Market Intelligence
& Analytics

CRISIL
An S&P Global Company

Continuum Green Energy Limited

Strategic assessment of power and renewable energy Market in India

Final report

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Consulting

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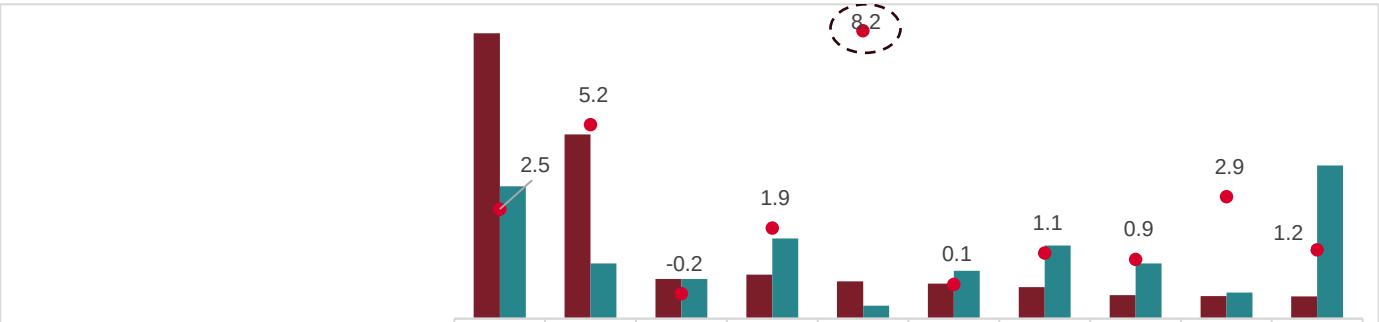
1 Overview of Indian macroeconomic landscape

1.1 Economic indicators

India's gross domestic product (GDP) at constant (fiscal 2012) prices was Rs. 173.8 trillion (provisional estimates) for fiscal 2024 as per the 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 FY 2023, according to the International Monetary Fund's (IMF) World Economic Outlook (April 2024). As per IMF GDP Forecasts, India's GDP growth is estimated at 6.5% in fiscal 2025, the highest amongst the top 10 economies. World Bank has also forecasted India's GDP to grow at 7% in fiscal 2025.

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



	United States	China	Germany	Japan	India*	United Kingdom	France	Italy	Brazil	Canada
Nominal GDP (Tn USD) CY23	27.36	17.66	4.46	4.21	3.57	3.34	3.03	2.26	2.17	2.14
Per capita electricity 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*

Indian GDP has been growing consistently. In the last 10 years, except for years affected by COVID-19, India's growth has been highest amongst the top 10 economies and other emerging countries as well. With the receding risk of global recession, India has been identified as an economic growth center by various International Agencies as well as global rating firms.

GDP grew 6.7% on-year in the first quarter of fiscal 2025, in line with CRISIL 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, the gross value added (GVA) growth of 6.8% was slightly higher than 6.7% GDP growth. In April 2024, IMF released World Economic Outlook. As per IMF, Economic activity was surprisingly resilient through the global disinflation of CY 2022–23. IMF estimated global growth at 3.2% in CY 2023, is projected to continue at the same pace in CY 2024 and CY 2025. Growth in India is projected to remain strong at 7% in 2024 and 6.5% in 2025, with the robustness reflecting continuing strength in domestic demand and a rising working-age population.

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

Country	CY24	CY25	CY26	CY27	CY28	CY29
India*	7.0	6.5	6.5	6.5	6.5	6.5
Brazil	2.1	2.4	2.1	2.0	2.0	2.0
Canada	1.3	2.4	1.9	1.7	1.7	1.7
China	5.0	4.5	3.8	3.6	3.4	3.3

Country	CY24	CY25	CY26	CY27	CY28	CY29
France	0.9	1.3	1.6	1.5	1.4	1.3
Germany	0.2	1.3	1.5	1.1	0.8	0.7
Italy	0.7	0.9	0.2	0.3	0.8	0.8
Japan	0.7	1.0	0.8	0.6	0.6	0.4
United Kingdom	0.7	1.5	1.7	1.7	1.6	1.4
United States	2.6	1.9	2.0	2.1	2.1	2.1

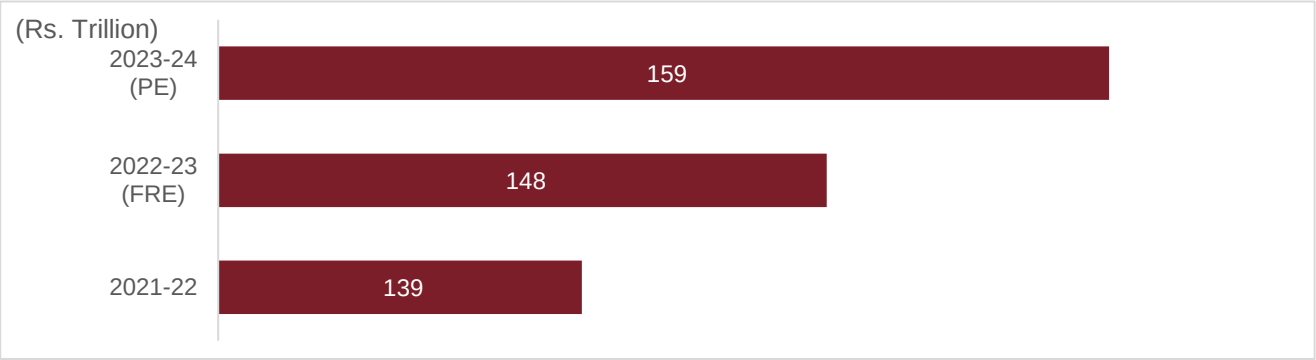
**For India financial Year.*

Source: IMF, CRISIL MI&A Consulting

1.2 GVA performance

The real GVA has grown by 7.2% in FY 2023-24 over 6.7% in FY 2022-23. This GVA growth has been mainly due to significant growth of 9.9% in Manufacturing sector in FY 2023-24 over -2.2% in FY 2022-23 and growth of 7.1% in FY 2023-24 over 1.9% in Mining & Quarrying sector.

Figure 2: GVA at basic prices



FRE: first revised estimates; PE: provisional estimates
Source: Ministry of Statistics and Programme Implementation, CRISIL MI&A-Consulting

1.3 Outlook

1.3.1 Consumer Price Index

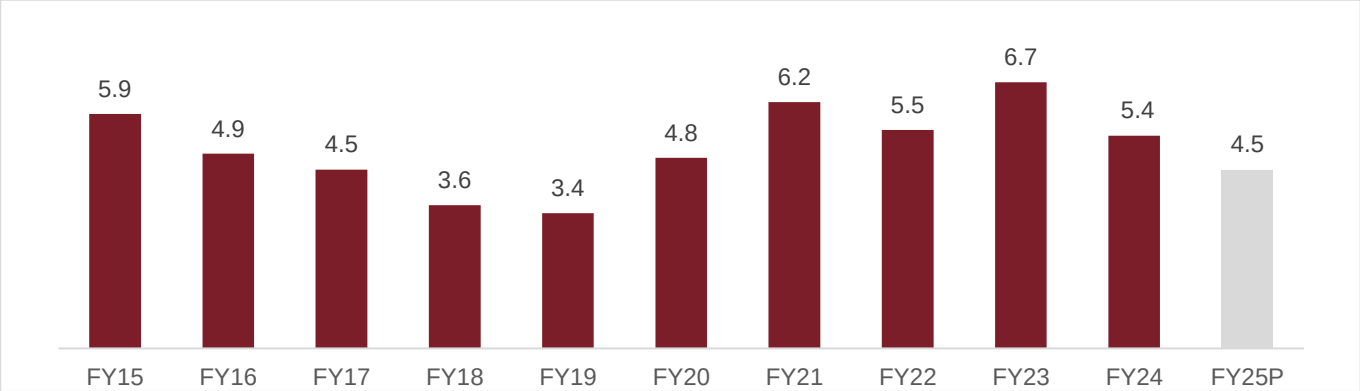
Though inflation based on the Consumer Price Index (CPI) inched up to 3.7% in August 2024 from 3.6% in July 2024, it remained below the Reserve Bank of India's (RBI) target of 4% for the second straight month. While the base effect has been supportive since July 2024 (mainly led by the food index), it somewhat faded in August 2023, causing the inflation rate to see a slight bump up. Food inflation rose to 5.7% in August 2024 from 5.4% in July 2024. That said, the sequential decline in prices kept a check on food inflation. Within food, the foodgrains inflation eased to a two-year low of 8.6%, while that in vegetables rose, compared with July 2024. Core (which excludes food and fuel) inflation eased 10 bps to 3.3% in August 2024.

A high base has helped keep inflation under 4% since July 2024. But September onwards, this effect is expected to fade considerably. Any further easing of inflation will depend on sustained softening of food prices.

For the fiscal 2025, the steady progress of monsoon and kharif sowing should bring down food inflation, compared with the past fiscal. Daily food prices show that the prices of key food items, such as cereals, pulses, tomatoes and milk have been declining in September 2024. A sustained drop in food inflation should help align the headline inflation to RBI's target of 4%, allowing RBI to initiate rate cuts.

Non-food inflation is expected to remain benign as commodity prices are projected to remain soft. CRISIL MI&A Consulting expects crude oil prices to average $80-85 per barrel, close to the levels of the previous year.

Figure 3:CPI inflation (%, y-o-y)



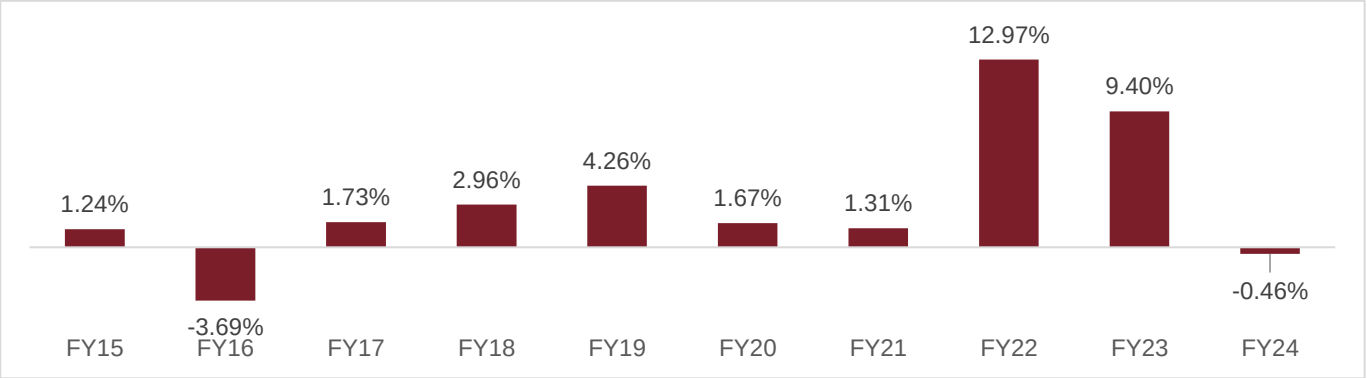
P: Projected; Source: NSO, CEIC, CRISIL MI&A-Consulting

1.3.2 Wholesale Price Index

Wholesale prices edged down in August 2024, easing to a four-month low as food as well as non-food inflation cooled. The Wholesale Price Index (WPI) inflation eased to 1.3% in August 2024 from 2% in July 2024.

Wholesale food inflation slowed to 3.3% in August 2024 from 3.6% a month earlier led by lower food grains inflation (10.3% in August vs 11.1% in July) and deeper deflation in vegetable prices (-10% in August vs -8.9% in July). Non-food inflation eased for the first time in five months to 0.5% in August 2024 from 1.4% in July 2024. Sequentially, non-food prices were broadly steady. Wholesale fuel and power inflation turned negative in August 2024, improving to -0.7% from 1.7% a month earlier, helped by a sharp fall in crude oil inflation (-1% vs 9.2% in July) in line with global trends. The wholesale index for manufacturing products also eased to 1.2% in August 2024 from 1.6% in July 2024.

Figure 4:WPI inflation (%, y-o-y)



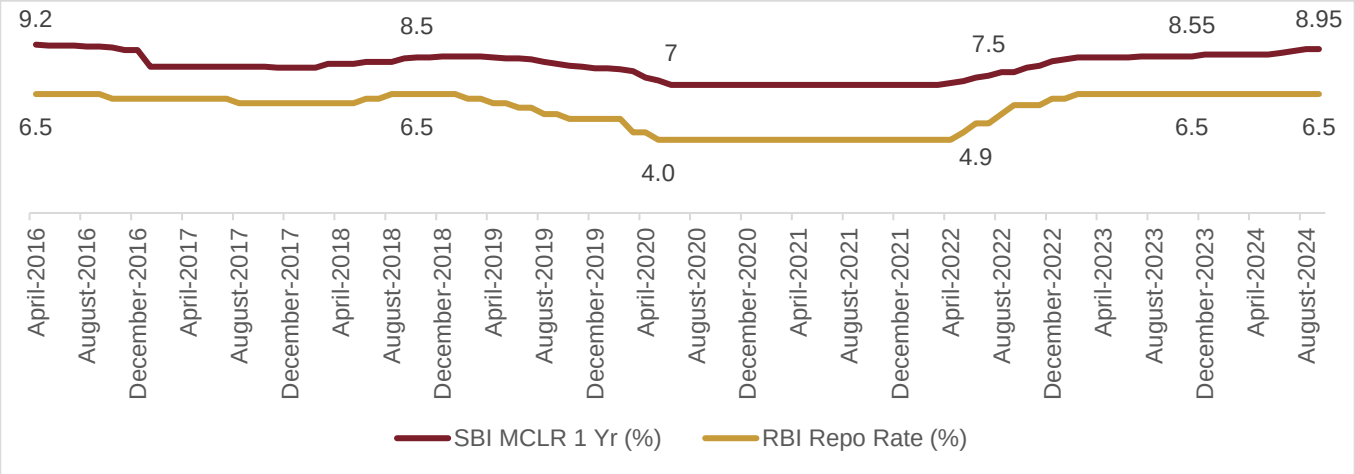
Source: NSO, CEIC, CRISIL MI&A-Consulting

1.3.3 Interest Rate

Focused on paring inflation towards its 4% target and comforted by high GDP growth, the Monetary Policy Committee (MPC) kept the repo rate unchanged for the tenth straight time at its October 2024 meeting. The last time RBI changed policy rates was in February 2023. The RBI has raised the repo rate by 250 basis points (bps) since March 2022.

Compared to March 2023, the 1-year marginal cost of lending rate (MCLR) has seen an increase of 45 bps. It has risen 195 bps since March 2022. Bank lending rates are above their pre-pandemic average, and higher lending rates could lead to some softening in bank credit going forward.

Figure 5: Interest rates increasing (%)



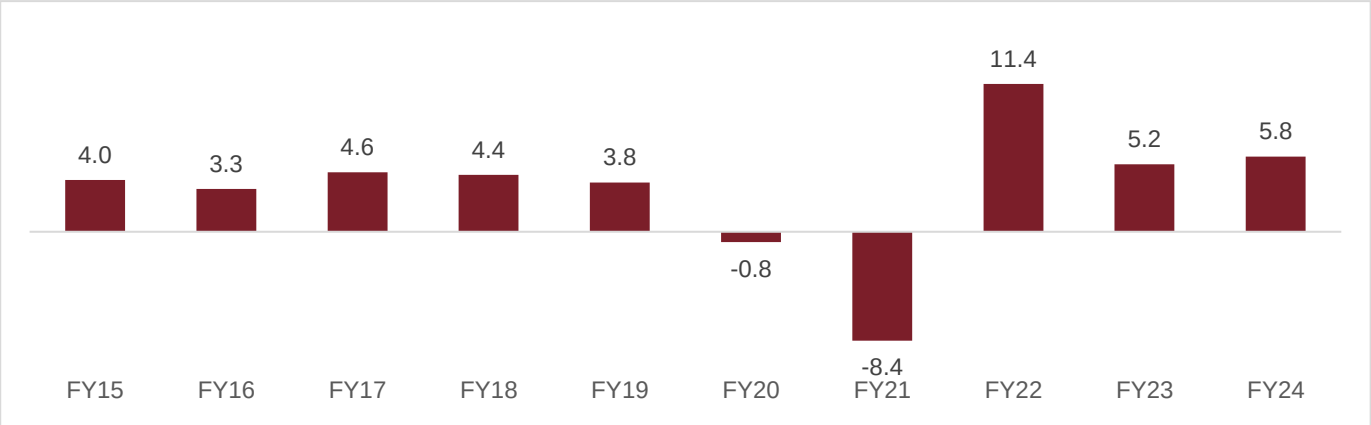
Source: RBI, SBI, CRISIL MI&A-Consulting

The Fed began cutting rates in September 2024 while the European Central Bank and Bank of England have already begun cutting rates since June 2024. Easing policy rates globally, particularly by the Fed, will give space to the RBI for a rate cut this fiscal. Domestic inflation remains a key gauge for the RBI's monetary policy decision. Elevated food prices have been the biggest hurdle in shifting its stance so far. However, conditions are turning favourable for a rate cut. Monsoon continued to fare well (7% above long period average as of September 19), and kharif sowing remained higher on-year.

1.3.4 IIP Trend

Index of Industrial Production (IIP) is an indicator that measures the changes in the volume of production of industrial products during a given period. IIP growth rate for fiscal 2024 over fiscal 2023 stood at 5.8%. The cumulative growth rates of the three sectors, Mining, Manufacturing and Electricity for the fiscal 2024 over the corresponding period of the previous year were 7.5%, 5.5% and 7.1% respectively.

Figure 6: Comparison of growth rates of Mining, Manufacturing and Electricity

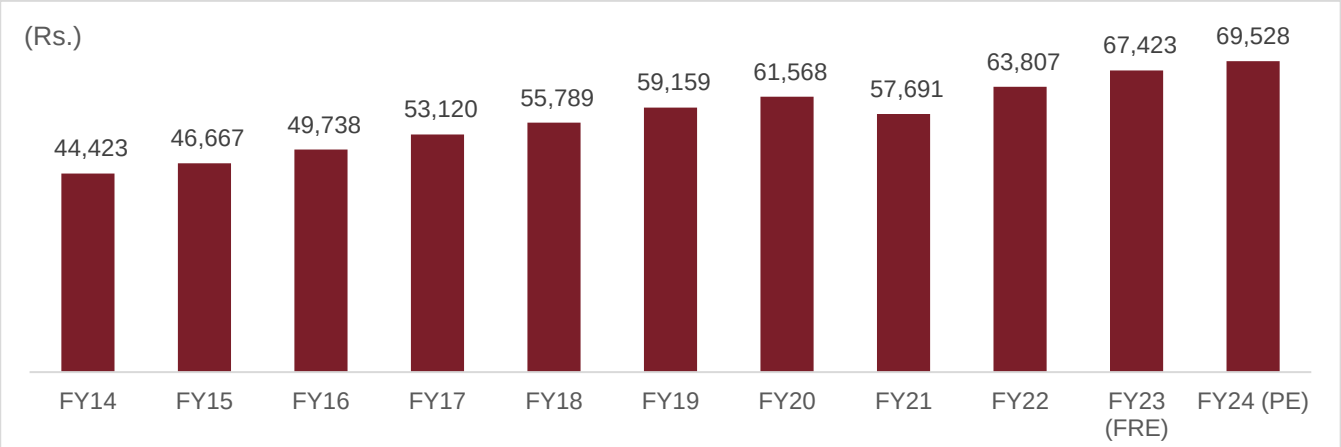


Source: NSO, MOSPI, CRISIL MI&A Consulting

1.3.5 Private Final Consumption Expenditure

The Private Final Consumption Expenditure (PFCE) is defined as the expenditure incurred on final consumption of goods and services by the resident households and non-profit institutions serving households (NPISH). India's per capita PFCE is expected to rise to Rs 69,528 in fiscal 2024 from Rs 44,423 in fiscal 2014 with a compound annual growth rate of 4.6%. In fiscal 2024, per capita income is expected to rise by 3.1% against 5.7% in fiscal 2023.

Figure 7: All-India per capita PFCE (at constant price)



Source: NSO, MOSPI, CRISIL MI&A Consulting

1.4 Assessment of the long-term potential drivers

Domestic economic growth hinges on revival in private consumption, lowering of banks' non-performing assets (NPAs), improvement in the investment climate and many more such factors. The GoI has taken the following steps in this regard:

- *Post-pandemic policies to revive the economy:* The Indian government has initiated several measures to revive the economy from the pandemic-induced stress, including SIDBI schemes for special liquidity support to micro, small and medium enterprises (MSMEs), state compensation schemes, increase in the threshold of default under Section 4 of the Insolvency and Bankruptcy Code, 2016 (IBC), among others. These are short-term measures, but likely to support long-term growth of the country as the economy recovers from the pandemic

- *Union Budget 2023-24:* The growth-centric and expansionary budget of fiscal 2024 focuses on giving a boost to investment in infrastructure and productive capacity, ultimately leading to rise in growth and employment. Some of the key announcements include:
  - Rs 10 Tn capital investment, a steep increase of 33% for the third year in a row, to enhance growth potential and for job creation, crowd-in private investments, and provide a cushion against global headwinds.
  - Investment of Rs 750 Bn, including Rs 150 Bn from private sources, for 100 critical transport infrastructure projects, for last- and first-mile connectivity at ports, coal, steel, fertilisers, and food grains sectors.
  - **New Infrastructure Finance Secretariat** established to enhance opportunities for private investment in infrastructure.
  - Continuation of 50-year interest-free loan to state governments for one more year to spur investment in infrastructure and to incentivise them for complementary policy actions.
  - Capital outlay of Rs 2.40 Tn has been provided for the railways
  - **Urban Infrastructure Development Fund (UIDF)** will be established through use of priority sector lending shortfall, which will be managed by the National Housing Bank, and will be used by public agencies to create urban infrastructure in Tier 2 and Tier 3 cities.
- *Union Budget 2024-25:* The key budgetary allocations of Rs 0.52 trillion and Rs 0.87 trillion were made to the MNRE and MoP, respectively. The allocation in key schemes under MNRE increased 25% from that announced in the interim budget owing to 16% higher allocation to the IREDA and PM- *Surya Ghar Muft Bijli Yojana* of Rs 6.25 billion for fiscal 2025 BE
  - Following the announcement of viability gap funding (VGF) support for Battery Energy Storage Systems (BESS) in February's interim budget, the government further announced removal of basic customs duty (BCD) on critical minerals, such as lithium and cobalt from the existing rate of 5%
  - Continued exemption for capital goods used in manufacturing photovoltaic (PV) cells and panels also announced, and the exemption of BCD for solar glass removed.
- *Monetary policy:* In its monetary policy in April 2022, the RBI had replaced the reverse-repo rate with a new standing deposit facility (SDF) rate as the floor of the policy corridor under the liquidity adjustment facility (LAF). The marginal standing facility (MSF) rate will remain at the corridor's upper end. The central bank restored the LAF policy corridor to the pre-pandemic symmetric width of 50 bps. Thus, the SDF will move 25 bps below, and MSF will stand 25 bps above the repo rate. In its monetary policy statement dated 9th October 2024, the Monetary Policy Committee (MPC) decided to keep the policy repo rate under the liquidity adjustment facility (LAF) unchanged at 6.50%. The SDF rate remained unchanged at 6.25% and the marginal standing facility (MSF) rate and the Bank Rate at 6.75%. The MPC also decided to change the monetary policy stance to 'neutral' and to remain unambiguously focused on a durable alignment of inflation with the target, while supporting growth.
- *Boost infrastructure:* The capital expenditure and effective capital expenditure, which are budgeted at Rs10 Tn and Rs 13.7 Tn will account for 3.3% and 4.5% of GDP, respectively. The Budget speech 2024 also enumerated the measures to be undertaken by the GoI to support the states and the private sector in boosting investments in infrastructure.
- *Thrust on manufacturing:* The government has made some progress in improving labour market efficiency through various programmes such as Skilling India and Make in India. The sector has shown strong resilience despite lockdowns and has remained above the 50 (the mark separating expansion from contraction). However, the overall reform process remains gradual in the manufacturing sector

  - *Consumption growth:* Given the favourable demographics and rising disposable income, the growing middle-class population is expected to help recover and eventually spur consumption growth in India. However, amid the raging pandemic, keeping inflation and interest rates in check is important to support consumption

- *Digitalisation:* The government has been quick to board the technology bandwagon with its Digital India programme, which aims to speed up financial inclusion and deliver government services electronically, by increasing internet connectivity and improving online infrastructure. Digitisation and digitalisation will create an efficiency-led growth spurt over the medium term. In the 2023-24 budget, the government announced certain initiatives in the digital space, including Digital Public Infrastructure for Agriculture, National Digital Library for Children and Adolescents, fintech services, Skill India digital platform, data embassy, fiscal support for digital public infrastructure, etc.

1.4.1 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 6 Mn new jobs (as per government estimates).

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

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

Table 2: Sector-wise focus of *Aatmanirbhar Bharat* Vision

Sector	Government spend	Key schemes
Renewable energy	~Rs 1.3 Tn	• Rs 45 Bn Production Linked Incentive Scheme 'National Programme on High Efficiency Solar PV Modules'. This was further increased by Rs 195 Bn in the budget for fiscal 2023, taking it to Rs 240 Bn; in Tranche I 8.7 GW and in Tranche II 39.6 GW capacity were allocated for domestic solar module manufacturing capacity under PLI. • PM Surya Ghar Muft Bijli Yojna: This scheme has a proposed outlay of Rs. 750 Bn and aims to light up 10 Mn 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 FY 2022 with central financial support of Rs 344.22 Bn. 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

Sector	Government spend	Key schemes
Power distribution companies (discoms)	~Rs.970 Bn	• Rs 1.35 Tn 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 3037.58 Bn over 5 years i.e., fiscals 2022 to 2026. The outlay includes an estimated Government Budgetary Support (GBS) of Rs 976.31 Bn.
New Energy	Rs. ~388 Bn	• Rs 181 Bn 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 197.44 Bn with an aim to boost domestic production of green hydrogen

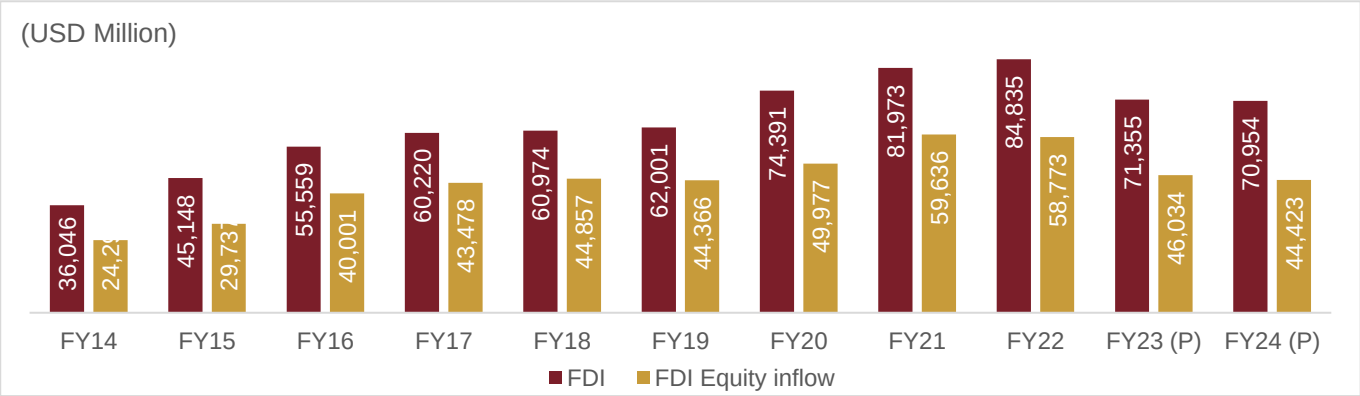
Source: Official portal of the Government of India; various ministries, PIB press releases, CRISIL MI&A-Consulting

1.4.2 Foreign Direct Investment

India remains one of the most popular FDI destinations in the world, ranking as the eighth-largest recipient of FDI in 2023, the third-highest recipient of FDI in greenfield projects and the second-highest recipient of FDI in international project finance deals according to the World Investment Report 2023.

Equity inflows declined to USD 44.42 billion in fiscal 2024 (3.49% decline over fiscal 2023) due to lower infusion in sectors such as services, computer hardware and software, telecom, auto and pharma. During fiscal 2024, the total FDI (includes equity inflows, reinvested earnings, and other capital) declined by ~1% marginally by over fiscal 2023o USD 70.95 billion during fiscal 2024 from USD 71.35 billion in fiscal 2023. It is pertinent to note that India received the highest ever FDI inflows of USD 84.83 billion in fiscal 2022.

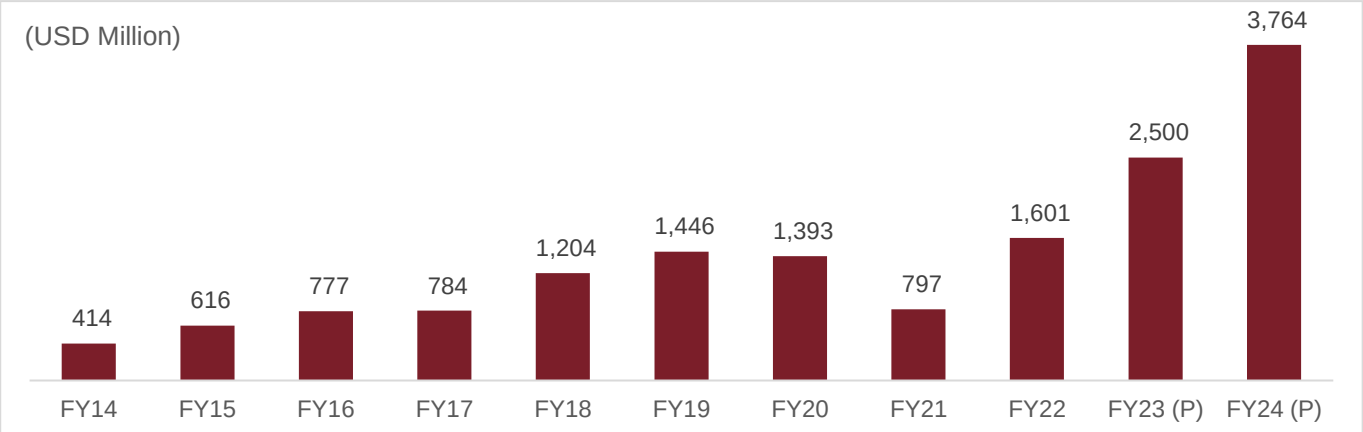
Figure 8: FDI inflows in India



Source: DPIIT; CRISIL MI&A

Under the extant Foreign Direct Investment (FDI) policy of the Government of India, FDI in renewable energy sector (RE Sector) is permitted up to 100% under the automatic route. The equity inflow in renewable energy sector has increased from USD 414 million in fiscal 2014 to USD 3,764 million which is ~9 times of 2014. Except for COVID affected 2021, the FDI in renewable has been increasing consistently. This has been the highest ever investment in Indian renewable energy sector in a fiscal year. Strong government push with ambitious target of 500 GW of non-fossil fuel-based energy capacity by 2030 in order to reduce carbon intensity as agreed in the COPS is one of the primary reasons for such increase.

Figure 9: FDI equity flows in Indian RE sector



Source: DPIIT; CRISIL MI&A

1.5 Supreme Court judgement on Climate Change

Supreme Court, in its judgement dated 21 March 2024, ruled that climate change may impact the constitutional guarantee of the right to equality. This recognition by Supreme Court is a right step taken towards environmental laws in India. Supreme Court has also recognized that right to a climate change already exists within Article 14 (right to equality) and Article 21 (right to life) of the Indian Constitution and hence emphasized that there is a right to be free from the adverse effects of climate change. This interpretation is expected to bring radical changes in legal framework related to environmental issues. This pivotal Judgement will act as a stern warning to everyone involved—the government, private companies, community groups, and people—to make the health of the Earth and its people a top priority, guaranteeing a future that is both sustainable and fair for future generations.

With this, the Supreme Court recalled an earlier order of April 2021 that required undergrounding of overhead transmission lines across an area of over 80,000 sq km in Rajasthan and Gujarat after the Central government pointed out concerns on feasibility of implementing the order. The Court ordered to appoint an expert committee balance the need for the preservation of the Great Indian Bustard (GIB) which is nonnegotiable, on one hand, with the need for sustainable development, especially in the context of meeting the international commitments of the country towards promoting renewable sources of energy, on the other hand. By leveraging scientific expertise and engaging stakeholders in meaningful consultations. This will ensure that conservation efforts are grounded in evidence and inclusive of diverse perspectives. The Committee is expected to give its Report by end of July 2024. As India is striving for sustainable growth, it's crucial for legal frameworks to adapt the changing environmental conditions, ensuring basic rights are protected and promoting environmental fairness for current and upcoming generations.

The Court has recognized India’s commitment to clean energy adoption. The ambitious target for 2030 i.e. 450 GW of RE capacity underscores India's recognition of the urgent need to accelerate the transition towards renewable energy to mitigate the impacts of climate change and achieve sustainable development.

The Judgment establishes the duty of the State to maintain ecological balance and a hygienic environment. Even though the right to a clean environment has been acknowledged, the right against climate change will force the states to give preference to environmental protection and sustainable development.

1.6 Outlook on Carbon Reduction Emission measures and corresponding developments

1.6.1 United Nations Climate Change Conference

COP 26

The 2021 United Nations Climate Change Conference (COP 26) 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 draft agreement called on countries to phase out coal power and inefficient fossil fuel subsidies to reduce carbon emissions significantly in order to reach a goal of limiting global warming this century to 1.5 degree Celsius. The draft recognised that limiting global warming to 1.5 degrees Celsius would require rapid, deep and sustained reductions in global GHG emissions, including reducing global carbon dioxide emissions by 45% by 2030 relative to the 2010 level and to net-zero levels around mid-century. It also expressed alarm and concern that human activities caused around 1.1 degrees Celsius of global warming to date and that impacts were already being felt in every region. The conference expected the parties to make enhanced commitments towards mitigating climate change and improved national pledges. The proposal also aimed at updating the time frame for revised targets NDCs to 2022/2023 — much sooner than the requirement of every five years as laid out in the 2015 Paris Climate Accord.

COP26 was a landmark event, as it saw a number of important decisions including

- A commitment to phase down coal power and to accelerate the transition to clean energy.
- A commitment to reduce methane emissions by 30% by 2030.
- A commitment to provide $100 billion per year in climate finance to developing countries.

Some of the key outcomes of COP26:

- Glasgow Climate Pact: It includes a number of commitments, including a commitment to phase down coal power and to accelerate the transition to clean energy.
- Global Methane Pledge: Countries committed to work collectively to reduce methane emissions by at least 30% below 2020 levels by 2030.
- Adaptation Action Framework: New financial pledges were made to support developing countries in achieving goals
- Santiago Declaration on Forests and Land Use: The declaration committed to prevent and reverse forest loss and land degradation by 2030.

India has submitted its updated first NDC working towards climate justice after COP26. Some of the key NDCs are

- 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, with the help of transfer of technology and low-cost international finance including from Green Climate Fund (GCF)
- To create an additional carbon sink of 2.5 to 3 billion tonnes of CO2 equivalent through additional forest and tree cover by 2030.

These are more ambitious and way beyond the current 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.

Initially, India has set a target of 450 GW renewable energy installed capacity by 2030. Now, as per the revised target, India is expected to have 500 GW non fossil fuel-based capacity installed by 2030. The estimated total

installed capacity of India is expected to reach to 777 GW by March 2030. The 500 GW target is ~65% of the total estimated installed capacity which is almost 25% higher than the commitment in Paris agreement. At present India meets only ~21% of its power requirement from renewable energy. Similarly, the estimated energy requirement of India will be around 2,325 BUs by March 2030 which is ~1,626 BUs for fiscal 2024. The revised target is 50% of its energy requirements from renewable energy by 2030.

However, to achieve such an ambitious target, a whole host of innovative policies and financing measures will need to be adopted. Further, to accommodate such a high proportion of variable generation in the overall energy mix, there will be a need for additional investment in battery storage and green energy corridors for transmission of variable renewable energy. Given the thrust on RE capacity addition and energy efficiency measures, the emissions intensity is expected to decline. However, with revised targets, more efforts will be required in all these areas as well as non-energy sectors such as agriculture and land use.

2 Overview of Indian power sector

2.1 Evolution of power sector and its structure

Electricity is a concurrent subject in India with the **Ministry of Power**, Government of India (GoI), mainly being responsible for creating the overall policy framework for the power sector in the country. All state-level policies and issues come under the purview of the respective state governments.

All states and union territories have set up **electricity regulatory commissions (SERCs)** to regulate and determine tariffs for generation, transmission as well as distribution companies (discoms). The **Central Electricity Regulatory Commission (CERC)** fulfils this responsibility for inter-state generation and transmission and also for central power utilities. The **Appellate Tribunal** for Electricity **(APTEL)** was established to hear appeals against the orders of adjudicating authorities (SERCs, JERC and CERC).

Grid Controller of India Ltd (formerly Power System Operation Corporation Ltd) manages the national and regional grid through the National Load Despatch Center (**NLDC**) and its five-regional load-despatch centers (**RLDCs**). These entities operate in unison to ensure the integrated operation of the grid in a reliable, efficient and secure manner. While the NLDC controls the load flow within the country, the RLDCs and state load despatch centers (**SLDCs**) are responsible for ensuring the integrated operation of the power system in the concerned regions and states.

Central Transmission Utility of India Limited (**CTUIL**), 100% subsidiary of Power Grid Corporation of India Limited (**PGCIL**), is notified as the Central Transmission Utility **(CTU)** and is responsible to undertake transmission of electricity through the inter-state transmission system (ISTS) and other functions as per the provisions of Electricity Act 2003. The National Committee on Transmission (NCT) is responsible for planning and examining the proposals of ISTS scheme for approval. The state transmission utilities (**STUs**) are tasked with the development of the intra-state transmission system. The transmission lines are operated in accordance with regulations/ standards of Central Electricity Authority (CEA) / CERC / SERCs.

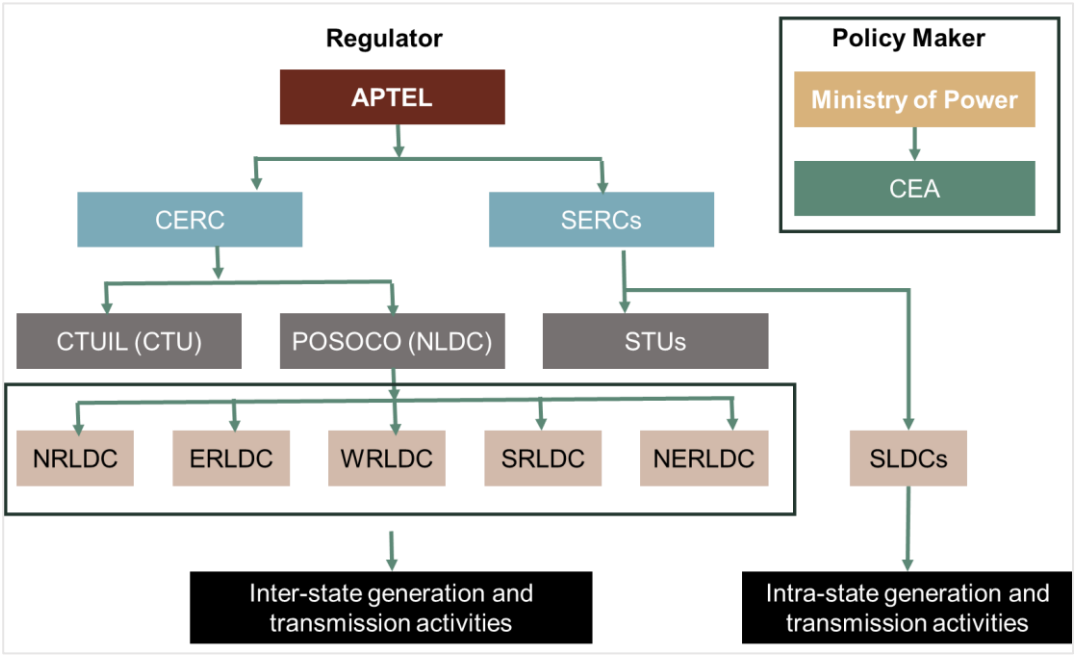
Power exchanges set up for trading of power and deepening markets are a distinct licensed activity (from generation, transmission and distribution) as recognised by the Electricity Act 2003. Power trading was introduced to meet the short-term requirement of electricity and to ensure optimum utilisation of power resources across regions, given demand-supply mismatches. **Several traders**, both Central government and the private sector, have established their presence; a few states have companies (e.g., Gujarat, Uttar Pradesh, Karnataka and Madhya Pradesh) to procure power on behalf of their state discoms.

The power distribution system is the last leg of the electricity value chain. The main function of the power distribution system is to provide power to the premises of individual consumers. Responsibility for distribution and supply of power to end-consumers rests with the states. The power distribution segment in India is largely dominated by the state government-owned distribution companies, although a few private entities are also present in the sector to serve end-consumers. Further, open access allows large consumers to procure power through traders, exchanges or via captive/group captive generation.

2.1.1 Operating and regulatory structure

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 10: Institutional and structural framework

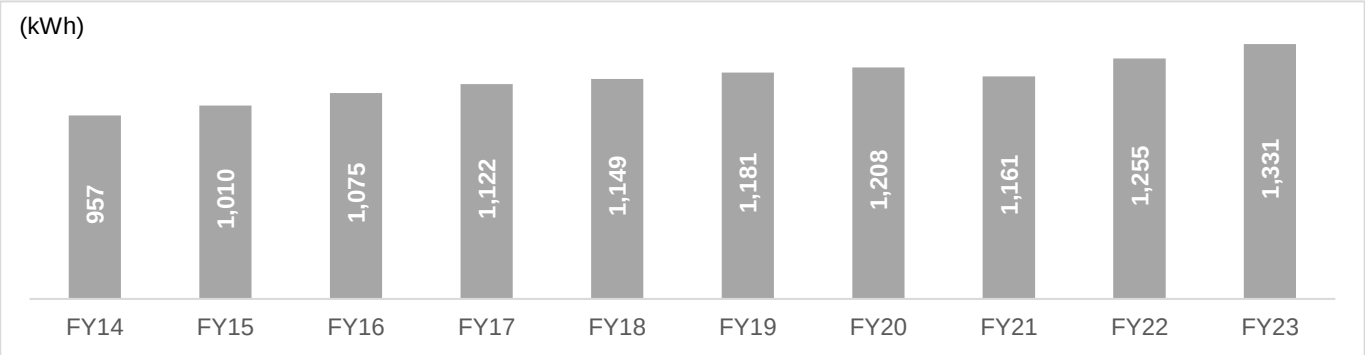


Note:
APTEL - The Appellate Tribunal for Electricity; CERC- Central Electricity Regulatory Commission; CEA- Central Electricity Authority; WRLDC- Western Regional Load Despatch Centre; ERLDC- Eastern Regional Load Despatch Centre; SRLDC- Southern Regional Load Despatch Centre; NLDC: National Load Despatch 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 Per capita electricity consumption of India remains significantly lower than the Global average of about 3.2 MWh/year

Electricity consumption per person rose to 1,331 kWh in fiscal 2023 (as per CEA's provisional data), from 957 kWh in fiscal 2015 at a CAGR of 3.7%, primarily led by increase in domestic consumption, rural electrification, strengthening of the transmission and distribution (T&D) network. Post successive on-year growth in consumption, demand declined in fiscal 2021, particularly from high-consuming industrial and commercial categories on account of weak economic activity following outbreak of the COVID-19 pandemic. In fiscal 2022, though, per capita consumption rebounded to 1,255 kWh on the back of recovery in demand, with a similar trend estimated in fiscal 2023. Similarly, the energy requirement grew at 4.4% CAGR over fiscals 2015 to 2023 i.e., from 1,069 BUs to 1,512 BUs.

