI and PTC, reduces risk and would support developer interest. State allocation, on the other hand, has slowed as several states have instead signed power sale agreements (PSAs) with PTC and SECI for procurement of wind power to help fulfil their non-renewable purchase obligation targets.

Considering above, CRISIL MI&A-Consulting expects wind power capacity additions to remain at ~32-34 GW over fiscals 2024-2029, higher than the ~12 GW seen over fiscals 2019-2024.

Figure 37: Expected annual wind power capacity additions



Source: CRISIL MI&A-Consulting

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 hybrid, round-the-clock, peak power supply and FDRE projects.

Although the exact split of wind vs solar for hybrid 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 hybrid 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 FDRE 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. With the rising trend of such tenders, wind power 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 (120 -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. 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 and 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 has further actively tied PPA capacity of ~12 GW over March 2017-June 2024 through wind only schemes. MNRE has outlined further plans to tender 10 GW of capacity each year by RE Implementing Agencies (like SECI, NTPC, NHPC, SJVN). 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, NTPC, NHPC, SJVN being party to the tripartite agreement).

Major payment security mechanisms to de-risk investment in renewable energy inter- alia include Letter of Credit (LC); Payment Security Funds and Tripartite Agreement (TPA) between Ministry of Power, 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 payment security mechanisms, 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.

Table 9: Competitive auctions (Only Wind) over fiscals 2023 & 2024

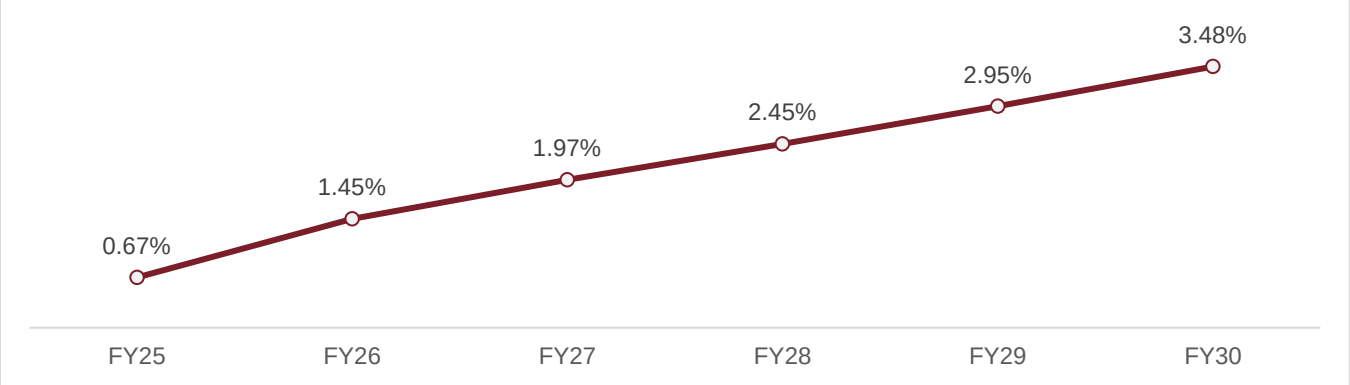
Fiscal	Capacity allocated (MW)	Wt. Avg. Tariff (Rs./kWh)
2023	3181	3.02
2024	1844	3.40

Source: CRISIL MI&A-Consulting

Upward revision in RPO targets

The MoP provided a new RPO long-term trajectory for wind energy till fiscal 2030 which proposes target of 0.67% for wind in fiscal 2025, increasing consecutively to 3.48% in fiscal 2030 for wind.

Figure 38: Revised Wind RPO trajectory



Source: MoP; CRISIL MI&A-Consulting

Most states in India have set lower RPO targets (pan-India avg. non-solar RPO target in fiscal 2023 is 8.9% vs 10.50% required as per MoP), resulting in higher compliance vis-à-vis the set targets. To meet the increased targets, states would have to procure more RE either via the REC route (which still leads to capacity additions) or via competitive bid out capacities. Waiver of ISTS charges by CERC for all projects set up until fiscal 2025 also enables states with low RE potential to procure from more able states. However, RPO compliance is dependent on strict enforcement by regulatory authorities. Amendment to the Electricity Act, 2003 has been proposed to include stricter provisions on penalty for non-compliance; however, this is yet to be passed.

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 business but 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 (Rs 6-6.5/unit), wind power is an attractive option since generation cost is about Rs 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.

3.4 Review of Wind Solar Hybrid sector in India

3.4.1 Overview of Indian wind solar hybrid (WSH) market

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 RTC power scheme.

India has introduced RTC generation tenders, including hybrid tenders to strengthen clean generation combining solar, wind and storage technologies. The MNRE introduced the National WSH Policy on May 14, 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 June 30, 2024, hybrid projects of aggregate capacity 12,884.35 MW are under construction in the country. It is expected that India will witness 21-24 GW of WSH capacity in the next five years (fiscal 2024 to fiscal 2029) out of which around 12-13 GW will be from wind.

Table 10: Tariff discovered in recent WSH Tenders

Sr No	Bidding scheme	Month of bidding	Winning tariffs discovered (Rs /unit)		Capacity (MW)		Sector	Winners
			Lowest	Highest	Tendered	Allotted		
1.	1200 MW SECI Pan India WSH Tranche-V	May 2022	2.53	2.54	1200	1200	Central	• TP Surya (TATA Power) • NTPC RE Ltd. • Amp Energy • SJVN
2.	750 MW, RUMS MP WSH	Sep 2022	3.03	3.04	750	750	State	• Sprng Ojas • Tata Power Renewable Energy • New Solar Power • TEQ Green Power IX (O2 Power)
3.	255 MW, TPDDL Pan India WSH	Dec 2022	3.00	3.00	355	255	State	• Tata Power Renewable Energy
4.	250 MW MSEDCL Pan India WSH Storage	Dec 2022	9.00	9.00	250	250	State	• Ayana Renewables • NTPC RE Ltd
5.	1000 MW, REMCL Pan India WSH Storage	Apr 2023	3.99	4.27	1000	900	Central	• Sprng Akshaya Urja • NTPC REL • Project Nine Renewable electricity (Ayana Power) • TEQ Green Power XIII (O2 Power)
6.	1200 MW SECI Multiple States WSH Tranche-VI	Apr 2023	4.64	4.73	1200	1200	Central	• AMP Energy Green • ReNew Vikram Shakti • Hero Solar Energy • ACME Cleantech
7.	150 MW WSH CESC Pan India	May 2023	**3.07**	3.07	150	150	Private	• AMP Energy
8.	225 MW, WSH TPC-D Pan India	Sep 2023	3.27	3.28	225	225	Private	• Juniper Green Energy • TPREL
9.	1500 MW, SJVN, Storage Hybrid (Peak Power)	Nov 2023	4.38	4.39	1500	1,184	Central	• Juniper Green Energy, Tata Power Renewable Energy, ACME Cleantech Solutions, Solarcraft Power India • Hero Solar Energy; TEQ Green Power XVI; Renew Solar power
10.	1500 MW WSH NTPC Pan India	Dec 2023	3.35	3.37	150	1,104	Central	• O2 Power • Sprng Energy • ACME Cleantech Solutions • Juniper Green Energy • Avaada Energy
11.	2000 MW SECI Multiple States WSH Tranche-VII	Jan 2024	3.15	3.21	2000	900	Central	• NTPC REL • Juniper Green Energy • Green Infra Wind Energy
12.	500 MW GUVNL WSH Tranche I	Jan 2024	2.99	3.04	500	200	State	• KPI Green • Juniper Green Energy
13.	750 MW, REMCL RTC	Jan 2024	4.25	4.43	750	650	Central	• ACME Cleantech Solutions • ReNew Solar Power • Tata Power Renewable • O2 Power • NTPC REL • Torrent Power
14.	1500 MW SJVN Pan India WSH Tranche I	Feb 2024	3.43	3.49	1500	1500	State	• Juniper Green Energy • Datta Power Infra • Green Infra Wind Energy • Energizent Power (O2 power) • Green Prairie Energy • Avaada Energy