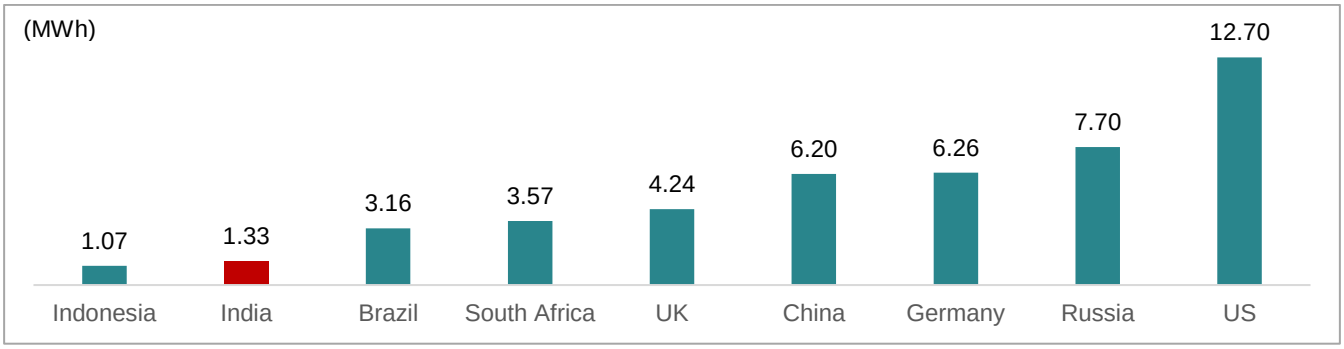
Figure 11: Per capita electricity consumption trends in India



Source: CEA, CRISIL MI&A Consulting

Despite this healthy increase, the per-capita electricity consumption remains significantly lower than other major as well as developing economies. The world's per capita electricity consumption is about 3.2 MWh. Developing countries, such as Brazil, Malaysia and China, have significantly higher per-capita electricity consumption than India.

Figure 12: Per-capita electricity consumption across countries in CY 2022

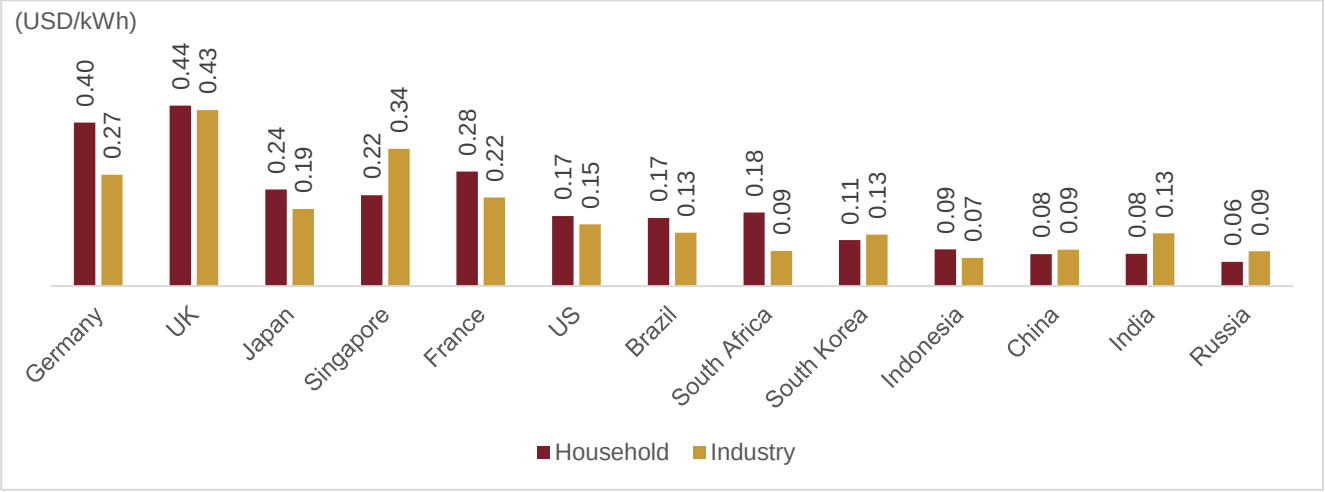


**India's data as of FY23; Source: World Bank, CRISIL MI&A Consulting*

India is still a developing economy and electricity expenditure constitutes a small percentage of the total household expenditure. Healthy economic growth is expected to increase per-capita income, in turn, resulting in higher disposable income available to spend on electricity. Also, the rise in income would improve the general standard of living, which, in turn, would further propel demand for electricity.

The chart below shows the price of electricity for households and industries across key economies. The prices include distribution and energy cost, various environmental and fuel cost charges and taxes. The world average price is 0.155 USD per kWh for household users and 0.151 USD per kWh for industries as of December 2023. The electricity prices in EU have lowered from 2022 levels but are still comparatively higher due to increase in energy taxes, discontinuation of energy price support measures. Industrial tariffs in India are competitive than developed countries but are still more than that of China, Indonesia, Russia, South Africa.

Figure 13: Industrial and household electricity tariff across countries in CY 2023



Source: CRISIL MI&A Consulting

2.3 Review of power demand supply scenario

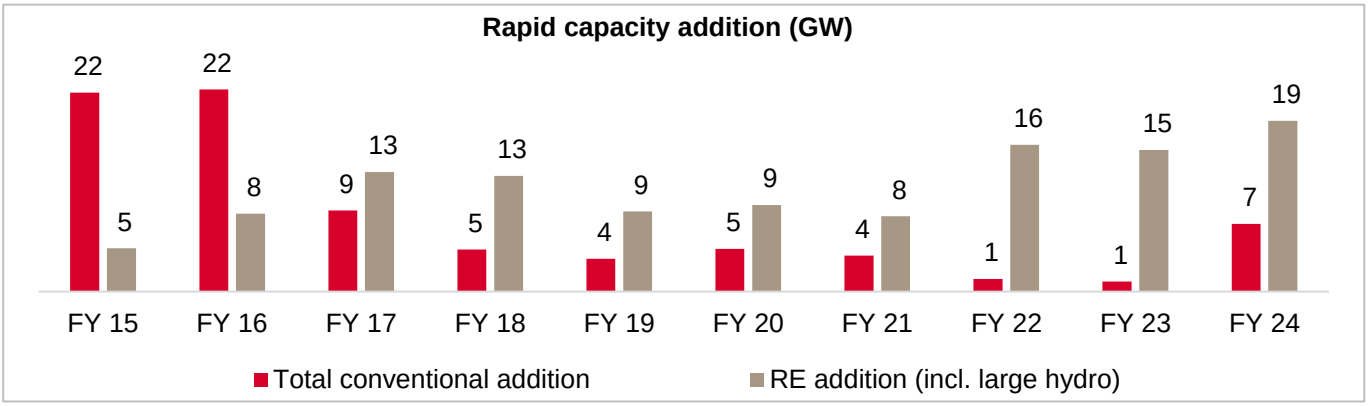
India witnessed robust growth in capacity addition over the past decade, led by delicensing of the power-generation business through the Electricity Act, 2003, followed by strong government thrust on RE through favourable policies and regulations.

2.3.1 Review of installed capacity and fuel mix

The total installed generation capacity as of March 2024 was ~442 GW, of which 194 GW of capacity was added over fiscal 2015-24. The overall installed generation capacity has grown at a CAGR of 5.4% over the same period.

Between fiscals 2013 and 2016, conventional power capacity addition, particularly coal-based, rose at a break-neck speed with an addition of ~80 GW. Renewable energy made significant inroads in the subsequent period until fiscal 2024 with the addition of 102 GW between fiscal 2017-24.

Figure 14: Historical Thermal and RE capacity addition trend

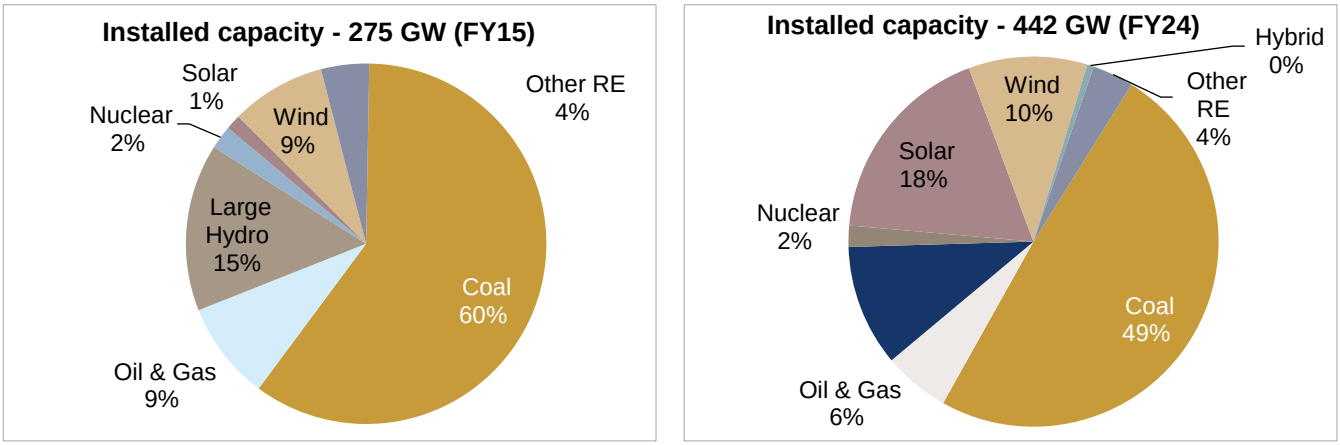


Source: CEA, CRISIL MI&A Consulting

Growth in gas and hydro-power capacities, however, remained muted over years. Between fiscals 2015 and 2024, ~6.4 GW hydro and 3.26 GW gas-based capacities have been added, leading to a change in the overall composition of installed capacity mix.

The share of coal-based and large hydro capacity in the overall installed capacity has declined to 49% (from 60%) and 11% (from 15%), respectively, between fiscals 2015 and 2024. Almost entire thermal capacity (93%) is added by government owned entities. The share of RE (excl. large hydro) in the overall installed capacity increased to ~32% in fiscal 2024 from ~14% in fiscal 2015. With continued government support, falling tariffs and strong investor interest, the share of RE (mainly solar and wind) is expected to rise further.

Figure 15: Fuel-wise breakup of generation capacity



Source: CEA, CRISIL MI&A Consulting

The percentage share of capacity addition from the private sector has also been on the rise. The total installed capacity from the private sector increased to 52% of the total installed capacity as of March 2024, compared with 39% as of March 2015.

As per CEA, about 15 GW of thermal capacity is expected to be commissioned in fiscal 2025 and the total thermal capacity of 26.8 GW is estimated to be added by fiscal 2030. Moreover, as on April 2024, a total of 157 GW of RE capacity is under various stages of development (89 GW under-construction and 67 GW is under-development stage) in the country which are expected to be completed by fiscal 2029.

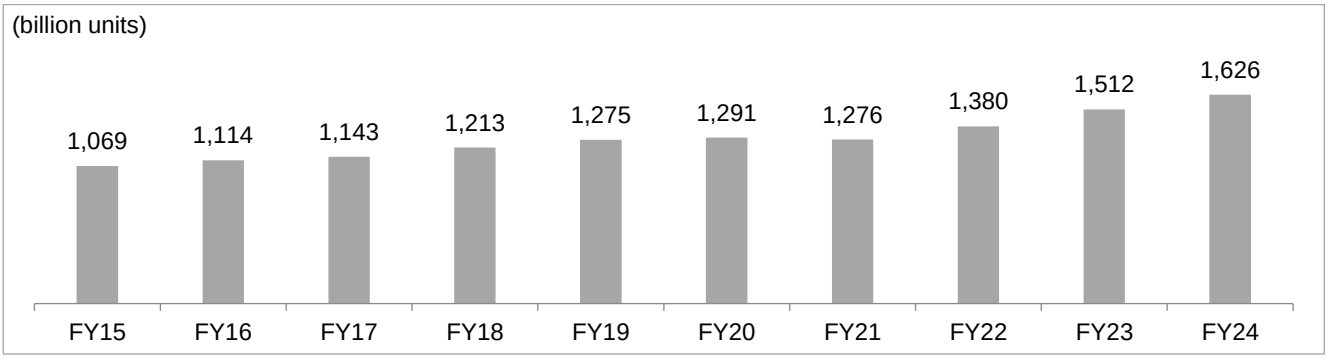
2.3.2 Energy requirements

Over the past 10 years (fiscals 2015 to 2024), energy requirement grew at a 5.0% CAGR. This was driven by rising power availability, gradual improvement in electricity access, rapid urbanisation, 24x7 power supply, make in India initiative driven by production linked incentive (PLI) schemes in various sectors, increasing per-capita income, railway electrification and continued government support.

On the other hand, certain factors – reduction in T&D loss, focus on energy efficiency and reduction in energy intensity in GDP mix with healthy growth in services sector – constrained growth in the energy requirement.

Energy-requirement growth had slowed down during COVID times, due to a slowdown in economic growth as well as weak financial health of power distribution companies, which restricted off-take. In fiscal 2023 and 2024, the energy requirement increased by 9.6% and 7.6% y-o-y, respectively. This demand push is largely supported by high economic activity with a gradual pick-up in manufacturing activity, jump in agricultural activity, and infrastructure spending by government along with erratic weather driven by climate changes.

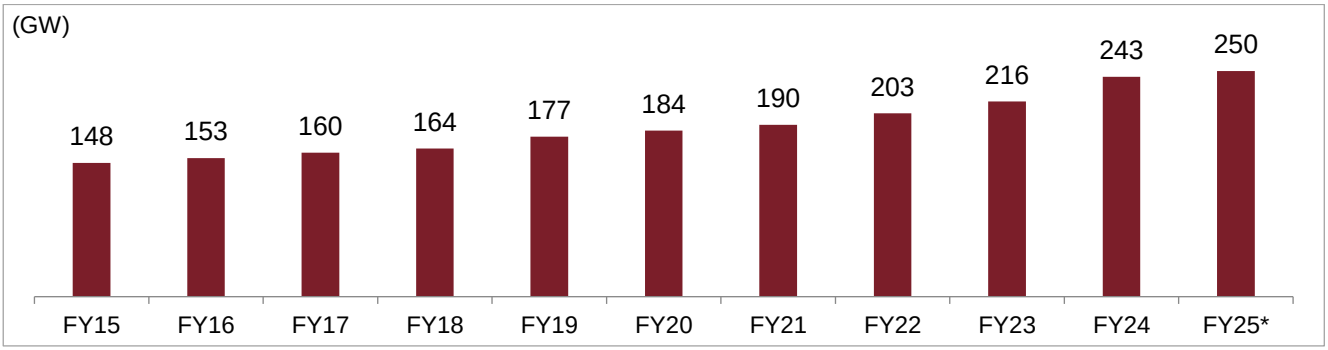
Figure 16: Historical trend of Energy requirement in India



Source: CEA, CRISIL MI&A Consulting

Peak demand has managed to constantly rise over the past years even during COVID, which witnessed base demand falling into negative territory. Between fiscal 2015 and 2024, peak demand has grown from 148 GW to 243 GW leading to a growth of 5.7% CAGR. The constant rise in peak demand can be attributed to economic growth, seasonal vagaries, and an increasing daily average temperature that India has experienced over the last decade. In Q1 fiscal 2025, power demand has surged by 11% on year led by heatwaves and a 6.7% on year growth in GDP. Prolonged and severe heatwaves were especially prominent in the northern part of the country which was also impacted by deficient rainfall in July 2024. CRISIL MI&A Consulting expects power demand to increase by 6.5-7.5% in fiscal 2025.

Figure 17: Historical trend of Peak demand requirement in India



**Upto July 2024*
Source: CEA, CRISIL MI&A Consulting

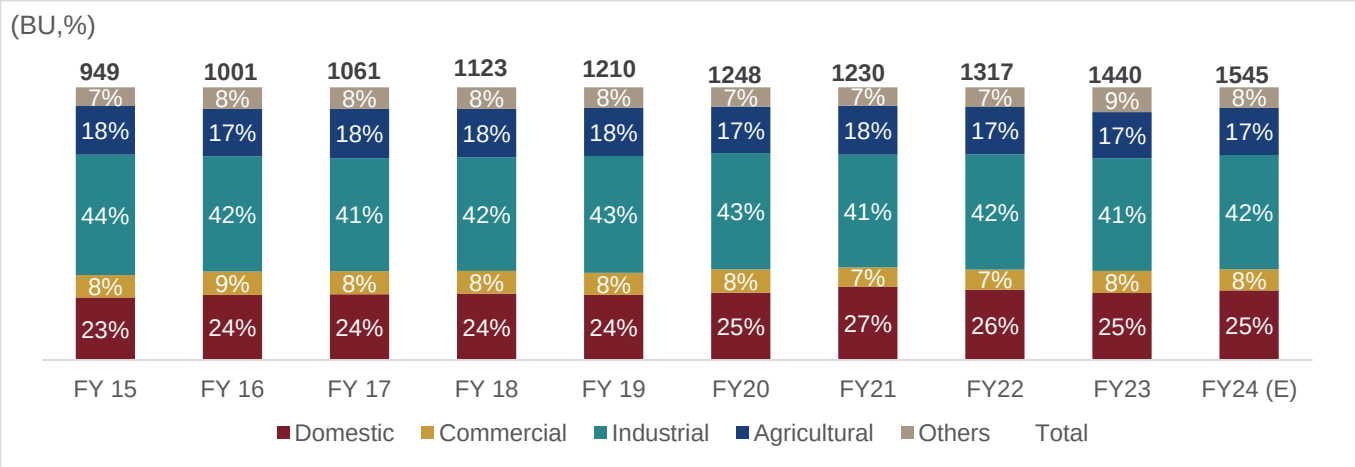
2.3.3 Consumer category wise energy sales

Industrial consumers are the largest consumers of electricity in absolute terms. Going forward, India's economy is expected to continue to expand beyond fiscal 2022, with industrial activity gradually picking up over the medium term. Trickle-down effect of Aatmanirbhar Bharat relief package, government spending on infrastructure through the National Infrastructure Pipeline, commissioning of the dedicated freight corridors, expansion of the services industry, rapid urbanization, and increased farm income from agriculture-related reforms are key macroeconomic factors fostering the power demand. Significant policy initiatives such as PLI schemes and low corporate tax rates, among others have aided large scale manufacturing in India which will further boost power demand in the country.

In fact, several sectors including automobiles, mobile handsets and tablets, solar, lithium-ion batteries, food & beverages and defence are expected to witness fresh investments including foreign direct investments from global majors.

Further, railway electrification, rapid transition to EVs, increased urbanisation and Industrialisation, smart city projects, upcoming metro projects primary tailwinds providing impetus to power demand. A confluence of these factors is expected to drive energy sales to the commercial consumer segment.

Figure 18: Consumer segment-wise energy sales in India



E: Estimated
Source: CERC, CRISIL MI&A Consulting

Growth in domestic and industrial consumption has been the key driver in the overall increase in energy demand. Between fiscals 2015 and 2023, domestic and industrial electricity consumption has grown at a CAGR of 6.3% and 4.5%, respectively, from ~217 BUs to ~353 BUs in domestic consumption and from ~418 BUs to ~595 BUs in industrial consumption. Growing population, expanding economy along with rising urbanization, industrialization

government's 'Make in India' initiative encouraging domestic manufacturing, PLI schemes, emergence of special economic zones and industrial parks and access to grid-based electricity to rural households have played key roles for such an increase in energy consumption. The demand in fiscal 2024 is expected to grow by 8.3% from fiscal 2022 due to increase in industrial production, mining activity, and infrastructure development. The general IIP has increased at a CAGR of 3.4% in the last two years from 148.8 (March 2022) to 159.2 (March 2024 – Provisional). This signifies that the growth in the production volume of industrial products picked up driven by favourable government policies.

The share of domestic consumption has increased from 23% in fiscal 2015 to 25% in fiscal 2023 in the total energy demand. This has increased due to the rising urbanisation rate, improvements in the standard of living, increase in air conditioning requirements to mitigate soaring temperatures and offering free units upto a certain level to some category/regions of India. Pradhan Mantri Sahaj Bijli Har Ghar Yojana (Saubhagya), which was launched by the GoI in September 2017, has helped achieve universal household electrification across the country. Under the scheme, 28.6 million households were electrified in the country. The scheme is completed and, in turn, drives electricity demand.

The programme also aims to ensure 24x7 power supply to separate agriculture and non-agriculture feeders, facilitating judicious fostering of supply to agricultural and non-agricultural consumers in rural areas and strengthening the sub-transmission and distribution infrastructure in rural areas, including metering of distribution transformers/feeders/consumers. It is also expected that electricity currently being supplied through back-up facilities, such as invertors and DGs, may move back to the grid with increased quality of supply.

Demand from Commercial sector grew at ~5.2% CAGR between fiscal 2015-23, due to rapid urbanization as more people migrate to urban centers seeking better opportunities, the need for commercial spaces, educational institutions, and healthcare facilities has increased, consequently driving up electricity consumption.

2.3.4 Correlation between GDP and electricity requirement

Historically, power demand in India has shown strong correlation with GDP driven by factors such as industrialization, urbanisation and economic expansion. In fiscal 2024, the energy deficit across states and union territories stood at 0.3%. States including Bihar, Maharashtra and Jharkhand have registered the highest peak deficit during fiscal 2024. GDP in India has grown at a CAGR of 6.14% since fiscal 1985 and stood at Rs 148 Tn in fiscal 2023. Over the same period, power demand rose at a CAGR of 6.1% to reach 1,512 billion units in fiscal 2023.

Correlation of coefficient ("Multiple R") of national power demand with GDP (fiscal 2012 onwards) showed strong relation at 98.7%.

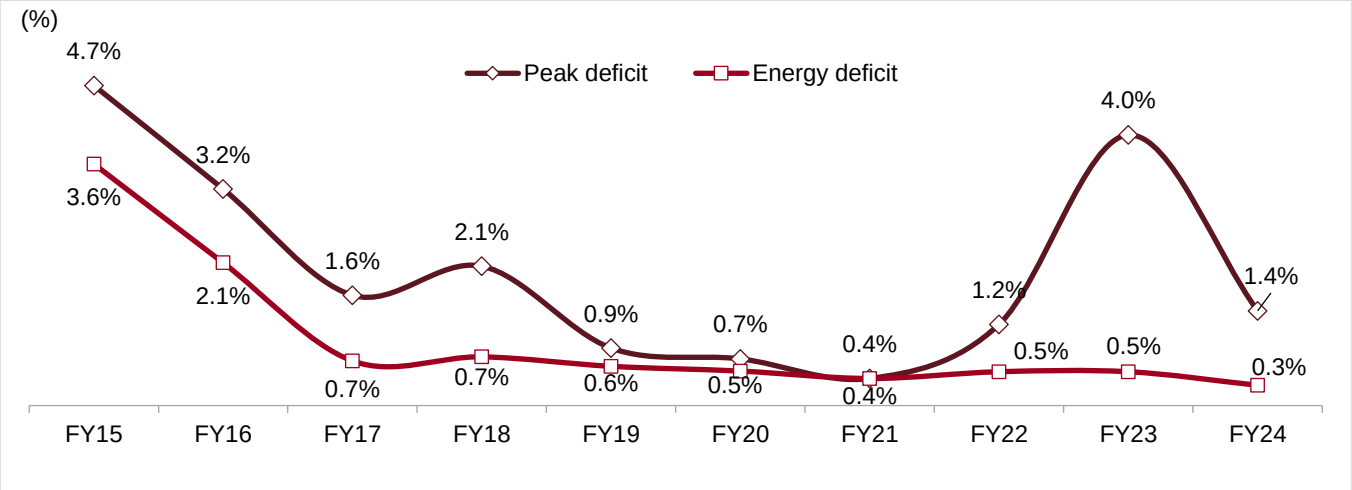
2.3.5 Assessment of power deficit/surplus situation

On the back of strong growth in installed capacity, growth in energy availability outpaced demand growth. As a result, the gap between demand and supply narrowed, both in terms of energy as well as peak demand in the country. Peak demand shortage fell sharply to 1.4% in fiscal 2024, from 4.7% in fiscal 2015, whereas the energy shortage fell to 0.3% from 3.6% during the same period.

Peak power demand has surged due to extreme weather conditions coupled with buoyant industrial and manufacturing activities. Between fiscal 2019 and 2023, peak demand has grown from 177 GW to 216 GW. In fiscal 2024, peak demand was 240 GW as seen in September 2023. The constant rise in peak demand can be attributed to economic growth, seasonal vagaries, and an increasing daily average temperature that India has experienced over the last decade. Adequate generation to keep up with booming demand resulted into decrease in peak demand deficit to 1.4% for fiscal 2024 as compared to 4.0% in fiscal 2023.

It is expected that the base deficit to persist, though remaining negligible at 0.3-0.5% over the medium-term, as deficit is expected in under-penetrated areas due to weak distribution infrastructure, with underserved populations expected to gradually come onto the grid in the long term.

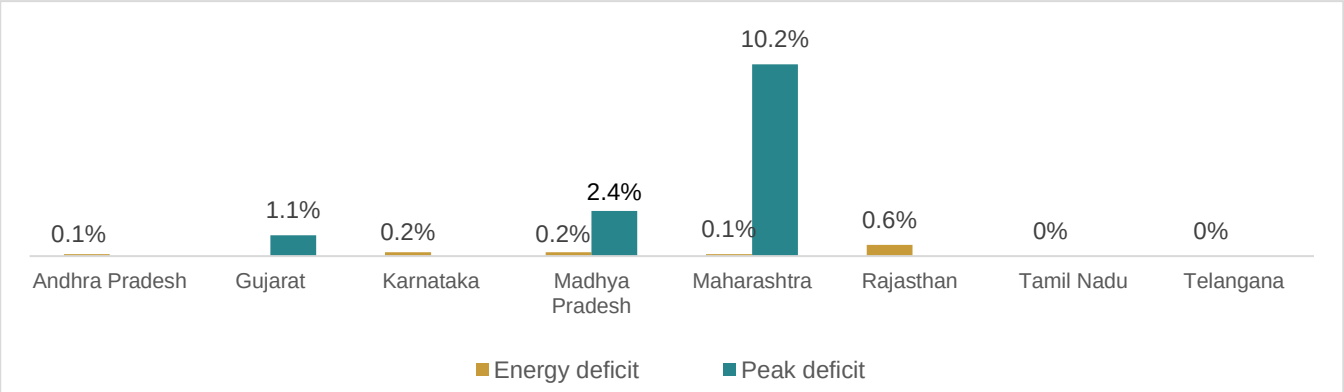
Figure 19: Energy and peak demand shortage trend during the past 10 years



Source: CEA; CRISIL MI&A Consulting

In fiscal 2024, the energy deficit across states and union territories stood at 0.3%. Of the identified states, Maharashtra registered the highest peak deficit during fiscal 2024 followed by Madhya Pradesh and Gujarat.

Figure 20: Energy and peak demand shortage in FY24 for identified states



Source: CEA; CRISIL MI&A Consulting

In India, the electricity demand typically peaks during morning and evening hours, creating a demand deficit during that period. Addressing this demand deficit is important for maintaining grid stability and ensuring uninterrupted power supply. Wind energy with its distinctive generation patterns can help in meeting these peak demand deficit periods. Wind generation tends to be higher during evening and early morning hours when solar energy generation is minimal or non-existent, aligning well with the times when the electricity demand is at its peak.

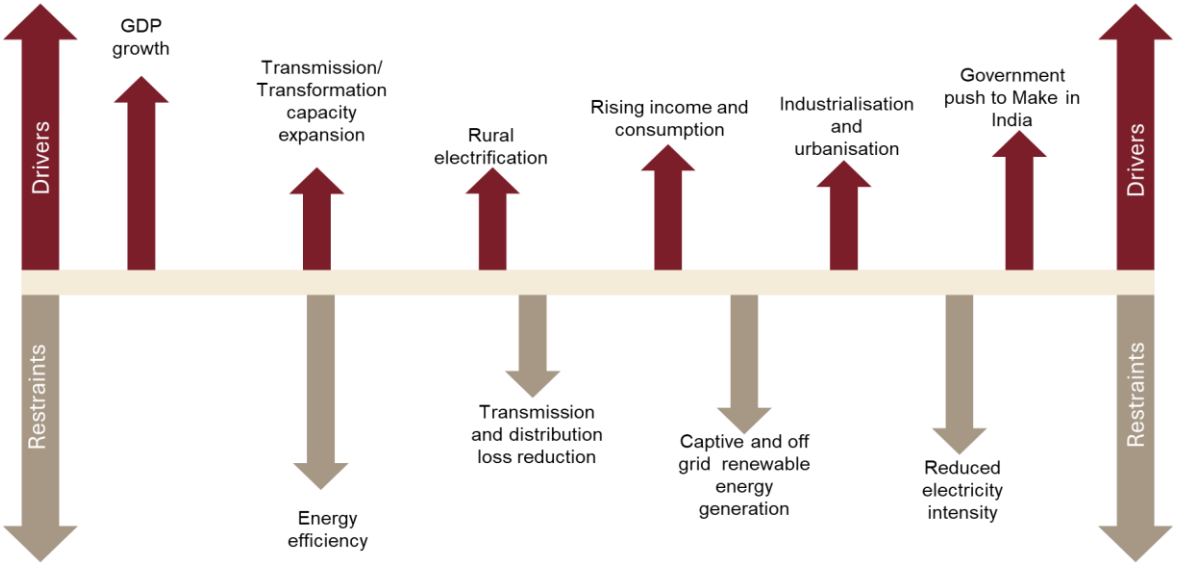
This synchronicity between high wind generation and peak electricity demand can significantly enhance the utilisation and economic value of wind energy. The deployment of wind energy particularly during peak hours not only supports grid stability but also improves the financial viability of the project, ensuring high realisation.

In order to manage peak deficit, Utilities may resort to various demand side management measures such as higher tariffs for peak hours, demand side management, load management etc. This has negative impact on C&I consumers. Even if Utilities buy expensive short-term power, large part of the burden goes on to C&I consumers only. The peak deficit in electricity can have a significant impact on C&I tariffs, leading to higher tariffs, changes in tariff structures, and incentives for load management and renewable energy integration.

2.4 Long term drivers and constraints for demand growth

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 5.8% over the past decade. The trickle-down effect of Aatmanirbhar Bharat relief package, government spending on infrastructure through the National Infrastructure Pipeline, commissioning of the dedicated freight corridors, expansion of the services industry, rapid urbanization, and increased farm income from agriculture-related reforms are key macroeconomic factors fostering the power demand. Significant policy initiatives such as production-linked-incentive (PLI) schemes, among others have aided large scale manufacturing in India which will further boost power demand in the country.

Figure 21: 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, and 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.

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

Indian Railways has planned to become a net zero emitter by 2030. The Indian government aimed to achieve 100% electrification of Indian Railways by December 2023. However, given delayed electrification works due to pandemic-induced lockdowns, coupled with the sluggish pace of electrification, 100% electrification is expected to be achieved by fiscal 2025 and lead to incremental power demand of around 23 BUs on average every year between fiscal 2025 to 2029. The power sector is poised to witness most of the incremental demand from railway electrification; however, lower energy consumption for electrification per km due to energy efficiency improvements will partially offset the demand.

Metro rail has seen substantial growth in India in recent years, and the rate of growth is set to double or triple in the coming years with multiple cities seeking metro rail services to meet daily mobility requirements. Around 712 km of metro rail is under construction and 1,878 km is proposed to be added. These developments are expected to add incremental power demand of 5-6 BUs every year on average between fiscal 2025 to 2029. Currently, metro rail projects constitute a marginal share of total incremental demand, but the share is expected to increase due to a large quantum of upcoming metro projects.

Further, EV charging requirements are likely to boost power demand over the medium term, with a gradual increase in the share of EVs in the vehicle population. CRISIL MI&A-Consulting projects that adoption of EVs will boost power demand by 12-13 BUs annually on average over fiscals 2025 to 2029.

Declining T&D losses, an increase in off-grid/rooftop projects and open access transactions to drive power demand downward

T&D losses have been declining, and the reduction in losses is expected to continue further aided by a slew of government measures, primarily the Revamped Distribution Sector Scheme (RDSS). RDSS is a reform-based and result-linked scheme for improving the quality and reliability of power supply to consumers through a financially sustainable and operationally efficient distribution sector. Power demand is expected to be reduced by 20-25 BUs on average every year between fiscal 2025 to 2029 owing to lower T&D losses.

Further, with a boost to rooftop solar and the declining cost of renewable energy generation, the decentralized distributed generation is expected to increase, reducing power demand from the grid. By fiscal 2029, 32-33 GW of rooftop capacities are expected to come onstream, resulting in a reduction of 2-3% in base demand.

Captive consumption has been on a rising trajectory since fiscal 2013. The top four industries, namely iron and steel, sugar, aluminium, and steel account for 65% of the total captive consumption. Captive consumption is expected to maintain its growing trajectory going forward driven by increasing production in the mentioned industries. These industries are expected to add ~3-4 GW of captive capacity over the next five years, adding on average 290-300 BUs of demand over the period which may lead to a reduction in demand from the grid.

With higher tariffs and increasing operating expenses, commercial and industrial (C&I) consumers are opting for renewable energy through solar rooftops or open access to optimize the production costs. Thus, this segment opens up an avenue for more and more RE installations and provides an opportunity for RE players to expand their market.

2.5 Distribution sector reforms

Distribution being the most important link in the power sector value chain, sustainability of discoms is of great importance. Hence, the GoI extended support to state distribution utilities for capital investments (IPDS, DDUGJY) and financial sustainability (UDAY) through various schemes and initiatives. In July 2021, the GoI launched the RDSS with the objective of improving the quality and reliability of power supply to consumers through a financially sustainable and operationally efficient distribution Sector.

The government has also notified various rules and guidelines to support discoms. As per Electricity Rules, 2022, the government have provided a mechanism for automatic pass through of any variation in power purchase cost arising on account of the variation in fuel prices to the consumer tariff on a monthly basis for timely recovery of power purchase cost by discom. If the discom fails to calculate fuel and power purchase adjustment surcharge on time, the discom will lose the right to recover the costs for that surcharge. The MoP also issued directions related to ensuring regular revision of tariffs including true ups in timely manner so that creation of fresh regulatory asset does not arise and to have a mechanism for fuel and power purchase cost adjustment in place for automatic pass through of any variation in such costs.

As per PFC's 12th Annual Integrated Rating report for fiscal 2023, the AT&C losses improved to 15.4%, billing efficiency improved to 87% and collection efficiency at 97.3%. The days payable reduced from 163 days to 126 days and days receivable improved to 119 days from 142 days. Overall, the trend in financial performance improvement seen over the years is due to a lot of initiatives undertaken by the utilities and the reforms taken by centra and state governments.

2.5.1 Integrated Power Development Scheme (IPDS)

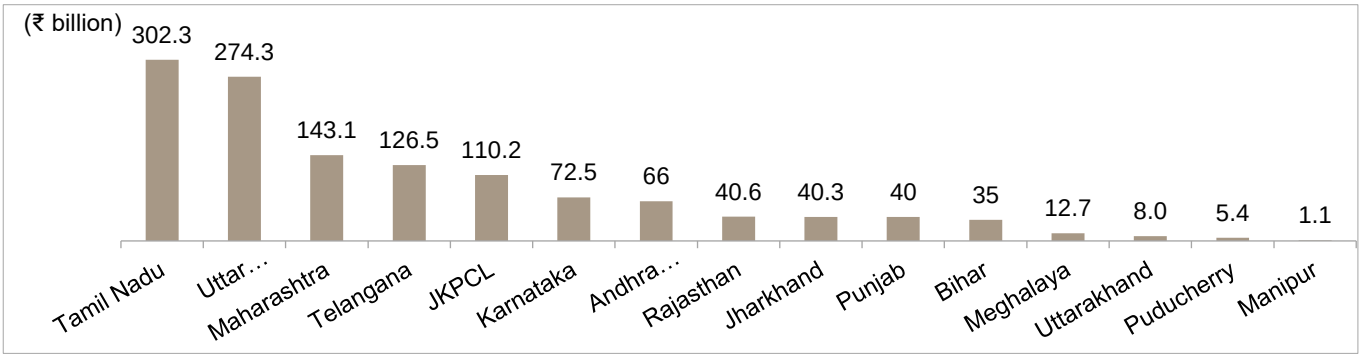
IPDS was launched with the objectives of strengthening the sub-transmission and distribution network in urban areas, metering of distribution transformers/ feeders / consumers in urban areas and IT enablement of the distribution

sector. The component of IT enablement of the distribution sector and strengthening of the distribution network, approved by CCEA in June 2013 in the form of R-APDRP for 12th and 13th plans, have been subsumed under this scheme. The total cost of projects envisaged under this scheme during the 12th and 13th plans was ~Rs 700 billion.

2.5.2 Liquidity infusion scheme for discoms under Aatmanirbhar Bharat Abhiyaan

To address the problems faced by discoms due to the COVID-19 related lockdown, the GoI announced a liquidity package of Rs 900 billion for discoms to clear their pending dues towards power generators. Later, this amount was enhanced further to Rs 1,350 billion. Disbursal of the liquidity infusion package is linked to reform measures such as states' undertaking to liquidate outstanding payments to discoms, installation of smart prepaid or prepaid meters in government departments, digital payment of electricity bills, timely payment of subsidies, and an action plan to be provided by states to bring down losses over the next 3-4 years. Against the sanctioned amount of Rs 1,355 billion worth of loans, Rs 1,037 billion has already been disbursed till January 2022.

Figure 22: Central government support to states under discom relief package



Source: Ministry of Power, PFC/REC

2.5.3 Revamped distribution sector scheme (RDSS)

RDSS is a reform-based and result-linked scheme for improving the quality and reliability of power supply to consumers through a financially sustainable and operationally efficient distribution sector.

In Union Budget 2022, 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 improving the operational and more importantly financial parameters like ACS-ARR gap of 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 GoI has laid down the guidelines and criteria for availing funding under the scheme, which aims to improve operational efficiency, distribution infrastructure, and governance and compliance standards of state discoms. The scheme's primary objective is to reduce AT&C losses to 12-15% at pan-India levels and reduction of ACS-ARR gap to zero by fiscal 2025. As per the MoP's guidelines, the tariff revision is one of the pre-conditions for release of funds under RDSS and no new Regulatory Assets have been created in the latest tariff determination cycle.

As of December 2023, out of the 52 discoms that submitted DPR for approval, the GoI have approved DPRs worth Rs 2.52 trillion, out of which Rs 1.30 trillion is sanctioned for smart meters and Rs 1.22 trillion for loss reduction.

Figure 23: Key objectives under RDSS

S. No.	Parameters	Target/objective under RDSS
1.	ACS-ARR	To bring ACS-ARR gap to zero by fiscal 2025
2.	AT&C losses	National target of 12-15% by fiscal 2025
3.	Tariff reforms	Cost reflective tariff to ensure profitability
4.	Direct benefit transfer	Direct transfer of the subsidy to the end consumer

S. No.	Parameters	Target/objective under RDSS
5.	Working capital rationalisation	Payable days to creditors for the year under evaluation to be equal to or less than the projected trajectory
6.	Hours of supply	Govt aiming for 24*7 power for all under a parallel programme
7.	DT metering and smart metering	Non-agriculture and agriculture DT metering to be completed by June 2023 and March 2025, respectively. Smart metering to be completed by March 2025
8.	Corporate governance and compliance	Discom to publish audited annual accounts by December-end of following fiscal for the first 2 years of the scheme and by September-end from 3rd year onwards. Tariff Orders to be issued by SERCs by April 1 of new fiscal

Source: MoP, CRISIL MI&A-Consulting

2.5.4 Lending by PFC and REC to discoms

The MoP has directed PFC and REC to extend lending only after assessing the ability of the discoms to pay their loans. The assessment should be based on actual receipts rather than on an accrual basis. As per MoP's directives the computation of income should not include any subsidy due but not paid, any regulatory income (unless it is passed through in tariff and recovered) and UDAY grants. Any power purchase dues to be deducted from the profits while determining the debt repayment ability. All such parameters to be considered to formulate a ratio for evaluation of discoms' capability to pay their immediate liabilities against the loans before fresh loan proposals are processed.

In order to recover regulatory assets by discoms, the PFC and REC have developed a policy for funding against regulatory assets of discoms. The funding would be available only 50% against the regulatory assets recognized by the respective SERCs in previous three years' tariff orders and recovery schedule included in the tariff order. It must include a time bound recovery plan of the regulatory asset by SERC and plan for recovery of carrying cost of the regulatory assets by SERC.

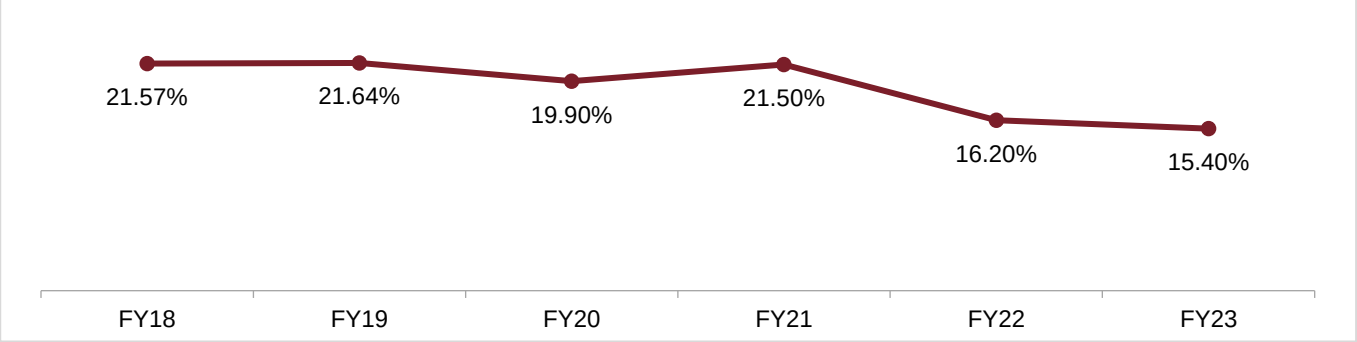
2.5.5 Discom's financial health

2.5.5.1 Review of AT&C loss and ACS-ARR gap of state discoms

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 24: AT&C loss trajectory (%)

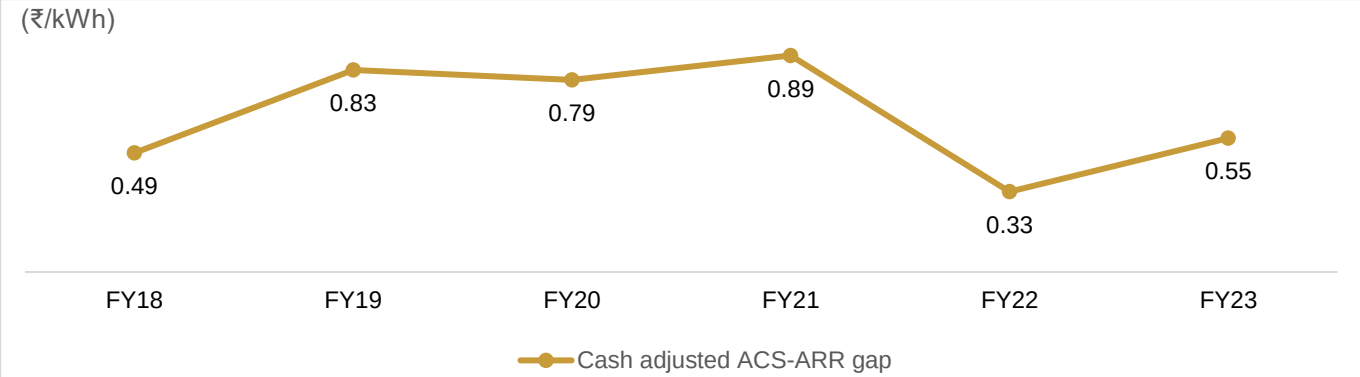


Source: PFC, CRISIL MI&A-Consulting

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.