Sr No	Bidding scheme	Month of bidding	Winning tariffs discovered (Rs /unit)		Capacity (MW)		Sector	Winners
			Lowest	Highest	Tendered	Allotted		
15.	1500 MW NHPC Pan India WSH Storage (Firm power) Tranche II	Feb 2024	4.55	4.64	1500	1400	Central	• BN Hybrid power 1 • Hero Solar • Solarcraft Power India 20 • Juniper Green Energy • Renew Solar Power • ACME Cleantech Solutions
16.	1500 MW, SECI Pan India WSH Storage (Firm power) Tranche II	Mar 2024	5.59	5.60	1500	480	Central	• Hero Solar Energy • JSW Neo Energy • Serentica Renewables India • ReNew Solar Power
17.	1500 MW, NTPC Pan India WSH Tranche II	Mar 2024	3.27	3.32	1500	1500	Central	• ABC Cleantech (Axis Energy) • Juniper Green Energy • ACME Cleantech Solutions • ReNew Solar Power
18.	3000 MW, NTPC Pan India WSH Storage (Firm power)	Mar 2024	4.64	4.73	3000	1584	Central	• BC Cleantech (Axis Energy) • ACME Cleantech Solutions • Juniper Green Energy • Hero Solar Energy • Serentica Renewables India 11 • Tata Power REL
19.	1000 MW, NTPC Pan India Solar wind hybrid Tranche V	Apr-2024	3.41	3.47	1000	1000	Central	• Sprng • AmpIn • Juniper Green Energy • Renew • Avaada Energy
20.	500 MW, GUVNL Pan India Solar wind hybrid Tranche II	June-2024	3.33	3,39	500	560	State	• KPI Green • Juniper Green Energy • JSW Neo • Hinduja Renewables
21.	1500 MW, SJVN Pan India Solar wind hybrid Tranche II	June-2024	3.41	3.42	1500	1500	Central	• AmpIn • Solarpack • Juniper Green Energy • Datta power Infra • Evergreen • JSW Neo • Avaada Energy
22.	1200 MW, SECI Pan India Solar wind hybrid Tranche VII	Jun-2024	3.43	3.46	1200	1200	Central	• Juniper Green Energy • UPC Solar • JSW Neo • AmpIn • Datta power Infra • Avaada Energy
23.	2000 MW, MSEDCL Pan India Solar wind hybrid Tranche III	Jul-2024	3.60	3.69	1200	426	State	• JSW Neo • Juniper Green Energy • BrightNight • Avaada Energy
24.	1200 MW, SECI Pan India Solar storage hybrid Tranche VII@	Jul-2024	3.41	3.42	1200	1200	Central	• Pace Digitek • JSW Neo • Hero Future • ACME
25.	1200 MW, SECI Pan India Solar Wind storage hybrid (firm power) Tranche IV	Jul-2024	4.98	4.99	630	630	Central	• Vena Energy • Hero Future • JSW Neo • Hexa Climate Solutions • Serentica Renewables
26.	1000 MW, NTPC Pan India Solar	Jul-2024	3.43	3.46	1000	1000	Central	• Juniper Green Energy • JSW Neo • TEQ Green power (O2 power)

Sr No	Bidding scheme	Month of bidding	Winning tariffs discovered (Rs /unit)		Capacity (MW)		Sector	Winners
			Lowest	Highest	Tendered	Allotted		
	wind hybrid Tranche VI							• Adyant Enersol (Datta Infra) • Avaada Energy
27.	1200 MW, NHPC Pan India Solar Wind storage hybrid (firm power) Tranche II	Sep-2024	4.37	4.38	1200	1200	Central	• Essar Renewables • Juniper Green Energy • Serentica Renewables • Hexa Climate Solutions • Avaada Energy

@The recent SECI auction held in July 2024 witnessed the highest tariff of Rs 3.71 per unit in Tranche-XV
WSH: Wind Solar Hybrid; Source: Industry, CRISIL MI&A-Consulting

FDRE bids of total capacity of around 8.25 GW were auctioned in India during fiscal 2024. ACME, Renew, Hero Solar, JSW Neo are leading players in FDRE.

3.4.2 Key growth drivers

WSH 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 hybrid power. Depending on the project requirements, the hybrid projects can be co-located or located in different locations also 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.

3.4.3 Support policies for WSH plants

National Wind-Solar Hybrid Policy 2018

This policy aims to encourage new technologies, methods and way-outs involving combined operation of wind and solar PV plants. The aim is to reduce RE variability and improve grid stability.

Capacity: A wind-solar plant will be recognised as hybrid if the rated power capacity of one resource is at least 33% of the rated power capacity of other resource.

Integration: The policy provides for integration of both energy sources, wind and solar, at alternating current (AC) and direct current (DC) level.

RPO: The power procured from the hybrid project can be used for fulfilment of solar RPO and non-solar RPO in the proportion of rated capacity of solar and wind power in the hybrid plant.

Hybridisation of existing wind/solar PV plants: Existing wind or solar power projects, willing to install solar PV plant or WTGs to avail benefit of hybrid project may be allowed to do so under certain conditions.

Incentives: All fiscal and financial incentives available to wind and solar power projects will also be made available to hybrid projects.

Battery storage: Battery storage may be added to the hybrid project to reduce the variability; providing higher energy output for a given capacity and ensuring availability of steady power during a particular period.

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 11: 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 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 sale for projects set up within the state	-	-
Additional surcharge	-	Captive: 100% exemption Third-party sale: 25% concession	-	-	75% exemption
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	**Hybrid:** 50% concession for captive/ third party sale for 7 years from project commissioning. **Hybrid + 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 applicable for third parties

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

Source: MNRE, respective state policy documents, CRISIL MI&A-Consulting

4 Global RE landscape

4.1.1 Solar capacity addition

The strong global thrust on clean energy is driving renewable installations worldwide led by reducing RE generation costs, favourable policies, improved emphasis on energy security and access, and socio-economic benefits. The last decade saw a remarkable evolution in solar PV segment marked by large scale installations, signification reduction in tariffs and technological advancements.

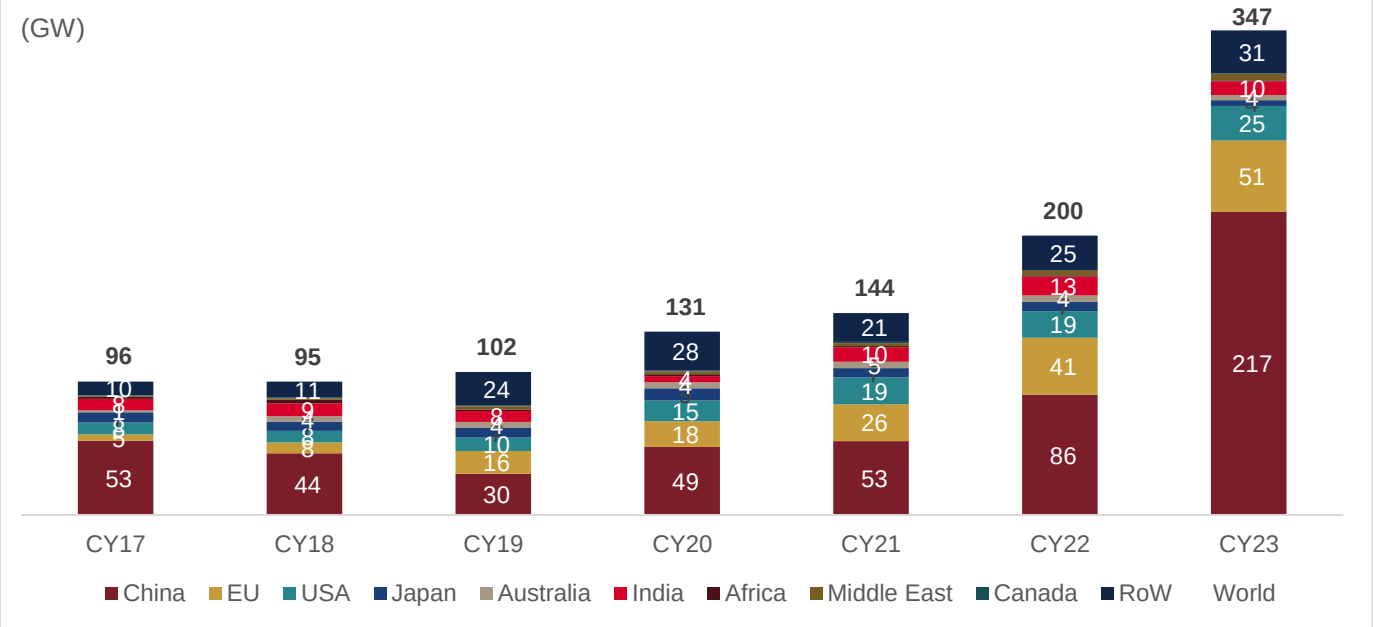
Concerns over climate change are at the heart of the energy shift towards RE and its increasing utilisation will be key for decarbonisation. Various initiatives, such as Kyoto Protocol, Paris agreement, Conference of Paris (COP), RE 100, ISA, and subsequent favourable policy interventions, have helped strengthen the RE segment. The transition towards RE is critical to limit the rise in global average temperatures to well below 2 degrees Celsius and ideally below 1.5 degrees Celsius above pre-industrial levels.

Countries that are part of the Paris Agreement are required to submit their plans for climate action, known as nationally determined contributions (NDCs). These NDCs represent the efforts these countries need to take to reduce national emissions. Various countries have provided policy impetus to the solar PV industry through various mechanisms, such as FiT, 'must run' status, renewable purchase obligations, tax incentives, AD, favourable regulatory frameworks, subsidies, and PLIs. This has accelerated global growth in solar PVs.

Investments in solar PV is expected to increase further as it is rapidly becoming the preferred and lowest-cost option for electricity generation globally. As per IEA, average annual solar generation should grow by an average 25% between 2022-2030 to meet the Net Zero Emissions Scenario by 2050. This translates to over 3x increase in annual capacity deployment until 2030.

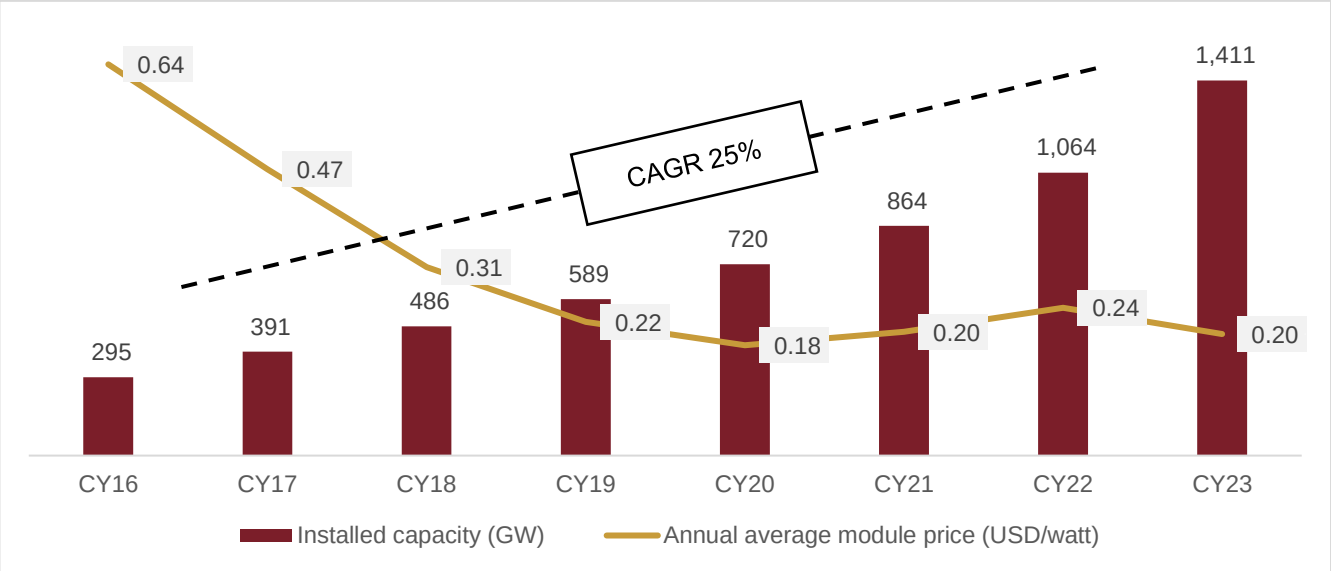
As per IRENA, globally, ~347 GW of solar PV capacity was added in 2023, taking the installed capacity to 1,411 GW, which is a ~33% increase over the previous year. China continued to lead the market with total cumulative capacity of ~609 GW, whereas the US came in second with ~138 GW, followed by Japan at ~89 GW.

Figure 39: Annual solar capacity additions in major economies



Note: The annual capacity addition numbers pertain to calendar year (January-December)
Source: IRENA Renewable Capacity Statistics 2024 (Jul 2024); CRISIL MI&A-Consulting

Figure 40: Global solar PV installed capacity registered about 25% CAGR between 2016 and 2023



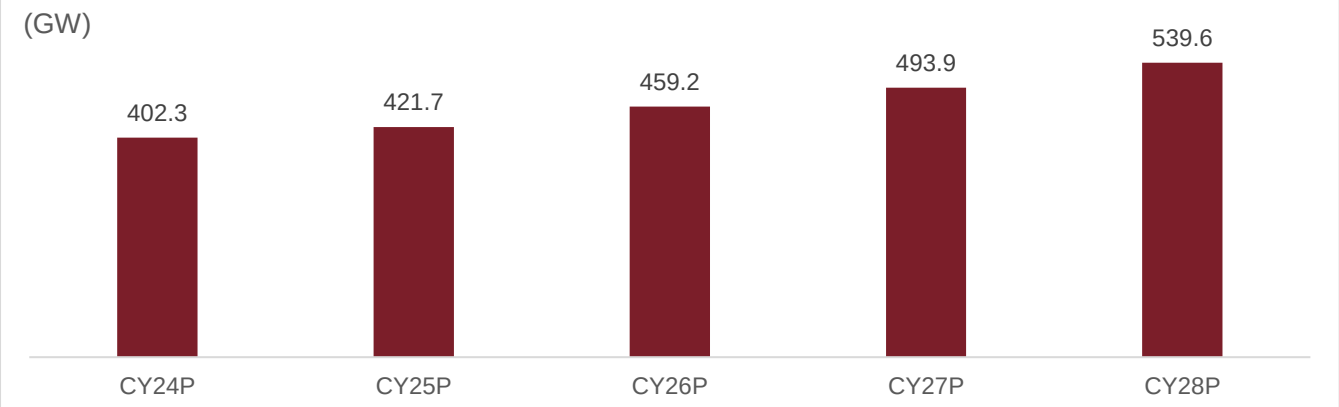
Source: IRENA Renewable Capacity Statistics 2024 (July 2024), CRISIL MI&A-Consulting

4.1.2 Global solar outlook

IEA has estimated a capacity addition of 2317 GW over a period of CY2024-28. As per IEA, Renewable power capacity additions will continue to increase in the next five years, with solar PV and wind accounting for a record 96% of it because their generation costs are lower than for both fossil and non-fossil alternatives in most countries and policies continue to support them.

Solar PV and wind additions are forecast to more than double by 2028 compared with 2022, continuously breaking records over the forecast period to reach almost 710 GW.

Figure 41: Projected annual Solar PV capacity additions CY24-28



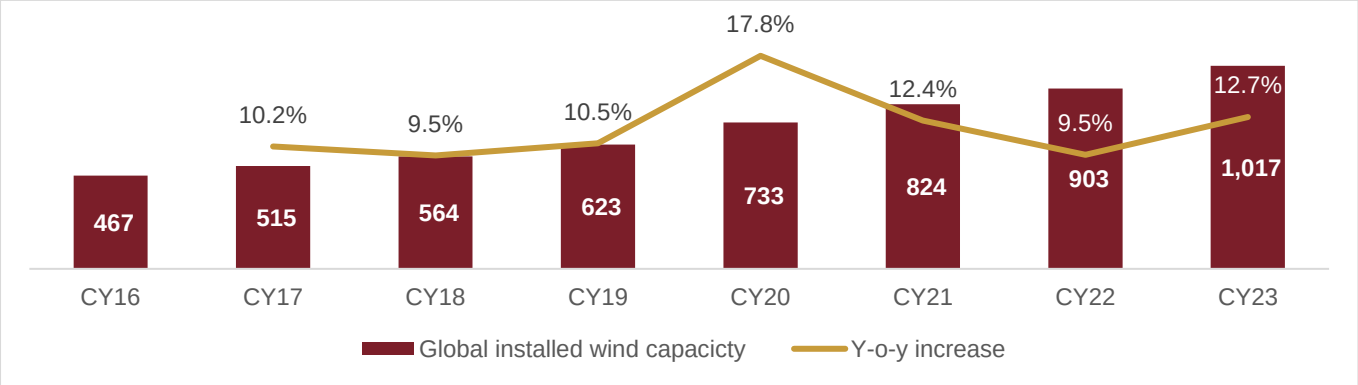
Note: Including PV distributed systems and PV Utility scale systems; (P): Projected
Source: IEA Renewables 2023, CRISIL MI&A-Consulting.

4.1.3 Review of Global Wind energy capacity additions

Since 2016, global installed capacity for wind energy has grown at a CAGR of ~12%, to ~1,017 GW in 2023 from ~467 GW in 2016. In terms of cumulative installations, China, US, Germany, Brazil, India, and Spain remain the top markets, collectively making up 75% of the total 1,017 GW of installed wind power capacity across the world. Countries transitioning away from feed-in-tariffs to market-based mechanisms, thrust on sustainability, falling costs and relatively firm generation solar wind hybrid models gaining traction have driven wind capacity additions in the past few years.

Offshore wind is increasingly playing an important role in driving global wind installations, with the segment witnessing record installations of 21.1 GW in 2021, accounting for a share of 22.9% of wind power additions. However, in 2022 and 2023, offshore wind contributed to~9-10% of new installations due to the conclusion of the FiT program.