Under the *AatmaNirbhar Bharat* liquidity infusion package, the MoP had issued guidelines to the States for availing the benefits of concessional loans from PFC and REC on 14th May, 2020. PFC and REC had advised their loan scheme to States on 16th May, 2020. Against the Liquidity Infusion package, Rs.1.33 Lakh Cr worth of loans have been sanctioned and Rs. 112456 Cr has already been disbursed/ released till 31-03-2023. Further, the MoP notified LPS Rules on June 3, 2022, which provide a mechanism for settlement of outstanding dues of generating companies, inter-state transmission licensees and electricity trading licensees

Figure 25: ACS-ARR gap



Source: PFC, CRISIL MI&A-Consulting

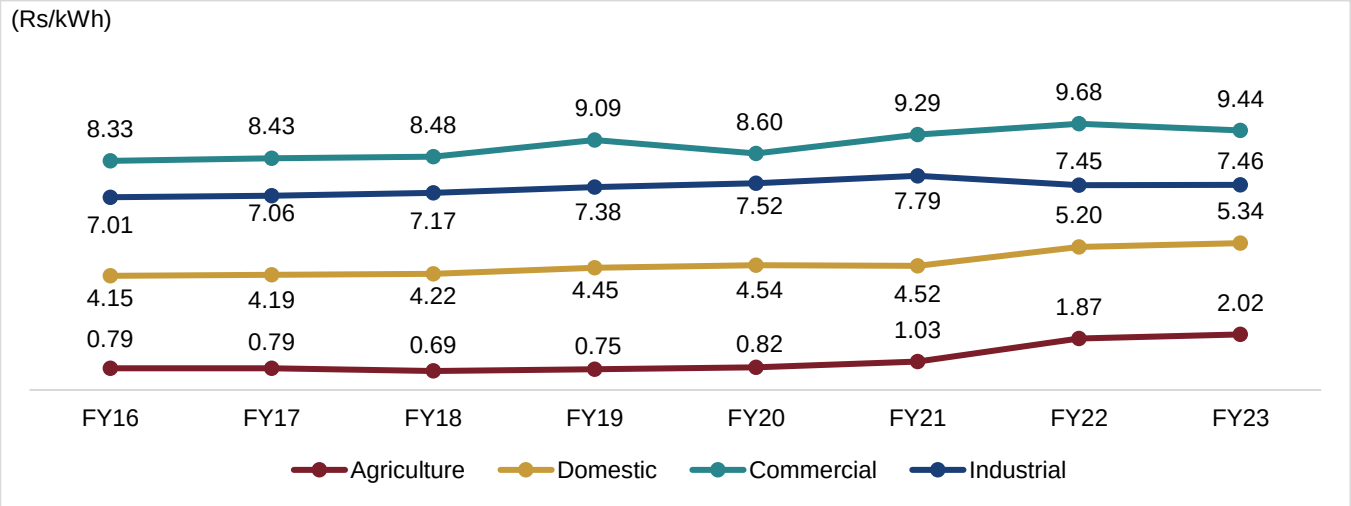
To bridge the gap between ARR and ACS, the State Discoms are consistently increasing the tariffs. Considering the legacy issues and prevailing tariffs, large part of the increased tariffs is borne by the C&I consumers and consumers from agriculture and domestic category continue to be cross subsidised by high paying C&I consumers. C&I consumers pay the highest per kWh tariffs and account for a significant share in distribution utilities revenues.

2.6 C&I tariff trend over the last 10 years

The tariffs across categories have increased at a CAGR of ~3.8%- between fiscal 2014 and 2024, with domestic tariffs have increased at a rate of 6.1% followed by commercial and industrial tariffs at ~3.0% and 3.5%, respectively. Consequently, grid tariffs for agriculture are highly cross subsidised by C&I consumers. In fact, in fiscal 2024, the average cross-subsidisation levels (tariffs above average cost of supply) for commercial and industrial consumers as per the approved tariffs for different categories have remained high at ~116%. Thus, grid power is expected to remain costlier for C&I consumers with limited scope for tariff rationalization as inability of discoms to increase domestic and agriculture tariffs to put increased pressure on C&I tariffs. Further, unlike Bid based PPAs which lock tariffs for long term (mostly for 25 years), C&I developers have an option to not lock in tariffs or shorter lock in period of 3 to 5 years.

The consumer category wise average billing rate at India level demonstrates that the growth in agriculture tariff over the years has been insignificant as the rates are highly subsidized. The domestic tariff was in the range of Rs 4.2 – 4.5/kWh until fiscal 2021. The C&I tariff is fixed much higher than the average cost of supply to subsidise the agriculture tariffs and some categories of domestic consumers. However, the increase in domestic tariff has been witnessed after the launch of Revamped distribution sector scheme (RDSS) in fiscal 2022, which is aimed to reduce the ACS-ARR gap to zero by fiscal 2025 and to bring correction in retail tariffs across categories. Moreover, the National Tariff Policy 2016 also mandates that the power supply costs should gradually be reflected in tariffs, and limits cross-subsidies to no more than +/- 20% of average cost of supply

Figure 26: Category wise historical average billing rate at India level



Source: PFC, NITI Ayog, CRISIL MI&A Consulting

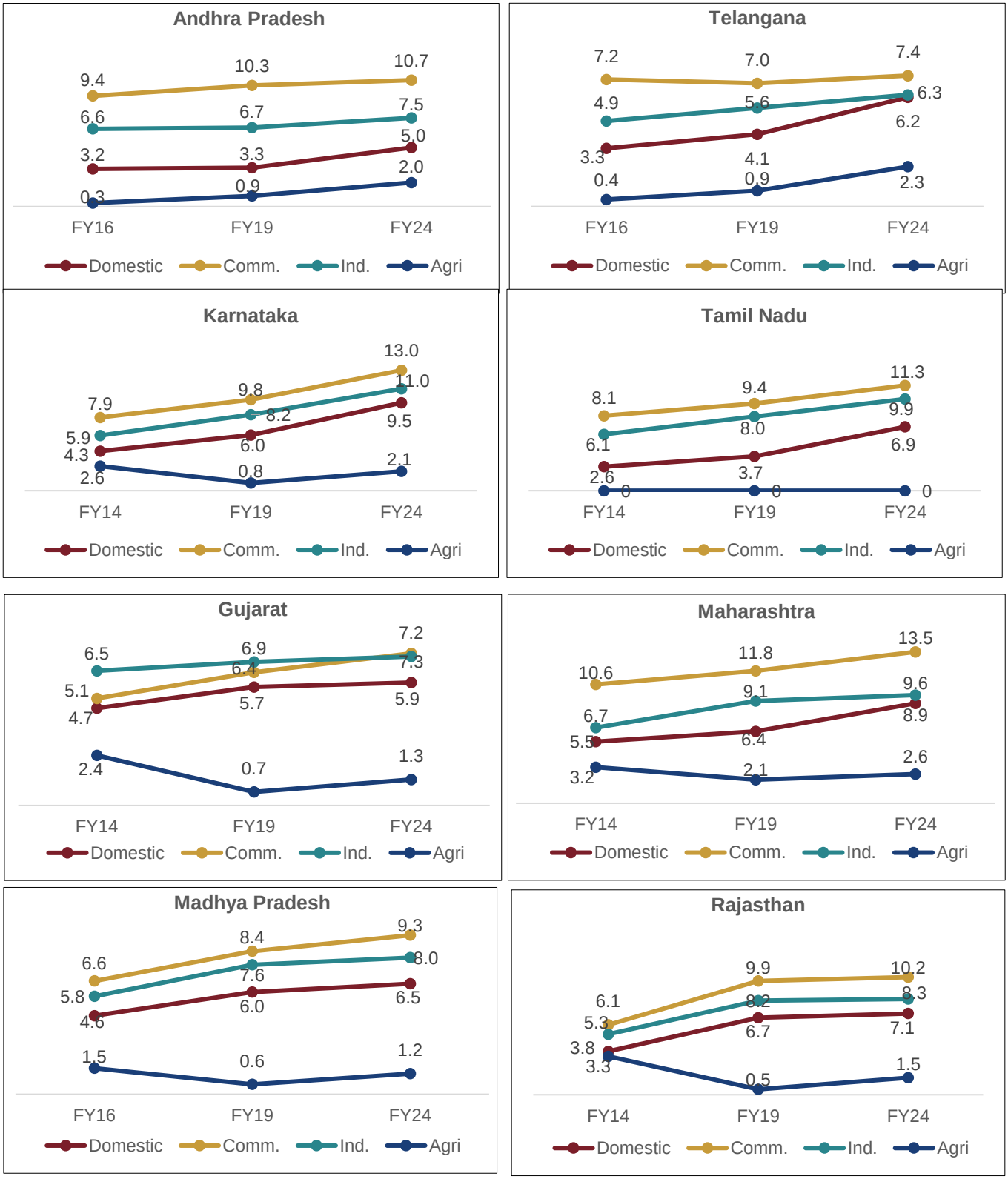
The increase in utility tariffs in India can be attributed to several factors that have collectively put pressure on the power generation and distribution sector. One of the key factors is the rising cost of coal due to inflationary pressures, which is the primary source of fuel for thermal power plants in the country. As the demand for electricity continues to grow with rapid urbanization and industrialization, the increasing cost of coal has a direct impact on the overall generation cost, prompting power producers to pass on these expenses to consumers through higher tariffs. Additionally, scarcity of water in case of some thermal generating station also affects the PLF and in turn lead to higher fixed costs.

Another significant reason is the increasing penetration of RE sources, such as solar and wind, which has led to a decrease in the utilization of thermal power plants. As RE generation becomes more prevalent, the Plant Load Factor (PLFs) of thermal power plants decreases, making it economically challenging to cover the fixed costs of these plants. To offset this, utilities often need to depend on expensive balancing power to maintain grid stability, thereby contributing to higher generation costs and, in turn, elevated tariffs.

Furthermore, in India, electricity tariffs for certain consumer categories, particularly domestic and agricultural, are subsidized by charging higher tariffs to C&I consumers. The burden of cross subsidization falls on these C&I consumers, resulting in increased tariffs to maintain financial viability for the power utilities. Moreover, aging infrastructure and transmission losses also play a role in escalating tariffs. The costs of maintaining and upgrading power transmission and distribution networks are significant, and inefficiencies in the system lead to an increased financial burden on utilities, which are ultimately passed on to consumers.

Multiple schemes and rules/regulations are being passed by GoI to ensure adequate correction in the retail tariffs such as RDSS scheme which require better financial practice by discom, timely recovery of increase in cost of power purchase cost and automatic pass through into the consumer tariff and recovery of regulatory assets and limit the creation of any further regulatory assets by SERC.

Figure 27: Snapshot of consumer category-wise average billing rates (Rs/kWh) across key states



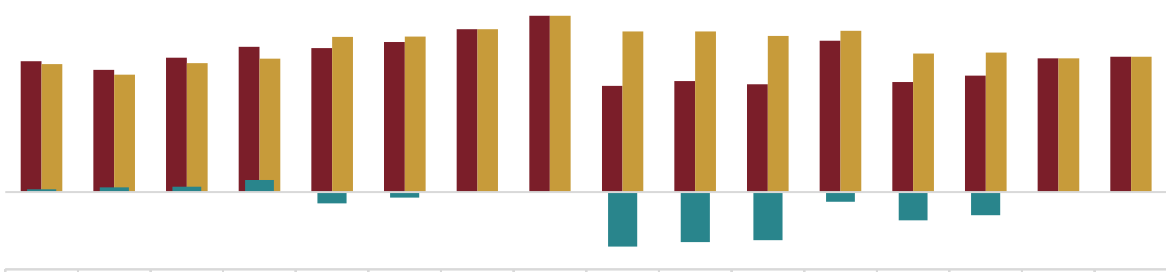
Note: FY24 figures are as per respective SERC approved discom's tariff orders;
Source: State Tariff Orders, PFC Report on Performance of State Power Utilities, CRISIL MI&A Consulting

The state-wise gross ABR and average cost of supply (ACoS) for the last four fiscals is also shown in the below chart. It shows that the ABR has increased by 3.9% y-o-y whereas the ACoS has increased at a rate of ~1.8% over the last four years. The ACoS of states like Maharashtra and Karnataka has increased by over 3.2% and 4.3%, respectively over the same period. The average gap between ABR and ACoS for these states has reduced from Rs

-0.64/kWh to Rs +0.10/kWh from fiscal 2021 to fiscal 2024. The MoP also issued multiple rules and guidelines over the years to rationalize the tariffs and to ensure no creation of fresh regulatory assets by ensuring regular and timely revisions of tariffs. The draft electricity amendment rules, 2023 have also proposed to liquidate the regulatory assets within seven years of equal instalments. These measures are expected to remove the gap by fiscal 2025 if taken rigorously by SERCs.

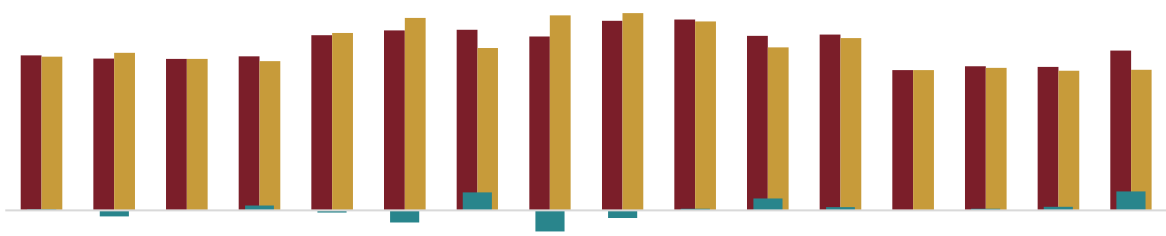
Figure 28: State wise ABR and ACoS for last four financial years

(₹/kWh)



	FY21	FY22	FY23	FY24	FY21	FY22	FY23	FY24	FY21	FY22	FY23	FY24	FY21	FY22	FY23	FY24
	Andhra Pradesh				Karnataka				Tamil Nadu				Telangana			
ABR	6.77	6.33	6.95	7.52	7.45	7.76	8.43	9.12	5.50	5.74	5.58	7.84	5.70	6.03	6.92	7.00
ACoS	6.62	6.08	6.67	6.90	8.03	8.05	8.43	9.12	8.32	8.32	8.08	8.35	7.17	7.22	6.92	7.00
Deficit/Surplus	0.15	0.25	0.28	0.62	-0.58	-0.29	0.00	0.00	-2.82	-2.58	-2.50	-0.51	-1.47	-1.19	0.00	0.00

(₹/kWh)



	FY21	FY22	FY23	FY24	FY21	FY22	FY23	FY24	FY21	FY22	FY23	FY24	FY21	FY22	FY23	FY24
	Madhya Pradesh				Maharashtra				Rajasthan				Gujarat			
ABR	6.83	6.69	6.68	6.79	7.72	7.94	7.96	7.67	8.36	8.41	7.70	7.75	6.18	6.35	6.32	7.04
ACoS	6.78	6.95	6.68	6.58	7.82	8.48	7.16	8.60	8.69	8.33	7.18	7.60	6.19	6.28	6.16	6.20
Deficit/Surplus	0.05	-0.26	0.00	0.21	-0.10	-0.54	0.80	-0.93	-0.33	0.08	0.52	0.15	-0.01	0.07	0.16	0.84

Source: State Tariff Orders, REC Report on key regulatory parameters of Power Utilities 2023, CRISIL MI&A Consulting

2.7 Over 50% of the discom's revenue comes from C&I consumers

The below chart shows the share of revenue across each consumer category for leading states in the last 10 years. Industrial consumers constitute approximately 80% of the electrical consumption in the C&I segment, which in turn constitutes approximately 50% of total electricity consumption in India. The average share of revenue from C&I consumers has been ~50% of the total revenue with Gujarat, Maharashtra and Andhra Pradesh leading at over 60%. Some of the states such as Andhra Pradesh, Tamil Nadu, Maharashtra have registered a decline in C&I revenue over the years due to increase in open access sales. Further states such as Madhya Pradesh, Rajasthan, Telangana and Karnataka have a significant revenue share of over 25% from agricultural consumers which comes in the form of subsidy through state government.

Figure 29: Historical trend in state discom's revenue share from different consumer categories

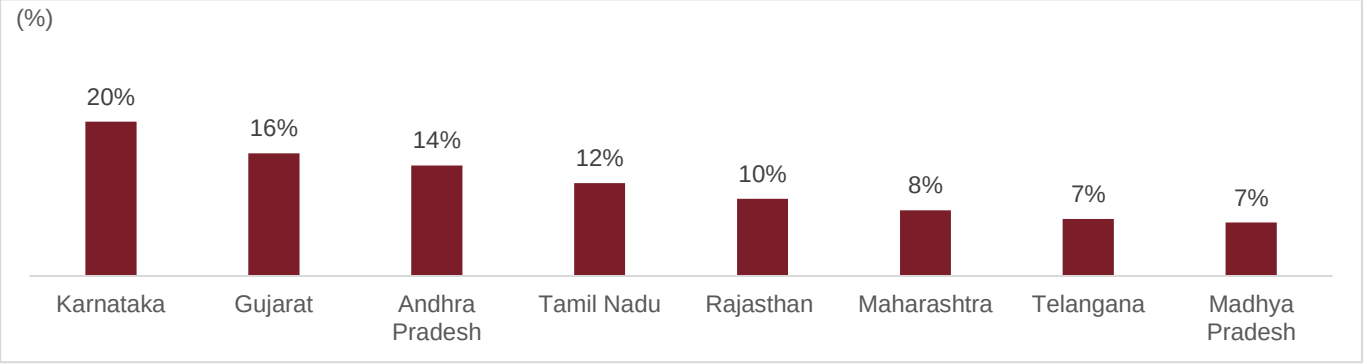
Note: FY24 figures are as per respective SERC approved discom's tariff orders;
Source: State Tariff Orders, PFC Report on Performance of State Power Utilities, CRISIL MI&A Consulting

C&I tariffs have been rising over the years, and they're likely to continue to rise over the medium term due to several factors.

- India is heavily dependent on thermal power for base load and cost of fuel for thermal plants have been increasing.
- Increasing RE penetration requires additional infrastructure and management cost.
- India's power demand is growing rapidly, leading to peak demand management issues. To manage peak demand, utilities may increase tariffs during peak hours to discourage consumption and prevent grid overload.
- With increasing inflationary pressures, the power costs are likely to increase with increasing T&D cost and grid balancing cost.
- Due to legacy issues, cross subsidisation will continue at least for some years leading to higher tariffs for C&I consumers.
- India's power grid requires modernization and upgradation to accommodate growing demand and increasing share of renewable energy.

The costs associated with above factors will result in higher utility tariffs for C&I consumers. Due to these additional costs, the landed cost of RE becomes expensive as compared to the bid prices quoted by RE developers. This ultimately gets passed on to the C&I consumers by utilities through increased tariffs.

Figure 30: Share of captive consumption in total sales during FY23



Source: CEA, CRISIL MI&A Consulting

3 Government support – policy, regulatory and RE market

The GoI has extended significant support to boost RE through the launch of multiple programs, policies and incentives. The government is committed to driving growth in the sector by holistically promoting investments, proactively resolving industry issues and addressing policy concerns.

The following section explains the key policies, regulations and initiatives undertaken by the GoI to support the power and renewable energy market.

3.1 Assessments of key policies and regulations driving the RE market

3.1.1 Renewable purchase obligations (RPO) to support RE capacity additions; strict enforcement - a key monitorable

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

To promote the installation of solar power systems across various Indian states, the government amended the National Tariff Policy in fiscal 2016, proposing an increase in RPO target to 21.0% by fiscal 2022. Consequently, several states set RPO targets based on their respective RE potential.

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

Table 3: RPO targets by MoP notified in October 2023

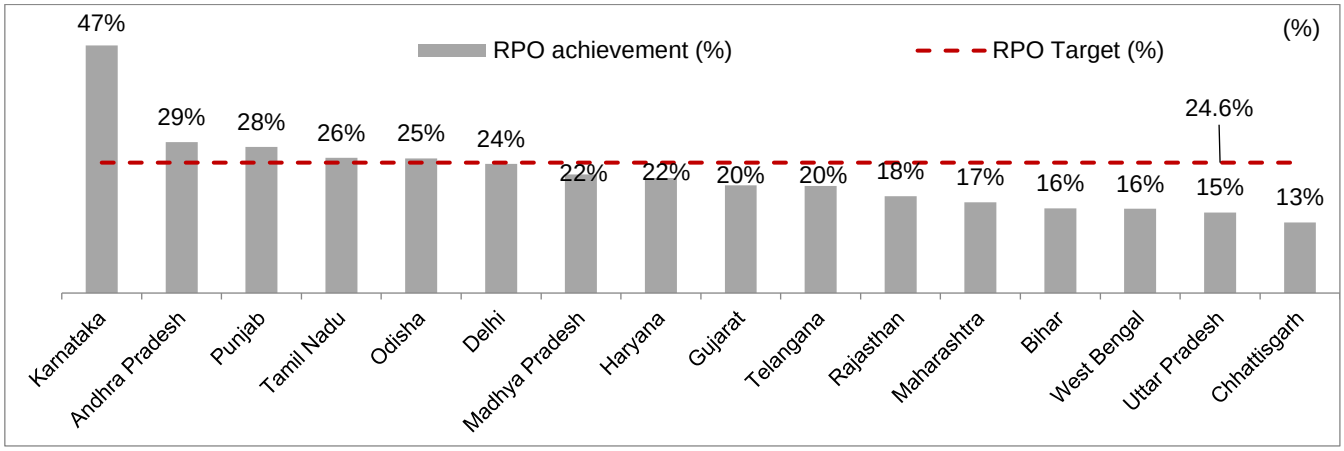
Category	FY25	FY26	FY27	FY28	FY29	FY30
Wind RPO	0.67%	1.45%	1.97%	2.45%	2.95%	3.48%
HPO	0.38%	1.22%	1.34%	1.42%	1.42%	1.33%
Distributed RE	1.50%	2.10%	2.70%	3.30%	3.90%	4.50%
Other RPO	27.35%	28.24%	29.94%	31.64%	33.10%	34.02%
Total	**29.91%**	**33.01%**	**35.95%**	**38.81%**	**41.36%**	**43.33%**

Source: Ministry of Power, CRISIL MI&A Consulting

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

While RPOs have helped drive RE capacity additions, lack of strict enforcement has resulted in non-uniform RPO compliance across states. Going forward, it is critical that strict enforcement across states is ensured by the respective SERCs. In fact, through amendments to the Electricity Act 2003, a National RE Policy is proposed, which will enable a support system to promote procurement of RE through RPO obligations and penalties for not complying with the same.

Figure 31: RPO compliance status across states for FY2023



Source: CEA, State discom tariff orders, CRISIL MI&A Consulting

To fulfil state RPO targets, as per respective trajectories, there has been increased tendering by states like Maharashtra, Gujarat, Uttar Pradesh, Madhya Pradesh, Punjab under their state schemes allocated over fiscals 2018-2023. In addition, any excess unit generated by the obligated entity, i.e., over and above its obligations, would be utilised by discoms to meet their solar RPO targets.

The overall RPO compliance in majority of the states has been more than 70% in fiscal 2023. This is mostly on account of the over-achievement of existing RPO targets by a few states such as Karnataka, Andhra Pradesh, Tamil Nadu, Punjab which have seen significant RE consumption. The hydro rich states such as Sikkim, Himachal Pradesh, Uttarakhand have registered over two times of the RPO target set by MoP for fiscal 2023.

Further, the Energy Conservation Act requires designated consumers to meet a minimum share of energy consumption from non-fossil sources. It also empowers the government to charge a penalty of upto Rs 1.0 Mn for non-compliance. Additionally, a penalty amounting to Rs 3.72/kWh (based on price of one metric ton of oil equivalent (mtoe) for fiscal 2020) for shortfall in RE consumption shall be payable by designated consumers from 1st April 2024 onwards. One TOE is equivalent to 11,630 kWh and value of 1 TOE is Rs. 21,650; penalty per unit of unmet RPO is twice the amount of Rs. 21,650 divided by 11,630 kWh which is equal to Rs. 3.72/kWh. At 29.91% RPO for fiscal 2025 and penalty of Rs 3.72/kWh, the non-compliance cost will be Rs 1.11/kWh. Jharkhand SERC has already adopted the penalty provided in Energy Conservation Act; Gujarat SERC has published the Draft RPO Regulations with said penalty provisions and others to follow.

The Central Government is also contemplating for renewable generation obligation (RGO) mandating thermal power generators to generate certain percentage of their additional capacity from renewable energy.

3.1.1.1 Renewable Energy Certificates (REC) to support RPO

The Ministry of Power has approved the amendments to the existing REC mechanism. Those RE generators will be eligible for issuance of REC whose tariff is neither determined under the provisions of the Act nor selling power through power exchanges / traders and has not availed any waiver / concession on open access charges. The registration of eligible entity for issuance of certificates will be valid for a period of 15 years from the data of commissioning of the project and 25 years for the existing RE project. The certificates issued will remain valid until they are redeemed. The certificates will be issued basis technology multiplier, and the price of certificate will be discovered through power exchanges / traders. The CERC will have a monitoring and surveillance mechanism to ensure that there is no hoarding of RECs.

The REC mechanism facilitates RPO compliance by obligated entities which include discoms, captive power plants & open access consumers. It is one of the simplest ways for small, obligated entities, such as captive power plants / open access consumers to comply with RPO regulations and to those C&I consumers who are committed to 100% energy consumption from green sources.

Although REC certification rates have fallen from their peak in fiscal 2015, and unsold inventory increased to over 19 million in fiscal 2023. Until 2022 RECs were exchanged only in the power exchanges approved by CERC within the band of a floor price and a forbearance price determined by CERC. The ceiling price of a solar REC has fallen by over 90% since 2010-12 and the price of non-solar REC by over 30%. Only about 5% of total RE capacity is REC accredited as of December 2023. The prices have fallen from Rs 1000 per REC in April 2023 to below Rs 300 per REC in March 2024.

3.1.2 Must-run status for RE generation partly offsets operational risk

Power is scheduled on a day-ahead basis and the same is then dispatched by load dispatch centres under the merit order dispatch mechanism by prioritising the lowest-cost sources. Given the infirm nature of RE coupled with high RE tariffs, scheduling and dispatching RE would have been a challenge.

To address this issue, the Indian Electricity Grid Code, 2010, exempted RE from the merit order dispatch mechanism and scheduling regulations and provide (except biomass power plants with installed capacity of 10 MW and above) must-run status. This ensures offtake of RE sources and does not allow its curtailment unless it causes any grid stability issue.

However, the Grid Code does not provide for any remedy on the failure of a procurer to schedule power from must-run power plants apart from grid safety/technical constraints. Hence to resolve such issues the MoP notified Electricity (Promotion of Generation of Electricity from Must-Run Power Plant) Rules, 2021 which are applicable to all RE projects. RE projects including but not limited to wind, solar, wind-solar hybrid, hydropower sources, must be considered a must-run project as per the rules and the power from these projects must not be curtailed. The Rule provides monetary relief for any curtailment of the generation of must-run power plants by the procurer, regardless of whether it arises out of grid safety or technical constraints.

The must-run status has played a crucial role in partly offsetting operational risk and facilitating growth of the RE sector in India.

TNERC, in its Order dated 1st August 2024 awarded compensation for loss of generation on account of arbitrary and unsustainable curtailment orders for reasons other than grid security.

3.1.3 Green energy corridors and RE zones to enable smooth RE integration

To facilitate integration of RE projects and transmission of RE from RE-rich states to other parts of the country, India launched the Green Energy Corridor (GEC) project in 2013. The project is implemented by eight RE-rich states such as Tamil Nadu, Andhra Pradesh, Karnataka, Maharashtra, Gujarat, Madhya Pradesh, Rajasthan and Himachal Pradesh. GEC target of ~9,700 ckm of intra-state transmission lines by December 2020 has overshot the timeline both due to operational reasons and COVID related restrictions. Once commissioned, it will reduce the concentration risk of RE and help non-RE-rich states to benefit.

In addition to GEC Phase-I, the government approved GEC Phase-II in January 2022. The scheme will facilitate grid integration and power evacuation of 20 GW of RE power projects in seven states namely, Gujarat, Himachal Pradesh, Karnataka, Kerala, Rajasthan, Tamil Nadu and Uttar Pradesh. The transmission systems will be created over a period of five years between fiscals 2022 and 2026. Under Phase-II, MNRE has sanctioned implementation of 13 GW of RE Projects along with 12 GWh BESS in Ladakh in February 2024.

India has a target of 500 GW of non-fossil fuel capacity by 2030. For integration of additional wind and solar capacity by 2030, the estimated length of transmission line and sub-station capacity planned is around 50,890 ckm and 4,33,575 MVA, respectively. As per MoP, the investment required for the green transmission is estimated to be around Rs. 2,440 billion. Out of this, Rs. 281 billion will be required for integration of offshore wind capacities while Rs. 2,160 billion will be required for new solar and wind (onshore) plants.

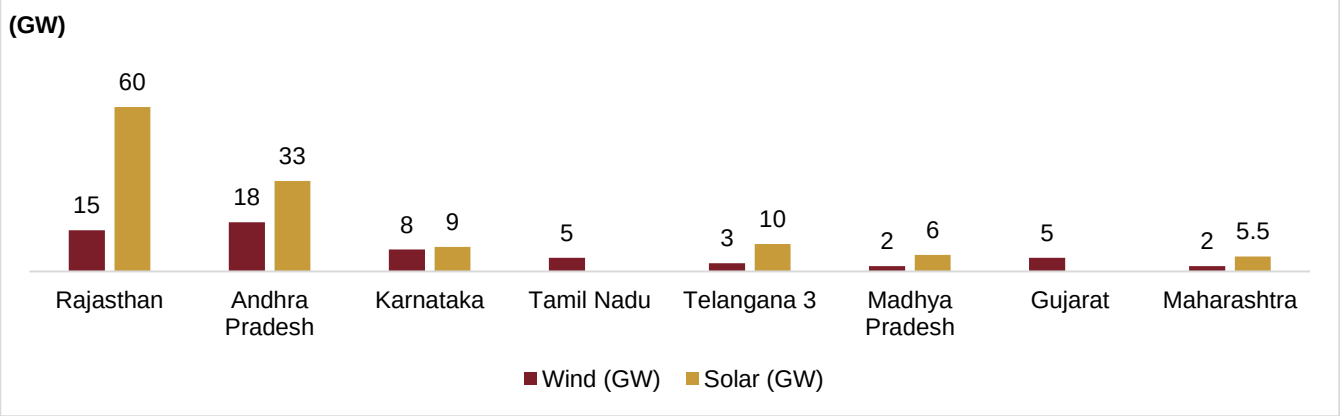
The next growth driver for ISTS projects is the Inter-State transmission system planned for evacuation and grid integration of 66.5 GW Renewable Energy Zone (REZ) spread across the states of Tamil Nadu, Andhra Pradesh,

Karnataka, Gujarat, Maharashtra, Rajasthan, and Madhya Pradesh. PGCIL has also come out with a scheme for setting up grid infrastructure in identified REZ. Under this, key areas with concentration of existing / planned renewable energy projects have been identified in the Western and Southern regions of the country. Out of this, 8 GW of grid capacity will be added for wind projects in the Western region and 9 GW in the Southern region.

In line to this, the government in June 2024, approved new ISTS schemes to evacuate 9 GW of RE power from Rajasthan and Karnataka. The power evacuation scheme of Rajasthan Renewable Energy Zone (REZ) will evacuate 4.5 GW of RE power from Rajasthan and 4.5 GW RE power from Koppal and Gadag area of Karnataka.

MNRE/SECI have identified REZs totaling 181.5 GW for likely benefits by the year 2030. These REZ's are located in eight states as detailed below:

Figure 32: Potential RE zones identified by MNRE/SECI



Source: CEA: Transmission System for Integration of over 500 GW non fossil fuel-based Capacity by 2030

Out of 181.5 GW RE capacity, 56 GW RE capacity is likely to be commissioned by March 2025, 62.1 GW RE capacity is likely to be commissioned by December 2027 and 63.4 GW RE capacity is likely to be commissioned by December 2030.

3.2 Evolving state RE open access regulations help in adoption of green energy by C&I consumers

Consumers opting to procure power under open access are liable to pay various charges to transmission and distribution utilities to use their network to wheel power from the third-party supplier to the consumption point. Consumers opting to procure power under open access routes are liable to pay various charges to transmission and distribution utilities to use their network to wheel power from the third-party supplier to the consumption point. These charges include cross-subsidy surcharge, transmission and wheeling charges and losses, connectivity charges, and LDC charges, among others. Further, cross-subsidy surcharge are determined by respective state regulatory commissions to compensate distribution companies for loss of revenue on account of the shift of high paying C&I consumers. However, as per the National Tariff Policy 2016, cross-subsidy surcharge should not be so onerous to eliminate competition through open access route. Moreover, Cross Subsidy Surcharge (CSS) are not applicable to captive / Group Captive sales and are applicable only to third party non-captive sales. CSS is capped at 20% of the ACoS rate to industries. Further, as per Green Open Access Rules, 2022 provide that AS will not be applicable to renewable energy if fixed charges are being paid by such consumers. The Electricity (Promoting renewable energy through green energy open access) rules, 2022 states that cross-subsidy surcharge should not be increased by more than 50% for a period of 12 year from the date of project commissioning and full waiver on additional surcharge if fixed charges being paid by the consumer.

The expansion of the T&D networks, availability of more efficient systems to maintain grid stability, and increased operating efficiency of the utilities will free up network capacity to open access users. The increased operating efficiency and network availability would keep a rein on transmission and wheeling charges & losses.

Thus, the rationalization of cross-subsidy and efficiency in grid operations would make open access routes more attractive for bulk consumers.

SERCs of different states have either exempted or provided concessions to RE projects from payment of various open access charges from time to time to promote the use of renewable energy among C&I consumers. For instance, Tamil Nadu and Rajasthan have provided 50% concession in the wheeling and transmission charges for renewable projects, Tamil Nadu has concessional cross-subsidy charges at 30% of conventional power. Many states have reduced banking provisions for renewable energy projects from an annual energy banking settlement to monthly energy banking.

Despite the discontinuation of open access charges exemptions/incentives for new projects, it is important to note that these benefits will be applicable until their expiry for the old projects commissioned during the period when such benefits were introduced. However, the landed cost of open access projects without any exemptions/incentives could remain competitive as compared to utility tariff as the discom variable tariffs for C&I category are expected to continue to rise in future. There would be a sufficient margin between the levelized cost of RE and variable discom's C&I tariff to mitigate the risk of reducing/withdrawing the open access charges incentives. The savings will improve further if consumers opt for captive mode.

3.3 Growing prospects for open access sale

3.3.1 Introduction of green energy open access rules

The Electricity (Promoting renewable energy through green energy open access) rules, 2022 give consumers an option to draw green energy through open access whose contract demand is 100 kW or above and no limit for supply of power for captive consumers. It states that cross-subsidy surcharge should not be increased by more than 50% for a period of 12 year from the date of project commissioning and full waiver on additional surcharge if fixed charges being paid by the consumer. Banking is allowed on a monthly basis on payment of banking charges. The un-utilised surplus banked energy would be lapsed at the end of each banking cycle and the RE generating station would get RECs to the extent of the lapsed banked energy. It also allows a consumer to purchase green energy by placing a requisition with their discom.

In addition, as per the rules, the electricity produced from offshore wind projects commissioned upto December 2032 will not attract additional surcharge for the energy supplied to open access consumer.

The rules provide long-term certainty of the open access charges for the stakeholders which will help in determining their returns from the project. Further, if an open access application is not approved within 15 days, it will be deemed approved. This will ensure timely execution of projects by minimizing any risk of cost escalations. The demand for green energy open access from C&I consumers is likely to increase after implementation of these rules. However, discom cooperation, regulatory proactiveness in timely tariff orders and green energy tariffs are a key monitorable.

3.3.2 Deviation in Green energy open access regulations adopted by the States from MOP rules

Most of the large industrial and RE rich states have notified green energy open access regulations, largely in line with the original Rules. However, there are a few deviations observed which are listed in the below table. Tamil Nadu and Rajasthan have not notified green open access regulations however they have provisions under their respective state regulations for RE open access.

Table 4: Comparison of MoP's green open access rules with state notified RE open access regulations

	Eligibility	Banking	Cross subsidy surcharge for third party sale (waived for group captive)	Additional surcharge for third party sale (waived for group captive)	Standby charges	Compensation for unused banked power
MoP Rules	100 kW or above	Monthly; Banked quantum – 30% of monthly consumption for discom Banking charges at 8% of banked energy	Shall not increase by more than 50% in 12 years; CSS should not exceed 20% of ACoS	Not applicable if fixed charge being paid	Not applicable if notice is given 24 hrs before the delivery of power; Should not exceed 25% of energy charges	Entitled to get REC for the lapsed banked energy
Andhra Pradesh	✓	✓	No cap on CSS	No AS exemption	✓ (20%)	Paid at 75% of the last discovered SECI tender for given RE source
Gujarat	✓	Banking charges of Rs. 1.5/kWh	✓	✓	✓ (10%)	✓
Karnataka	✓	2% additional banking charges for drawal of off-peak banked energy during peak hrs	No cap on CSS	✓	✓	✓
Madhya Pradesh	✓	✓	✓	✓	✓	✓
Maharashtra	✓	✓	No cap on CSS	✓	-	✓
Rajasthan	Minimum 1 MW contracted load	Banking on annual basis; Allowed only for CPPs; Banked energy – max. of 25% of RE injected or 30% of total monthly consumption form discom,	No cap on CSS	No AS exemption	-	✓

	Eligibility	Banking	Cross subsidy surcharge for third party sale (waived for group captive)	Additional surcharge for third party sale (waived for group captive)	Standby charges	Compensation for unused banked power
		whichever is higher Banking not applicable post FY2030				
Telangana	✓	✓	✓	✓	✓	✓

Source: MoP, Respective SERC Regulations, CRISIL MI&A Consulting

3.3.3 Summary of State RE policy

State	Benefit	Evolution
Tamil Nadu	• 50% concession on Transmission Charge / Wheeling (Distribution) Charge • 100% concession on Cross Subsidy / Additional Surcharge, for Captive sale • 40% (Wind) & 30% (Solar) concession on Cross Subsidy / Additional Surcharge, for non-Captive sale • Annual banking facility	• No annual electricity banking facility available to solar projects commissioned after March 2020 • Prior projects not connected to high voltage grids also have to pay an additional wheeling charge plus additional wheeling losses • Resource charges of Rs.5 Mn/MW for all future wind projects and pending applications, with CTU connectivity
Gujarat	• 50% concession in CSS and additional Surcharge for non-Group captive open access sale • 50% concession on Wheeling Charges and Losses for captive sale • 100% concession on Cross Subsidy / Additional Surcharge, for Captive sale • No banking charges	• Earlier Policy benefits only to solar projects commissioned by December 2020, wind projects commissioned by December 2023, Hybrid projects by June 19, 2023 • 50% rebate in CSS & AS and low banking charge for 25 years for capacity commissioned by dates stated above • No concession in Wheeling Charges and Losses
Madhya Pradesh	• 50% in Wheeling Charges for all RE projects (non-storage) for 5 years from COD • 100% concession on Cross Subsidy / Additional Surcharge, for Captive sale • State levies an additional development fee of INR 0.10/ kWh on open access projects	
Rajasthan	• 100% concession on Cross Subsidy / Additional Surcharge, for Captive sale	

State	Benefit	Evolution
	• Solar 50% and Solar + storage/Wind/Hybrid/Repowered wind 75% concession in wheeling and transmission charges for 7 years	

Source: State Policies, Industry, CRISIL MI&A Consulting

The States are slowly moving away from the benefits/waivers given to RE projects since the industry is now mature and new projects are not getting the concessions/waivers available to old projects commissioned before the implementation of new policies. This gives an added advantage to old projects with multiple grandfathered benefits.

3.3.4 Captive/group captive policies

As per electricity Rules, 2005 a power plant could qualify as a captive generating plant (CGP) if the captive user holds at least 26% ownership. A group captive mode is where a developer develops a power plant for collective usage of many consumers. A power project is considered 'captive' if the consuming entity or entities consume at least 51% of the power generated and owns at least 26% of the equity.

As per the Rules, each captive user of a CGP has to consume electricity, on an annual basis, in proportion to its shareholding in the CGP entity, subject to a variation of +/-10%. As per Electricity (Amendment) Rules, 2023 notified in September 2023 has amended the provisions relating to CGPs. It has allowed the power consumption by a subsidiary company, or the holding company of a captive user shall also be considered as captive consumption by the captive user. The amendment Rules also appointed CEA to verify the captive status of CGPs where the projects and their users are located across multiple states.

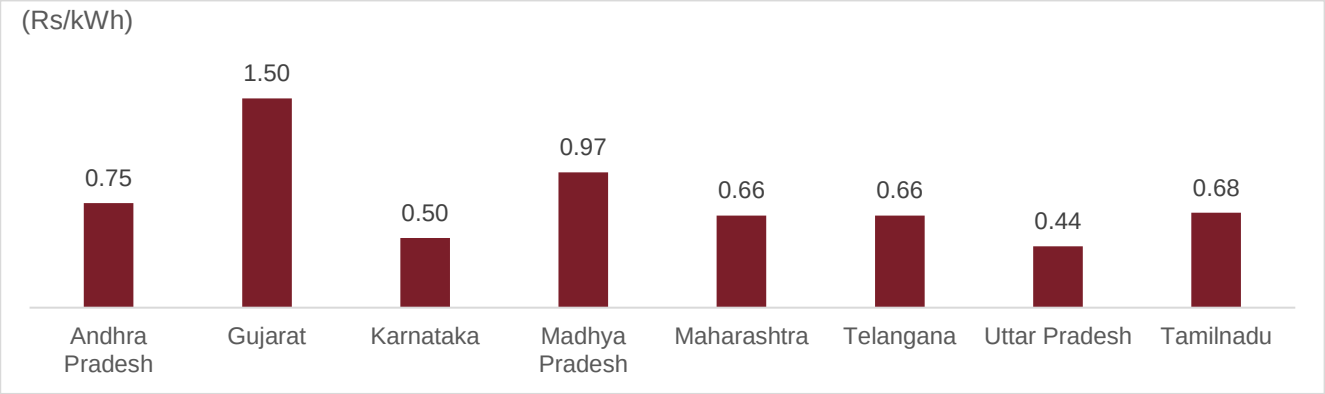
The Supreme Court judgement dated October 2023 also provided clarity relating to captive generation. It reaffirmed that the captive users must together hold 26% of ownership of the CGP and consume at least 51% of the aggregate electricity generated by CGP. It also mentioned that the minimum ownership requirement of 26% must be met and satisfied throughout the year and not at the end of the financial year. It also clarified the proportionality principle where the owner of every 1% shareholding in CGP should have minimum consumption of 1.96% with a variation of +/- 10%. The 51% Consumption requirement would be tested on yearly basis

As far as benefits for captive users are concerned, as per section 42(2) of the Electricity Act, 2003, captive power plants, set up by end-users for their consumption, are exempted from payment of cross-subsidy surcharge and the additional surcharges, otherwise would be applicable for open access consumers. Thus, the central government's policy support has played a role in promoting the captive/group captive model, especially for C&I consumers.