Figure 42: Global cumulative installed wind power capacity (GW)



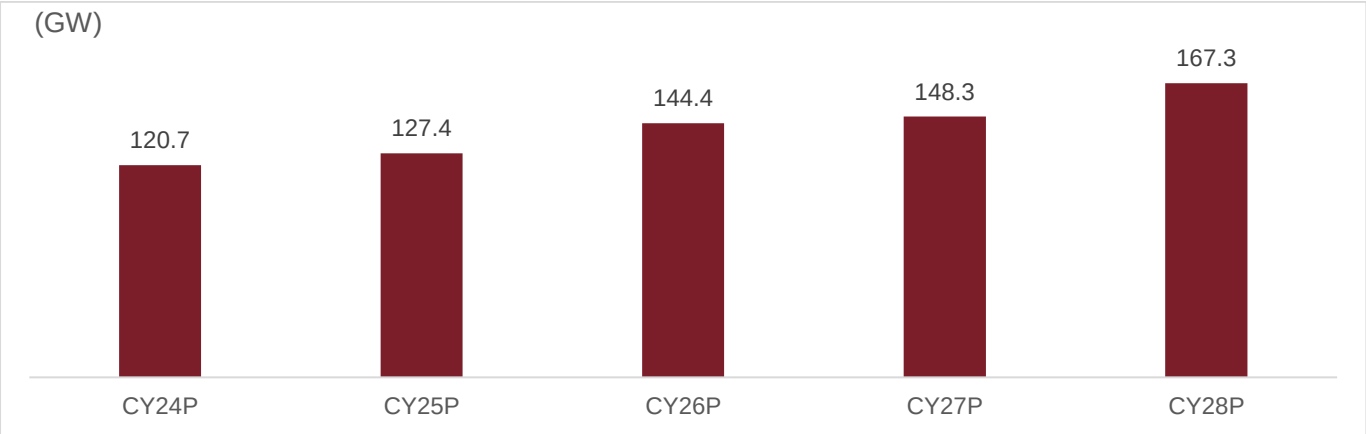
Source: IRENA, CRISIL MI&A-Consulting

Nearly ~115 GW of wind-based power capacities were added in 2023 (Jan-Dec), mainly led by additions made by China (76 GW), USA (6.3 GW), Brazil (4.9 GW), UK (1.3 GW), Germany (3.3 GW), Brazil (4,9 GW) and India (2.8 GW).

4.1.4 Outlook 2023-2027: Wind energy capacity additions to be driven by China and USA

As per IEA, following two consecutive years of decline, onshore wind capacity additions are on course to rebound in 2023 to ~107 GW, an all-time record installation. This is mainly due to the commissioning of delayed projects in China following Covid-19 restrictions. Faster expansion is also expected in Europe and the United States owing to supply chain challenges pushing project commissioning into 2023 from 2022. On the other hand, offshore wind growth is not expected to match the record expansion it achieved two years ago due to the low volume of projects under construction outside of China. As per IEA ~708 GW of wind capacity is expected to be added globally between 2024 and 2028.

Figure 43: Annual wind capacity additions over 2024-2028



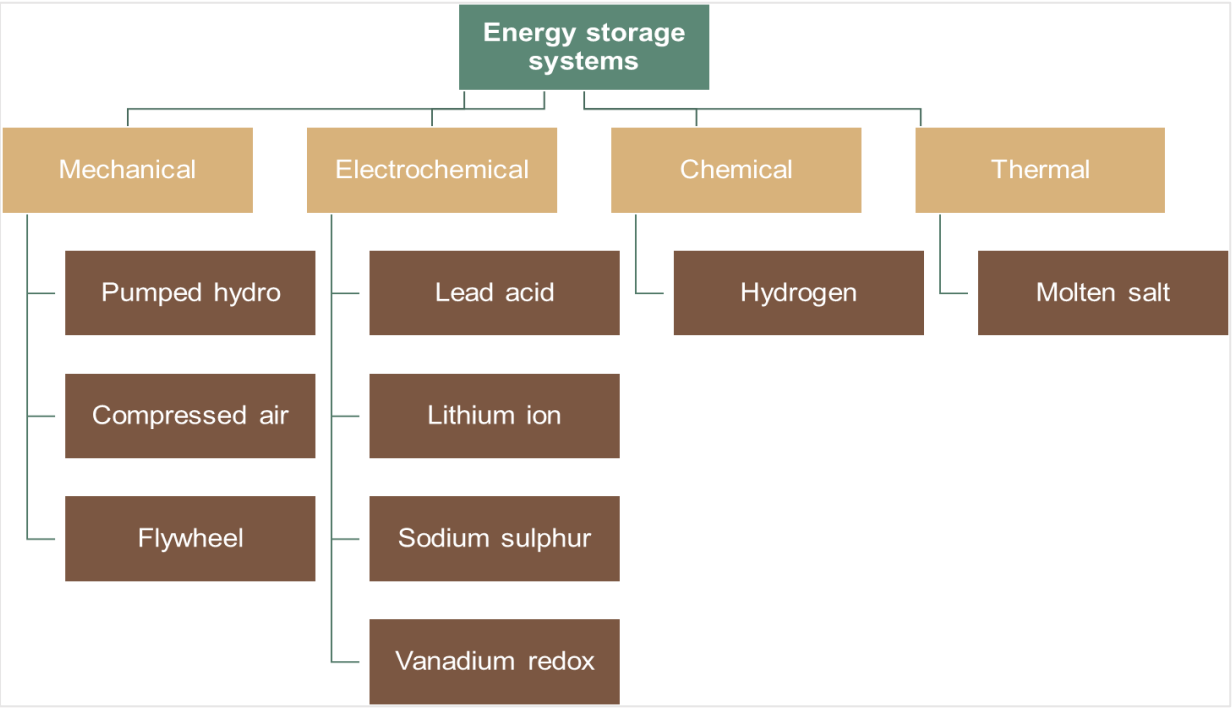
Source: IEA; CRISIL MI&A-Consulting

5 Energy Storage

5.1 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 pumped hydro storage (PHS), 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.

Figure 44: Major types of storage technologies



Source: Industry reports, CRISIL MI&A-Consulting

Pumped Hydro Storage Project (PHSP) is the most widely used and commercially available means of energy storage technology in India. However, the total installed capacity of PHSP 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 & frequency control, etc.

Energy storage technologies could play a vital role in smoothening the delivery of intermittent resources like wind and solar energy. By storing excess energy during periods of high generation and use of the same during high demand period thereby ensuring grid stability. This balancing effect helps ensure a more consistent and reliable energy supply, reducing dependence on immediate availability and improving overall grid stability.

5.1.1 Advantages of PHS projects

Some of the major advantages provided by PHS are as follows:

- **Peak shaving -** PHS has a very high ramp rate. As per CEA's study, the ramp rate of Pondage /Storage Hydro-based power plants is about 50% of its capacity per minute, the highest amongst the different categories of

plants. In comparison to this, the ramp rate of combined cycle gas-based plants is up to 10% per minute. The lowest ramp rate is that of coal-based power plants, maximum of 3% for super-critical power plants.

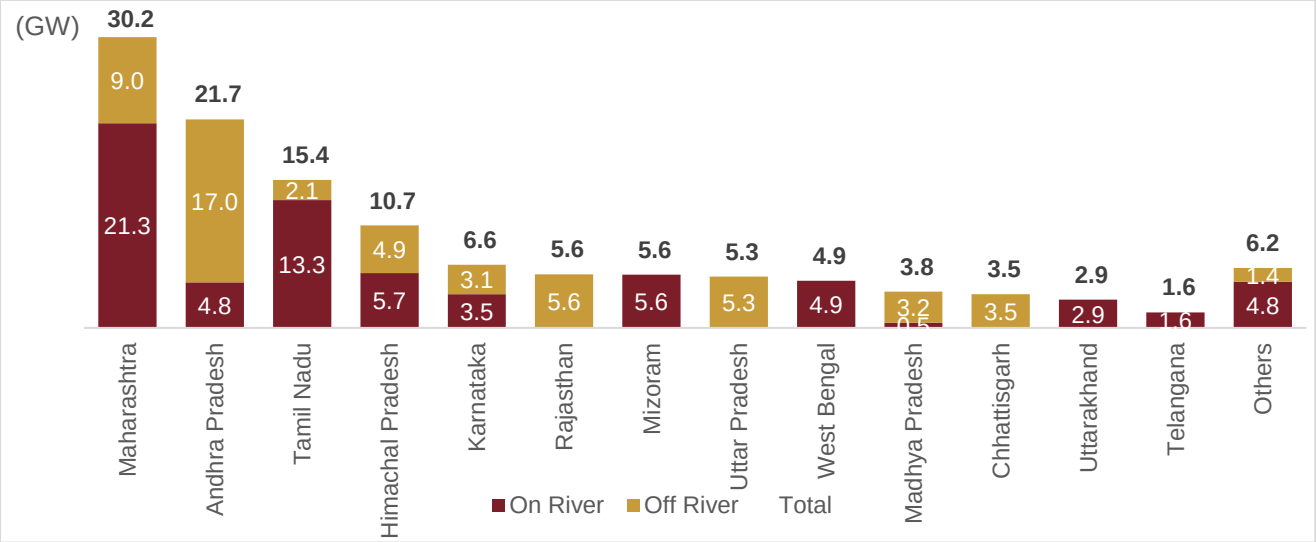
- **Load balancing -** PHS can play a crucial role in load balancing, i.e., storing power during off-peak hours and utilising it when required during periods of high demand.
- **Frequency and voltage regulation -** PHS can respond rapidly to changes in grid frequency to maintain the frequency within the given band. PHS can be operated in pumping mode when frequency is higher than 50 Hz, to help the grid bring down frequency to 50 Hz. On the other hand, in case of frequency lower than 50 Hz, it can be operated in generation mode to provide necessary relief to the grid. PHS can also help control grid voltage within acceptable limits by adjusting their generation levels by rendering reactive power balancing services.
- **Spinning Reserve -** PHS can also be used to provide back-up reserve, spinning reserve, with its high ramping rate and can be operated in case of sudden outage or failure of any load in the grid.
- **Black Start Services -** PHS can provide black start capability, which means, if the upper reservoir of PHS is full and ready for generation, it can be used for energizing the grid in case of cascade tripping.