3.3.5 Option for green tariff under green open access rules

In line with the rules, the MoP directed SERCs to take necessary measures for the determination of green tariffs and clarified that the green tariff should not exceed the average power purchase cost of RE, including a surcharge equivalent to 20% of the average cost of supply, along with a margin of 25 paise. So far, the states like Andhra Pradesh, Karnataka, Gujarat, Maharashtra, Uttar Pradesh, Telangana have notified green tariffs for their states and only a few states have either implemented or issued draft green open access rules such as Karnataka, Punjab, Gujarat, Maharashtra, Madhya Pradesh, Telangana, West Bengal, Haryana.

Figure 33: Prevailing green tariff premium in key states



Source: State Tariff Orders

3.4 Amendments in Electricity Act, 2003 and Tariff Policy augur well for growth of RE sector

3.4.1 The Electricity Amendment rules, 2022

- **Timely recovery of power purchase costs by distribution licensee:** The respective SERCs to specify a price adjustment formula for recovery of the costs arising due to various reasons. If the discom fails to calculate fuel and power purchase adjustment surcharge on time, the discom will lose the right to recover the costs for that surcharge.

  Surcharge payable by Consumers seeking Open Access: The surcharge determined by the SERC shall not exceed 20% of the ACoS.

3.4.2 The Electricity (Late payment surcharge) rules, 2022

Enforcement of late payment surcharge against delay in payments by discoms or electricity trader to generators or by a user of transmission system to a transmission licensee is another positive measure proposed in the amendments. The rules provisioned for converting discoms' outstanding dues to these companies into equated monthly instalments (EMIs) for gradual liquidation of these dues.

The rule provides rates for late payment surcharge, payment security mechanism and process for adjustment of arrears. In case of non-payment of dues by discoms the short-term power supply to the defaulting discom would be regulated entirely as per LPS Rules. Continuing default after regulation of short-term power supply would result in regulation of long-term access and medium-term access by 10%, with progressive increase of 10% for each month of default. Also, the supply from gencos end would be reduced to 75%, and balance 25% power may be sold through power exchanges, upon non-maintenance and/or non-payment of outstanding dues by the Default Trigger Date. Further, continuance of such default shall entitle GENCO to sell its 100% power through power exchanges. Stricter implementation of the above is expected to deter distribution utilities from delaying payments to IPPs that are facing financial challenges due to non-payment of dues by discoms.

As per LPS Amendment Rules, the generators who were not offering declared but unrequisitioned surplus capacity in the market will now not be eligible to claim capacity or fixed charges corresponding to that surplus quantum. Additionally, this surplus power cannot be offered for sale in the power exchange, at a price of more than 120% of energy charge plus applicable transmission charge. This is expected to utilise the surplus electricity through trading on power exchanges and increase availability of power to consumers.

The pending dues of generators, which were about Rs. 1.4 trillion in June 2022, came down to about Rs 500 billion by January 2024. As per MoP's Praapti portal the current dues as of March 2024 were about Rs. 540 billion.

3.4.3 Electricity amendment rules, 2024

The MoP issued the Electricity (Amendment) Rules, 2024 in January, with several reforms aimed at facilitating power transmission and open access and improving the financial viability of discoms. The provisions in the rules to rationalise the open access charges by introducing a different methodology for computing these charges. Further, it also aims to prevent the creation of revenue gaps/regulatory assets and provide time-bound liquidation of such assets. Some of the key highlights of the rules are:

Open access charges – The changes focus on calculating open access and wheeling charges in a manner such that the consumers availing for short-term open access or T-GNA using STU network, the charges shall not be more than 100% of the charges levied on long-term OA consumers or GNA using STU network. No additional surcharge shall be applicable to the extent of contract demand being maintained with the discom. In case open access is availed more than the contract demand and no fixed charge or variable charge is being paid for additional quantum, in that case additional surcharge shall be paid which should not be more than per unit fixed cost of power purchase of the discom. Moreover, for a person availing GNA or open access, any additional surcharge should be eliminated within four years from the date of granting open access or GNA, if it is continued to be availed.

The reduced charges and limitations on additional surcharges provide cost advantages and greater transparency, enabling C&I consumers to make informed decisions based on their specific energy requirements and financial considerations for the long term. These changes can drive higher interest in open access among C&I consumers, leading to increased participation in the open access market.

Gap between approved ARR and estimated annual revenue from approved tariffs – The Rule emphasises that the approved tariff should be aligned with the approved annual revenue requirements, with a permissible gap of no more than 3% of the approved ARR, except in cases of natural calamities. Any existing gaps, along with carrying costs at the base rate of LPS, should be liquidated over a maximum of three equal yearly installments, commencing from the next financial year. It is expected to ensure cost reflective tariff, and all the prudent costs are passed through into the tariff.

3.4.4 Other Rules notified by the government over the period

- **Electricity (Timely Recovery of Costs due to Change in Law) Rules, 2021-** The Rules would be applicable to gencos and transcos. Timely recovery of the costs due to a change in law is crucial for maintaining the financial viability of the project. At present the pass through under change of law takes a lot of time, forcing the drying of the investment in the power sector. In order to ensure timely recovery of recurring/ non-recuring costs arising due to change in law, the rule is expected to provide relief available to the affected party, irrespective of a specific change in law clause in the PPAs.
- **The Electricity (Rights of Consumers) rules, 2020** obligate distribution licensees to supply 24x7 power to all consumers. The discom to supply electricity on request made by any consumer. Consumers would get connection within 7 days in metro cities, 15-30 days in rural and other cities.
- **The Electricity (Rights of Consumers) amendment rules, 2021** give consumers of electricity right to set up renewable energy generation unit either by themselves or through third party service providers. The consumers can set up solar rooftop system up to 500 kW under net-metering and gross-metering for loads above 500 kW. This is expected to boost open access transactions by corporate consumers.
- **The Electricity (Rights of Consumers) amendment rules, 2023** introduced Time of Day (ToD) Tariff mechanism wherein the tariff during solar hours of the day shall be 10%-20% less than the normal tariff, while the tariff during peak hours will be 10% - 20% higher. This would be applicable for C&I consumers

having maximum demand of 10 kW and above, from 1st April 2024 and for all other consumers except agricultural consumers, latest from 1st April 2025.

3.5 PLI scheme for batter energy storage system

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.

VGF scheme for development of 4,000 MWh of BESS capacity

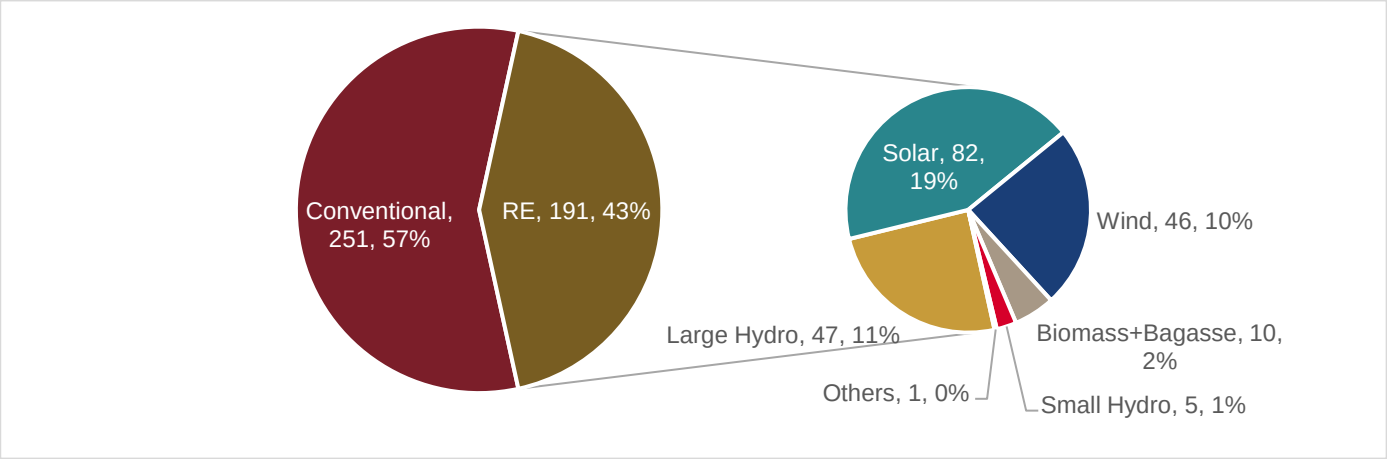
In September 2023, the government approved the VGF scheme for development of 4,000 MWh of BESS capacity by fiscal 2031. An initial outlay of Rs. 94 billion including budgetary support of Rs. 37.6 billion has been provided under the scheme. The VGF would be provided from fiscal 2024-26 and will be capped 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. 181 billion, which includes more than 10 GWh grid-scale battery storage. As of December 2023, out of 50 GWh capacity, 30 GWh capacity has already been allotted through competitive bidding process.

3.6 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 to ~191 GW as of March 2024, as compared with ~63 GW as of March 2012 and ~80 GW as of March 2015 (*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 ~43% of the total installed generation base in India. This growth has been led by solar power, which has grown to ~82 GW from merely ~0.09 GW over the discussed time period (i.e. from March 2012).

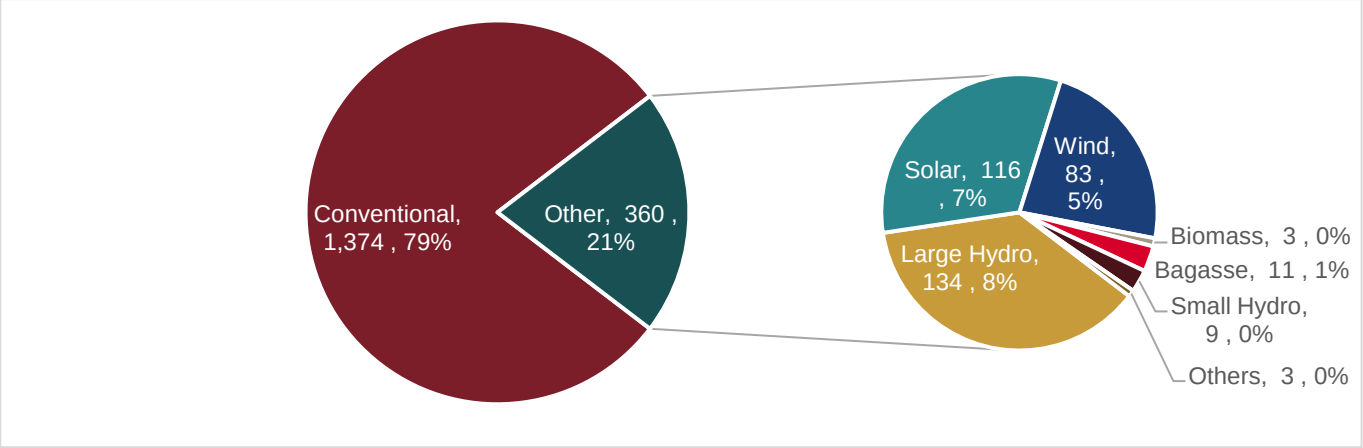
Figure 34: India's RE (incl. large hydro) capacity was 43% at the end of March-2024



Conventional: Coal, Gas, Lignite, and Nuclear
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 ~360 BUs for fiscal 2024.

Figure 35: India's RE (incl. large hydro) penetration was about 21% at end of fiscal 2024

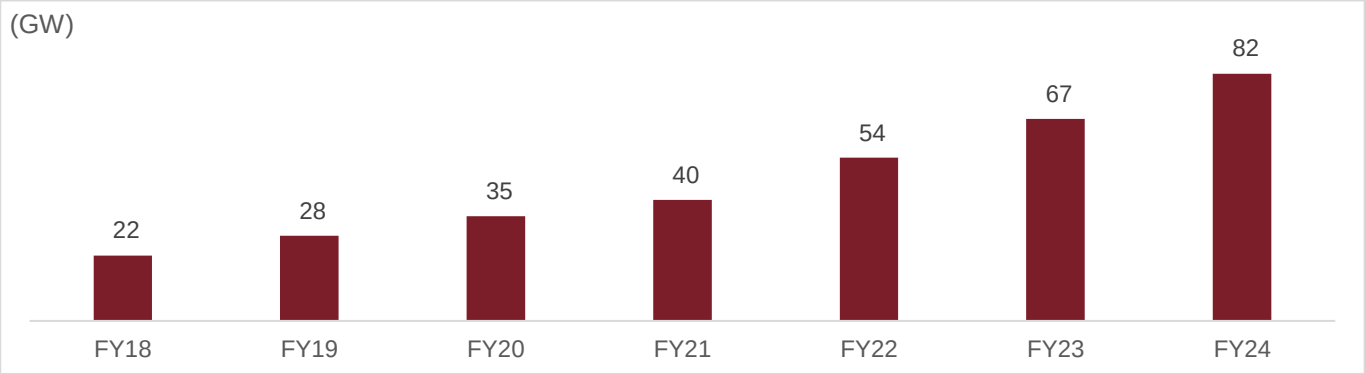


At CEA RE Generation data lags compared to installed capacity data.
Conventional: Coal, Gas, Lignite and Nuclear
Source: MNRE; CEA, CRISIL MI&A-Consulting

3.7 Solar energy capacity additions in India (FY2014-2024)

In the renewable energy basket (excl. large hydro) as of March 2024, solar energy accounted for a share of 43%. Growth in the solar power sector over the last five years has been robust. As much as ~60 GW capacity was added in the segment over fiscals 2018-23, 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.

Figure 36: Trend in solar capacity installation in India



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

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

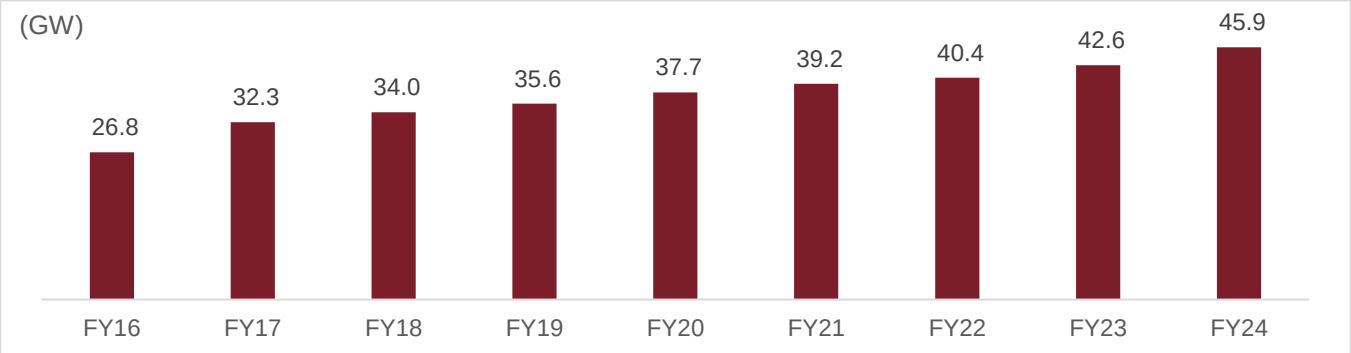
During fiscals 2018-2023, ~55 GW of solar capacity has been commissioned compared with the expected commissioning of 60-65 GW. Despite the second pandemic wave, ~14 GW of solar capacity was added in fiscal 2022. The momentum continued in fiscal 2023 and 2024, with robust solar capacity additions of ~13 GW and ~15 GW respectively.

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.

3.8 Wind energy capacity additions in India (FY2014-2024)

India has the fourth largest installed wind power capacity in the world, with ~46 GW as of 31 March 2024. Wind power accounted for nearly 10.4% 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 37: Cumulative Wind power installed capacity



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

Fiscal 2024 has witnessed healthy capacity addition of ~3.25 GW. 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.

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 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).

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

The top five states (Gujarat, Tamil Nadu, Karnataka, Rajasthan, Maharashtra) make up ~84% of the installed wind capacity (as of 31 March 2024), with some regions within these states accounting for most wind power projects. Since April 2021, ~80% the new capacity additions have happened in 3 states – Gujarat, Tamil Nadu, and Karnataka.

Gujarat, with the highest installed wind capacity of 11,723 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 10,604 MW, most projects are located in districts of Tirunelveli, Nilgiris, Erode, Tuticorin, Coimbatore and Tiruppur. Likewise, for Karnataka (6,020 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.

3.9 India’s renewable potential and global rank

India stands 4th globally in Renewable Energy Installed Capacity, 4th in Wind Power capacity and 5th in Solar Power capacity. Despite strong capacity additions, there is huge untapped potential for RE installations in India, as is evident from the table below.

Table 5: Potential and cumulative capacity of RE (technology-wise)

Technology	Potential (GW)	Cumulative capacity (GW) (as of March 24)	Untapped potential
Wind	~696 (120 m hub height)	45.89	93.41%
Solar	750	81.81	89.06%
Bioenergy	25	10.36	58.58%
Hydro	165	51.93	68.53%
Waste to energy	NA	0.59	NA

Hydro: Large + Small hydro

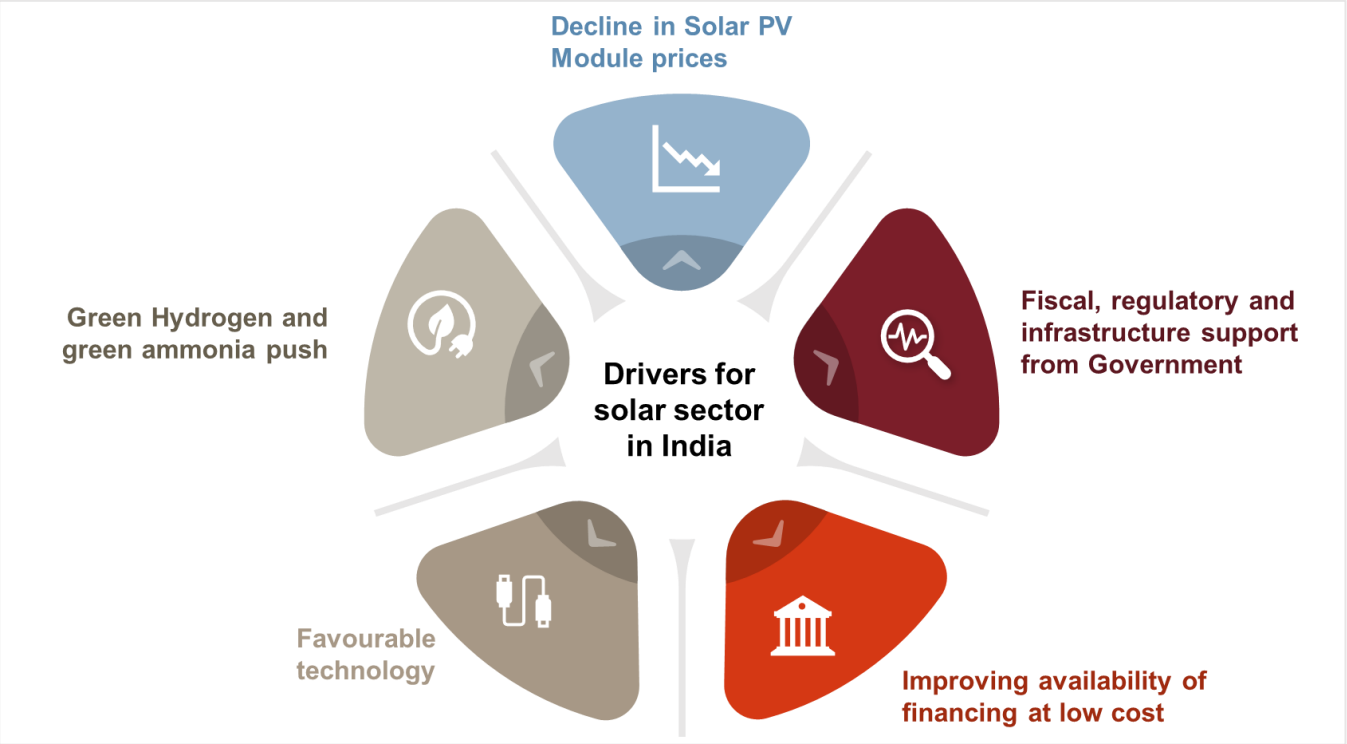
Source: MNRE; NITI Aayog; CRISIL MI&A Consulting

India's focus on development of RE aligns with broader sustainability goals and International RE commitments to combat climate change. RE Sector in India is poised for continued expansion and innovation, with ambitious targets for RE capacity additions, including addition of 500 GW of non-fossil-fuel based capacity by 2030. Indian RE sector has now matured which can be seen from its large size, comparatively lower risks, predictable yields and medium to high returns. The untapped potential and conducive investor friendly environment along with supportive government policies, RE sector provides a huge opportunity for investors.

3.10 Key factors impacting the evolution of Solar, Wind & Hybrid Power in India

3.10.1 Solar

Figure 38: Key growth drivers for solar



Source: Industry, CRISIL MI&A Consulting

a) **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 (China FOB, 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.

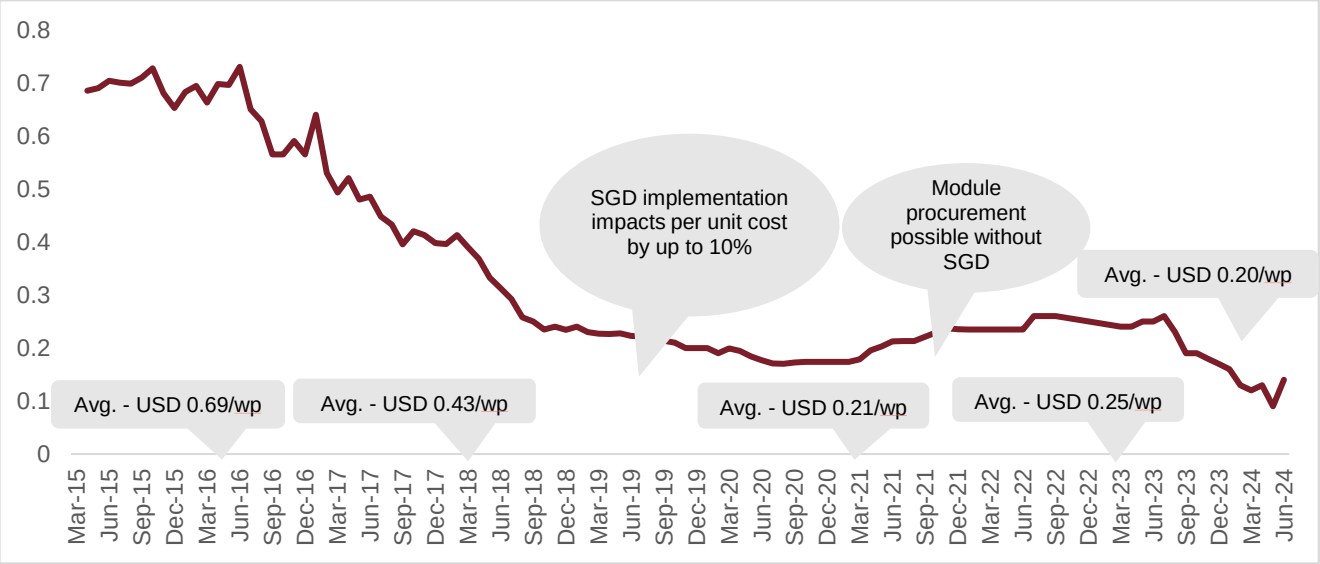
Module prices started to fall in CY 2023 owing to the ramp-up in the production of upstream components. Prices of modules fell to $0.15-0.20 per watt-peak in April-November 2023 from $0.23 per watt-peak in January 2023. This has eased some pressure on capital costs in fiscal 2024. Prices of Monofacial module had touched USD 0.20 Wp by Q4 of fiscal 2024. Global solar module prices have reached a historic low, standing at just $0.09 per

watt-peak in June 2024. CRISIL MI&A Consulting projects module prices to be in the range of USD 0.21-0.23 per watt-peak and USD 0.22-0.24 per watt-peak for imported and domestic mono-crystalline respectively in fiscal 2025 owing to limited room for discount at the manufacturing end. Also, solar glass pricing, another key input to modules, was also lower on-year owing to falling prices of soda ash on account of low demand. While the long-term end-market demand remains strong amidst the renewable energy target of tripling capacity, the present oversupply is expected to persist in fiscal 2025.

It is also pertinent to note that due to declining tariffs of solar, the tariffs for hybrid projects are also getting more competitive than thermal power. Competitive tariffs of hybrid projects also drive the solar capacity additions.

Also, there is significant Solar PV module capacity additions is going on in India which would lead to competition/pricing pressure between the Solar PV module manufacturers themselves, which would help IPPs in future growth.

Figure 39: Module prices declined over 200% from fiscal 2015 to 2024 (USD/Wp)



Source: Industry, 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).

Table 6: 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

b) **Fiscal, regulatory and infrastructure support from Government:** 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. 750 billion and aims to light up 10 million households by providing up to 300 units of free electricity every month.

Subsidy for residential households

- 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 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 85.8 billion, 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 7 million/MW which was subsequently reduced to Rs 5.5 million/MW for the 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 FY 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 renewable energy power parks (UMREPPs) 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 CEA report, as of April 2024, 55 Solar Parks/UMREPPs with an aggregate capacity of 39.8 GW have been envisaged in 13 States in the country since the launch of the Scheme i.e. December 2014. An aggregate capacity of 11.3 GW of solar projects have been commissioned in 21 Solar Parks, so far. Apart from this, 11.1 GW is under construction and the remaining 17.3 GW is under award/tendering.

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.

c) **Availability of debt and equity finance:** To facilitate growth of renewable energy and, in particular, the solar power sector, the GoI has provided several measures to facilitate finance availability to developers. Some of these steps taken are as follows:

- *Funding from lending institutions such as IREDA, REC and PFC:* Government financial institutions such as Power Finance Corporation (PFC), Rural Electrification Corporation (REC) and IREDA are financing many solar projects. As of December 2023 (9MFY24), REC has sanctioned Rs. 1250.54 billion loans to RE incl.

large hydro. Further, for IREDA, the cumulative sanctions as of March 2023 stood at Rs. 1,025 billion for RE incl. large hydro.

- *Green bond / masala bonds market:* A green bonds is like any other bond; however, it invests the proceeds to support green investments including renewable energy projects. The tenure of the bonds typically ranges from 18 months to 30 months and are issued for a tenure of 1-10 years. India is the second country after China to have national-level guidelines for green bonds; in India's case, they were published by SEBI. The green bonds may be issued by the national government; multilateral organisations such as Asian Development Bank, the World Bank or the Export-import (EXIM) bank of the country; financial institutions; and corporations.
- *Pension funds / endowment funds*: Pension / endowment funds are expected to play a key role in financing solar projects. Long-term 25-year PPAs with limited operational risk are very suitable to this investor category. Mahindra Group and Ontario Teachers' Pension plan have launched RE InvIT named Sustainable Energy Infra Trust (SEIT). Both Mahindra Group and Ontario Teachers' had committed to investing upto Rs. 30.5 billion and Rs. 35.5 billion respectively into Mahindra Susten and SEIT. Canada Pension Plan Investment Board (CPPIB) owns more than 50% stake in Renew Power.
- *Funding from multilateral banks and International Solar Alliance (ISA):* Further, the government channelises the funds available from multilateral banks and financing institutes such as World Bank and KfW. Funds are also provided to various CPSUs/ Central NBFCs with Indian government backing under the Climate Investment Fund of the World Bank. For instance, SBI has also received ~$625 million of soft loans with a long tenure of 20 years from the World Bank at a concessional rate to support viable grid-connected rooftop solar PV projects. On the same lines, KfW Germany provided a 1-billion-euro loan through IREDA for funding solar projects. Further, European Investment Bank has signed a long-term loan of 150 million euros with IREDA to finance clean energy projects in India.

The ISA, an association of solar-resource-rich countries, launched by the governments of India and France, aims at mobilising $1,000 billion in funds by 2030. The alliance intends to make joint efforts through various policy measures, such as an international credit enhancement mechanism that is expected to de-risk investments and reduce the cost of financing for solar projects. The ISA member countries, in collaboration with the United Nations, the Green Climate Fund, multilateral development banks, investors, insurers, private financial institutions, and other interested stakeholders will finance solar projects.

d) 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 CY 2023, the share of bifacial variant in module imports increased from 8% in Q1 2022 to 37% in Q4 2023. 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 CY 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.

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 CY 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 CY 2023 to around 16% in CY 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.

Green Hydrogen and green ammonia push: India has announced a target of energy independence by 2047 and a net-zero by 2070. Green Hydrogen is expected to play a substantial role in achieving these goals. The production of Green Hydrogen using renewable energy sources like solar, wind, and hydropower can provide energy security, reducing dependence on fossil fuels and ensuring a stable and reliable source of energy. Green hydrogen can also be produced locally, reducing the need for costly and environmentally damaging imports. Furthermore, Green Hydrogen produced using waste biomass provides an additional revenue stream for farmers and local communities. Hence, India has launched the National Green Hydrogen Mission with an outlay of Rs. 197.44 billion with a target of 5MMT production capacity of Green Hydrogen per annum. Green hydrogen push from the government will likely push for the installation of solar energy for consumption.

In July 2023, SECI has issues a Tender for selection of green hydrogen producers for setting up 450,000 MT per annum production facilities for green hydrogen in India under the SIGHT Scheme (Mode-1-Tranche-I). The green hydrogen auction, which offered a per-kilogram maximum of 50 rupees in the first year, 40 rupees in the second, and 30 rupees in the third, awarded subsidies to eight out of thirteen bidders. Total Capacity available for bidding under Technology Agnostic Pathways (Bucket I) was 410,000 MT/annum and Biomass Based Pathways (Bucket II) 40,000 MT/annum. Under its first green hydrogen tender, India has awarded incentives to various bidders for a total production of more than 400kt per annum.

Government of India has already initiated pilot scheme for use of hydrogen in shipping, steel and transport sector.

The Green Hydrogen Mission will have wide ranging benefits- creation of export opportunities for Green Hydrogen and its derivatives; Decarbonisation of industrial, mobility and energy sectors; reduction in dependence on imported fossil fuels and feedstock; development of indigenous manufacturing capabilities; creation of employment opportunities; and development of cutting-edge technologies.

3.10.2 Wind

Figure 40: Key growth drivers for wind

Source: Industry, CRISIL MI&A Consulting

a) **New tender opportunities:** New opportunities have emerged in the wind sector in India with SECI coming up with newer kind of project tenders in the form of hybrid, round-the-clock, and peak power supply projects. 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 and peak power supply 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.

b) **Improved technology:** Newer wind turbines are being launched that have higher rated capacity and higher hub height (over 100-120 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. As per industry interactions, the capital costs will encompass improvement in turbine technology, and 3.5 MW and above wind turbine technology have already started to be used in India. This improvement in technology will enable capacity additions outside the windy region and allow developers to transition from key windy regions to other areas, thereby driving capacity additions.

c) **Large-scale central allocations:** Post competitive bidding of 1 GW by SECI in February 2017, SECI further allocated ~12 GW (excluding cancelled contracts) of capacities over March 2017-December 2023 through wind only schemes. MNRE has outlined further plans to tender 10 GW of capacity each year, of which the majority portion should be expected from SECI/NTPC. 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 NTPC are better rated and provide various payment security mechanisms (LCs, payment security fund and SECI being party to the tripartite agreement).

d) **Revision in RPO targets:** MoP has provided new RPO long-term trajectory for wind energy till fiscal year 2030 which propose target of 0.81% for wind in fiscal 2023, increasing consecutively to 6.94% in fiscal 2030 for wind. These targets, however, need to be met from wind plants commissioned after 31st March 2022, thus requiring installation of new capacity. To meet the increased targets, states would have to procure more renewable energy either via the REC route (which still leads to capacity additions) or via competitively bid out capacities. Waiver of Interstate transmission system (ISTS) charges by Central electricity regulation commission (CERC) for all projects set up until fiscal 2025 also enables the states with low renewable potential to procure renewable power from more able states. However, RPO compliance is dependent on strict enforcement by regulatory authorities.

e) **High industrial tariffs in select states:** In states such as Maharashtra, Karnataka, Tamil Nadu and West Bengal, where industrial tariffs are high (Rs 7-8/unit), wind power is an attractive option since generation cost is about Rs 3.0-4.0 per unit. Capacity can be set up via the open-access mode, i.e., bilateral agreements directly with consumers such as commercial/industrial entities.

f) **National Green Hydrogen Mission:** The National green Hydrogen Mission with an objective to make India leading producer and supplier of Green Hydrogen by developing 5 MTPA of Green hydrogen per annum, as per target set by the Government by 2030. But production of green hydrogen is expected to start from fiscal 2026 itself, necessitating installation of renewable from fiscal 2025. Demand from green hydrogen is expected to drive the additions but will remain a key monitorable.

g) **Data centres –** They require significant uninterrupted power on RTC basis for continuous operations. This could enhance the proposition for hybrid project requirement. About 4.8-5.2 GW of power is estimated for data centers. This will help wind and solar to expand additionally by seeking C&I PPAs due to green commitments.

Challenges in project execution

While both wind and solar projects share some common challenges, there are some unique difficulties that arise during the execution of wind projects compared to solar projects.

Parameter	Wind	Solar
Site selection and Accessibility	Mostly in remote locations, difficult to transport equipment; adds to transportation and personnel cost	Comparatively accessible sites; easier to transport equipment and personnel
Equipment installation	Turbines are complex, require specialised installation and maintenance	Panels are relatively simple to install and maintain due to lesser moving parts
Civil works/foundation	Deep foundations for stability, complex and requires more time	Simpler foundations or tracking systems, comparatively easy to install
Electrical infrastructure	Extensive electrical infrastructure, including medium-voltage cables and substation	Less extensive electrical infrastructure, with simpler connections to the grid.
Environmental impact	Greater impact on wildlife, particularly birds and bat; mitigation measures are crucial	Lower environmental impact, but still require assessments and mitigation measures to minimize effects on local ecosystem
Noise	Turbines can generate noise, can be a concern for local communities	Not a major concern
No. of components and sourcing	Turbines are complex machines with many component; can lead to supply chain and sourcing issues	Panels are simple, with fewer components,
Land acquisition and permissions	Require large land areas, complex land acquisition and permissions	Typically require smaller land area, relatively, simpler land acquisition and permissions
Construction time	Longer construction timelines due to the complexity of turbine installation and foundation work	Shorter construction timelines, with faster installation and commissioning processes.
O&M	Frequent and complex maintenance, detailed performance monitoring and data analysis	Less frequent maintenance, with simpler performance monitoring and data analysis.

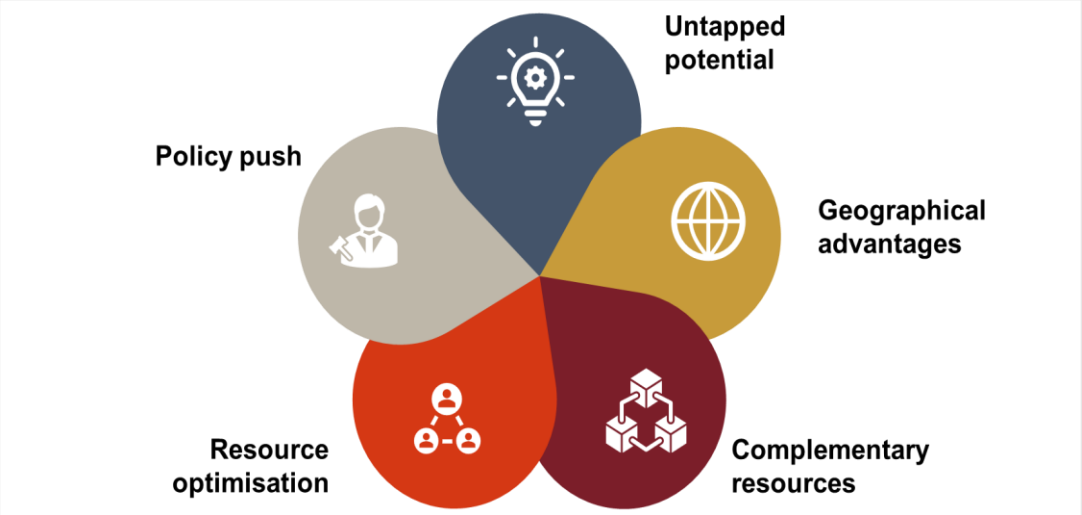
Source: Industry, CRISIL MI&A Consulting

While both wind and solar projects come with their unique challenges, wind projects tend to be more complex and require more specialized expertise, particularly in terms of turbine installation, maintenance, and electrical infrastructure.

Additionally, even with marginal improvement in RE technology, due to increasing commodity prices and lack of resource rich sites, the new capacity might be more expensive than the old one.

3.10.3 Wind Solar Hybrid

Figure 41: Key growth drivers for wind solar hybrid



Source: Industry, CRISIL MI&A Consulting

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

a) **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.

b) **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.

c) **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).

d) **Resource optimisation:** Co-located WSH plants can help in 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.

e) **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.

f) **Installation of pumped storage projects:** The government's support for PSP would help resolve the intermittency issues associated with solar and wind projects by storing excess energy for later use. As the

demand for hybrid projects is increasing and integrating them with PSPs can prevent curtailment issues which would potentially improve the utilisation of hybrid projects allowing more wind projects installations.

WSH projects are commercially attractive compared to standalone wind and solar projects, as they generate more energy (kWh) per MW of grid open access capacity or possess a higher plant load factor on grid open access capacity. Compared to standalone solar or wind projects, WSH projects offer greater annual energy cost savings for C&I consumers at the same per kWh tariffs. This is primarily due to (a) higher kWh generation per MW of installed capacity, with WSH outperforming both solar and wind alone, (b) greater kWh supplies from WSH projects during peak tariff hours (typically 4 hours in the morning and 4 hours in late evening) when the tariffs charged by distribution utilities are higher as mandated by the Electricity (Rights of Consumers) Rules, 2023, displacing higher-cost energy for longer periods, and (c) lower per MW transmission cost which is charged only on the higher of the wind or solar AC capacity and not on sum of both. In addition, WSH projects also have lower per MW transmission costs and reduced capital expenditure on account of sharing of common infrastructure.

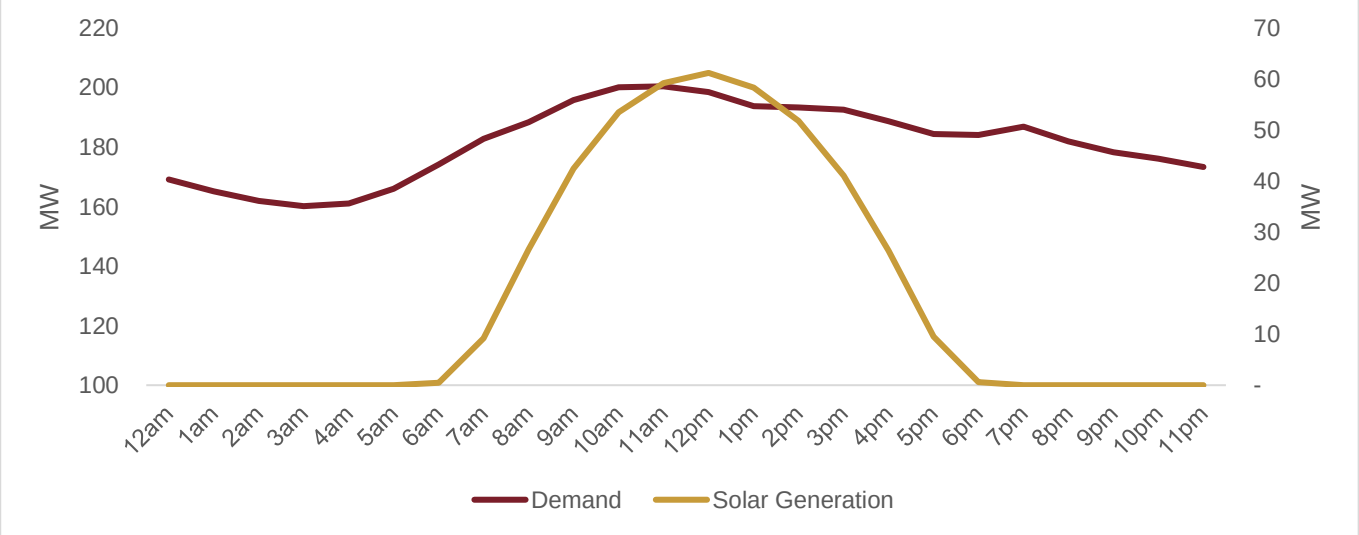
3.11 Energy storage solutions and their outlook

3.11.1 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: The share of energy generated using solar power has increased significantly in the grid and hence this increases the importance of wind, WSH, Storage in managing the non-solar peak hours which leads to additional generation and ramping requirements. 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.

Figure 42: Demand profile and solar generation curve



Annual average demand; typical solar generation curve; (Note: the above chart is only for illustration to demonstrate typical demand curve and solar profile)
Source: NITI Aayog dashboard, CEA, Industry, CRISIL MI&A Consulting

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 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.

4 Power demand, supply and tariff outlook for the identified states

4.1 National Level

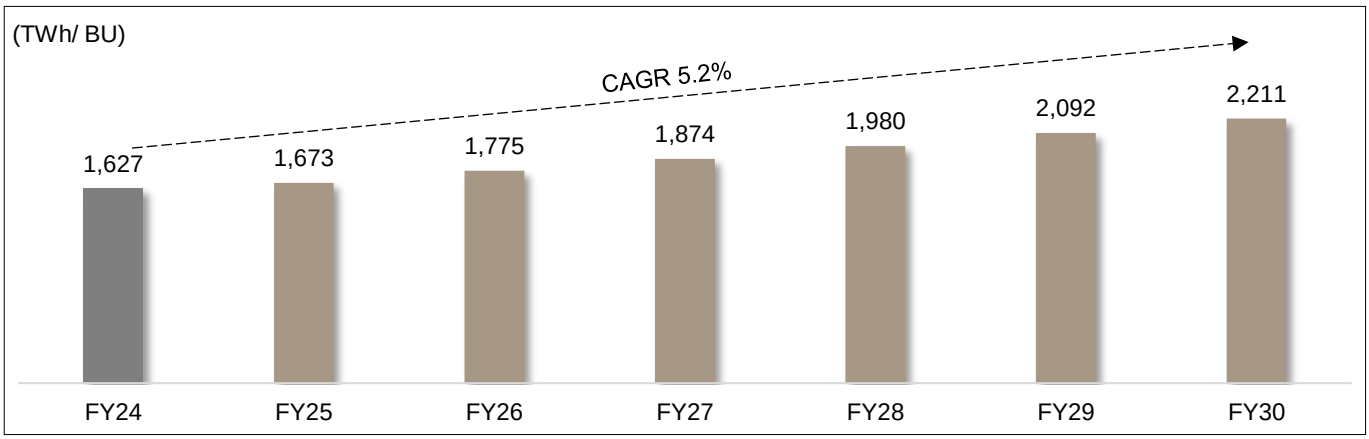
4.1.1 Demand Projections

Base level demand has been projected by regressing GDP growth of the economy and capex by state utility by providing a weightage of 75% and 25% respectively. This base level demand has been adjusted with demand drivers and restraints to estimate overall demand.