5.2 Pumped hydro storage projects in India

5.2.1 Potential of PHS in India

The identified potential of PHS in the country is about 124 GW (comprising 114 PHSP). However, the operational capacity of PHSP is merely 4.7 GW, which indicates the large potential growth in this segment.

Figure 45: State wise PHS Potential in India



Source: MoP, CEA (Pumped storage potential as of May 2023), CRISIL MI&A-Consulting

5.2.2 Overview of PHS projects in India

As on July 2024, India has an installed capacity of 4.75 GW of on-river pumped storage projects in operation. Further, as per CEA, 4.05 GW is under construction, of which 2.2 GW is expected to be commissioned during fiscal 2025. Also, 3.6 GW projects have been cleared by CEA and will shortly commence construction and about 60 GW of PHS 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. The summary of PHS projects at different stages is tabulated below:

Table 12: Status of PHS development in India as of July 2024

Description	Pumped storage capacity	
	Nos	**MW**
Identified on-river & off-river PHS potential as per CEA	**114**	**1,23,951**
Operational pumped storage projects	8	4,746
Under construction projects	4	4,050
Projects allotted by States for development	45	64,910
Total capacity – operational & under various stages	**57**	**73,706**
Status of projects allotted for development		
Projects cleared by CEA and yet to be taken up for construction	3	3,600
Projects under survey & investigation	42	61,310
Total	**45**	**64,910**

Source: CEA, CRISIL MI&A-Consulting

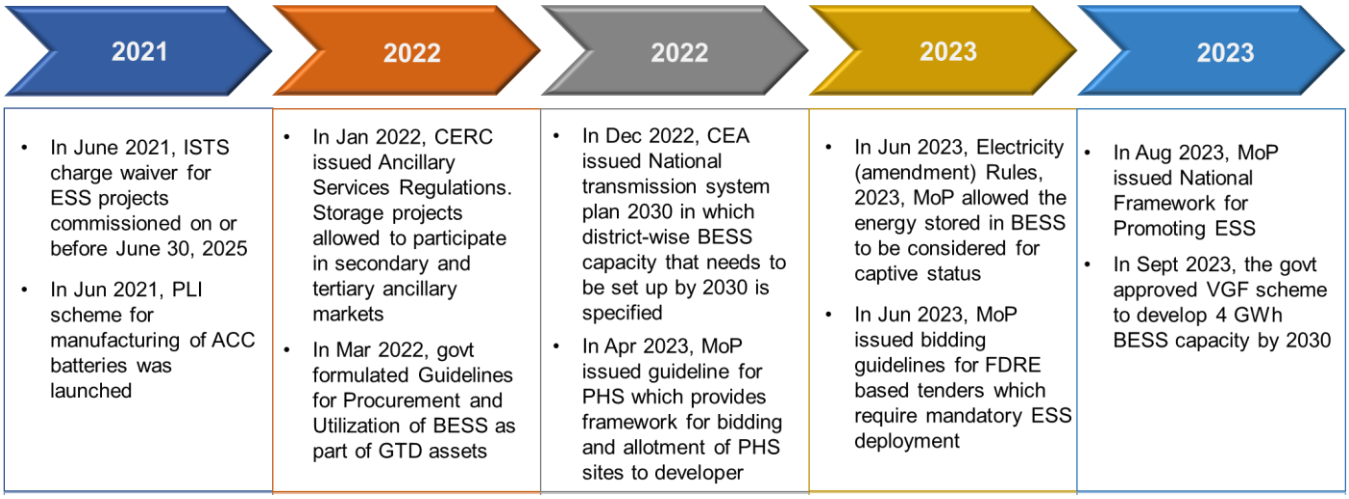
5.3 Battery energy storage

Battery Energy Storage Systems (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 7-10 years, depending upon usage.

5.4 Policy and regulatory landscape 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 46: Key policy measures for storage projects



Source: MoP, MNRE, CRISIL MI&A-Consulting

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 initiatives taken to promote growth of energy storage technologies in India are summarised below:

a) MoP issued legal status for ESS on January 2022 wherein ESS has been designated as a power system element which can be utilized as a Generator, Transmission or Distribution element.

b) ESO trajectory till fiscal 2030 and bidding guidelines for BESS has been notified by MoP. 1% energy storage target in FY 2024, going up by 0.5% every year to 4% in FY 2030. However, the ESO has been removed from the RPO notification released by MoP in October 2023.

c) Waiver of ISTS charges on PHS will be applicable to those Projects whose construction work would be awarded up to 30th June 2025. The waiver is applicable for a period of 25 years for PHS. The waiver of ISTS charges for BESS projects commissioned up to 30th June 2025 would be provided for a period of 12 years.

d) Revised scheme for flexibility in generation and scheduling of thermal/ hydro projects through bundling with RE and storage power.

e) In the amendment to Electricity Rules, 2023, GoI has allowed the energy stored in BESS to be considered for captive status.

f) The 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.

For PHS projects, several provisions are proposed to facilitate the allocation and development of PHS. No upfront premium is required to pay for project allocation. Appropriate regulatory commissions are mandated to ensure that ancillary services are monetized, and they will determine peak and off-peak tariffs. This will provide assurance of revenue realization and improve off-take chances. PHS will be allowed to participate in all market segments, including the high-price segment of the day-ahead market, thereby expanding the market available for sale. Developers will have the freedom to utilise surplus capacity for optimisation purposes.

To ensure financial viability, the GoI may notify a benchmark cost, and only PHS with a levelized cost within the benchmark cost may be considered for development. While this measure intends to maintain cost control, it may pose challenges to growth in this segment. However, in the PHS guidelines, measures such as reducing the equity component from the existing 30% upto 20% has been suggested. Financial institutions such as PFC, REC, and IREDA are expected to treat PHS at par with other RE projects and provide long-term loans with tenures more than 18 years, with a debt-equity ratio of 80:20. This availability of loans at competitive rates will support the financial aspects of PHS development.

To encourage PHS development, certain tax and duty incentives are provided. 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. Furthermore, PHS will be exempt from ISTS charges.

In addition, the PHS will be exempted from free electricity obligation, doing away with the need for environmental impact assessment studies and public hearings if such projects are built on existing dams or areas away from the main river water (off-the-river). The guidelines also mandated using green finance like sovereign bonds or concessional climate finance for funding such projects.

CEA has also established a Single Window Clearance Cell for approval of PHSPs. It has nominated Officers from Central Water Commission and Geological Survey of India to fast-track the clearance of design and geological aspects of DPR, respectively. The timeline for concurrence of DPR has been reduced from 90 days to 50 days for PHSPs awarded under section 63 of Electricity Act, 2003, part of integrated RE project and being developed as captive plants or merchant plants. The timeline for concurrence of DPR of other PHSPs has been reduced from 125 days to 90 days.

MoP vide its office memorandum dated 28th September 2019 provided budgetary support of Rs. 1 Crore per MW (for projects above 200 MW) and Rs. 1.5 Crore per MW (for projects below 200 MW and up to 25 MW) for the construction of roads and bridges for hydropower projects (including PHS projects) whose construction started after 8 March 2019.

Also, the MoP issued guidelines in April 2023 to regulate and promote development of PHSP projects in India. The guideline highlights methods for allotment of projects on nomination basis where states can directly award projects to developers. While this can expedite development, it could also lead to project delays. Another method is the competitive bidding process. This method is advantageous for the market as it introduces competition. However, the provision that grants the home state the right of first refusal for 80% of the project capacity could hamper interests of private developers.