CRISIL MI&A Consulting forecasts a GDP growth of 6.8% for FY25 on the back of improving consumer sentiments, increasing utilization in the manufacturing sector and growing momentum of contact-based services. Regression co-efficient between GDP and power demand is 98.2% indicating a strong correlation between GDP and power demand.

On regression with GDP, power demand is estimated to grow at a CAGR of 5.2% from FY24 to FY30, to reach 2,211 billion units by FY30. Renewable energy's proportion of this expected growth is supported by various GOI policies, rising environmental concerns and incentives for renewable capacity installations

Figure 43 : Power demand forecast with respect to GDP

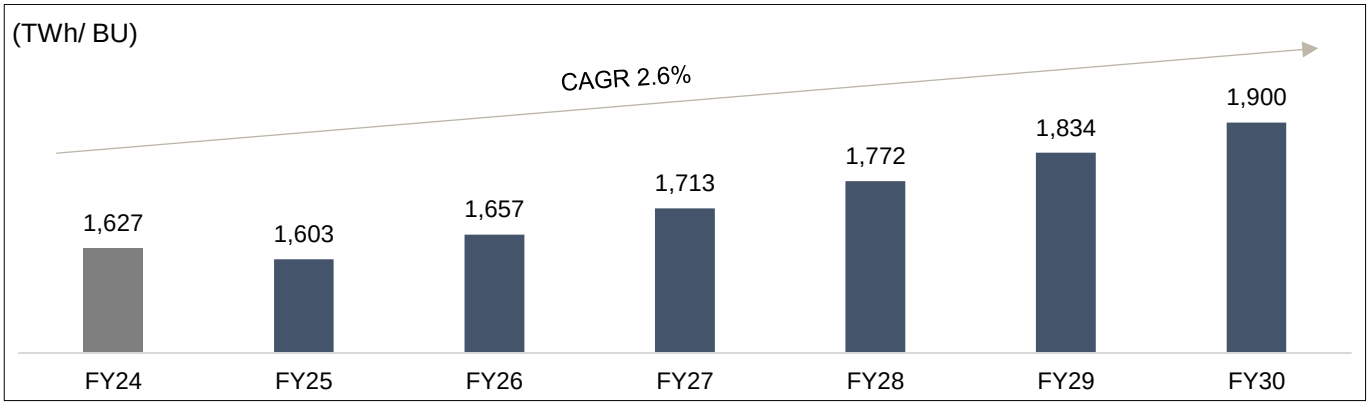


Source: CRISIL MI&A Consulting

Utility financials will continue to be stretched and hence capex investments are expected to grow by 6-8% till FY30 majorly focused on improving network infrastructure. Regression co-efficient between state utility capital expenditure and power demand is 91.3% indicating a strong correlation between state utility capital expenditure and power demand.

Basis regression with state utility capital expenditure, power demand is estimated to grow at CAGR of 2.6% from FY24 to FY30, resulting in power demand of 1,900 billion units by FY30.

Figure 44 : Power demand forecast with respect to capital expenditure by state utilities



Source: CRISIL MI&A Consulting

Latent demand: Latent demand includes demand from the residential sector (due to improved reliable power supply owing to reduced power cuts) and industrial sector (due to the switch from captive to grid for power supply).

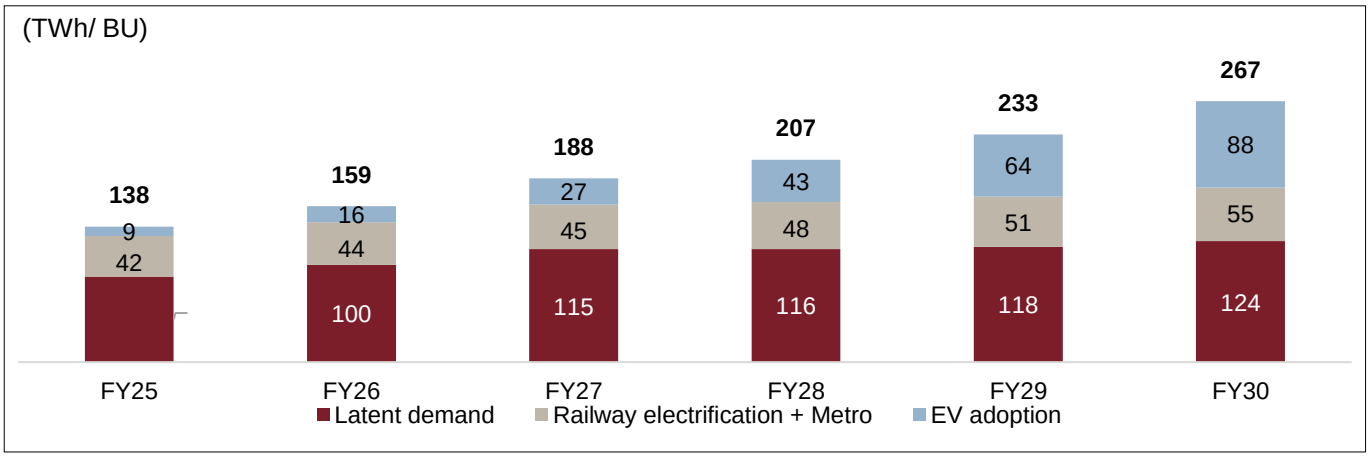
Railway electrification: India aims to achieve 100% electrification of its Broad-Gauge network by adding ~17,400km electrified tracks by FY25. Further, Indian Railways is setting up 30 GW of RE projects by FY30. A new railway line connecting Gujarat and Rajasthan (~117km) is under construction. Another line connecting Chandigarh and Baddi-Amritsar-Kolkata corridor (~30km) to be completed by FY26.

Metro and dedicated freight corridor (DFC): India has 816 km of operational metro, with 1168 km under construction. Delhi has the longest metro line of 348 km, with another 311 km under construction. Cities with metro being constructed for the first time include Patna (49 km), Surat (40 km), Indore (32 km). Eastern DFC of 1327 km and Western DFC of 847 km to come online by 2024.

Data centres: The rapid expansion of India's digital population and the burgeoning digital economy have led to strong growth in data centers to meet increasing demands. The data center industry in India is evolving to meet the diverse needs of enterprises, government agencies, and cloud service providers. The market size is estimated to be ~ USD 1.9-2.2 billion, with a market volume of ~2 GW in 2024. It is expected to reach USD 4.5-5.5 billion by 2029, with a market volume of ~4.8-5.2 GW, growing at a CAGR of ~18-20%.

EV adoption: By FY30, 2W and 3W to witness maximum EV penetration of 25% & 22%, respectively. 4W and buses to also pick up traction with 17% and 9% of respective penetration. PVs to see maximum penetration in cab/taxi segment. Govt. support via (FAME)-2 and tax rate cuts to boost EV sales. MoRTH to set up new EV charging kiosks at each petrol pump to minimize range anxiety and accelerate adoption.

Figure 45 : Outlook on major power demand drivers



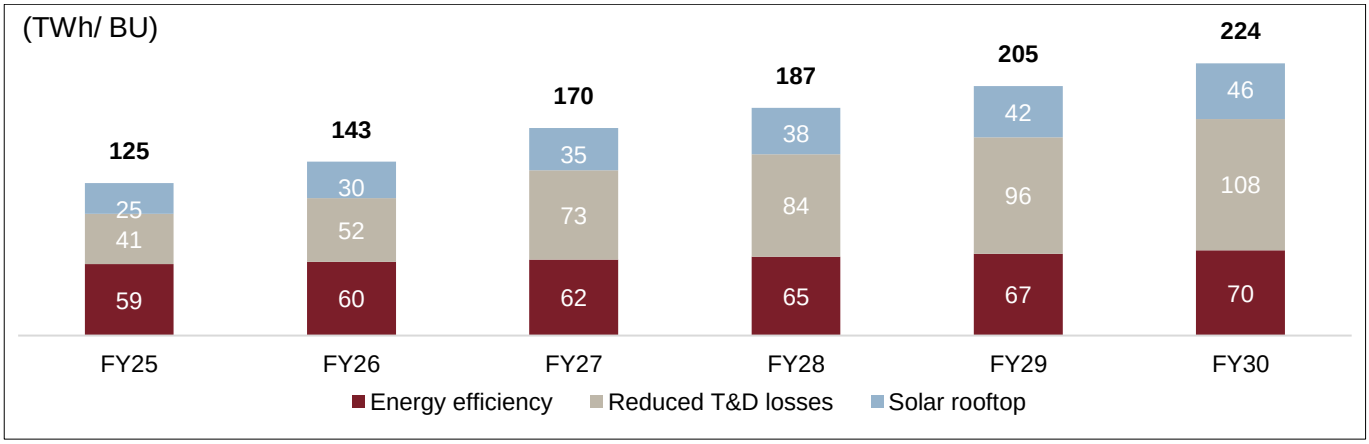
Source: CRISIL MI&A Consulting

Energy efficiency: Sale of LED lamps, tube lights to grow at fast pace till FY30. Fans, streetlights & agricultural pumps will witness stable growth. Domestic manufacturing and maturity in supply ecosystem to boost adoption of these products.

Reduced T&D losses: With all-India T&D losses reducing to ~16% in FY30, requirements of strengthening and augmenting the network is expected to reduce.

Solar rooftop: Solar rooftop capacity of 13-14 GW expected to be commissioned over FY23-27. In the long-run, capacity addition is driven by falling module prices and technological innovation. The industrial sector alone accounts for ~54% of rooftop capacity. Provisions like low-cost financing, net metering and capital subsidy to boost addition.

Figure 46 : Outlook on major power demand constraints



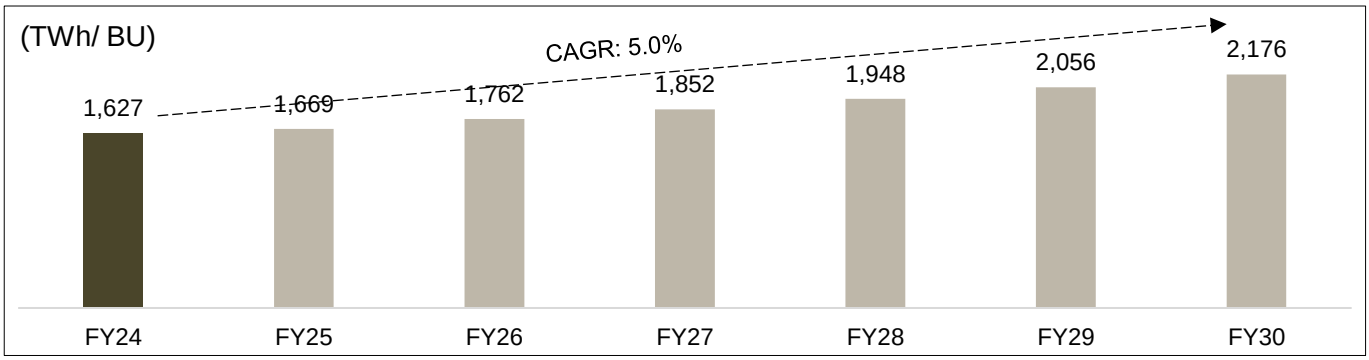
Source: CRISIL MI&A Consulting

Power demand was estimated by regression with GDP (75% weightage) and state utilities CAPEX (25% weightage). However, the correlation of demand with GDP was higher than that with utility expenditure. Further, state wise historic power demand has been analyzed to derive the total power forecast. Result when adjusted for demand drivers and constraints gave power demand of ~2,176 billion units by FY30, indicating a CAGR of 5.0%, in line with the national targets.

Energy demand from C&I consumers in India reached 711 BU, representing approximately 49% of the total energy demand in India in fiscal 2023 and is expected to grow at a CAGR of 5-6% to 1000-1100 BU, representing approximately 45-50% of the total energy demand in India in fiscal 2030.

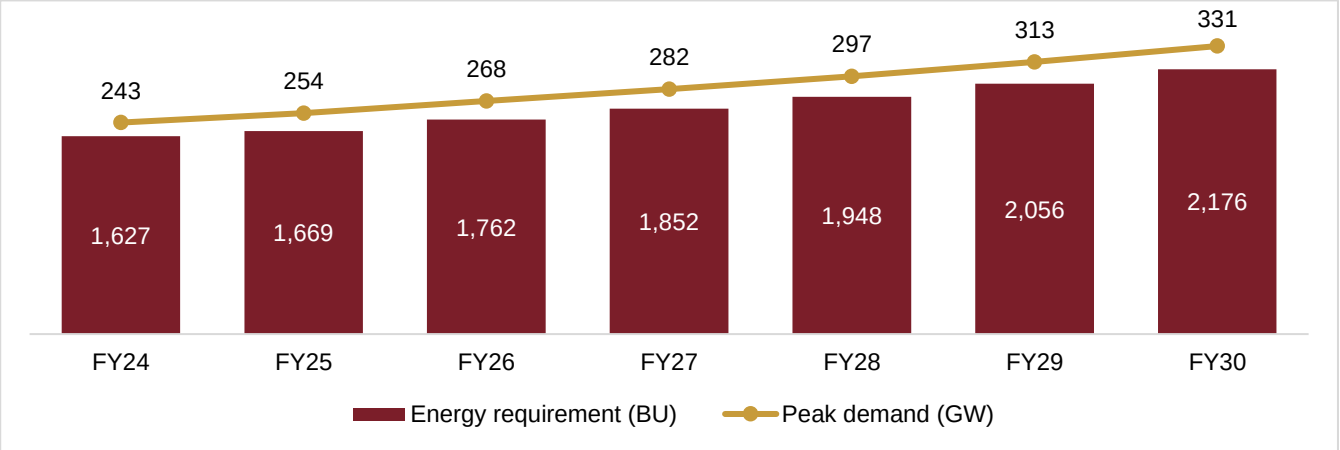
Using the Load factor, the ex-bus energy requirement is grossed up to arrive at the peak requirement. Peak demand (ex-bus bar) of the state is expected to reach ~331 GW by FY30.

Figure : Estimated and adjusted overall demand growth



Source: CRISIL MI&A Consulting

Figure 47: Total energy requirement and peak demand for India

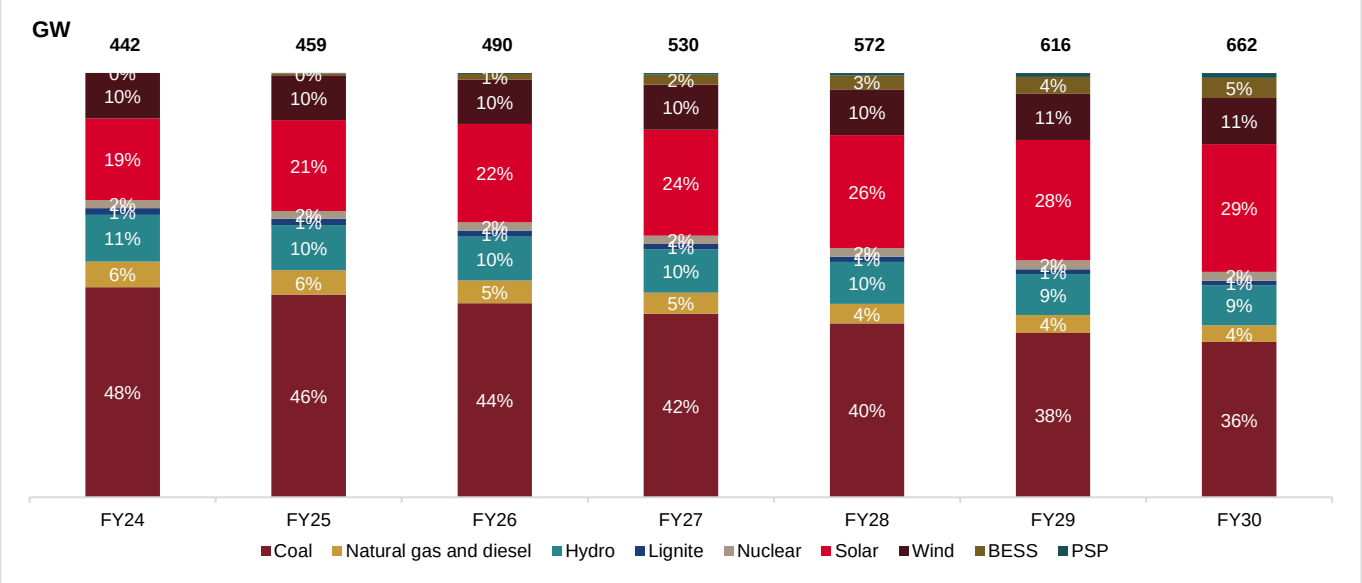


Source: CRISIL MI&A Consulting

4.1.2 Outlook on RE capacity additions in India

The share of coal in the country's energy mix is estimated to decline to 36% by FY30, due to limited thermal plant capacity additions. Hydropower capacity additions, including PSP (pumped storage) expected to be commissioned from FY24 to FY30, resulting in 7-9% share. 20 nuclear plants to be commissioned by FY31, resulting in capacity additions of ~6GW. Renewable energy would account for the largest capacity addition of a total of ~136 GW till FY30. Share of total RE to reach 48% till FY30. Solar capacity is expected to increase steadily whereas wind expected to keep the share up. Share of energy storage capacities (PSP and BESS) to increase from ~0-1% in FY24 to ~6% in FY30 to provide adequate storage capacity for sustained renewable energy capacity addition.

Figure 48 : Overall installed capacity



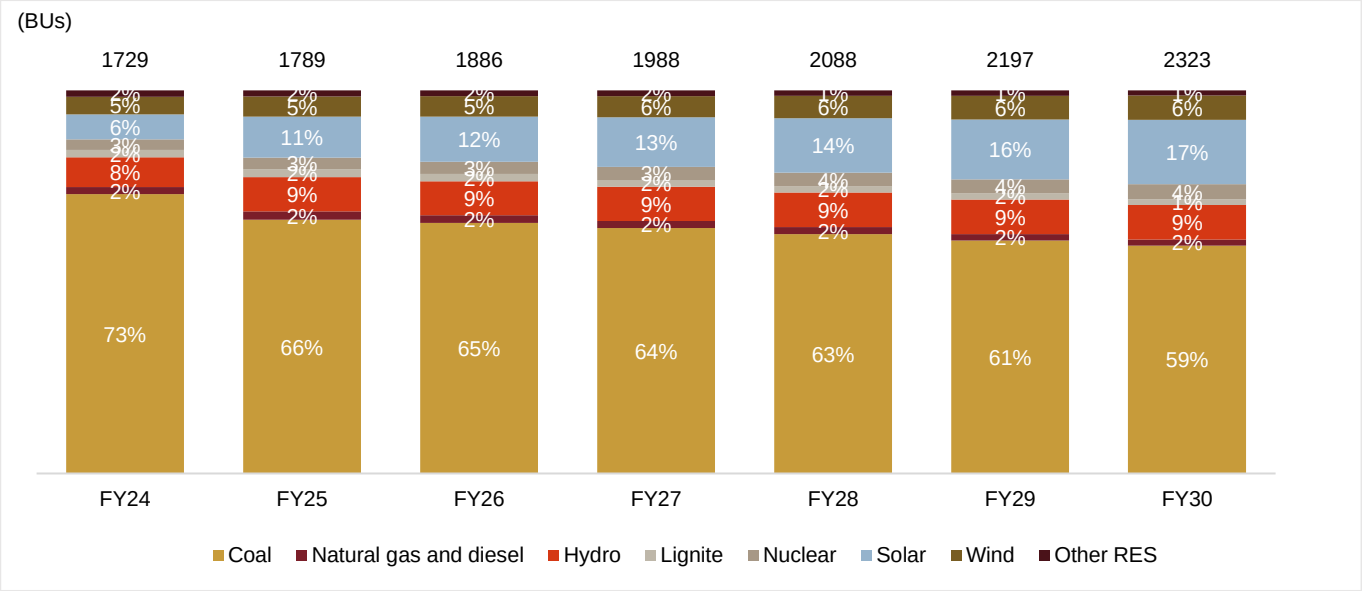
Source: CRISIL MI&A Consulting

4.1.3 Supply Projections

The share of coal in the country's generation mix is estimated to decline to 59% by FY30, due to limited thermal plant capacity additions. Hydropower capacity additions, including PSP to account for ~9% of the total generation. Increase in nuclear generation due to commissioning of plants to result in higher share of 4% in FY30 vis-à-vis current share

of ~3%. Renewable energy (solar, wind and other RES) to account for an increase to 25% in FY30 from current share of 13%. The RE is expected to serve the incremental demand to a large extent.

Figure 49 : Overall energy supply across different technologies

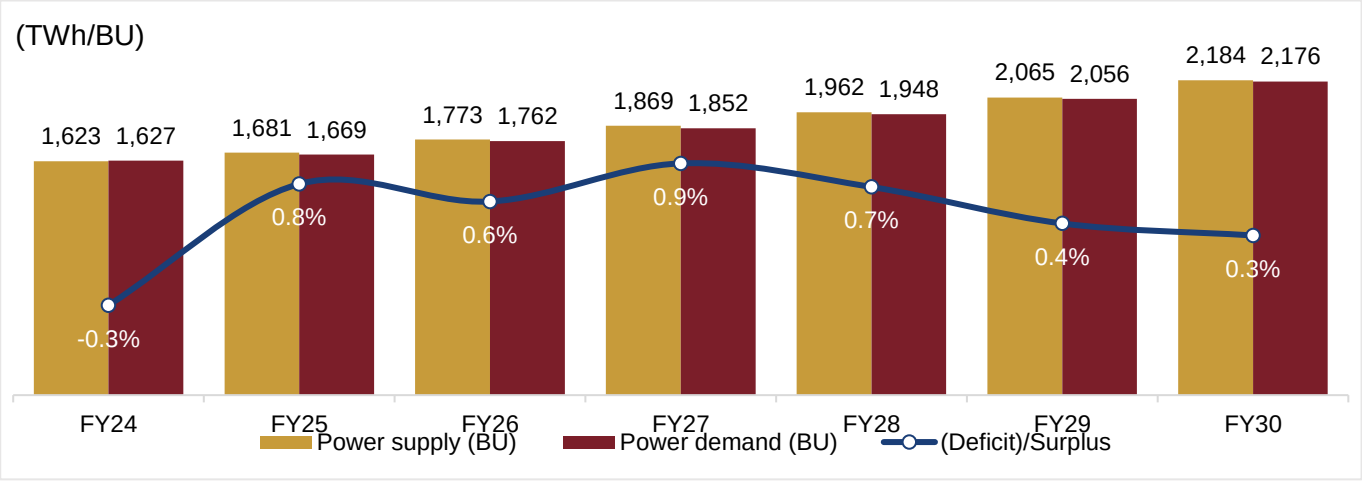


Source: CRISIL MI&A Consulting

4.1.4 Demand Supply and surplus/deficit scenario

Robust capacity additions to result in excess power supply over demand. Going forward, power surplus to remain in the range of 0.3-0.5%. Power supply to grow at a CAGR of 5.1% between FY23-30, in line with power demand growth for the same period. Improved supply accompanied by healthy investments in transmission and distribution infrastructure is expected to support rising demand

Figure 50: Demand-supply position



Source: CRISIL MI&A Consulting

4.2 Gujarat

4.2.1 Demand Projections

4.2.1.1 Historical demand supply position

Energy requirement in Gujarat has increased from 116 BU in FY19 to 146 BU in FY24, growing at a CAGR of 4.6%. Energy availability has also shown a similar growth trajectory growing at a CAGR of 4.6%. There has been a marginal deficit between FY19 to FY24 except in FY22 where the deficit was 0.23%. The peak demand increased from 17 GW to 25 GW from FY19 to FY24 registering a CAGR of 7.8%. The peak demand in the state has been met, however, with a slight deficit. In FY24, due to a national surge in power demand, the peak met was much lower than peak demand, recording a deficit of 1.15%, highest in the last 5 years.

Table 7: Historical power demand supply position for Gujarat

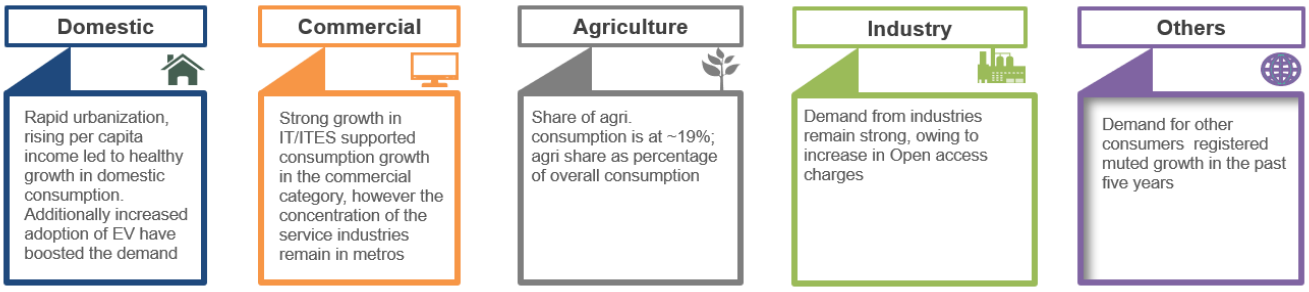
Particulars	FY 19	FY 20	FY 21	FY 22	FY 23	FY 24
Energy requirement (MUs)	116,372	113,940	111,622	123,953	139,043	145,768
Energy availability (MUs)	116,356	113,939	111,622	123,666	138,999	145,740
Energy Surplus/(deficit)	**-0.01%**	**0.00%**	**0.00%**	**-0.23%**	**-0.03%**	**-0.02%**
Peak Demand (MW)	17,053	18,437	18,528	19,451	21,464	24,829
Peak Met (MW)	16,963	18,424	18,483	19,431	21,382	24,544
Peak Surplus/(deficit)	**-0.53%**	**-0.07%**	**-0.24%**	**-0.10%**	**-0.38%**	**-1.15%**

Source: CEA, CRISIL MI&A Consulting

4.2.1.2 Demand drivers and constraints

The following figure depicts the various drivers for power demand in Gujarat.

Figure 51: Drivers for power demand in Gujarat



Source: CRISIL MI&A Consulting

Major constraints for demand from discoms are the growth of rooftop solar and energy efficiency measures. Rooftop capacity has increased more than 10 times from FY19 from 320 MW to 3455 MW accounting for ~25% of the total solar installed capacity in the state. The growth can be attributed to successful residential policy and the favourable stance of its DISCOMs towards rooftop solar projects.

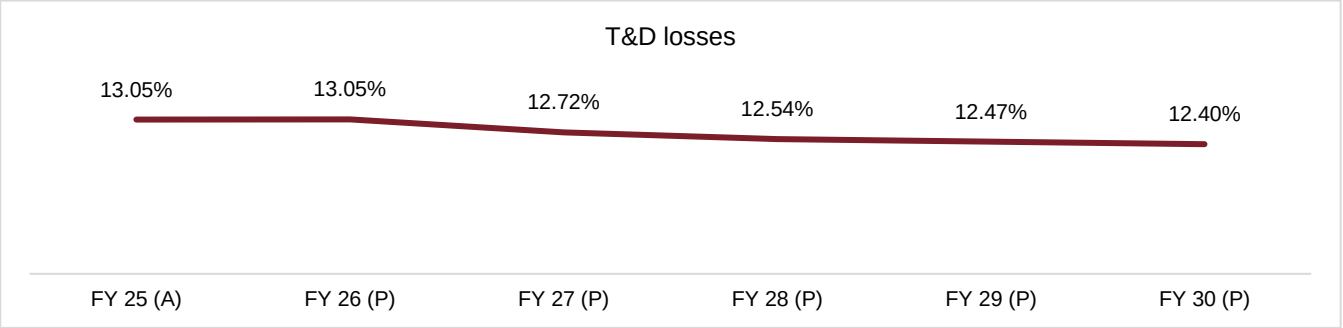
With respect to energy efficiency measures, 51 units have been identified under the Perform Achieve and Trade (PAT) scheme to save ~1.8 million tonnes of oil equivalent till FY25. Under the UJALA scheme of energy scheme, 41.4 million LED bulbs have been distributed in Gujarat.

4.2.1.3 T&D Losses

T&D losses in Gujarat have reduced from ~17% in FY19 to ~13% in FY24. The discoms make continuous investments in renovation/replacement of old Distribution line, bifurcation of feeder, installation/augmentation of Distribution Transformer to reduce T&D losses. Further, the central government has sanctioned a total outlay of Rs

166.6 billion over a period of five years from FY 2021-22 to FY 2025-26 under RDSS for the power sector in Gujarat. Improved collection efficiency and distribution network strengthening schemes are expected to improve T&D losses from ~13% in FY25 to 12.4% in FY30.

Figure 52: T&D Losses in Gujarat



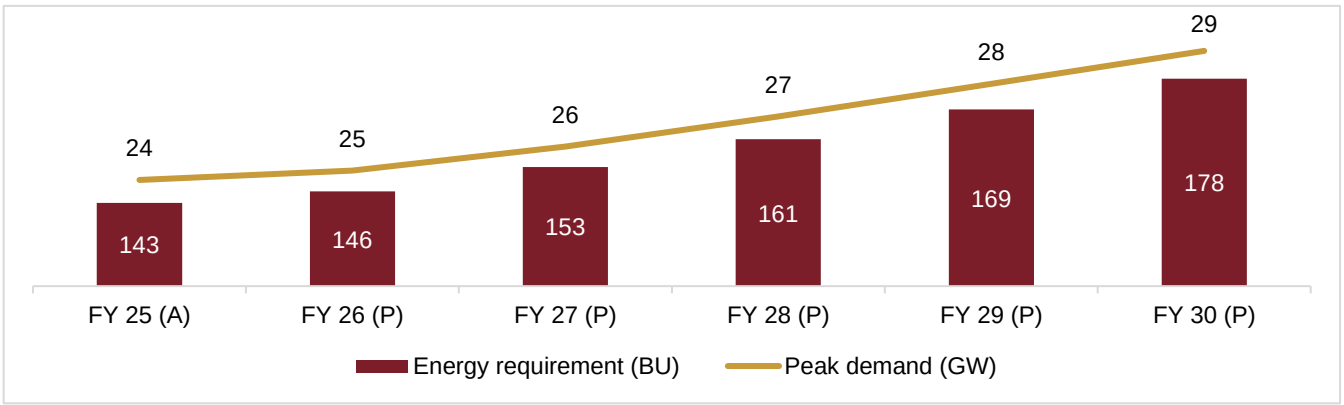
Note: FY25 approved by GERC
Source: GERC, CRISIL MI&A Consulting

4.2.1.4 Energy requirement

The energy requirement in Gujarat has grown at a CAGR of 5% from FY19 to FY24. The correlation between GSDP and electricity consumption for domestic category was 96%, for commercial sector it was 97% and for industrial sector it was 98%. The agriculture category had a lower correlation of 73% whereas others had a correlation of 61%. Considering this, the appropriate weights for CAGR and GSDP have been established and accordingly the constrained energy sales have been estimated.

Considering the demand drivers and constraints, the unconstrained sales for the state has been estimated which is further grossed up to calculate the ex-bus energy requirement in the state. Overall energy requirement (ex-bus bar) of Gujarat is expected to reach ~178 BUs by FY 30. Using the Load factor, the ex-bus energy requirement is grossed up to arrive at the peak requirement. Peak demand (ex-bus bar) of the state is expected to reach ~29 GW by FY30. Demand side management majors by discoms to flatten the load curve, installation of off-grid solar across consumer categories, and use of energy efficient appliances is some of the factors which are expected to restrain the peak demand.

Figure 53: Total energy requirement and peak demand for Gujarat



Note: FY 25 approved by GERC
Source: GERC, CRISIL MI&A Consulting

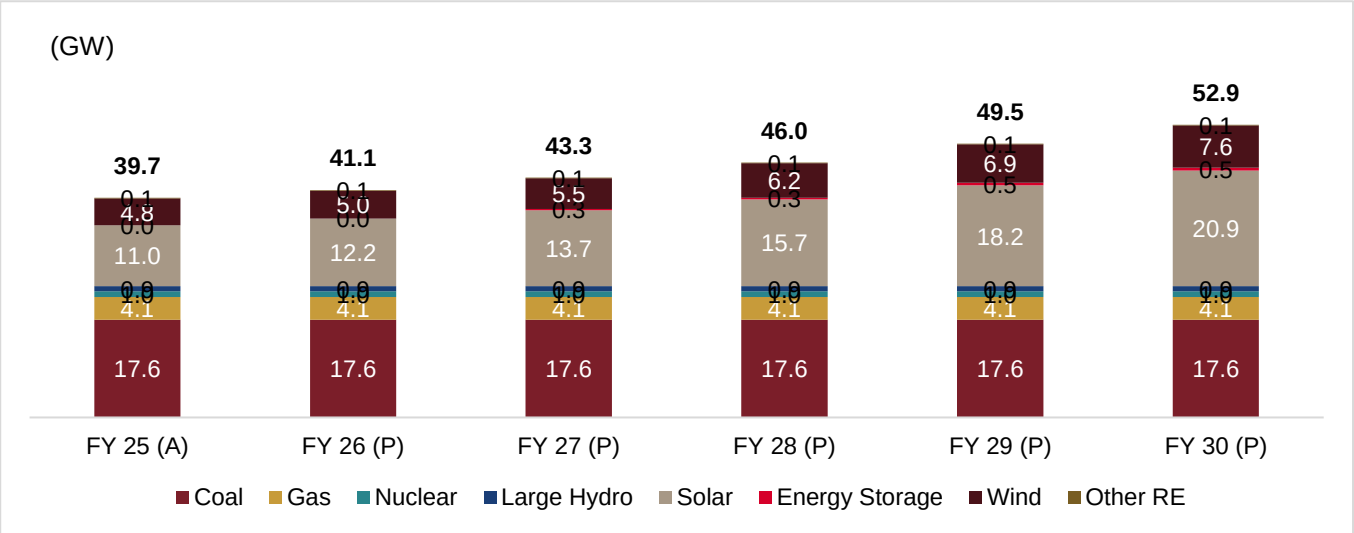
4.2.2 Supply Projections

4.2.2.1 Supply forecast

Gujarat has witnessed a rapid growth in the installed capacity driven by the growth in renewable energy. The state share in installed capacity is ~8 GW consisting of ~5 GW of thermal based capacity. ~2 GW of the state installed capacity is contributed by the gas power. Central allocations of ~9.5 GW comprise of thermal based capacity account of ~8 GW, nuclear capacity of ~1 GW and balance hydro capacity. The private sector has the highest share in the overall installed capacity accounting for ~22 GW driven mainly by the renewable energy of ~16 GW.

During the forecast period, major capacity additions are expected in renewable energy. ~13 GW of renewable capacity is expected to be added by FY30.

Figure 54: Projected installed capacity incl. share from central projects for Gujarat (GW)



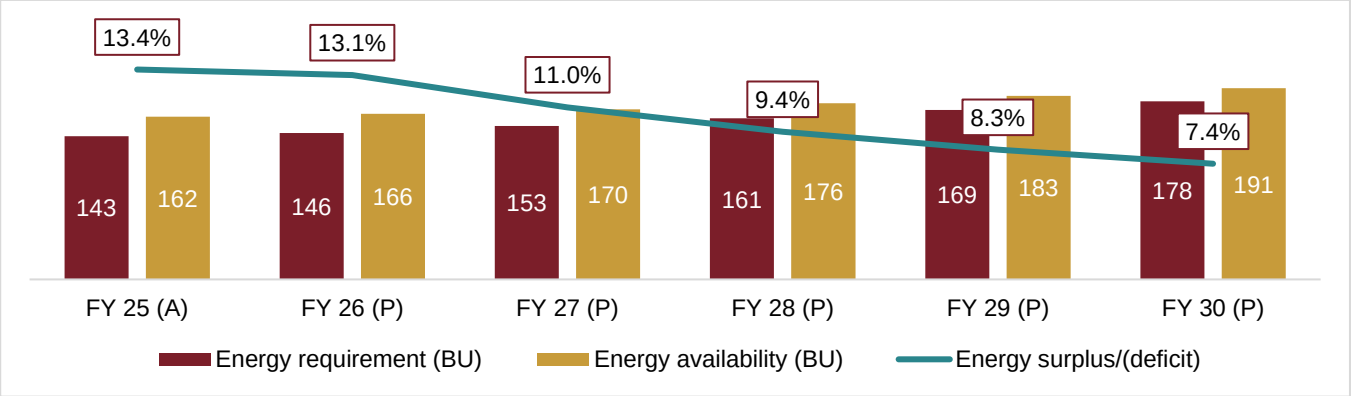
Note: FY 25 based on approved sales by GERC
Source: GERC, CRISIL MI&A Consulting

Energy availability is expected to grow at a CAGR of 3.3% driven by ~13 GW of additions between FY26 and FY30. Thermal energy would witness a decline in the share of total energy supplied, however, it will continue to dominate the fuel mix with 56% share in FY30. The share of RE is expected to increase from 26% in FY25 to 37% in FY30. Hydro, gas, and nuclear power are expected to have a total share of ~8% by FY30.

4.2.3 Demand Supply and surplus/deficit scenario

To ride through unforeseen events such as grid disturbances such as line faults, transformer failures, planned and unplanned outages of generating stations, maintenance shut down, accidents, equipment failures, etc. and to ensure smooth grid operations, each discom needs to have adequate contracted capacity which can be scheduled whenever needed. High urbanization and industrial development are likely to reduce the power surplus in the state.

Figure 55: Increase in demand and slowdown in conventional capacity additions to reduce surplus for Gujarat



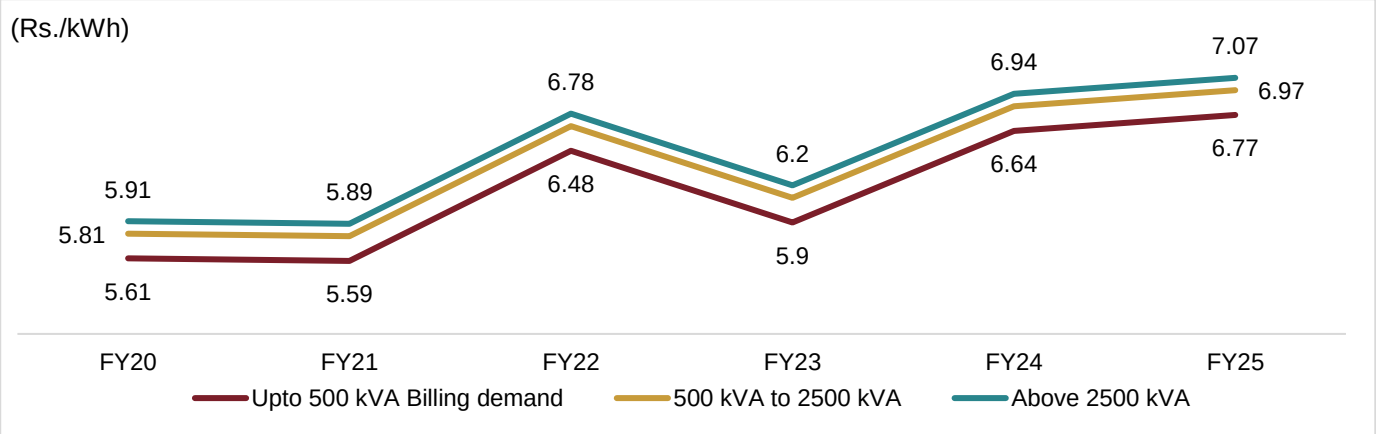
Note: FY 25 based on approved sales by GERC
Source: GERC, CRISIL MI&A Consulting

4.2.4 Category wise tariff projections

4.2.4.1 Historical variable charges for C&I consumers

The following chart summarises the approved variable charges for commercial and industrial category consumers in Gujarat.

Figure 56: Historical variable charges for commercial and industrial consumers-Gujarat

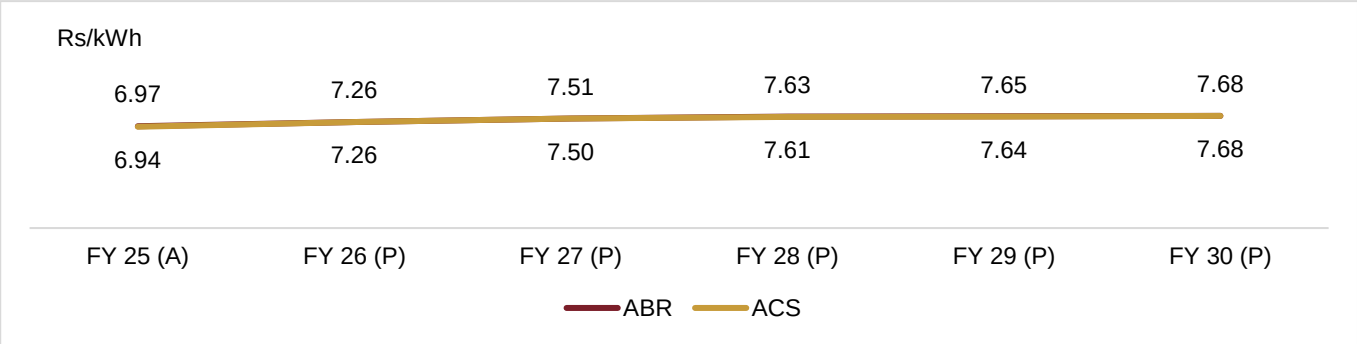


Source: GERC; CRISIL MI&A Consulting

4.2.4.2 ABR and ACS Trajectory

Tariff hikes are expected on account of an increase in power purchase costs and other expenses. These tariffs are approved by GERC. ACS is expected to increase at a CAGR of 2% during the forecast period. To bridge the gap, the ABR is also expected to increase by a similar pace of 2%.

Figure 57: ACOS-ABR Gap for Gujarat (Rs. /kWh)

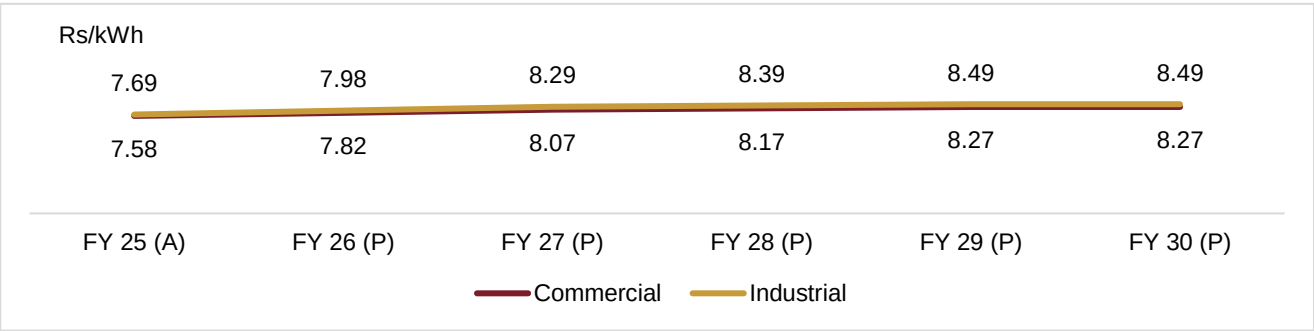


Note: FY 25 approved by GERC
Source: GERC, CRISIL MI&A Consulting

4.2.4.3 ABR projections for Commercial and Industrial category

Commercial tariffs are likely to increase at a moderate pace of 1.8% CAGR till FY30. Similarly, industrial tariff is expected to increase at 2% to balance the tariff subsidy provided to the agricultural consumers. The C&I consumers would continue to cross-subsidize the balance sectors during the forecast period; however, the burden is expected to be reduced by FY30.

Figure 58: Commercial and Industrial category ABR for Gujarat (Rs./kWh)



Note: FY25 Approved by GERC
Source: GERC, CRISIL MI&A Consulting

4.2.5 Open access charges

Regulations 87 of the GERC (MYT) Regulations, 2016 specifies that the Commission shall determine the wheeling charges of distribution wires business of the Distribution Licensees in the Tariff Order. Considering the allocation matrix provided in the GERC Tariff Regulation/Order, the costs allocated to Wheeling and Supply activities. Distribution costs at 11 kV, 22 kV & 33 kV are determined at 30% of the total distribution cost.

In accordance with the National Tariff Policy and MoP Green Energy Open Access Rules, the CSS is capped at 20% of the average cost of supply for the consumers seeking Open Access. Accordingly, the applicable CSS is computed considering the ACOS for the respective year.

Table 8: Summary of key parameters in Gujarat

Particulars	Units	FY 25 (P)	FY 26 (P)	FY 27 (P)	FY 28 (P)	FY 29 (P)	FY 30 (P)
Peak demand	GW	24	25	26	27	28	29
Overall demand	BU	125	127	134	141	148	156
Energy requirement	BU	143	146	153	161	169	178

Particulars	Units	FY 25 (P)	FY 26 (P)	FY 27 (P)	FY 28 (P)	FY 29 (P)	FY 30 (P)
% energy consumed by C&I users	%	64%	63%	63%	64%	64%	64%
Renewable energy as a % of total energy (incl large hydro)	%	27%	28%	30%	33%	35%	38%
Open access charges							
Wheeling charges	Rs/kWh	0.15	0.17	0.18	0.19	0.19	0.20
Transmission Charges	Rs/kWh	0.40	0.42	0.46	0.52	0.55	0.56
CSS	Rs/kWh	1.39	1.45	1.50	1.52	1.53	1.54

Source: CRISIL MI&A Consulting

4.3 Maharashtra

4.3.1 Demand Projections

4.3.1.1 Historical demand supply position

Energy requirement for Maharashtra has increased from 155 BUs in fiscal 2019 to 207 BUs in 2024 registering a growth of 5.9% (CAGR). The 5-year CAGR for energy availability was also 5.9%. Similarly, the peak demand reached 31.1 GW in fiscal 2024 from 23.8 GW in fiscal 2019 with a CAGR of 5.5%. Rural electrification, improved power availability, increased industrialisation, and urbanisation, thrust on EV are some of the reasons for the increase in demand. During fiscal 2024, the state witnessed a surge in electricity demand by 11% due to a significant increase in power consumption by the industrial sector.

Table 9: Historical power demand supply position for Maharashtra

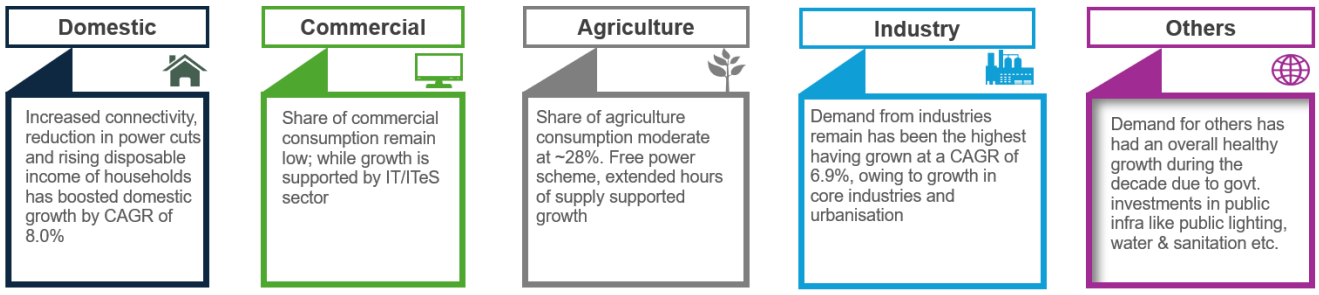
Particulars	FY 19	FY 20	FY 21	FY 22	FY 23	FY 24
Energy requirement (MUs)	155,159	155,166	150,679	172,823	187,309	207,108
Energy availability (MUs)	155,159	155,166	150,663	172,809	187,197	206,931
Energy Surplus/(deficit)	**0.00%**	**0.00%**	**-0.01%**	**-0.01%**	**-0.06%**	**-0.09%**
Peak Demand (MW)	23,864	24,550	25,576	28,075	30,935	31,178
Peak Met (MW)	23,254	24,550	25,513	28,016	28,846	27,996
Peak Surplus/(deficit)	**-2.56%**	**0.00%**	**-0.25%**	**-0.21%**	**-6.75%**	**-10.21%**

Source: CEA, CRISIL MI&A Consulting

4.3.1.2 Demand drivers and restraints

The following figure depicts the various drivers for power demand in Maharashtra.

Figure 59: Drivers for power demand in Maharashtra



Source: CRISIL MI&A Consulting

Key constraints impacting the demand from discoms is the growth of rooftop solar and energy efficiency measures adopted by the state. Maharashtra Government provides upto 100% subsidy on rooftop solar panels for government and semi government offices and up to 15% for private offices under the Maharashtra Solar Rooftop Policy. Rooftop solar installations have increased from 942 MW in FY19 to ~2072 MW in FY24 indicating a spur in the rooftop adoption in the state.

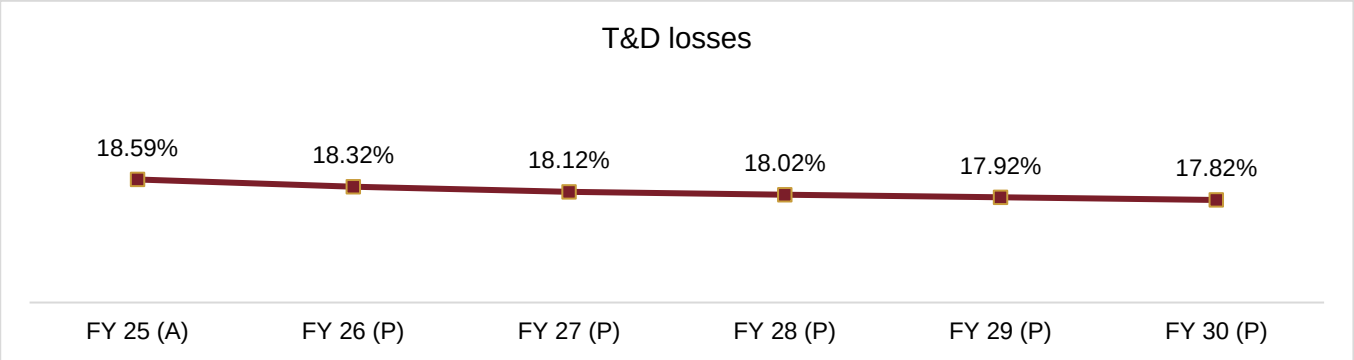
Under the PAT scheme, ~31 units are identified as Designated Consumers with a reduction of specific energy consumption as notified in the BEE resulting in a saving of ~190,000 tonnes of oil equivalent. Under the UJALA scheme Maharashtra has installed ~22 million LEDs till date resulting in a savings of ~3 BU of annual energy.

4.3.1.3 T&D Losses

T&D losses in MSEDCL have reduced from 19.36% in FY18 to 18.43% in FY23. MERC has stipulated a trajectory of reduction in distribution loss at 12% for FY25. It has also considered the intra-state transmission loss of 3.18% and inter-state transmission loss of 3.55% for FY25. T&D loss reduction beyond 17% is expected to be challenging owing to the large geographical area coupled with expansion into rural households and agriculture segment.

The overall T&D loss for fiscal 2023 was 18.43%. The projected T&D losses in the forecast period are given below.

Figure 60: T&D Losses trajectory in MSEDCL



Note: FY 25 approved by MERC
Source: CRISIL MI&A Consulting

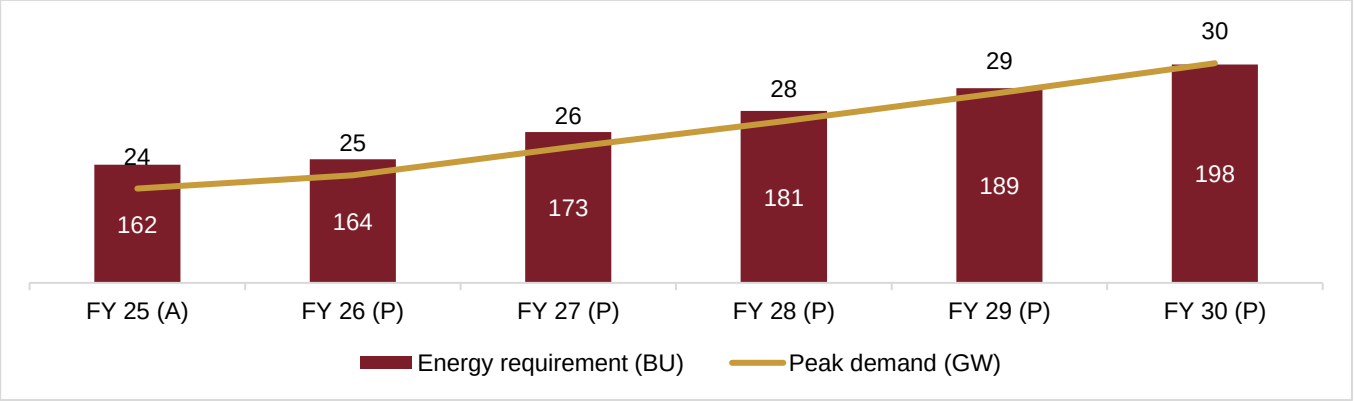
4.3.1.4 Energy requirement

The historic CAGR of energy requirement was 3.4% from FY19 to FY23. The highest growth was in domestic demand followed by the industry sector.

The correlation between GSDP and electricity consumption was 96% in the domestic demand. For commercial 79%, industry 57%, agriculture sector 41% and others 44%. Appropriate weights are provided for computing demand using CAGR and GSDP approaches, and the constrained energy sales are estimated.

Considering the above-mentioned drivers and constraints, un-restricted energy sales have been estimated, which are grossed up to the extent of T&D losses to arrive at the ex-bus energy requirement for MSEDCL. The overall energy requirement is expected to reach 198 BU by FY30.

Figure 61: Total energy requirement and peak demand for MSEDCL



Note: FY 25 approved by MERC
Source: CRISIL MI&A Consulting

Using the Load factor, the ex-bus energy requirement is grossed up to arrive at the peak requirement. Peak demand (ex-bus bar) of MSEDCL is expected to reach ~28-29 GW by fiscal 2030, from 24 GW in fiscal 2025. Demand side management majors by discoms to flatten the load curve, installation of off-grid solar across consumer categories, and use of energy efficient appliances is some of the factors which are expected to restrain the peak demand.

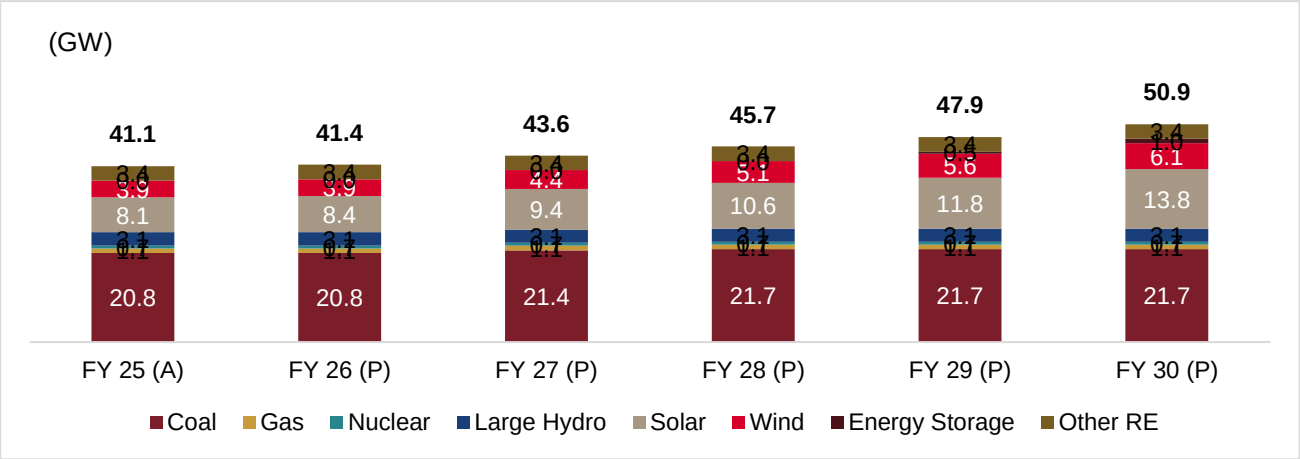
4.3.2 Supply Projections

4.3.2.1 Supply forecast

The total installed capacity of MSEDCL as of fiscal 2025 is estimated at 41 GW mainly driven by the increase in renewable energy. The private sector has contributed to the increase in renewable energy capacity. Central capacity primarily includes the allocations for coal power of ~5.4 GW, nuclear power of ~0.7 GW. State capacity accounts for ~13 GW which includes thermal capacity of ~10 GW and the balance hydro power. Private sector concentration is in the renewable power accounting for ~15 GW. The private sector also has a presence in thermal capacities with ~6 GW.

Upcoming thermal projects are expected in Lara (Chhattisgarh) and Bhusawal within the forecast period. Maharashtra's Unconventional Energy Generation Policy aims at implementing 17 GWs of RE projects by FY25, including 13 GWs of solar. As of April 2024, about 1768 MW of solar projects are awarded of which 1627 MW are under construction. Similarly, about 2.4 GW of wind projects are under construction. These projects are scheduled to be commissioned in the next 2-3 years. There are additional projects under development for solar, wind, and solar-wind hybrid projects.

Figure 62: Projected effective installed capacity incl. share from central projects for Maharashtra (GW)



Note: FY 25 approved by MERC
Source: CRISIL MI&A Consulting

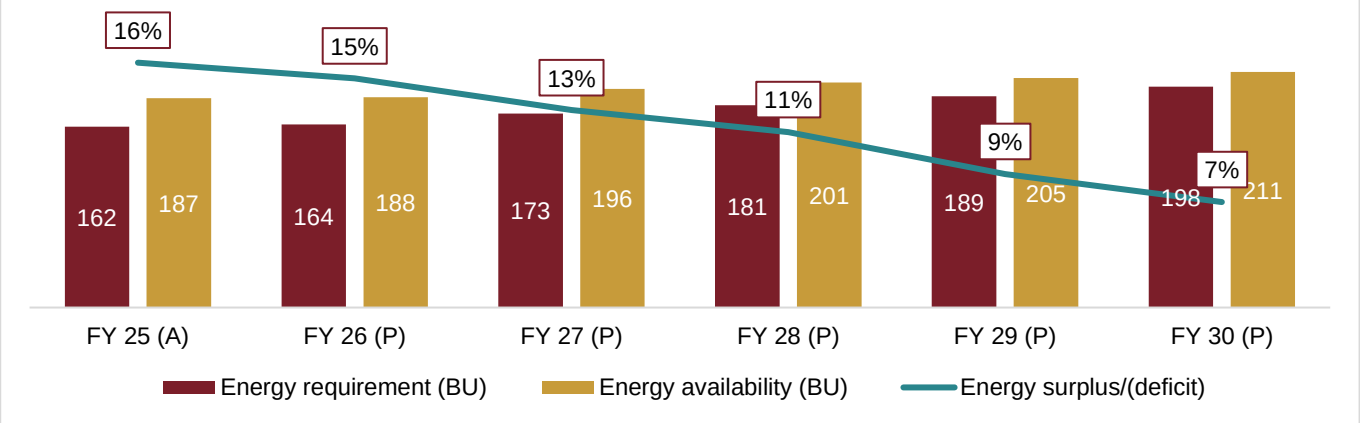
Energy availability is likely to grow at a CAGR of ~2.4% between fiscal 2025 and 2030 driven by ~9-10 GW additions over the same period. Although thermal energy is expected to reduce in the share of energy supplied, it will continue to dominate the energy mix with 67% share. The share of RE in energy supplied is expected to increase from 19% in FY25 to 25% in FY30. RE capacity addition will be driven by RPO targets as well as Government thrust on achieving the sustainability goals including COP commitments. Nuclear and gas are expected to have the least share of 2-3% each.

4.3.3 Demand-Supply and surplus/deficit scenario

Discoms to strive to manage availability to maintain system reliability in the event of grid disturbances such as line faults, transformer failures, planned and un-planned outages of generating stations, maintenance shut down, accidents, equipment failures, etc. Thus, to ride through such events and to ensure smooth grid operations, each discom needs to have adequate contracted capacity which can be scheduled whenever needed.

It is expected that, the state will continue to be in surplus position due to commissioning of ~9 GW of RE projects and ~1 GW of thermal projects.

Figure 63: Energy requirement and availability projections in MSEDCL



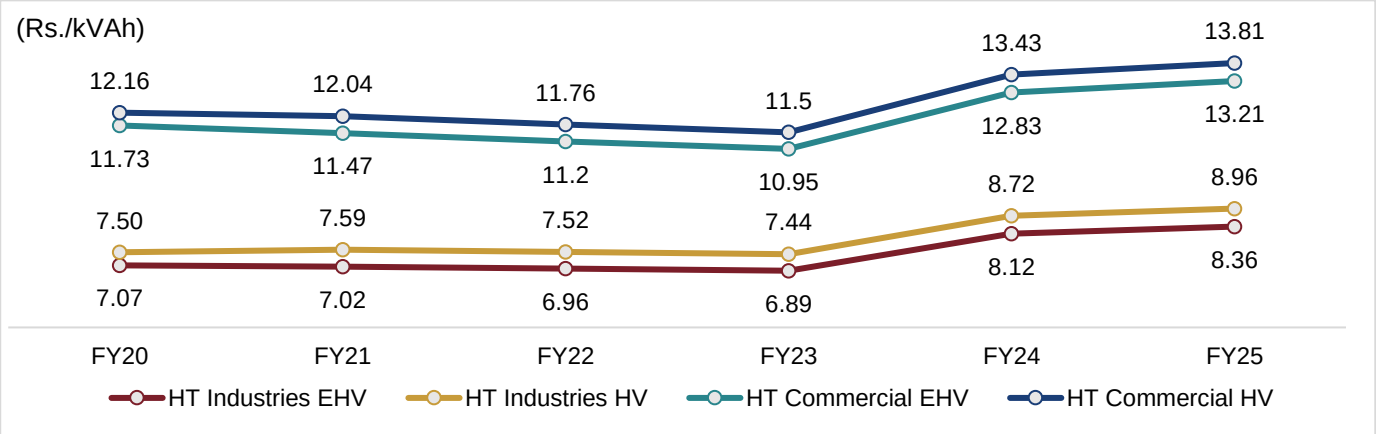
Note: FY 25 approved by MERC
Source: CRISIL MI&A Consulting

4.3.4 Category wise tariff projections

4.3.4.1 Historical variable charges for C&I consumers

The following chart summarises the approved variable charges for commercial and industrial category consumers in Maharashtra.

Figure 64: Historical variable charges for commercial and industrial consumers-Maharashtra

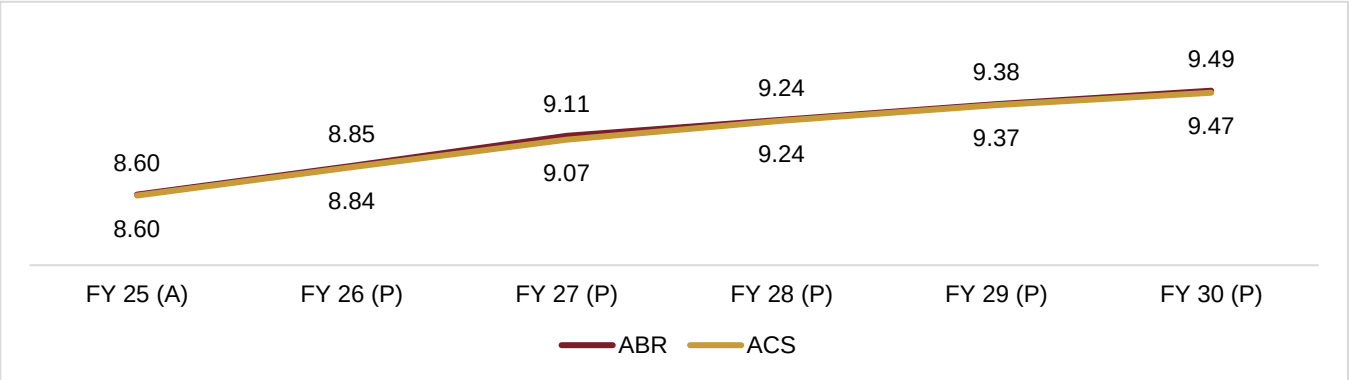


Source: MERC, CRISIL MI&A Consulting

4.3.4.2 ABR and ACS Trajectory

Increase in power purchase costs, O&M and other expenses result in an increase in the overall cost which is expected to increase the tariffs for the consumers. The increase in tariffs is approved by MERC on a periodic basis considering the increase in the costs. During the forecast period, ACoS is expected to increase at a CAGR of 2.0%. Similarly, the ABR is also expected to increase at a CAGR of 2.0% to reach Rs. 9.49/kWh by fiscal 2030, to bridge the gap between ABR-ACoS.

Figure 65: ACoS-ABR Gap for MSEDCL

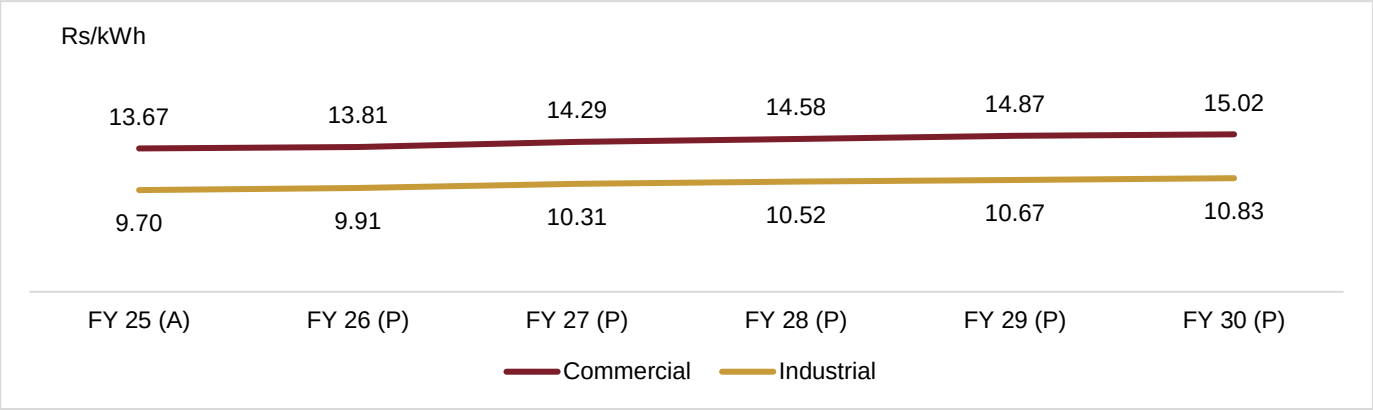


Note: FY 25 approved by MERC
Source: CRISIL MI&A Consulting

4.3.4.3 ABR projections for Commercial and Industrial category

ABR for commercial and industrial sector are expected to grow till fiscal 2030 on account of subsidized power to agriculture/domestic consumers. The commercial ABR is expected to increase at a CAGR of 1.9% to reach Rs. 15.02/kWh. Similarly, industrial ABR would also witness an increase in CAGR of 2.2% to reach Rs. 10.83/kWh by fiscal 2030.

Figure 66: Commercial and Industrial category ABR for MSEDCL



Note: FY 25 approved by MERC
Source: CRISIL MI&A Consulting

4.3.5 Open access charges

The Allocation Matrix for segregation of the ARR between the Wires and Supply Business has been specified in Regulation 71 of the MYT Regulations, 2019 for MSEDCL. The allocation of network costs to HT and LT is in the ratio of 30:70. The overall wheeling charges have been calculated by dividing the distribution ARR with energy sales. The wheeling charges for HT and LT network are determined by considering the HT:LT ratio.

As per MERC's tariff order, the cross-subsidy surcharge (CSS) is capped at 20% of the tariff applicable to the consumer category. Accordingly, the applicable CSS is computed for commercial and industrial consumers.

Table 10: Summary of key parameters in Maharashtra

Particulars	Units	FY 25 (P)	FY 26 (P)	FY 27 (P)	FY 28 (P)	FY 29 (P)	FY 30 (P)
Peak demand	GW	24	25	26	28	29	30
Overall demand	BU	132	134	142	148	155	162
Energy requirement	BU	162	164	173	181	189	198
% energy consumed by C&I users	%	48%	47%	47%	47%	47%	46%
Renewable energy as a % of total energy (incl large hydro)	%	22%	22%	23%	24%	26%	28%
Open access charges							
Wheeling charges	Rs/kWh	0.59	0.61	0.63	0.64	0.65	0.65
Transmission Charges	Rs/kWh	0.50	0.47	0.46	0.50	0.50	0.51
CSS	Rs/kWh	1.72	1.77	1.81	1.85	1.87	1.89

Source: CRISIL MI&A Consulting

4.4 Madhya Pradesh

4.4.1 Demand Projections

4.4.1.1 Historical demand supply position

Historically, Energy requirement for MP has increased from 76 BUs in FY 2019 to 99 BUs in fiscal 2024 registering a growth of 5.5% (CAGR). The 5-year CAGR for energy availability was 5.4% leaving a deficit of 0.2% for FY23-24.

Similarly, the peak demand reached to 18.3 GW in fiscal 2024 from 13.8 GW in fiscal 2019 with a CAGR of 5.7% against a growth of 5.2% (5 yr CAGR) in peak availability leaving a peak deficit of about 2.4% in fiscal 2024. Rural electrification, improved power availability, increased industrialisation, and urbanisation, thrust on electric vehicles and metro railways are some of the reasons for the increase in demand.

Table 11: Historical power demand supply position for Madhya Pradesh

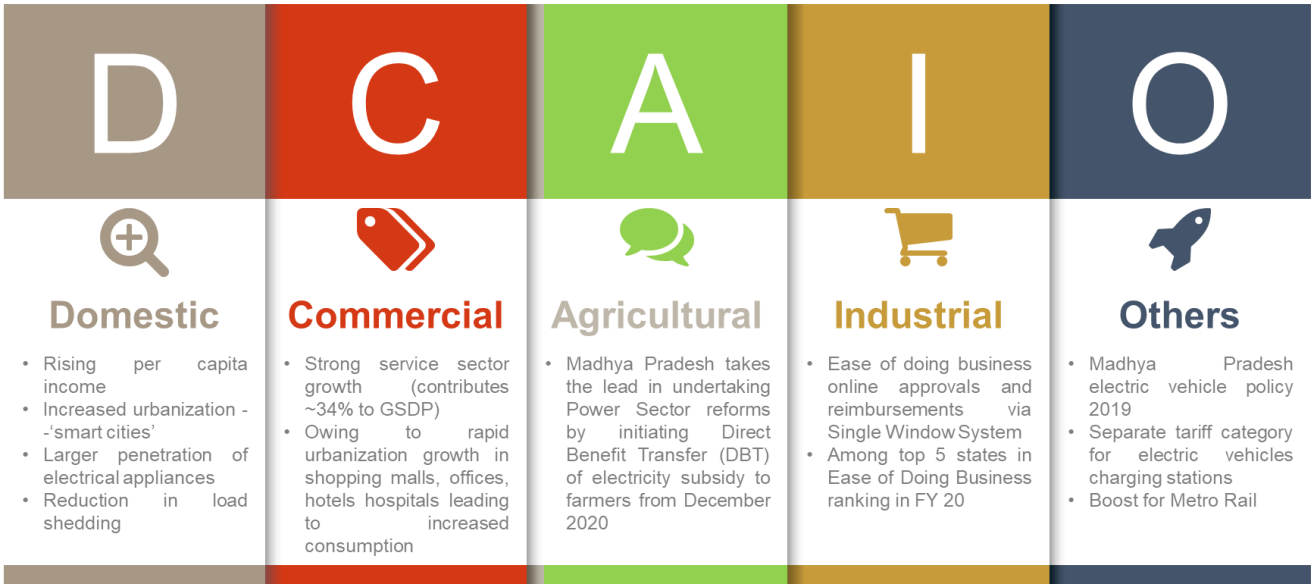
Particulars	FY 19	FY 20	FY 21	FY 22	FY 23	FY 24
Energy requirement (MUs)	76,056	76,172	83,437	86,501	92,683	99,301
Energy availability (MUs)	76,054	76,172	83,437	86,455	92,325	99,150
Energy Surplus/(deficit)	**0.0%**	**0.0%**	**0.0%**	**-0.1%**	**-0.4%**	**-0.2%**
Peak Demand (MW)	13,815	14,886	15,756	15,917	17,347	18,252
Peak Met (MW)	13,815	14,855	15,668	15,917	17,238	17,817
Peak Surplus/(deficit)	**0.0%**	**-0.2%**	**-0.6%**	**0.0%**	**-0.6%**	**-2.4%**

Source: CEA, CRISIL MI&A Consulting

4.4.1.2 Demand drivers and restraints

The following figure depicts the various drivers for power demand in Madhya Pradesh.

Figure 67: Drivers for power demand in Madhya Pradesh



Source: CRISIL MI&A Analysis

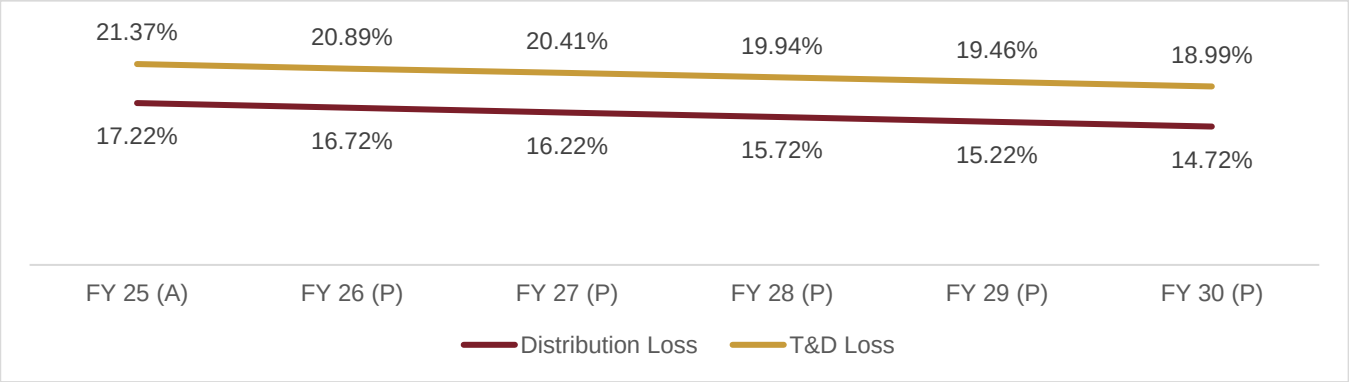
Rooftop solar and energy efficiency are some of the key constraints which may affect the demand from Discoms. As per the Madhya Pradesh RE policy 2022, domestic and large institutional setups having connected load of more than 6 kW shall mandatorily have to install solar rooftop subject to technical feasibility. Further, Facilitation of expeditious approvals through single window clearance and financial incentives to discoms through World Bank and SBI has helped Rooftop solar to grow in the State. Moreover, Perform Achieve and Trade (PAT) scheme. Supply of LED bulbs to domestic consumers, strong government push on use of LED etc. have achieved significant energy efficiency.

4.4.1.3 T&D Losses

T&D losses for MP Discoms have been reduced by more than 3% over the last five years. Going forward, investments in network augmentation to drive further reduction in losses. Considering the existing levels, T&D loss reduction

beyond 18-19% is expected to be challenging owing to large geographical area coupled with expansion into rural households and agriculture segment. RDSS has set up a target of reduction of AT&C losses to pan India level at 12-15% by FY 2024-25. Implementation of various distribution network strengthening schemes, improvement in collection efficiency and the overall reduction in AT&C losses are expected to bring down the T&D loss level to ~18%-19%. Under RDSS scheme, a total outlay of Rs 69.2 billion has been sanctioned for smart metering works and loss reduction works. Further, the Government of Madhya Pradesh has also granted approval of Rs 22.3 billion towards Distribution Infrastructure works for modernisation. All these schemes are expected to curb the T&D losses and improve collection efficiency.

Figure 68: T&D Losses in Madhya Pradesh



Note: FY 25 approved by MPERC
Source: MPERC, CRISIL MI&A Consulting

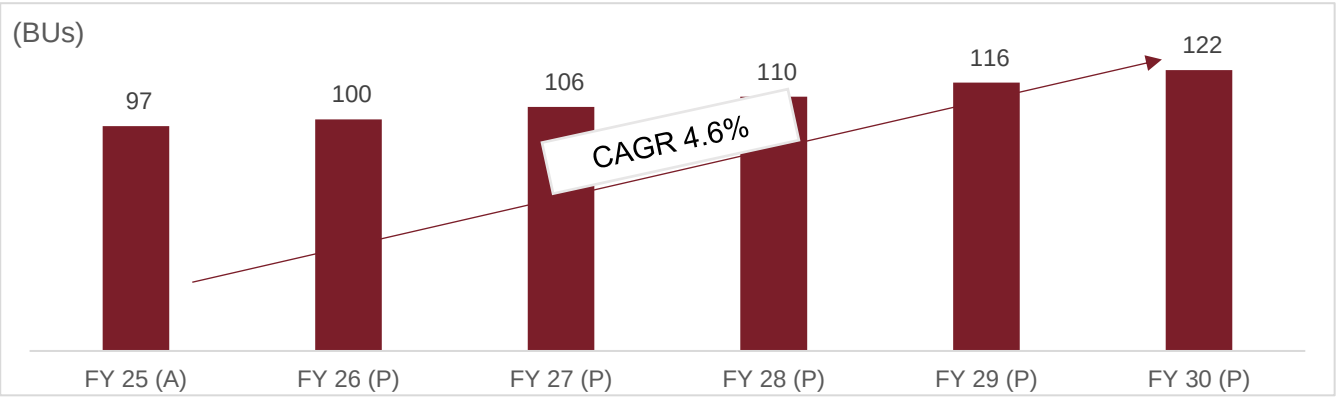
4.4.1.4 Energy requirement

The five-year CAGR for energy consumption in Madhya Pradesh was 7.5% (FY24 over FY19). The domestic category has seen the highest growth of 9.2% followed by 7.8% by agriculture category. Commercial and Industrial category grown by 6.1% and 6.4% respectively over the said period.

Similarly, the correlation between GSDP and electricity consumption for domestic category is more than 96%, Industrial 95.2%, commercial 95%, agriculture 92.5% and others 5.5%. Considering this, the appropriate weights for CAGR and GSDP have been established and accordingly the constrained energy sales have been estimated.

Furthermore, using the demand drivers and constraints, the un-constrained sales for the MP Discoms have been estimated which is then grossed up to arrive at the ex-bus energy requirement in Madhya Pradesh as summarized in following figure. Overall energy requirement (ex-bus bar) of Madhya Pradesh is expected to reach ~122 BUs by FY 30 driven by residential, industrial and agricultural consumption at a CGAR of 4.6% (FY 30 over FY25)

Figure 69: Total energy requirement for Madhya Pradesh is expected to growth at a CAGR of 4.6%

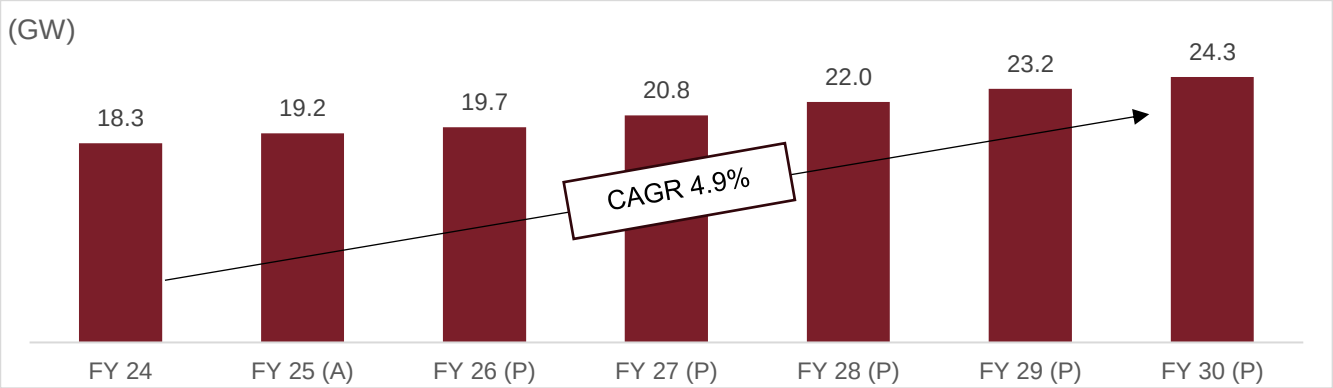


Note: FY 25 approved by MPERC

Source: MPERC, CRISIL MI&A Consulting

Using the Load factor, the ex-bus energy requirement is grossed up to arrive at the peak requirement. Peak demand (ex-bus bar) of the state is expected to reach ~24 GW by FY30, an increase of ~5 GW over FY 24. Demand side management majors by discoms to flatten the load curve, installation of off-grid solar across consumer categories, use of energy efficient appliances are some of the factors which are expected to restrain the peak demand.

Figure 70: Peak demand projections for Madhya Pradesh



Note: FY 25 based on approved sales by MPERC
Source: MPERC, CRISIL MI&A Consulting

4.4.2 Supply Projections

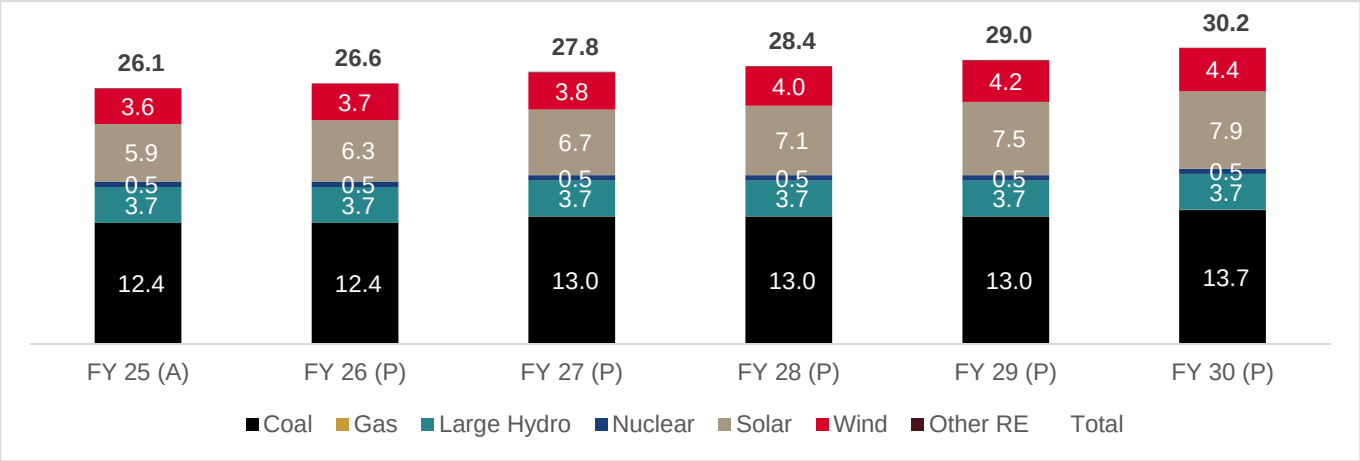
4.4.2.1 Supply forecast

Madhya Pradesh has witnessed a rapid rise in capacity additions by the private sector (~8.5 GW) over the last 10 years, especially from thermal and renewable energy sources. The state share in overall installed base is ~7 GW, which consists of coal and hydro based capacity. State draws ~7 GW power from central allocations which includes ~0.2 GW gas power and ~0.5 GW of Nuclear power.

Coal based additions are expected to slow down due to the focus on clean energy. Further, increasing fuel costs and reducing cost competitiveness with renewable energy to deter coal-based additions over the long-term. Around 1.32 GW coal-based capacity is expected to get commissioned by 2030. Hydro and gas capacity projects are likely to benefit from rising RE penetration for balancing purposes; but overall share to remain low.

Both solar and wind are likely to dominate capacity due to govt. thrust, incentives, technological advancements and ~3 GW expected to be added by 2030.

Figure 71: Projected installed capacity incl. share from central projects for Madhya Pradesh (GW)



Note: FY 25 based on approved sales by MPERC
Source: MPERC, CRISIL MI&A Consulting

Energy availability is likely to grow at a CAGR of ~1.7% between FY25 to FY30 driven by ~4.1 GW additions over same period. Despite the reduction in share, thermal energy will continue to dominate the fuel mix. Additions in renewable space will drive the share of RE in total supply to ~20% in FY30 as against ~16% in FY25. RE capacity addition will be driven by RPO targets as well as Government thrust on achieving the sustainability goals incl. CoP commitments. The share of energy through gas and nuclear power plants is likely to be ~3% and that of hydro power plants ~7%.

4.4.3 Category wise tariff projections

4.4.3.1 Historical variable charges for C&I consumers

The following chart summarises the approved variable charges for commercial and industrial category consumers in Madhya Pradesh.

Figure 72: Historical variable charges for commercial and industrial consumers-Madhya Pradesh

Rs./kWh

Tariff HV-3.1	19-20		20-21		21-22		22-23		23-24		24-25	
(Industrial)	A*	B*	A	B	A	B	A	B	A	B	A	B
11 kV supply	7.00	6.00	7.10	6.10	7.10	6.10	7.20	6.20	7.30	6.30	7.30	6.30
33 kV supply	6.90	5.90	7.05	6.00	7.05	6.00	7.16	6.11	7.26	6.21	7.26	6.21
132 kV supply	6.50	5.50	6.62	5.65	6.62	5.65	6.75	5.76	6.85	5.86	6.85	5.86
220/400 kV supply	6.10	5.10	6.20	5.20	6.20	5.20	6.30	5.30	6.40	5.40	6.40	5.40
Tariff HV-3.2	**19-20**		**20-21**		**21-22**		**22-23**		**23-24**		**24-25**	
Non-Industrial	**A**	**B**	**A**	**B**	**A**	**B**	**A**	**B**	**A**	**B**	**A**	**B**
11 kV supply	7.30	6.40	7.45	6.55	7.45	6.55	7.55	6.65	7.70	6.80	7.70	6.80
33 kV supply	7.10	6.20	7.25	6.30	7.25	6.30	7.38	6.40	7.53	6.55	7.53	6.55
132 kV supply & above	6.70	5.60	6.80	5.70	6.80	5.70	6.90	5.80	7.05	5.95	7.05	5.95

**Note:*
A: For consumption up to 50% load factor
B: For consumption in excess of 50% load factor

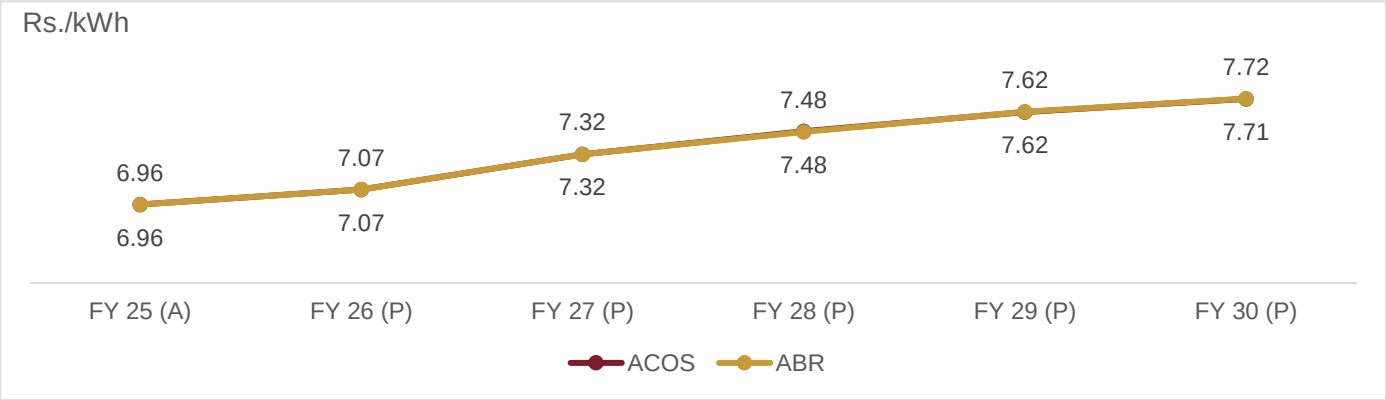
Source: MPERC; CRISIL MI&A Consulting

4.4.3.2 ABR and ACS Trajectory

Considering the increase in power purchase cost and other expenses, regular tariff hikes would be required to bridge the gap. It is pertinent to note that the state has been getting tariffs revisions through annual tariff orders by MPERC. Further, the Power Ministry has urged the banks to be more cautious while issuing loans to State discoms having

regulatory assets. Also, to achieve the targets of schemes like RDSS and get financial assistance from the Central Government, the State is expected to go for annual tariff revisions. ACOS is expected to increase at CAGR of ~2.3% during the period of 5 years, with power purchase cost to contribute mostly for such increase. ABR is expected to increase at same pace ~2.3% CAGR between FY 25 and FY 30, resulting in bridging the ABR-ACOS gap.