Further, in August 2023, MoP published the National Framework for promoting Energy Storage Systems. The framework reaffirms various policies and provisions that have encouraged the planning and installation of ESS in the country. Additionally, it proposes various incentives to further encourage the development of ESS. The comprehensive framework is an important step towards developing the ESS and will facilitate a conducive ecosystem for its development. The policy proposes measures to ensure adequate storage capacity to supply reliable power. New RE projects (excluding Hydro Projects) with an installed capacity of over 5 MW may be mandated to install ESS (of at least 1 hour storage) for minimum 5% of the RE capacity. Further Hydro Projects may be encouraged to have minimum pondage capacity to manage variability and peak demand.

In September 2023, the government approved the VGF scheme for development of 4000 MWh of BESS capacity by fiscal 2031. An initial outlay of Rs.9,400 crore including budgetary support of Rs.3,760 crore has been provided under the scheme. The VGF would be provided from fiscal 2024-26 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 Rs. 18,100 Crore, which includes more than 10 GWh grid-scale battery storage. The Scheme expects direct investment of around Rs. 45,000 crore 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. On the supply side too, several private sector developers have announced plans and signed agreements with state governments to develop PHSPs. Strong state government support in developing project sites proactively and a differential time-of-day pricing mechanism can go a long way in boosting PHS prospects.

5.5 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 the recently announced firm and dispatchable renewable energy (FDRE) tenders. The table below shows the classification of ESS tenders in India.

Table 13: Types of storage tenders

Tender type	Description
RTC tender	To ensure round-the-clock availability of power to the offtakers with or without storage
Peak power supply	To meet the power requirements of the offtakers during peak hours through a combination of RE and ESS
Solar + BESS	Small-scale tenders with mandatory fixed solar and BESS components
Standalone ESS	Fulfills on demand power requirement of the offtakers, treats “ESS as-a-service”
FDRE	Demand profile following ESS tenders ensuring firmness and dispatchability of renewable energy power

Source: CRISIL MI&A-Consulting

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 ~ Rs 6.12/kWh) with pumped hydro storage

and ReNew Power (300 MW at peak tariff of Rs 6.85/kWh) with BESS were awarded the project. The first FDRE tender of 1500 MW conducted by SJVN in November 2023 witnessed the lowest tariff of Rs 4.38/kWh.

Also, a few large-scale standalone ESS tenders were also issued by SECI, NTPC and Power Company of Karnataka Limited (PCKL) in fiscal 2023. In terms of ESS technology, SECI's tender was for BESS, while PCKL's tender was for PHS. 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 and 300 MW in PCKL's tender, whereas Greenko won the NTPC tender and 700 MW in PCKL tender.

As of July 2024, ~11 GW of grid-scale ESS capacity has been tendered of which ~6 GW has been awarded.

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.

A list of recently concluded storage tenders are mentioned below:

Table 14: Recently concluded storage tenders

Sr. No.	Tender name	Tender type	Capacity (MW/MWh)	Result date	Lowest bid	Winners
1.	SECI Rajasthan Tranche - II	Standalone BESS	1000 MW / 2000 MWh	Sept 2024	Rs 4.57 Mn/MW/year	JSW, Reliance
2.	SECI	Solar+Storage	600 MW/1200 MWh	Jul 2024	Rs 3.42/kWh	Acme, Hero, JSW
3.	GUVNL	Standalone BESS	250 MW/500 MWh	Mar 2024	Rs 4.48 Lakh/MW/month	Gensol, Indigrid
4.	SJVN, Firm Power	FDRE	1500 MW	Nov 2023	Rs 4.38/kWh	Acme, Juniper, Tata, ReNew, Bluepine, Hero, O2 Power
5.	PCKL	Standalone ESS	1000 MW /8000 MWh	Mar 2023	Rs 14.75 Mn	JSW (300 MW) Greenko (700 MW)
6.	NTPC Storage	Standalone ESS	500MW/ 3000 MWh	Dec 2022	Rs 2.79 Mn/MWh/year	Greenko
7.	SECI Rajasthan	Standalone ESS	500MW/ 1000 MWh	Aug 2022	Rs 1.08 Mn/MWh/month	JSW
8.	KSEB Storage	Standalone ESS	10 MW / 20 MWh	Jul 2022	Rs 1.13 Mn/MW/month	Hero

Source: SECI, Bidding agencies, CRISIL MI&A-Consulting

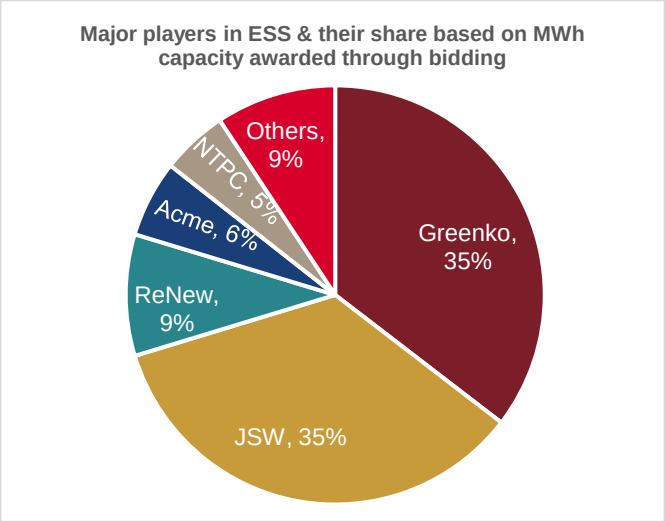
There were other small scale solar-cum-storage tenders issued by SECI, NLC for regions such as Leh, Andaman and Nicobar Islands and Lakshadweep of capacities less than 50 MW, which have also been successfully awarded by the bidding agencies.

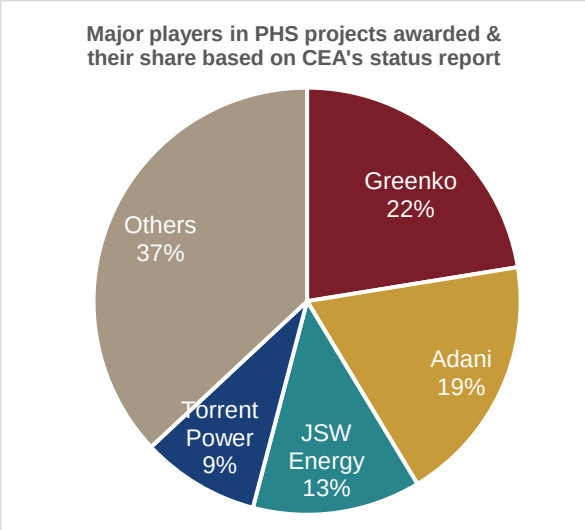
While PHS is primarily useful for long duration energy storage requirement (i.e., for 6–10-hour storage) while BESS is typically useful for shorter duration storage requirement (2-4 hours). Hence, both the technologies have their unique requirements and use cases.

5.6 Major players in pumped storage and BESS technology

Major RE developers such as ReNew, Greenko, Torrent Power, JSW, Acme are aggressively adopting ESS. ReNew won two ESS tenders (Peak Power Supply, RTC-1). Greenko is developing ESS through PHS. It is developing Integrated Renewable Energy Storage Projects (IRESP) in Andhra Pradesh combining GW scale wind, solar and PHS power.

Figure 47: Major players and their share in ESS/PHS based projects as of July 2024





Source: CEA, SECI, Bidding agencies, CRISIL MI&A-Consulting

Greenko has the highest share in terms of capacity awarded under energy storage projects. It has won 2.1 GW under tariff based competitive bidding conducted by SECI, PCKL and NTPC. According to CEA's status report on PHS development as of July 2024, a cumulative capacity of ~13.5 GW has been allotted to Greenko. Other players such as Adani Green Energy, JSW, Torrent Power are cumulatively developing ~25 GW of PHSPs. Acme is also developing 600 MW Off-river PHSP in Uttar Pradesh under MoU route.

Further, the developers who won RTC, peak power, FDRE tenders under competitive bidding route such as ReNew, Acme, Tata Power, Bluepine, O2 Power, NTPC are deploying BESS to meet the power requirements of their respective offtakers as indicated in the RfP.