Figure 73: ACOS-ABR Gap for Madhya Pradesh (Rs./kWh)

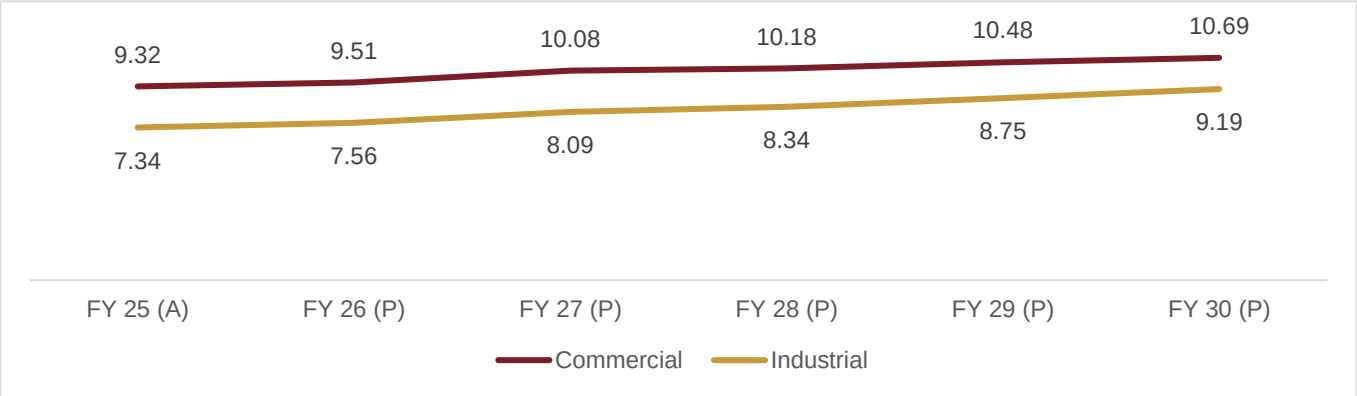


Note: FY 25 approved by MPERC
Source: MPERC, CRISIL MI&A Consulting

4.4.3.3 ABR projections for Commercial and Industrial category

Commercial and Industrial ABRs to rise at moderate pace (2.8% and 4.6% respectively) as state is expected to further stabilise cross-subsidization to balance tariff subsidy burden on account of continued free power to agriculture consumers and lower tariffs for domestic categories.

Figure 74: Commercial and Industrial category ABR for Madhya Pradesh (Rs./kWh)



Note: FY25 Approved by MPERC
Source: MPERC, CRISIL MI&A Consulting

4.4.4 Open access charges

Considering the allocation matrix specified in the MPERC Tariff Order, the costs allocated to Wheeling and Supply activities. Further, based on the allocation of wheeling costs to 33 kV consumer and below 33kV consumers considered by MPERC, the wheeling costs allocated. Using the sales for 33 kV consumers and below 33kV consumers, the wheeling charges are determined.

As per MoP Green Energy Open Access Rules and MPERC MYT Regulations, 2021, the CSS is capped at 20% of the average cost of supply for the consumers seeking Open Access. Accordingly, the applicable CSS is computed

considering the ACOS for the respective year. CSS is waived for Group Captive capacity. Wheeling losses are expected to remain at around 5.06%.

Table 12: Summary of key parameters in Madhya Pradesh

Particulars	Units	FY 25 (P)	FY 26 (P)	FY 27 (P)	FY 28 (P)	FY 29 (P)	FY 30 (P)
Peak demand	GW	19.2	19.7	20.8	22.0	23.2	24.3
Overall demand	BU	77	79	84	88	93	98
Energy requirement	BU	97	100	106	110	116	121
% energy consumed by C&I users	%	30%	28%	27%	27%	26%	26%
Renewable energy as a % of total energy (incl large hydro)	%	24%	25%	25%	26%	27%	27%
Open access charges							
Wheeling charges	Rs/kWh	0.17	0.16	0.17	0.17	0.17	0.17
Transmission Charges	Rs/kWh	0.43	0.45	0.46	0.48	0.51	0.53
CSS	Rs/kWh	1.39	1.40	1.47	1.49	1.52	1.56

Source: CRISIL MI&A Consulting

4.5 Tamil Nadu

4.5.1 Demand Projections

4.5.1.1 Historical demand supply position

Energy requirement for Tamil Nadu has increased from 109 BUs in fiscal 2019 to 126 BUs in fiscal 2024 registering a growth of 2.9% (CAGR). The 5-year CAGR for energy availability was also 2.9%. Similarly, the peak demand reached 19 GW in fiscal 2024 from 15.5 GW in fiscal 2019 with a CAGR of 4.2%. Rural electrification, improved power availability, increased industrialisation, and urbanisation, thrust on EV vehicles and development of industrial corridors are some of the reasons for the increase in demand. In fact, in fiscal 2024, the energy demand rose to ~10% y-o-y due to increased manufacturing activity and infrastructure development. India's GDP growth rate was about 7.8%. This economic expansion leads to overall energy consumption.

Table 13: Historical power demand-supply position for the entire state of Tamil Nadu

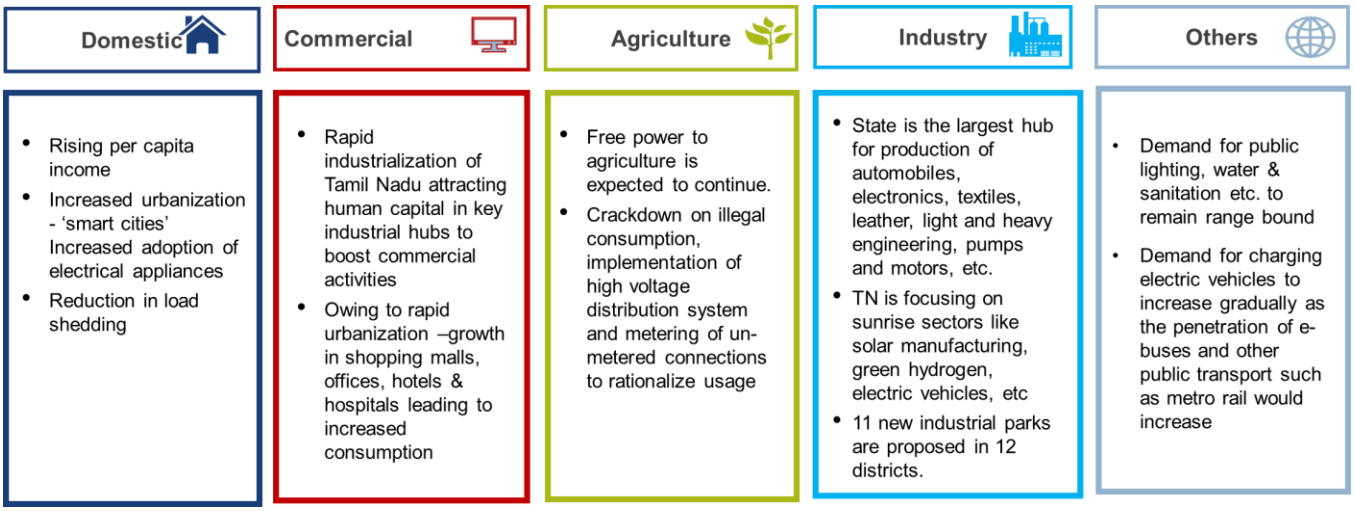
Particulars	FY 19	FY 20	FY 21	FY 22	FY 23	FY 24
Energy requirement (MUs)	109,482	108,816	1,01,194	1,09,816	1,14,798	1,26,163
Energy availability (MUs)	109,380	108,812	1,01,189	1,09,798	1,14,722	1,26,151
Energy Surplus/(deficit)	**-0.1%**	**0.0%**	**0.0%**	**0.0%**	**-0.1%**	**0.0%**
Peak Demand (MW)	15,483	15,727	16,263	16,891	17,729	19,045
Peak Met (MW)	15,448	15,668	16,263	16,891	17,729	19,045
Peak Surplus/(deficit)	**-0.2%**	**-0.4%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**

Source: CEA, CRISIL MI&A Consulting

4.5.1.2 Demand drivers and restraints

The following figure depicts the various drivers for power demand in Tamil Nadu.

Figure 75: Drivers for power demand in Tamil Nadu



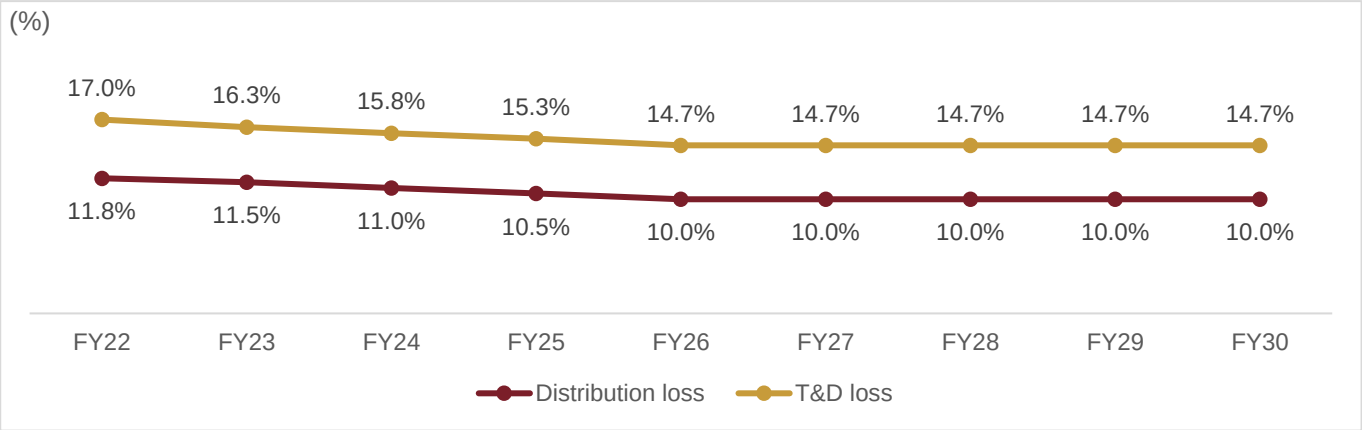
Source: CRISIL MI&A Analysis

Rooftop solar and energy efficiency are some of the key constraints which may affect the demand from Discoms. As of fiscal 2024, the State has over 665 MW of installed solar rooftop capacity including off-grid solar. Tamil Nadu promotes distributed solar installations through Solar policy 2019. To encourage rooftop solar adoption by MSMEs, the TNERC has reduced rooftop solar network charges by 50% in December 2023. Moreover, under Perform Achieve and Trade (PAT) scheme 81 nos. of industries have been identified as Designated Consumers (DCs) and target for reduction in Specific Energy Consumption has been specified by BEE in various PAT cycles. Supply of LED bulbs to domestic consumers, strong government push on use of LED etc. have achieved significant energy efficiency.

4.5.1.3 T&D Losses

T&D losses for TANGEDCO have reduced from 20.8% in fiscal 2018 to 16.3% in fiscal 2023. Going forward, investments in network augmentation to drive further reduction in losses. Considering the existing levels, T&D loss reduction beyond 14-15% is expected to be challenging owing to large geographical area coupled with expansion into rural households and agriculture segment. RDSS has set up a target of reduction of AT&C losses to pan India level at 12-15% by fiscal 2026. Implementation of various distribution network strengthening schemes, improvement in collection efficiency and the overall reduction in AT&C losses are expected to bring down the T&D loss level to ~14%-15%. Under RDSS scheme, a total outlay of Rs 283 billion has been sanctioned for smart metering works and loss reduction works. To reduce losses, actions have been initiated to implement agriculture feeder segregation works in 1,685 nos. feeders and HVDS works in 273 nos. feeders; separation of double DTs in 13,892 locations with HVDS; and reconductoring of 33 kV line for 542.08 kms. All these schemes are expected to curb the T&D losses and improve collection efficiency.

Figure 76: T&D Losses trajectory in Tamil Nadu



Note: FY 24 to FY 27 approved by TNERC
Source: TNERC, CRISIL MI&A Consulting

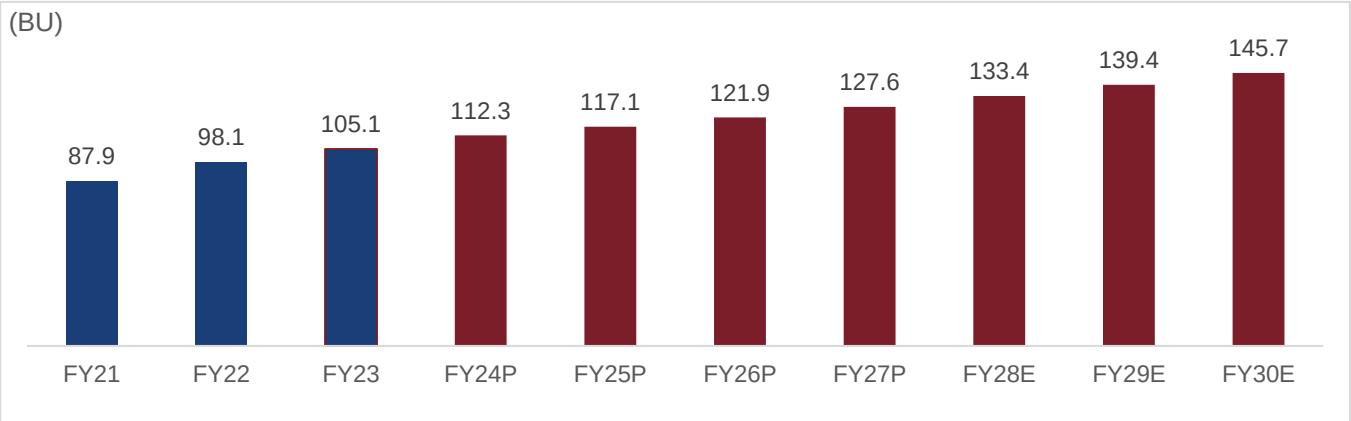
4.5.1.4 Energy requirement

The five-year CAGR for energy requirement for TANGEDCO was 5.0% (FY23 over FY18). The agriculture category has seen the highest growth of 7.9% followed by the industrial category at 6.1%. Domestic and Commercial category grown by 4.6% and 1.0%. respectively over the said period.

Similarly, the correlation between GSDP and electricity consumption for domestic category is 99%, Industrial 94.3%, Agriculture 66%, commercial 84% and others 83%. Considering this, the appropriate weights for CAGR and GSDP have been established and accordingly the constrained energy sales have been estimated.

Furthermore, using the demand drivers and constraints, the un-constrained sales for the TANGEDCO have been estimated which is then grossed up to arrive at the ex-bus energy requirement as summarized in following figure. Overall energy requirement (ex-bus bar) of TANGEDCO is expected to reach ~146 BUs by fiscal 2030 driven by residential, industrial and commercial consumption at a CAGR of 4.3% (FY30 over FY23).

Figure 77: Total energy requirement for TANGEDCO is expected to grow at a CAGR of 5.4%

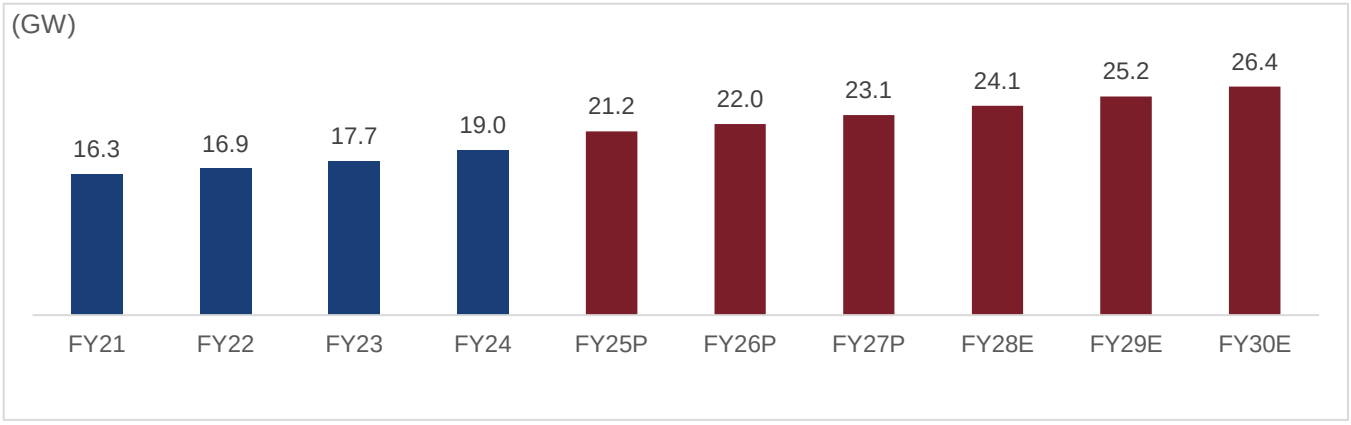


Source: TANGEDCO, TNERC, CRISIL MI&A Consulting

Using the Load factor, the ex-bus energy requirement is grossed up to arrive at the peak requirement. Peak demand (ex-bus bar) of the state is expected to reach ~26-27 GW by fiscal 2030, an increase of ~7 GW over fiscal 2024. Demand side management majors by discoms to flatten the load curve, installation of off-grid solar across consumer

categories, use of energy efficient appliances are some of the factors which are expected to restrain the peak demand.

Figure 78: Peak demand projections for Tamil Nadu



Source: CEA, TNERC, CRISIL MI&A Consulting

4.5.2 Supply Projections

4.5.2.1 Supply forecast

Tamil Nadu has witnessed a rapid rise in capacity additions by the private sector (~15.4 GW) over the last 10 years, especially from thermal and renewable energy sources. The state share in overall installed base is ~18%, which largely consists of coal and hydro based capacity. The state draws ~6.6 GW power from central allocations which includes ~4.9 GW coal power (incl lignite), ~1.5 GW of Nuclear power and 0.2 GW of renewable power.

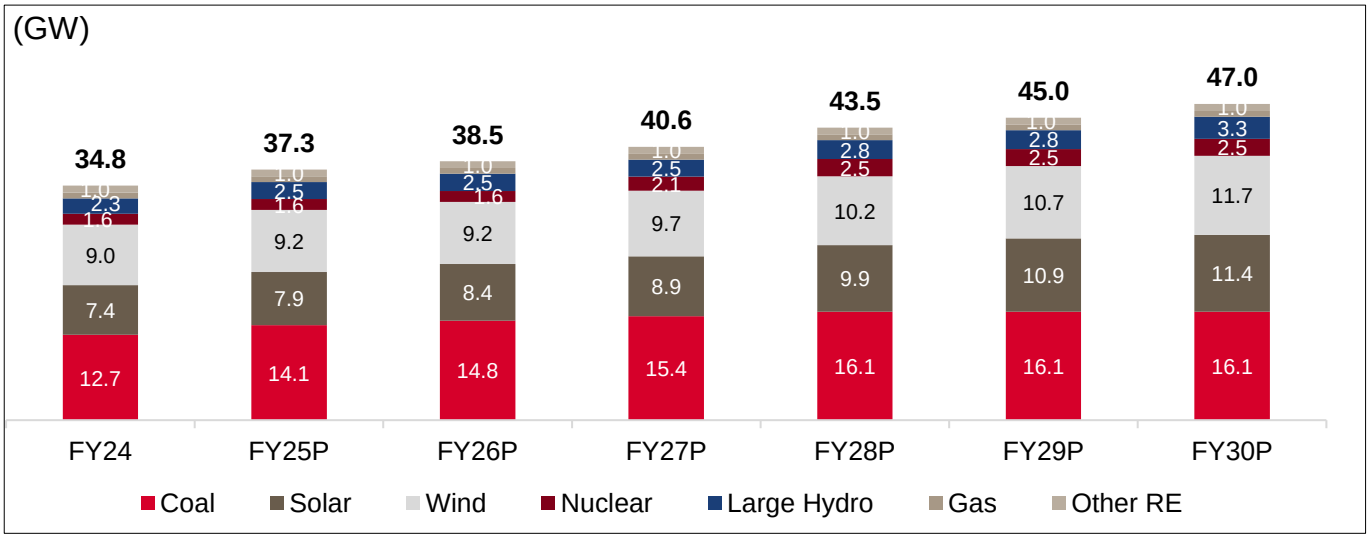
Coal based additions are expected to rise in Tamil Nadu which would be commissioned by TANGEDCO over the next 5 years. This is as per the national electricity plan notified by CEA to meet the base load demand of the state. Around 3.44 GW coal-based capacity by the State is expected to be commissioned by 2030. Further, Nuclear capacity addition of 4.0 GW and Hydro capacity addition of 1.5 GW is expected by 2030 as per the timelines given by the government. The proposed share of capacity from central sector power plants has been considered while estimating the supply from these proposed plants based on the existing share allocated for Tamil Nadu.

As far as RE capacity addition is concerned, solar capacity is likely to dominate due to government thrust, incentives, and technological advancements. As per the state government target, 20 GW of solar capacity addition along with 10 GWh of BESS is envisaged in the next 10 years. In Phase-I, 6 GW of solar power plant and 2 GWh of BESS has been planned. Moreover, about 1.4 GW of wind power is expected to be installed in the state by fiscal 2026. Tamil Nadu is also exploring offshore wind and TANGEDCO has given consent to procure 2 GW of offshore wind power.

Previously there were issues of renewable energy getting backed down for several reasons other than grid security. However, TNERC has issued detailed procedure for management of RE curtailment for wind and solar generation. In the said procedure, TNERC has provided compensation to the RE generators by the Licensee in case of RE curtailment is initiated by the SLDC for the reasons other than grid operational safety and grid security conditions.

Further, Tamil Nadu in August 2024 introduced “resource charges” of Rs 5 million/MW on wind projects connected to a CTU. This charge is intended to incentivize new wind power projects for STU connectivity, as CTU connected projects do not contribute to the state’s Wind RPO. The charge applies to all future projects and pending applications with CTU connectivity and is expected to increase wind energy generation costs by ~Rs 0.20/kWh, posing a significant risk, especially to already bid-out projects.

Figure 79: Projected effective installed capacity incl. share from central projects for Tamil Nadu (GW)



P: Projected; Source: CEA, Govt of TN, TNERC, CRISIL MI&A Consulting

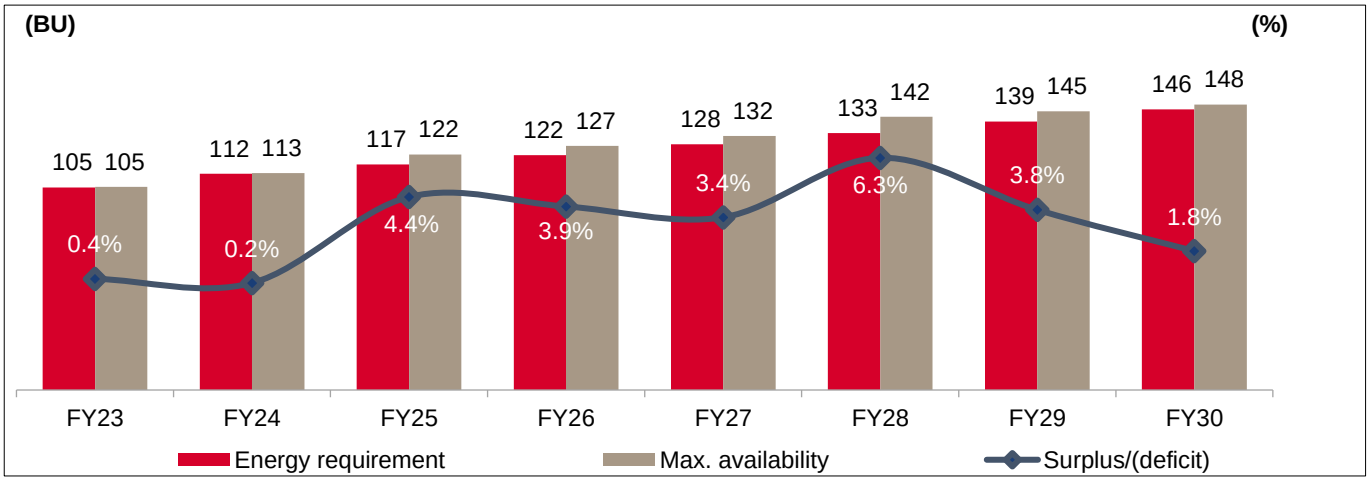
Energy availability is likely to grow at a CAGR of ~5.0% between fiscal 2023 and 2030 driven by ~12.1 GW additions over the same period. Despite the reduction in share, thermal energy will continue to dominate the fuel mix. Additions in renewable space will drive the share of RE in total supply to ~41% in fiscal 2030 as against ~16% in FY25. RE capacity addition will be driven by RPO targets as well as Government thrust on achieving the sustainability goals including COP commitments. The share of energy through gas and nuclear power plants is likely to be ~12-13% and that of hydro power plants ~6%.

4.5.3 Demand Supply and surplus/deficit scenario

Discoms need this additional capacity in order to maintain the system reliability in the event of grid disturbances such as line faults, transformer failures, planned and un-planned outages of generating stations, maintenance shut down, accidents, equipment failures, etc. As per the power supply position, the State has been able to meet the energy requirement of the State. TANGEDCO has executed a medium-term contract of 252 MW for a period of 3-5 years and short-term power procurement of 1,562 MW to meet the demand during peak months. TANGEDCO has entered into swap agreements with utilities to match the seasonal variations in surplus and deficit situations. The surplus power in other States is supplied to TANGEDCO in the required period and will be returned by TANGEDCO when surplus power is available during June to September of every year.

It is expected that in the forecast period, the state will be in surplus position due to commissioning of over 9 GW of coal, hydro and nuclear power plants cumulatively. Apart from this to meet the RPO requirement, solar and wind power projects would also be installed resulting in excess supply during the year.

Figure 80: Projected energy supply-demand situation for Tamil Nadu



Source: CRISIL MI&A Consulting

4.5.4 Category wise tariff projections

4.5.4.1 Historical variable charges for C&I consumers

The following chart summarises the approved variable charges for commercial and industrial category consumers in Tamil Nadu.

Table 14: Historical variable charges for commercial and industrial consumers-TANGEDCO

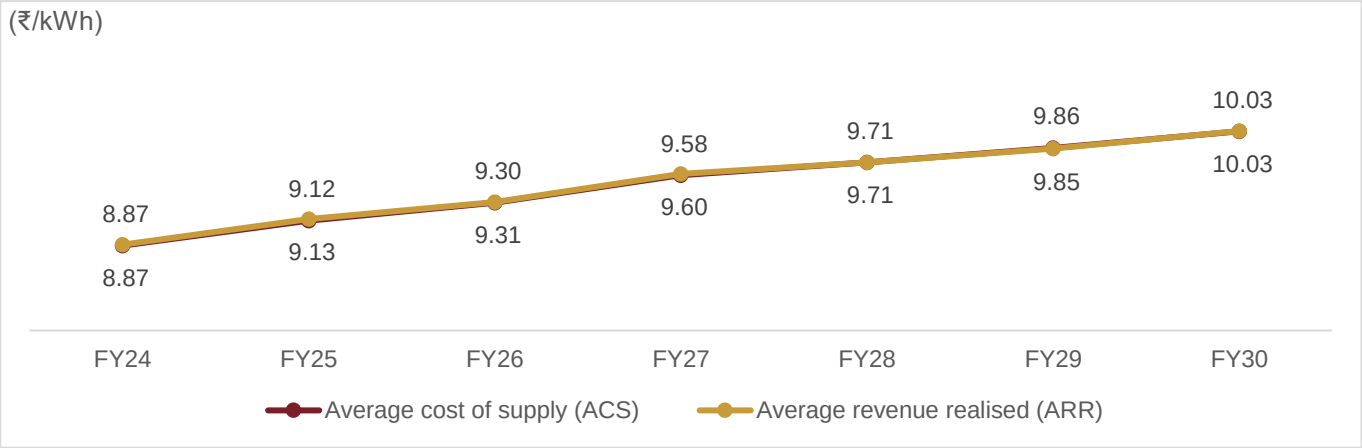
	FY20	FY21	FY22	FY23	FY24	FY25
Industry						
HT- I	6.35	6.35	6.35	6.75	6.90	7.25
LT- IIIA - upto 250 units	4.00	4.00	4.00	4.50	4.60	4.80
LT- IIIA - above 250 units	4.60	4.60	4.60	6.50	6.65	6.95
LT- IIIB	6.35	6.35	6.35	7.50	7.65	8.00
Commercial						
HT- III	8.00	8.00	8.00	8.50	8.70	9.10
LT- V - upto 50 units	5.00	5.00	5.00	6.00	6.15	6.45
LT- V - above 50 units	8.05	8.05	8.05	9.50	9.70	10.15

Source: TNERC Tariff Order

4.5.4.2 ABR and ACS Trajectory

Considering the increase in power purchase cost and other expenses, regular tariff hikes would be required to bridge the gap. It is pertinent to note that the state has been getting tariffs revisions through annual tariff orders by TNERC. Further, the Power Ministry has urged the banks to be more cautious while issuing loans to State discoms having regulatory assets. Also, to achieve the targets of schemes like RDSS and get financial assistance from the Central Government, the State is expected to go for annual tariff revisions. ACoS is expected to increase at CAGR of ~1.5% between fiscal 2023 and 2030, with power purchase cost to contribute mostly for such increase. ABR is expected to increase at ~3.0% CAGR during the same period, resulting in bridging the ARR-ACoS gap.

Figure 81: ACoS-ABR Gap for Tamil Nadu

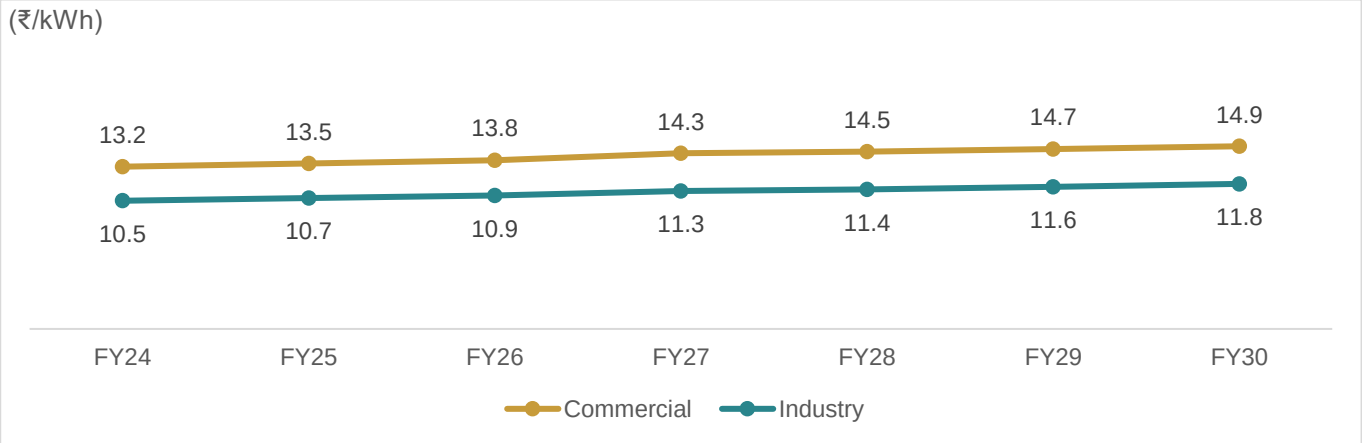


Source: TNERC, CRISIL MI&A Consulting

4.5.4.3 ABR projections for Commercial and Industrial category

Commercial and Industrial ABR to rise at 4.7% and 4.8%, respectively between fiscal 2023 and 2030 as state is expected to continue supplying subsidized/free power to agriculture, domestic, hut consumers, power loom industry, power loom weavers, handloom weavers, public worship places and cooperative societies. The tariff increase in C&I would cross-subsidise the above-mentioned consumers category to balance tariff subsidy burden on the state government.

Figure 82: Commercial and Industrial category ABR for Tamil Nadu



Source: CRISIL MI&A Consulting

4.5.5 Open access charges

Considering the allocation matrix specified in the TNERC Tariff Order, the costs have been allocated to Wheeling and Supply activities. The Commission has approved a HT:LT cost ratio of 70:30, the costs are divided considering the HT:LT sales, and after considering the total proportionate costs at each level and energy handled at each level, the wheeling charges for HT and LT levels are determined.

Transmission charges have been estimated based on the methodology adopted by TNERC in the transmission tariff order.

As per TNERC's tariff order, the cross-subsidy surcharge (CSS) is capped at 20% of the tariff applicable to the consumer category. Accordingly, the applicable CSS is computed for commercial and industrial consumers. CSS is waived for group captive consumers.

Table 15: Summary of key parameters in Tamil Nadu

Particulars	Units	FY 25 (P)	FY 26 (P)	FY 27 (P)	FY 28 (P)	FY 29 (P)	FY 30 (P)
Peak demand	GW	21.2	22.0	23.1	24.1	25.2	26.4
Overall demand	BU	95.8	100.0	104.3	108.7	113.2	117.8
Energy requirement (ex-bus)	BU	117.1	121.9	127.6	133.4	139.4	145.7
% energy consumed by C&I users	%	37%	37%	38%	38%	38%	38%
Renewable energy as a % of total energy (incl large hydro)	%	24%	24%	25%	25%	26%	29%
Open access charges							
Wheeling charges	Rs/kWh	1.01	1.00	1.00	1.00	0.99	0.99
Transmission Charges	Rs/kWh	0.54	0.57	0.59	0.62	0.65	0.69
CSS (Industry)	Rs/kWh	2.13	2.17	2.25	2.27	2.32	2.36

Source: CRISIL MI&A Consulting

4.6 Karnataka

4.6.1 Demand Projections

4.6.1.1 Historical demand supply position

Energy requirement for Karnataka has increased from 72 BUs in fiscal 2019 to 94 BUs in FY 2024, registering a growth of 5.6% (CAGR). The 5-year CAGR for energy availability was also 5.6%. Similarly, the peak demand reached 17.2 GW in fiscal 2024 from 12.8 GW in fiscal 2019 with a CAGR of 6.0%. Rural electrification, improved power availability, increased industrialisation, and urbanisation, thrust on EV are some of the reasons for the increase in demand.

During fiscal 2024, the state witnessed a surge in electricity demand by 24% due to significant increase in power consumption by agriculture sector. This increased demand is due to deficient rainfall, usage of irrigation pump-sets before normal hours and post COVID economic growth. The state government also proposed to supply power to IP sets for upto 7 hours a day would increase the demand going forward.

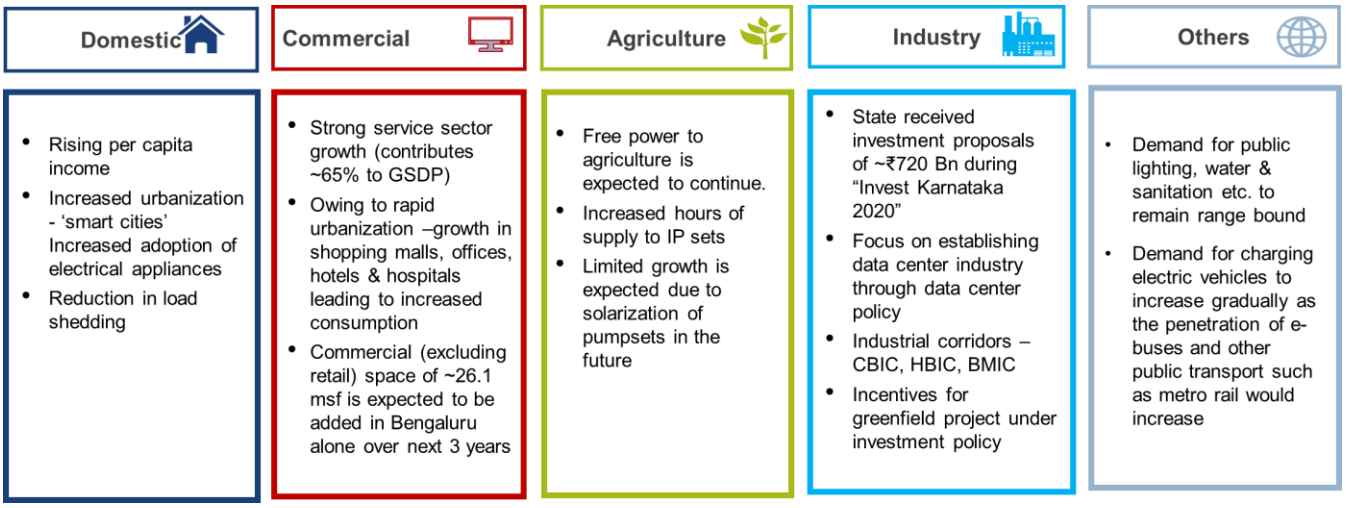
Table 16: Historical power demand supply position for Karnataka

Particulars	FY 19	FY 20	FY 21	FY 22	FY 23	FY 24
Energy requirement (MUs)	71,764	72,799	68,851	72,437	75,688	94,088
Energy availability (MUs)	71,695	72,796	68,831	72,417	75,663	93,934
Energy Surplus/(deficit)	**-0.1%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**-0.2%**
Peak Demand (MW)	12,877	13,272	14,367	14,830	15,828	17,212
Peak Met (MW)	12,877	13,258	14,367	14,818	15,828	17,212
Peak Surplus/(deficit)	**0.0%**	**-0.1%**	**0.0%**	**-0.1%**	**0.0%**	**0.0%**

4.6.1.2 Demand drivers and restraints

The following figure depicts the various drivers for power demand in Karnataka.

Figure 83: Drivers for power demand in Karnataka



Source: CRISIL MI&A Analysis

Rooftop solar and energy efficiency are some of the key constraints which may affect the demand from Discoms. As of fiscal 2024, the State has over 624 MW of installed solar rooftop capacity including off-grid solar. Karnataka has maintained its position in the top three states with one of the highest installed solar capacities. The State has aimed to install upto 1 GW of solar rooftop capacity under the Karnataka Renewable Energy Policy 2022-27. The state has been providing incentives, state subsidies to residential, MSME and industrial segment. Moreover, the state has also notified Karnataka Energy Conservation and Energy Efficiency Policy 2022-27 and proposed savings of 744 MU of electricity consumption which would reduce the carbon emission of around 0.61 Mn tonnes. Further, under National Electricity Plan, the state envisaged 7.6 MToE savings in total consumption by fiscal 2032 and under PAT scheme over 20 nos. of industries have been identified as Designated Consumers and target for reduction in Specific Energy Consumption has been specified by BEE in various PAT cycles. Under UJALA scheme, Karnataka has distributed over 24.2 million LED bulbs resulting in ~3 BUs of annual energy saving.

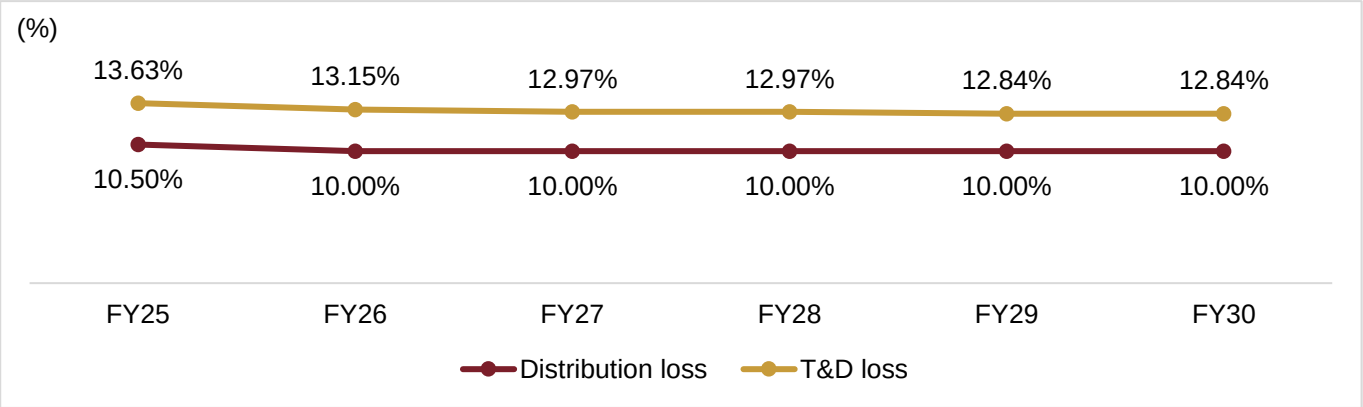
4.6.1.3 T&D Losses

T&D losses for Karnataka have reduced from 16.8% in fiscal 2018 to 15.3% in fiscal 2023. Going forward, investments in network augmentation to drive further reduction in losses. The Commission has observed in the annual performance review of state discoms for fiscal 2023 that discoms' distribution loss for fiscal 2023 was below the lower limit fixed by the Commission. The distribution losses have continuously come down for the last five years and hence considering the present level losses, the Commission has approved the distribution loss in the range of 7.97% - 12% for fiscal 2025.

Considering the existing levels, T&D loss reduction beyond this level is expected to be challenging owing to large geographical area coupled with expansion into rural households and agriculture segment. Further, the transmission losses have been in the range of 3-5% over the last five years. The Commission has approved the transmission loss of 3.35% for fiscal 2025 and the same has been considered for the forecast period.

The overall T&D loss for fiscal 2023 was 15.27% and considering the same loss levels as mentioned above the trajectory for the forecast period is shown in the below chart.