Table 15: List of key players in ESS segment

Key players	Achievements in ESS segment
Greenko	• 900 MW project won under SECI tender for peak power supply • 500 MW/3,000 MWh ESS capacity under NTPC tender • 700 MW/5,600 MWh PHS capacity under PCKL tender • Developing IRESP at Andhra Pradesh with 3 GW solar, 0.5 GW wind and 1.2 GW/10.8 GWh PHS
ReNew	• 300 MW peak power supply project with a storage capacity of 75 MW/150 MWh • 400 MW RTC project with storage capacity of 25 MW/100 MWh
JSW Energy	• Won 500 MW/1,000 MWh BESS under SECI tender • Won 300 MW/2,400 MWh PHS capacity under PCKL tender • Plan to install 5 GW/40 GWh energy storage capacity by 2030
NHPC	• Scouting for over 20 GW of PHSPs in the States of Andhra Pradesh, Maharashtra and Odisha and have also signed MoU with the respective State departments

Key players	Achievements in ESS segment
	• Signed MoU with Gujarat Power Corporation for investment in Kuppa PHSP of 750 MW
Hero Future Energies	• 10 MW/20 MWh BESS at Kerala
Tata Power	• 10MW/10MWh BESS commissioned in Delhi • 20MW/50MWh BESS project in Leh, Ladakh • 100 MW Solar with 40MW/120 MWh BESS at Chhattisgarh
L&T	• 20 MW solar with 8 MWh BESS at Andaman & Nicobar
Mahindra Susten	• 6MW Solar with 6MW/19MWh BESS at Gujarat

Source: Company websites, press release, CRISIL MI&A-Consulting

5.7 Outlook for ESS market

As per the updated NDC, India now stands committed to reduce emissions intensity of its GDP by 45% by 2030, from 2005 level and achieve about 50% cumulative installed electricity capacity from non-fossil fuel-based energy resources by 2030. This is expected to significant RE capacity additions by 2030. However, the increasing penetration of variable RE into the grid has risks with respect to grid stability and resilience. Energy storage will play an important role in ensuring the firmness and sustainable growth of RE in the electricity mix. PHSPs are likely to play a vital grid-scale storage solution in India for the next 5-7 years led by low cost, large scale, and no reliance on international supply chains.

Usage of battery storage is expected to be strong across the generation, transmission, and distribution segments as well as at the consumer end. The National Renewable Energy Laboratory has also forecasted a fall in the price of storage solutions, especially lithium-ion technology. With the greater adoption of lithium-ion battery storage, improvement in battery efficiency, and large-scale manufacturing, CRISIL MI&A Consulting expects the four-hour utility-scale lithium-ion battery costs to decrease to $90-100 per kWh in 2030 from the costs of $130-140 per kWh in 2023.

With the announcement of several large-scale PHS projects across the country, the PHS segment is also expected to witness significant adoption. According to the CEA's report on optimum power generation mix study in April 2023, India will require at least 41.7 GW/208 GWh of BESS and 18.9 GW of PHS by fiscal 2030.

5.7.1 Key driving factors for adoption of ESS in India

RE capacity addition: GoI has set an ambitious target of 450 GW of RE capacity addition by 2030. Such high quantum, variability, and intermittent nature of RE will drive installation of energy storage in India.

Demand profile: During non-solar peak periods, additional generation and ramping requirements are high. Further, the projected peak load growth and the expanding disparity between peak and base demand will necessitate sufficient capacity expansion and adoption of storage-based generation technologies. Additionally, energy storage will also help in addressing ramping requirements as well as providing capacity during non-solar hours.

Regulatory and Policy Support: The GoI has placed emphasis on developing BESS and PHS capacity to improve grid operations. In April 2023, the MoP issued guidelines and incentives for the PHS project to catalyse the growth of the PHS market. Other policy support to ESS includes transmission charges waiver, inclusion of ESO, VGF scheme for BESS, among others.

Storage duration: PHS offers energy storage of 6 to 12 hours, which is significantly longer than BESS. Thus, PHS is well suited for energy-shifting applications, wherein excess RE generation can be shifted to peak demand periods

of late evenings. On the other hand, a single BESS can be used for multiple applications such as voltage and frequency regulation, spinning reserves, peak shaving.

Maturity of technology: Pumped storage is a proven technology and has been in use for decades to support/balance grids. Unlike other storage technologies, performance of PHS is quite reliable on long term basis. With the evolution in BESS technology and falling costs, its adoption will also see an improvement.

Self-sufficiency of domestic equipment: PHS project infrastructure is similar to a hydropower plant. Thus, with India already having a significant presence in hydropower, most PHS project components can be sourced locally. This is in high contrast to BESS, wherein battery cells, a key project component, still need to be almost wholly imported. However, with capacities awarded under the PLI scheme for advanced chemical cell battery storage, share of indigenous solutions would increase.

Economical: PHS is a cost-effective ESS technology due to a significantly longer project life (40 to 50 years) as compared to other ESS technologies. For BESS solutions too, with rising R&D and subsequent improvement in technology as well as increasing scale, cost competitiveness of such solutions to improve.

Availability of finance: The long project life of PHS has the potential to provide a stable and consistent cash inflow for about 40 years. This healthy cash-flow profile enables favourable project financing arrangements for PHS, such as lower loan rates and a higher debt-equity ratio.

Sustainable: With long useful life (more than 40 years for plant and equipment and more than 80-100 years for Dam), PHS provide long term solution. Since it involves only the flow of water (uphill & downhill), it has relatively minimal environmental impact. For batteries, a special consideration is degradation. Batteries degrade as they age, decreases the amount of capacity they can store. The expected life of the batteries is about 10 to 15 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. Furthermore, the MoEF&CC has issued Battery Waste Management Rules, 2022 to ensure proper collection and recycling/refurbishment of waste batteries and use of recovered materials from wastes into new batteries. This will ensure environmentally sound management of waste batteries.

However, there are few disadvantages of BESS as outlined below:

- **Capital intensive/High upfront cost:** The initial investment required to purchase and install a BESS can be expensive specially for individuals or small organisations. BESS capex also depends on the commodity prices and the volatility in commodity prices can impact the BESS capex.
- **Size restrictions and life**: Batteries have limited energy density i.e. they can only store a certain amount of energy per unit of weight and volume. Also, batteries naturally lose their charge over time, even when not in use. Additionally, batteries have a limited number of charge-discharge cycles before their capacity begins to degrade. This may lead to inferior performance and shorter lifespan.
- **Safety:** Improper design, installation or maintenance of batteries can be hazardous. That may lead to issues such as overheating, fire, or even explode if handled incorrectly.
- **Environmental impact:** Mining of various materials used for battery manufacturing can impact the environment Additionally, the production and disposal of BESS can have adverse environmental impacts, including greenhouse gas emissions, water pollution, and waste generation.
- **Recycling:** Battery technology itself is in nascency. The recycling of lithium-ion batteries, in particular, is not yet developed and hence efficient and sustainable recycling of these batteries can be challenging.
- There aren't very many large size / utility scale BESS installation in India and hence there are not many data points available on the performance of the BESS.

6 Leading Project developers

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 (1.32 GW operational solar), Renew Power (~8.3 GW operational wind & solar), Adani Green Energy (~10.9 GW operational wind, solar and hybrid), NTPC Green Energy (~3.5 GW operational solar and wind), TATA Power RE (~4.5 GW operational solar and wind), Greenko (5.4 GW operational wind and solar) and Avaada Energy (operational ~4 GW Solar) as of 31st March 2024. These players also have sizeable quantum of capacity under consideration/development.

Table 16: Key competitors

Parameter	ACME Solar	ReNew Power	Adani Green Energy	JSW Neo	NTPC Green Energy	TATA Power RE Ltd.	Avaada Energy	Greenko
Ownership/Group	ACME Group	Renew Group	Adani Group	JSW	NTPC	TATA Power	Avaada Group	Greenko group
Years in Business (As on 30/06/2024)	~16 Yrs	~14 Yrs	~9 Yrs	~3 Yrs	~2 Yrs	~17 Yrs	~16 Yrs	~20 Yrs
Operational capacity (GW) as on 30th June 2024	Solar: 1.34	Solar:5.0 Wind:4.6	Solar:7.4 Wind:1.7 WSH:2.1	Solar:0.7 Wind:3.8	Solar:2.9 Wind:0.1	Solar:3.7 Wind:1.0	Solar:4.0	Solar: 2.2 Wind: 3.2
Under construction/ Development capacity (GW) as on 30st June 2024	Solar 1.8 @ Wind 0.15 Hybrid 0.83 FDRE 1.25	Solar:3.6 Wind:2.1	Solar:16.8 Wind:2.4 WSH:2.7	Wind:1.8 Wind: 1.0 (pipeline) Solar: 5.7 (pipeline)	Solar: 9.7 Wind: 2.0	Solar:1.0 Hybrid: 4.4	Pipeline capacity of 11 GW across solar, WSH	NA
Solutions offered	Renewable IPP, RTC Storage Hybrid, FDRE	IPP Corporate PPA Green credits Energy management RTC/Storage Solar PV manufacturing	IPP Corporate PPA RTC/ Storage Solar Park development	IPP RTC/ Storage	IPP RTC/ Storage	IPP Corporate PPA RTC/Storage Rooftop solar Solar PV manufacturing	IPP RTC/ Storage Corporate PPA Solar PV manufacturing	IPP RTC/ Storage Corporate PPA
Key Offtakers for operational capacity	SECI, NTPC, GUVNL, CSPDCL, MSEDCL,	SECI, MSEDCL, APSPDCL, GUVNL,	SECI, NTPC, PTC, TANGEDCO, Karnataka ESCOMS,	SECI, AP, HP, Maharashtra, Rajasthan, Telangana, PTC, Open	SECI, GUVNL, RUMSL, IREDA, NVVNL, REC/NTPC	SECI, SJVN TANGEDCO APDISCOMs GUVNL	Corporates, Gujarat Haryana, Karnataka, Maharashtra,	Central Counterparties (SECI, NTPC) JVVNL GUVNL,

Parameter	ACME Solar	ReNew Power	Adani Green Energy	JSW Neo	NTPC Green Energy	TATA Power RE Ltd.	Avaada Energy	Greenko
	UPPCL, MPPMCL, PSPCL, TSNPDCL, TSSPDCL, APSPDCL, NBPDCL & SBPDCL	MPPMCL, TSNPDCL, NTPC, PTC, Corporates etc.	UPPCL, PSPCL, MSEDCL, GUVNL, TSSPDCL, MPPMCL, Merchant etc.	Capacity, Others etc.	MPPMCL Raj. Discoms AP Discoms UPPCL Telangana Discoms etc.	BESCOM UPPCL NPCL MSEDCL TPCD KSEB MPPCL JVVNL, JdVVNL , Others	NHPC, SECI, UP	Discoms and third-party consumers

@ Additionally, ACME has secured a capacity of 350 MW and 300 MW from SECI and SJVN in July and August 2024 respectively.
NA: Not available Source: Company websites, Annual Reports, CRISIL MI&A-Consulting

- ACME is one of the largest renewable IPP in India and is among the top 10 renewable energy company in terms of operational capacity as on June 30, 2024, in India
- ACME Group has been one of the early entrants in the solar IPP business in India among the top 10 renewable energy companies

The following table summarises the competitive analysis of ACME Solar Holdings with 2 publicly listed IPPs.

Table 17: Competitive analysis with a publicly listed IPPs

INR Millions	ACME[1]					ACME[1] Adjusted for Acquisition /Divestment			Adani Green					ReNew				
Particulars	Q1 FY25 (A)	Q1 FY24 (A)	FY 24 (A)	FY 23 (A)	FY 22 (A)	FY 24 (A)	FY 23 (A)	FY 22 (A)	Q1 FY25 (UA)	Q1 FY24 (UA)	FY 24 (A)	FY 23 (A)	FY 22 (A)	Q1 FY25 (UA)	Q1 FY24 (UA)	FY 24 (A)	FY 23 (A)	FY 22 (A)
Operational Capacity (MW)	1,340	1,459	1,340	1,459	1,159	1,340	1,459	1,159	10.934	8,316	10,934	8,086	5,410	9,600	8,100	9,400	7,880	7,470
Average CUF (%)	26.99 (S)	25.12 (S)	24.59 (S)	22.08 (S)	21.93 (S)	24.59 (S)	22.08 (S)	21.93 (S)	25.4 (S) 36.2 (W) 46 (H)	26.9 (S) 38.7(W) 47.2 (H)	24.5 (S) 29.4 (W) 40.7 (H)	24.7 (S) 25.2 (W) 35.5 (H)	23.8 (S) 30.8 (W)	27.2 (S) 28.4 (W)	27.5 (S) 29.9 (W)	25 (S) 28 (W)	25 (S) 27 (W)	23.3 (S) 26.4 (W)
Average Grid Availability (%)	99.46 (S)	99.11 (S)	99.40 (S)	99.37 (S)	99.30 (S)	99.40 (S)	99.37 (S)	99.30 (S)	99.7 (S) 99.8 (W) 100 (H)	98.5 (S) 99.1(W) 99.6 (H)	99.5 (S) 99.3 (W) 99.8 (H)	99.4 (S) 92.1 (W) 99.2 (H(	N/A	N/A	N/A	N/A	N/A	N/A
Average Plant Availability	99.36 (S)	99.57 (S)	99.41 (S)	99.23 (S)	99.69 (S)	99.41 (S)	99.23 (S)	99.69 (S)	99.4 (S) 96.8 (W) 99.7 (H)	99.7 (S) 94.6 (W) 99.1 (H)	99.7 (S) 95.5 (W) 99.5 (H)	99.6 (S) 94.3 (W) 99.1 (H)	N/A	N/A	N/A	N/A	N/A	N/A
Revenue from Operations	3,096	3,691	13,193	12,949	14,879	10,676	NA	NA	28,340	21,620	92,200	77,760	51,330	22,988	21,359	81,948	79,328	62,043
Total Revenue	3,400	4,266	14,663	13,614	15,627	11,906	NA	NA	31,220	25,500	1,04,600	86,170	55,770	24,903	24,659	96,531	89,309	69,195

INR Millions	ACME[1]					ACME[1] Adjusted for Acquisition /Divestment			Adani Green					ReNew				
Particulars	Q1 FY25 (A)	Q1 FY24 (A)	FY 24 (A)	FY 23 (A)	FY 22 (A)	FY 24 (A)	FY 23 (A)	FY 22 (A)	Q1 FY25 (UA)	Q1 FY24 (UA)	FY 24 (A)	FY 23 (A)	FY 22 (A)	Q1 FY25 (UA)	Q1 FY24 (UA)	FY 24 (A)	FY 23 (A)	FY 22 (A)
EBITDA	2,717	3,217	10,891	11,726	12,403	8,579	NA	NA	26,220	21,310	75,860	49,900	35,110	17,633	16,564	58,648	54,416	36,091
EBITDA Margin (%) (as a % of Revenue from Operations)	87.75	87.15	82.56	90.55	83.36	80.36	NA	NA	92.52	98.57	82.28	64.17	68.4	76.71	77.55	71.57	68.60	58.17
PAT	14	823	6,978	(32)	620	119	NA	NA	6,290	3,230	12,600	9,730	4,890	394	2,983	4,147	(5,029)	(16,128)
PAT Margin (%) (as a % of Total Revenue)	0.41	19.3	47.59	(0.23)	3.97	1.00	NA	NA	20.15	12.67	12.05	11.29	8.77	1.58	12.10	4.30	(5.63)	(23.31)
Net debt/ Equity (x)	3.89	3.68	2.66	3.85	3.56	2.66	NA	NA	NA	NA	2.90	6.28	18.49	4.86	4.03	4.48	3.69	2.88
Cash RoE (%)	2.93#	8.02#	38.83	25.34	31.87	8.48	NA	NA	NA	NA	18.13	30.19	51.19	4.28#	6.08#	17.86	9.18	(1.87)
Days Sales Outstanding (DSO)	112	140	116	197	228	144	NA	NA	NA	NA	53	104	129	69	87	61	99	264

(W): Wind; (S): Solar and (H): Hybrid (A):Audited; (UA): Unaudited

Note: 1. - Average CUF, average grid availability and average plant availability includes calculations for installed capacity at the end of the period & excludes assets which were monetized during the period.

Presently, Adani Green and Renew are the only two listed comparable renewable energy players operating in India

Source: Company, Company websites, Annual Reports, Filings, CRISIL MI&A Consulting

Formulae used:

EBITDA: Earnings before interest, tax, depreciation, and amortization (Profit before tax + Finance cost + Depreciation and amortization expense - Other income - Exceptional items)

EBITDA margin: EBITDA / Revenue from operations

PAT: Profit after tax

PAT margin: PAT / total revenue

Cash RoE: (Profit after tax + Depreciation) / Equity; Cash ROE is not a financial metric related to a renewable energy sector specifically. The terminology is used as a measure of capital efficiency with focus on cash profit. It is calculated as a cash profit (profit after tax plus depreciation) for the year divided by equity. Given that the companies operate in a capital-intensive business with high depreciation and interest cost, profit may not represent the companies' performance accurately, accordingly Cash ROE has been used to describe the companies' performance. The operational life of solar power plants is around 30 years and depreciation is not a cash flow.

Net Debt/Equity: (Long term borrowing + Short term borrowing – Cash and cash equivalents – Other bank balances)/ Equity

DSO: Closing trade receivables divided by Revenue from Operations multiplied by 365 for yearly or 91 for quarterly calculations.

#Not annualized.

7 Threats and Challenges

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 ~70 GW of RE, only ~20 GW of conventional capacity is added over last 5 years.
- 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 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. Proposed amendment to 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 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.

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, with competitive tariffs, payment security mechanism, diversification in counter parties largely mitigates the counterparty credit risk.
- 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, 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 of 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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