Figure 84: T&D Losses trajectory in Karnataka



Source: CRISIL MI&A Consulting

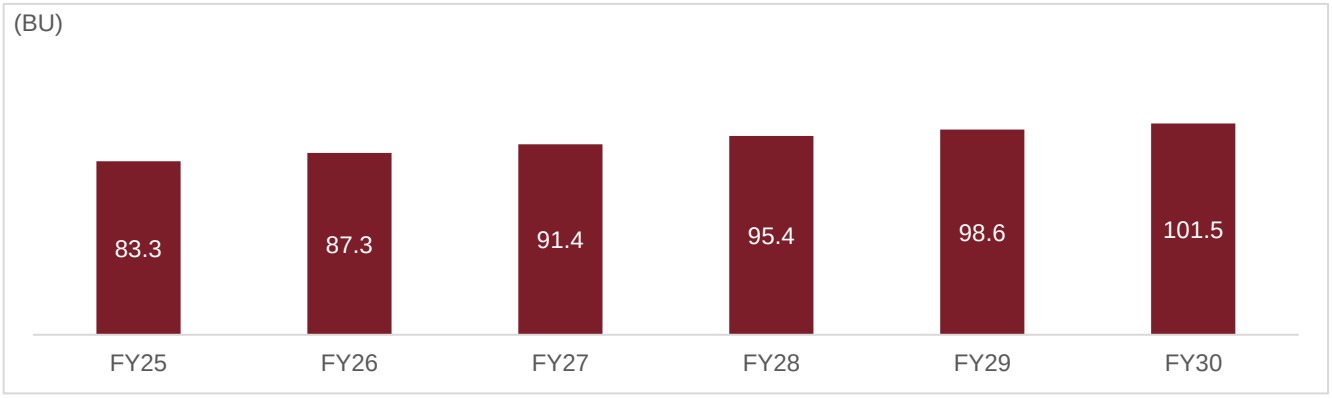
4.6.1.4 Energy requirement

The five-year CAGR for energy requirement for Karnataka discoms was 2.5% (FY23 over FY18). The agriculture and commercial categories have seen the lowest growth of 1.7% followed by the domestic and industrial category at 3.4% and 3.8%, respectively, over the said period.

Similarly, the correlation between GSDP and electricity consumption for domestic category is 98%, Industrial 81%, Agriculture 66%, commercial 71% and others 97%. Considering this, the appropriate weights for CAGR and GSDP have been established and accordingly the constrained energy sales have been estimated.

Furthermore, using the demand drivers and constraints, the un-constrained sales for Karnataka have been estimated which is then grossed up to arrive at the ex-bus energy requirement as summarized in following figure. Overall energy requirement (ex-bus bar) of Karnataka discoms is expected to reach ~102 BUs by fiscal 2030 driven by agriculture, industrial and commercial consumption at a CAGR of 4.8% (FY30 over FY23).

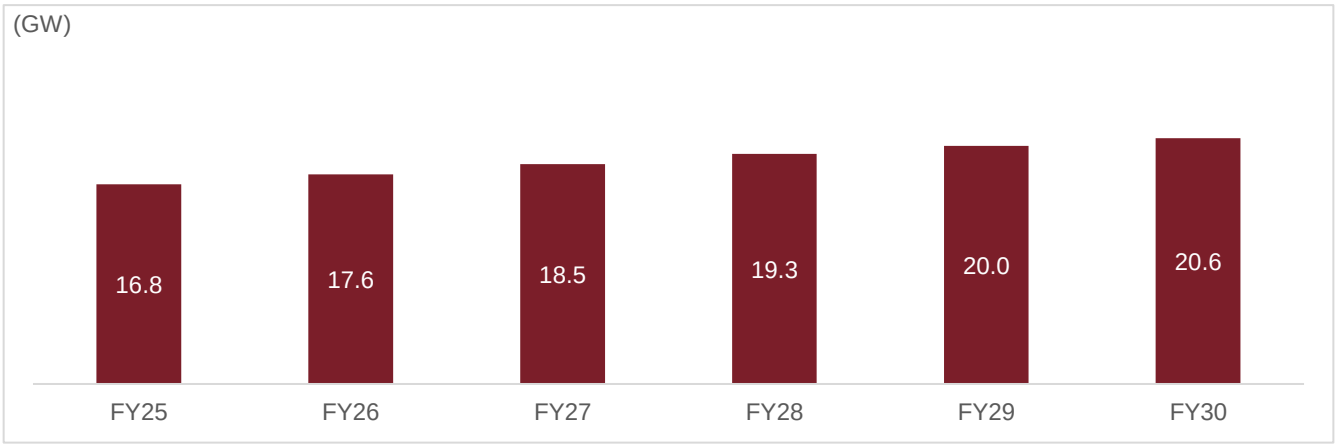
Figure 85: Total energy requirement for Karnataka discoms is expected to grow at a CAGR of 5.0%



Source: CRISIL MI&A Consulting

Using the Load factor, the ex-bus energy requirement is grossed up to arrive at the peak requirement. Peak demand (ex-bus bar) of the state is expected to reach ~20-21 GW by fiscal 2030, an increase of ~3-4 GW over fiscal 2024. Demand side management majors by discoms to flatten the load curve, installation of off-grid solar across consumer categories, and use of energy efficient appliances is some of the factors which are expected to restrain the peak demand.

Figure 86: Peak demand projections for Karnataka



Source: CRISIL MI&A Consulting

4.6.2 Supply Projections

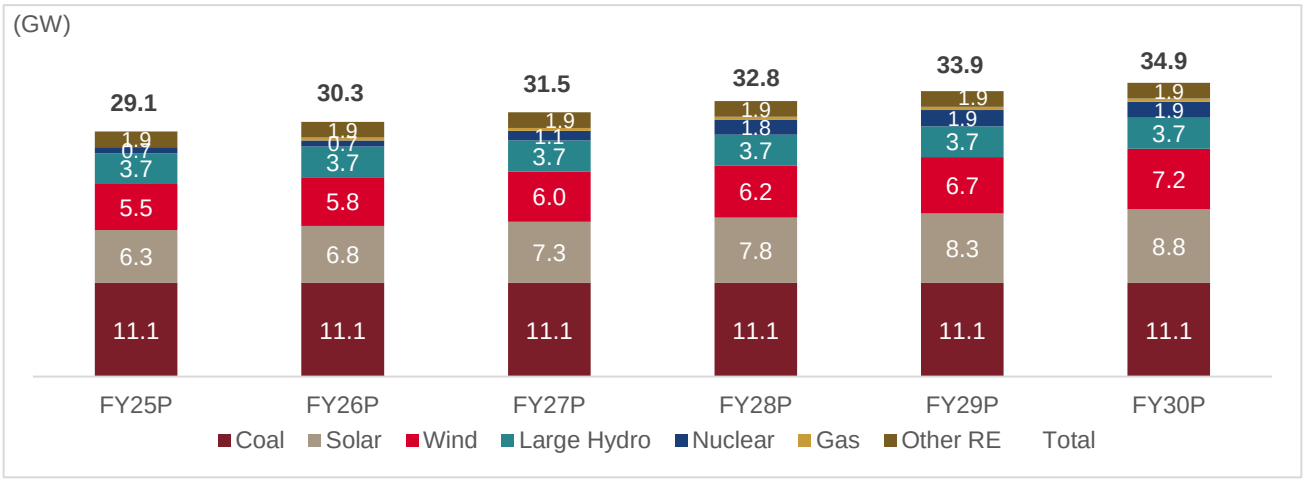
4.6.2.1 Supply forecast

Karnataka has witnessed a rapid rise in capacity additions by the private sector (~13.8 GW) over the last 10 years, especially from renewable energy sources. The state share in overall installed base is ~27%, which largely consists of coal and hydro based capacity. The state draws ~4.4 GW power from central allocations which includes ~3.7 GW coal power (incl lignite) and ~0.7 GW of Nuclear power.

As per the National Electricity Plan 2022, there is no coal-based capacity additions is envisaged in Karnataka till fiscal 2030. However, a 370 MW gas-based power plant has been proposed by KPCL at Yelahanka in Bengaluru Taluk which is expected to be commissioned in fiscal 2025. Further, a nuclear capacity addition of 1.4 GW at Kaiga APS Unit 5&6 is expected by fiscal 2027. Apart from this, the four units of nuclear plants proposed at Kundankulam, Tamil Nadu expected to be commissioned in fiscal 2028-29 could also get a share for Karnataka under Central allocation.

As far as RE capacity addition is concerned, the State RE policy has aimed to add an additional 10 GW of RE by fiscal 2027. Further as of April 2024, there are about 14 GW of RE capacity which is under construction, of which ~3.4 GW are ISTS connected RE projects expected to be commissioned in the next 2-3 years awarded under competitive bidding mechanism. The PCKL has also conducted competitive bidding for 1 GW of PSP based projects in March 2023 whose completion timeline was 36 months from date of signing PPA.

Figure 87: Projected effective installed capacity incl. share from central projects for Karnataka (GW)



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

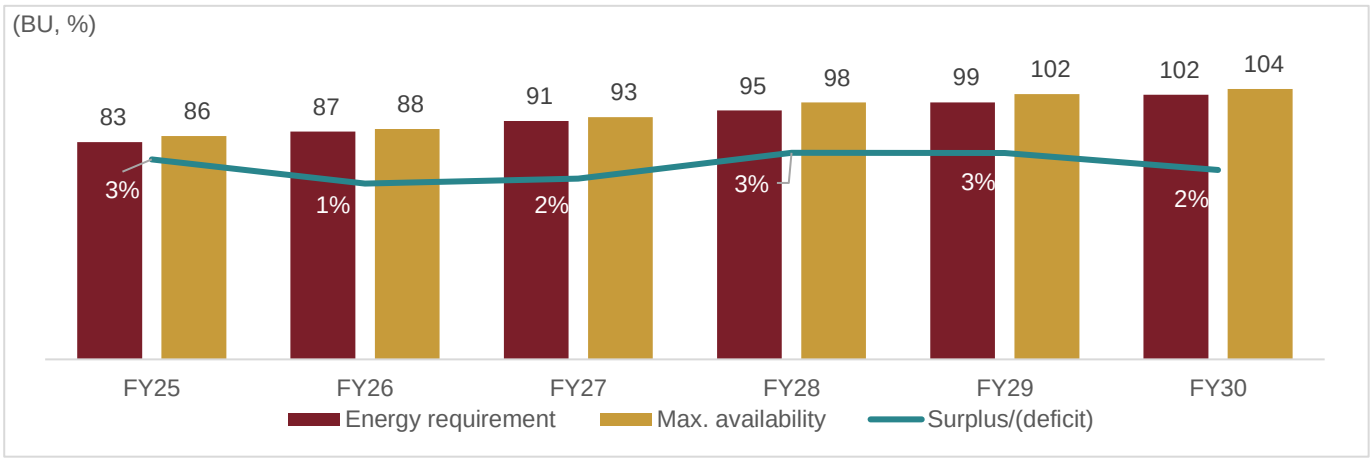
Energy availability is likely to grow at a CAGR of ~4.8% between fiscal 2023 and 2030 driven by ~6-7 GW additions over the same period. Despite the reduction in share, thermal energy accounts for ~51% of total energy supplied and will continue to dominate the fuel mix. Additions in renewable space will drive the share of RE in total supply to ~30% in fiscal 2030 as against ~25% in fiscal 2023. RE capacity addition will be driven by RPO targets as well as Government thrust on achieving the sustainability goals including COP commitments. The share of energy through gas and nuclear power plants is likely to be ~13-14% and that of hydro power plants ~10-11%.

4.6.3 Demand-Supply and surplus/deficit scenario

Discoms need this additional capacity in order to maintain the system reliability in the event of grid disturbances such as line faults, transformer failures, planned and un-planned outages of generating stations, maintenance shut down, accidents, equipment failures, etc. As per the power supply position, the State has been able to meet the energy requirement of the State. During fiscal 2023, the State discoms backed down of 18 BUs due to low load demand/high RE generation.

It is expected that in the forecast period, the state will be in surplus position due to commissioning of over 5 GW of RE projects and 1.2 GW of nuclear power plants.

Figure 88: Expansion in capacity additions for Karnataka



Source: CRISIL MI&A Consulting

4.6.4 Category wise tariff projections

4.6.4.1 Historical variable charges for C&I consumers

The following chart summarises the approved variable charges for commercial and industrial category consumers in Karnataka.

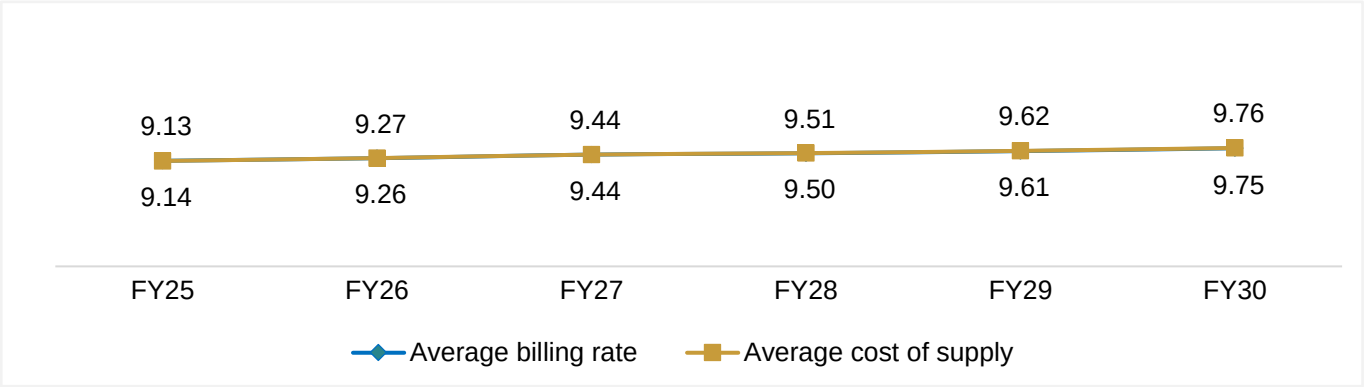
	FY21	FY22	FY23	FY24	FY25
Commercial					
LT 3a - **First 500 units**	8.25	8.35	8.40	8.50	8.00
More than 500 units	9.25	9.35	9.40		
HT 2b - **First 0.1 Mn units**	8.95	9.05	9.30	9.25	8.00
More than 0.1 Mn units	9.05	9.15	9.40		
Industry					
LT-5 (First 500 units)	5.90	5.70	6.05	6.10	6.10
More than 500 units	7.20	6.95	7.35	7.10	
HT 2a (First 0.1 Mn units)	7.35	7.45	7.50	7.40	6.90
More than 0.1 Mn units	7.65	7.75	7.80		

Source: KERC, CRISIL MI&A Consulting

4.6.4.2 ABR and ACS Trajectory

Considering the increase in power purchase cost and other expenses, regular tariff hikes would be required to bridge the gap. It is pertinent to note that the state has been getting tariffs revisions through annual tariff orders by KERC. Further, the Power Ministry has urged the banks to be more cautious while issuing loans to State discoms having regulatory assets. Also, to achieve the targets of schemes like RDSS and get financial assistance from the Central Government, the State is expected to go for annual tariff revisions. ACoS is expected to increase at CAGR of ~2.2% between fiscal 2024 and 2030, with power purchase cost to contribute mostly for such increase. ABR is also expected to increase at ~1.7% CAGR during the same period, resulting in bridging the ARR-ACoS gap.

Figure 89: ACoS-ABR Gap for Karnataka



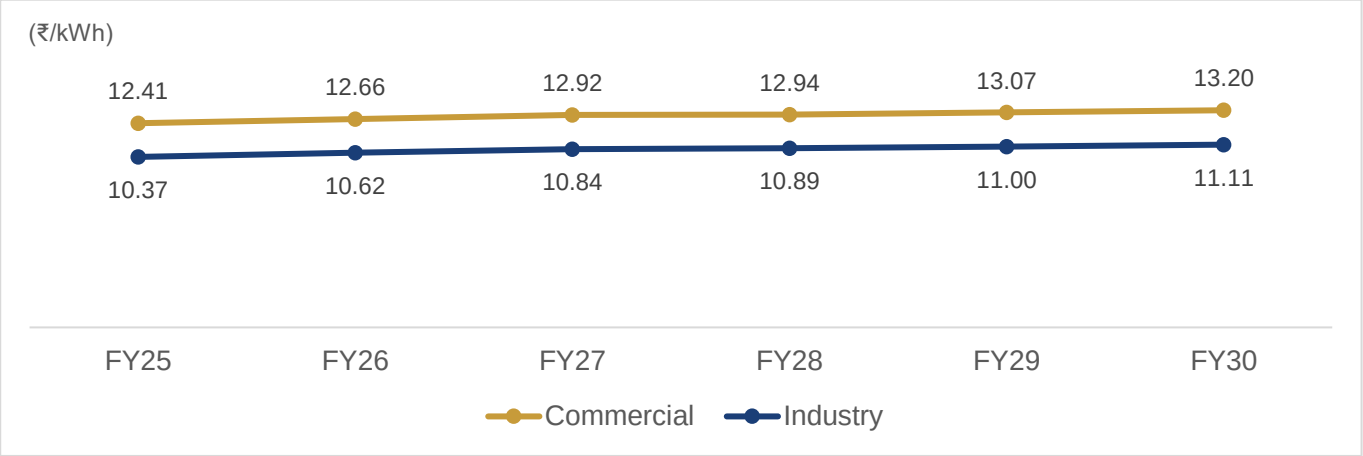
Source: CRISIL MI&A Consulting

4.6.4.3 ABR projections for Commercial and Industrial category

The KERC in its tariff order for fiscal 2025 reduced tariffs across all categories due to marginal surplus found in the ARR. The reduction of tariff is in the range of Rs 0.50 to 1.25/kWh in energy charge was observed in the Order. Accordingly, the ABR estimated for Commercial and Industrial ABR in the forecast period to rise at 1.3% and 1.2%, respectively between fiscal 2023 and 2030 as state is expected to continue supplying subsidized/free power to

agriculture pump-sets and domestic consumers. The tariff increases in C&I would cross-subsidise these consumers category to balance the tariff subsidy burden on the state government.

Figure 90: Commercial and Industrial category ABR for Karnataka



Source: CRISIL MI&A Consulting

4.6.5 Open access charges

Considering the allocation matrix specified in the KERC Tariff Order, the costs have been allocated to Wheeling and Supply activities. The Commission allocated the distribution network costs to the HT and LT network in the ratio of 30:70. The overall wheeling charges have been calculated by dividing the distribution ARR with energy sales. The wheeling charges for HT and LT network are determined by considering the HT:LT ratio.

Table 17: Summary of key parameters in Karnataka

Particulars	Units	FY 25 (P)	FY 26 (P)	FY 27 (P)	FY 28 (P)	FY 29 (P)	FY 30 (P)
Peak demand	GW	16.8	17.6	18.5	19.3	20.0	20.6
Overall demand	BU	72.1	75.7	79.2	82.6	85.2	87.7
Energy requirement (ex-bus)	BU	83.3	87.3	91.4	95.4	98.6	101.5
% energy consumed by C&I users	%	31%	32%	32%	32%	32%	32%
Renewable energy as a % of total energy (incl large hydro)	%	39%	39%	39%	38%	39%	40%
Open access charges							
Wheeling charges	Rs/kWh	1.06	1.05	1.05	1.06	1.07	1.08
Transmission Charges	Rs/kWh	1.34	1.35	1.36	1.38	1.41	1.45
CSS (industrial)	Rs/kWh	2.07	2.12	2.17	2.18	2.20	2.22

Source: CRISIL MI&A Consulting

4.7 Rajasthan

4.7.1 Demand Projections

4.7.1.1 Historical demand supply position

Energy requirement for Rajasthan has increased from ~80 BUs in FY19 to 107 BUs in FY24 registering a growth of 6.1% (CAGR). Correspondingly, the energy availability has increased at a CAGR of 6.0% from FY19 to FY24. The peak demand has increased from 13 GW in FY19 to 18 GW in FY24, registering a growth of 6.4%. Domestic consumption, improved power availability, increased industrialisation, and urbanisation, are some of the reasons for the increase in demand.

Table 18: Historical power demand supply position for Rajasthan

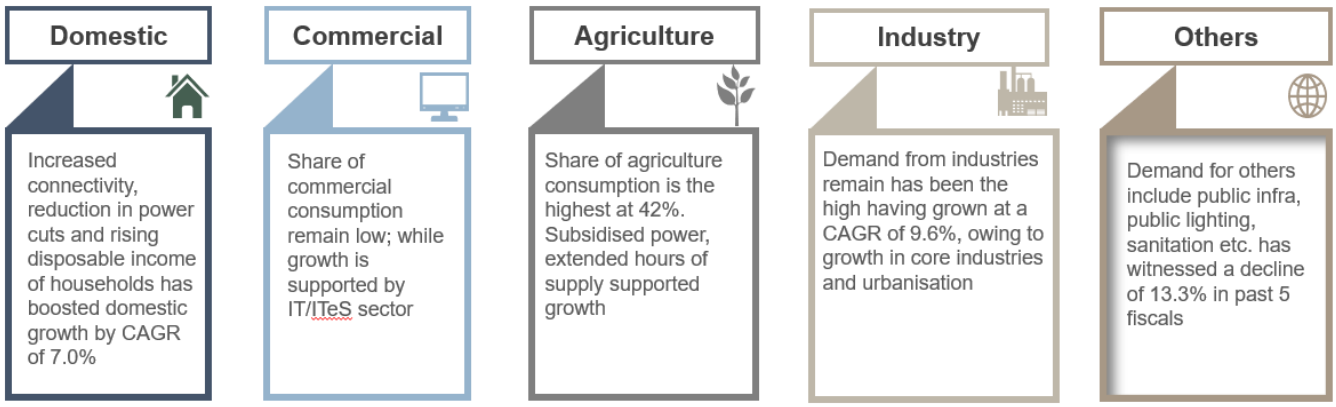
Particulars	FY 19	FY 20	FY 21	FY 22	FY 23	FY 24
Energy requirement (MUs)	79,826	81,294	85,311	89,814	101,801	107,422
Energy availability (MUs)	79,637	81,236	85,205	89,310	100,057	106,806
Energy Surplus/(deficit)	-0.2%	-0.1%	-0.1%	-0.6%	-1.7%	-0.6%
Peak Demand (MW)	13,276	14,277	14,441	15,784	17,399	18,128
Peak Met (MW)	13,276	14,277	14,441	15,784	17,206	18,128
Peak Surplus/(deficit)	0.0%	0.0%	0.0%	0.0%	-1.1%	0.0%

Source: CEA, CRISIL MI&A Consulting

4.7.1.2 Demand drivers and restraints

The following figure depicts the various drivers for power demand in Rajasthan.

Figure 91: Drivers for power demand in Rajasthan



Source: CRISIL MI&A Consulting

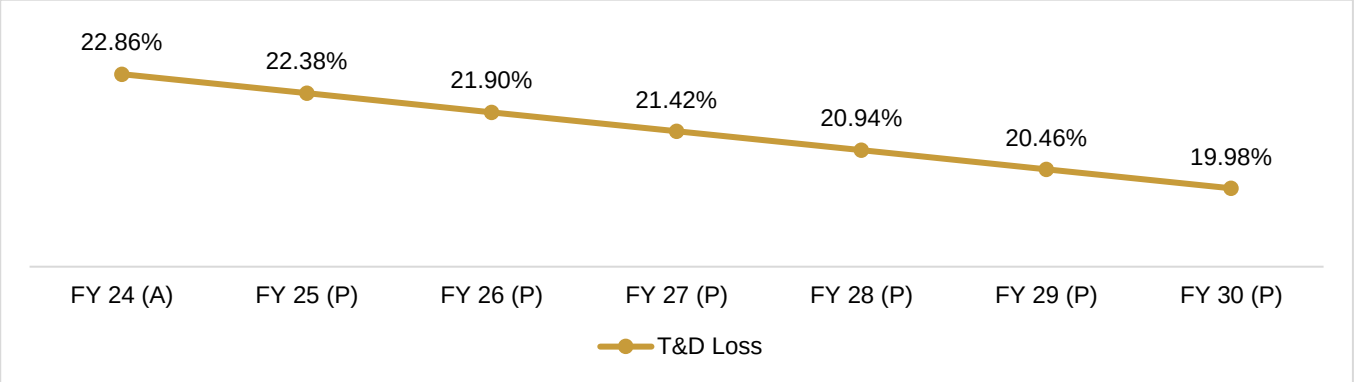
Rooftop solar and energy efficiency are some of the key constraints which may affect the demand from Discoms. State government is actively supporting solar rooftop by providing subsidies. As of FY24, solar rooftop capacity in the state stands at ~1.2 GW. Moreover, Perform Achieve and Trade (PAT) scheme, supply of LED bulbs to domestic consumers, strong government push on use of LED etc. have achieved significant energy efficiency.

4.7.1.3 T&D Losses

T&D losses for Rajasthan Discoms have been reduced significantly. Going forward, investments in network augmentation to drive further reduction in losses. Considering the existing levels, T&D loss reduction beyond 19%

is expected to be challenging owing to difficult geographical area coupled with expansion into rural households and agriculture segment. The projected T&D losses are given below

Figure 92: T&D Losses in Rajasthan



Note: FY 24 approved by RERC
Source: RJ Discoms, RERC, CRISIL MI&A Consulting

4.7.1.4 Energy requirement

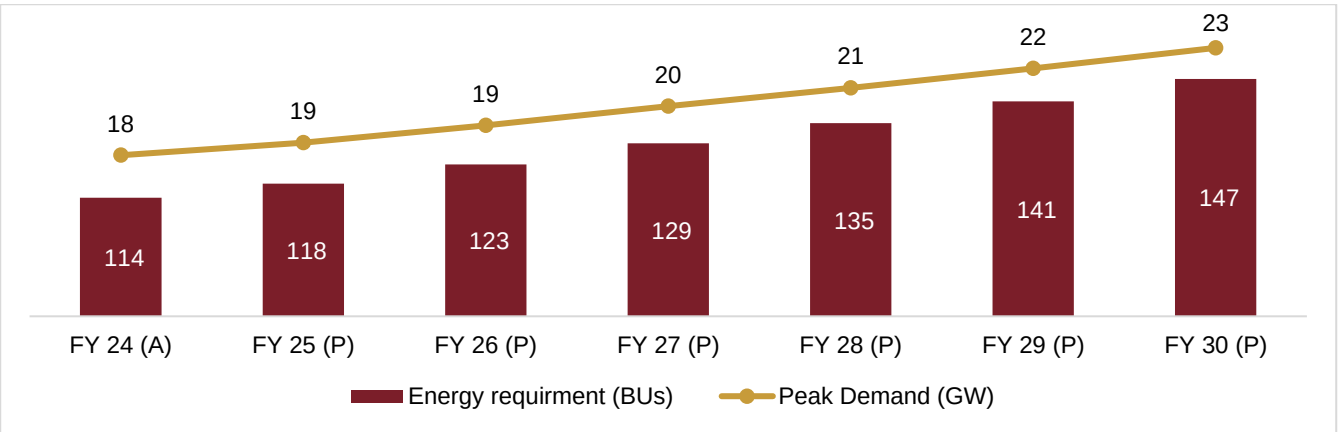
The five-year CAGR for energy consumption in Rajasthan was 6.9%. The Industrial category experienced a growth of 9.6% whereas the domestic category witnessed a growth of 7.0%. The commercial and agriculture category grown by 6.6% and 10.0% respectively over the said period.

Further, the correlation between GSDP and electricity consumption for domestic category is 97%, commercial 95%, Agriculture 90%, industry 72%, and others 55%. Considering this, the appropriate weights for CAGR and GSDP have been established and accordingly the constrained energy sales have been estimated.

Furthermore, using the demand drivers and constraints, the un-constrained sales for the Discoms have been estimated which is then grossed up to arrive at the ex-bus energy requirement. Overall energy requirement (ex-bus bar) of the state is expected to reach ~147 BUs by FY 30, growing at a CAGR of 4.4% driven by residential, industrial and agricultural consumption.

Using the Load factor, the ex-bus energy requirement is grossed up to arrive at the peak requirement. Peak demand (ex-bus bar) of the state is expected to reach ~23 GW by FY30, an increase from 18 GW over FY 24. Demand side management majors by discoms to flatten the load curve, installation of off-grid solar across consumer categories, use of energy efficient appliances is some of the factors which are expected to restrain the peak demand.

Figure 93: Total energy requirement and peak demand is expected to growth at a CAGR of 4.4%



Note: FY 24 approved by RERC
Source: RERC, CRISIL MI&A Consulting

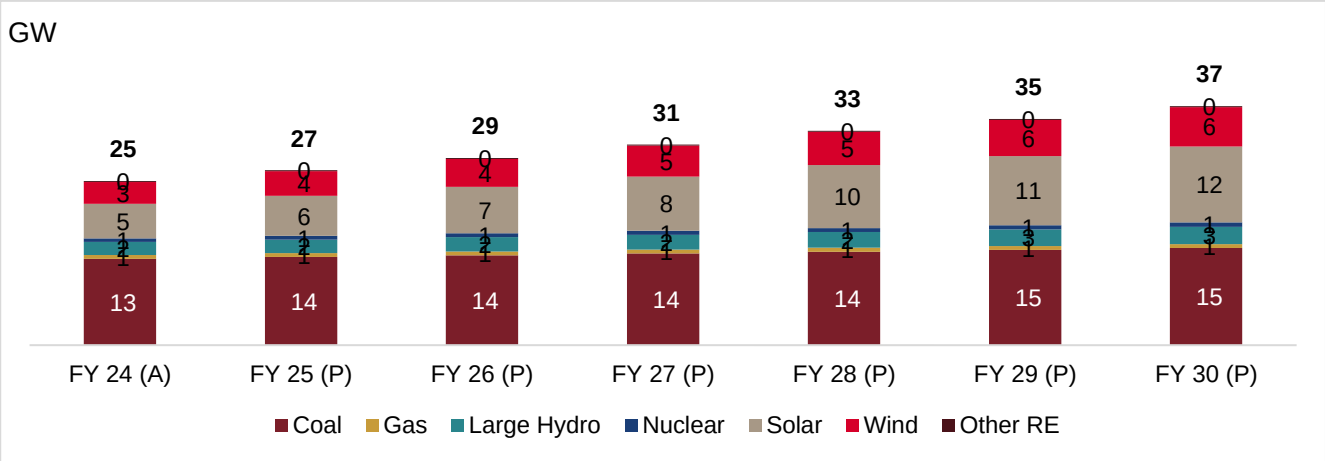
4.7.2 Supply Projections

4.7.2.1 Supply forecast

Rajasthan is one of the highest growing states in capacity additions. The state contributes to ~8 GW of total supply primarily from thermal based capacity which accounts for 7.7 GW. The balance is through hydro power plants. Central allocations are primarily from thermal, nuclear and large hydro power plants totaling to ~5 GW. The balance ~12.5 GW is driven by private players which have a higher share in renewable capacity.

Coal based additions are expected to slow down due to the focus on clean energy. Further, increasing fuel costs and reducing cost competitiveness with renewable energy to deter coal-based additions over the long-term. Around 1.7 GW coal-based capacity is expected to get commissioned. Hydro and gas capacity projects are likely to benefit from rising RE penetration for balancing purposes; but overall share to remain low. Rajasthan being a RE rich state, major capacity additions would be driven by renewable energy sources. Both solar and wind are likely to dominate capacity due to govt. thrust, incentives, technological advancements and ~9 GW expected to be added by FY30.

Figure 94: Projected installed capacity incl. share from central projects for Rajasthan (GW)



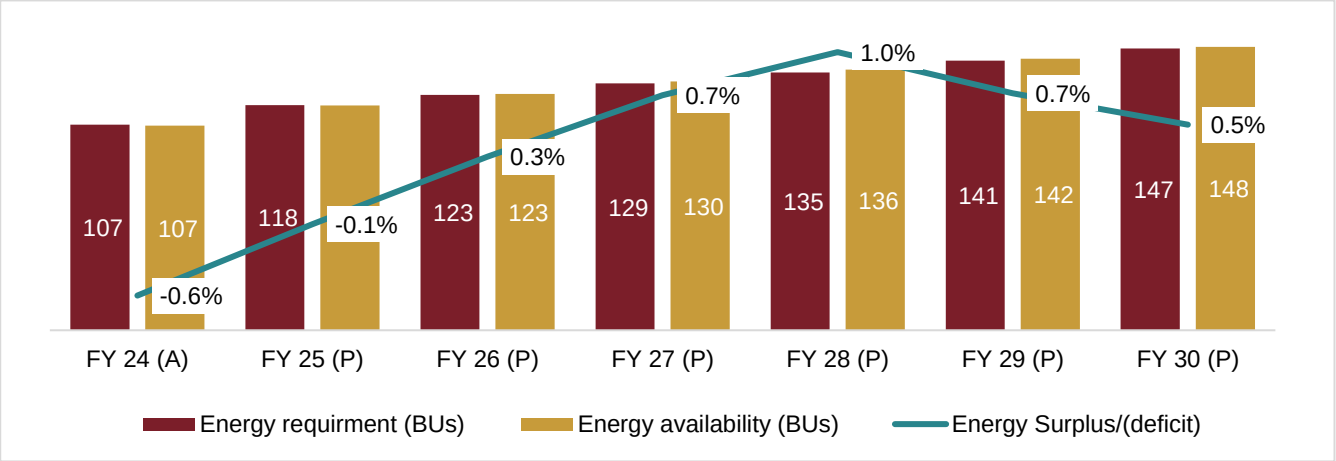
Note: FY24 based on approved power purchase and share from central stations
Source: RJ Discoms, RERC, CRISIL MI&A Consulting

Energy availability is likely to grow at a CAGR of ~5.4% between FY24 to FY30 driven by ~12 GW additions over same period. Thermal energy will continue to dominate the energy mix accounting for ~64% of the total energy supplied. RE capacity additions are expected to increase the share of RE in energy mix from 16% in FY24 to 27% by FY30. Hydro power is expected to have a stable share of 6% whereas gas and nuclear power would have a share of 1-2% by FY30.

4.7.3 Demand Supply and surplus/deficit scenario

Discoms need additional capacity to maintain the system reliability in the event of grid disturbances such as line faults, transformer failures, planned and un-planned outages of generating stations, maintenance shut down, accidents, equipment failures, etc. As per the power supply position, the State is expected to have a marginal surplus of energy by FY30. Slowdown in conventional capacities coupled with rapid increase in demand to curtail overall surplus levels.

Figure 95: Slowdown in conventional capacity additions to reduce surplus for Rajasthan



Note: FY 24 based on power purchase approved by RERC
Source: RERC, CRISIL MI&A Consulting

4.7.4 Category wise tariff projections

4.7.4.1 Historical variable charges for C&I consumers

The following chart summarises the approved variable charges for commercial and industrial category consumers in Rajasthan.

Figure 96: Historical variable charges for commercial and industrial consumers-Rajasthan

Rs./kWh

Particulars	FY20		FY21		FY22		FY23		FY24		FY25	
	A	B	A	B	A	B	A	B	A	B	A	B
HT Industries	7.30	6.30	7.30	6.30	7.30	6.30	7.30	6.30	7.30	6.30	7.30	6.30
11 kV	7.300	6.300	7.300	6.300	7.300	6.300	7.300	6.300	7.300	6.300	7.300	6.300
33 kV	7.081	6.111	7.081	6.111	7.081	6.111	7.081	6.111	7.081	6.111	7.081	6.111
132 kV	7.008	6.048	7.008	6.048	7.008	6.048	7.008	6.048	7.008	6.048	7.008	6.048
220 kV	6.935	5.985	6.935	5.985	6.935	5.985	6.935	5.985	6.935	5.985	6.935	5.985
HT Commercial	8.85		8.85		8.85		8.85		8.85		8.85	

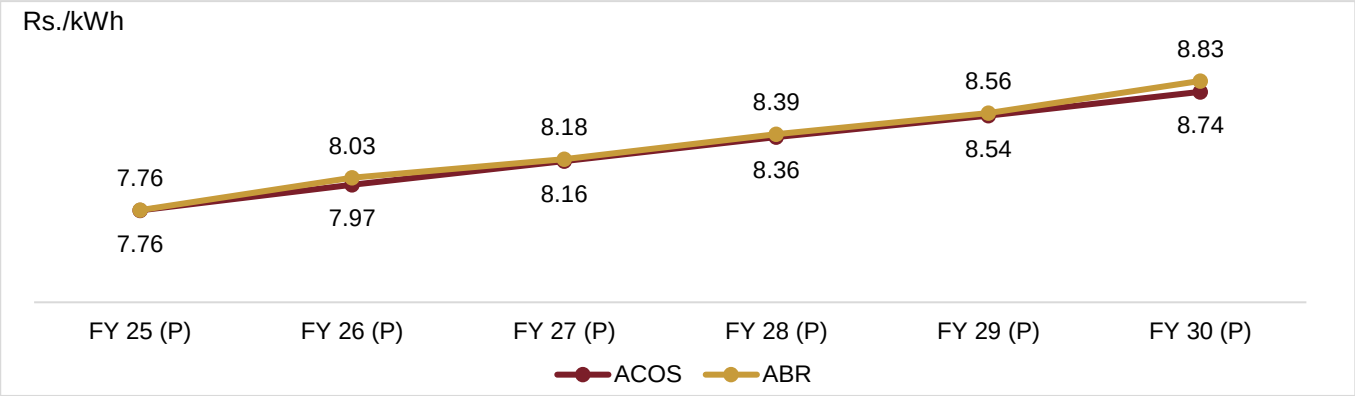
A: HT Industries (MD above 125 kVA)
B: HT Industries having BD 1 MVA or more

Source: RERC, CRISIL MI&A Consulting

4.7.4.2 ABR and ACS Trajectory

Increase in power purchase costs and other expenses would result in regular tariff hikes by RERC to bridge the gap. ACOS is expected to increase at CAGR of ~2.4% during the period of 6 years, with power purchase cost to contribute mostly for such increase. ABR is expected to increase at a similar pace of ~2.6% till FY30 to reach Rs 8.83/kWh.

Figure 97: ACOS-ABR Gap for Rajasthan (Rs./kWh)

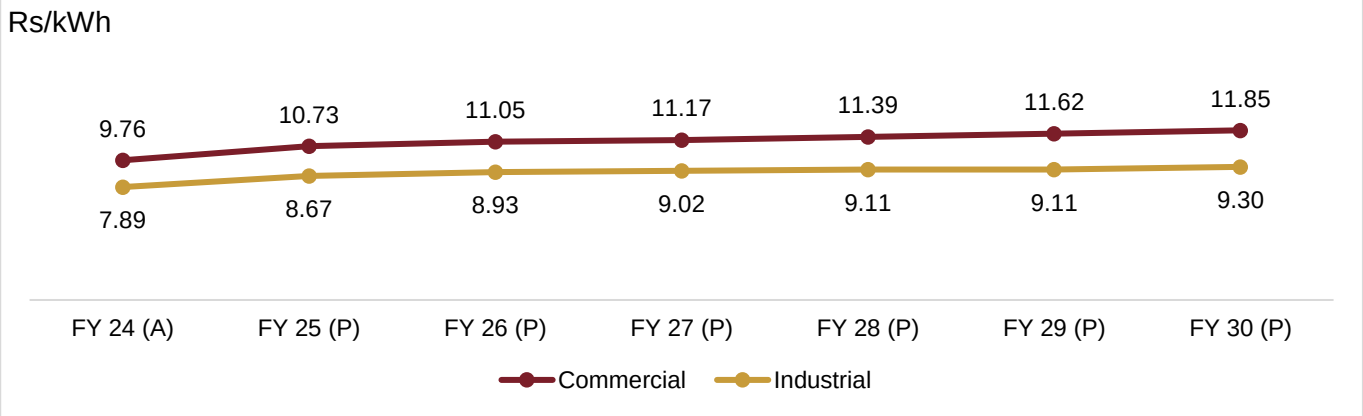


Source: RERC, CRISIL MI&A Consulting

4.7.4.3 ABR projections for Commercial and Industrial category

Commercial and Industrial ABRs to rise at a moderate pace (2.0% and 1.4% respectively) on account of continued cross-subsidization and lower tariffs for agricultural and domestic consumers.

Figure 98: Commercial and Industrial category ABR for Rajasthan (Rs./kWh)



Note: FY24 Approved by RERC
Source: RERC, CRISIL MI&A Consulting

4.7.5 Open access charges

Considering the wheeling ARR and losses approved by RERC for wheeling business and the power quantum to be wheeled, the wheeling charges are estimated for 11kV and 33 kV voltage.

AS per RERC tariff Order for FY24, the CSS is computed as minimum of 20% of ABR of the category. The projected open access charges are given below.

Table 19: Summary of key parameters in Rajasthan

Particulars	Units	FY 25 (P)	FY 26 (P)	FY 27 (P)	FY 28 (P)	FY 29 (P)	FY 30 (P)
Peak demand	GW	18	19	19	20	21	22
Overall demand	BU	88	91	96	101	106	112
Energy requirement	BU	114	118	123	129	135	141
% energy consumed by C&I users	%	35%	34%	34%	34%	35%	36%

Particulars	Units	FY 25 (P)	FY 26 (P)	FY 27 (P)	FY 28 (P)	FY 29 (P)	FY 30 (P)
Renewable energy as a % of total energy (incl large hydro)	%	22%	25%	27%	30%	31%	33%
Open access charges							
Wheeling charges – 11 kV	Rs/kWh	0.79	0.82	0.85	0.86	0.88	0.91
Wheeling charges – 33 kV)	Rs/kWh	0.14	0.16	0.18	0.19	0.19	0.20
Transmission Charges	Rs/kWh	0.30	0.31	0.32	0.33	0.33	0.34
CSS	Rs/kWh	1.59	1.59	1.63	1.67	1.71	1.75

Source: CRISIL MI&A Consulting

4.8 Andhra Pradesh

4.8.1 Demand Projections

4.8.1.1 Historical demand supply position

Energy requirement for Andhra Pradesh has increased from 64 BUs in fiscal 2019 to 80 BUs in FY 2024 registering a growth of 4.7% (CAGR). The 5-year CAGR for energy availability was also 4.7%. Similarly, the peak demand reached 13 GW in fiscal 2024 from 9 GW in fiscal 2019 with a CAGR of 7%. Increase in commercial and industrial activities in the state has resulted in a substantial increase in the energy requirement.

Table 20: Historical power demand supply position for Andhra Pradesh

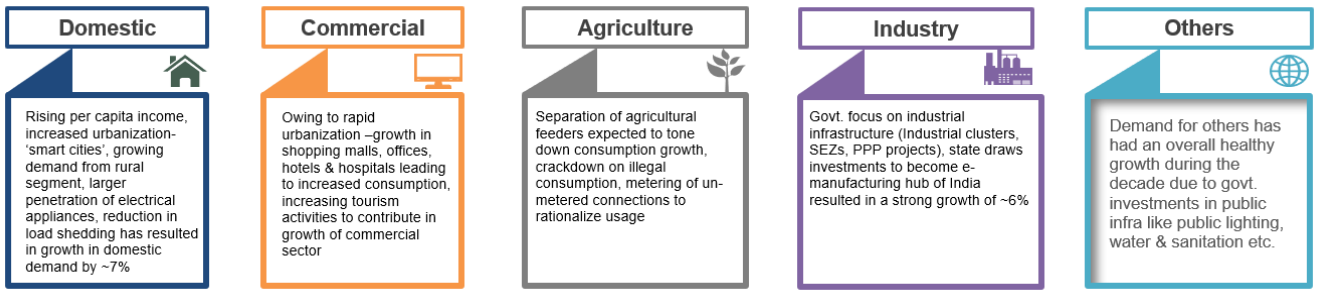
Particulars	FY 19	FY 20	FY 21	FY 22	FY 23	FY 24
Energy requirement (MUs)	63,861	65,452	62,080	68,413	72,302	80,209
Energy availability (MUs)	63,804	65,414	62,076	68,219	71,893	80,151
Energy Surplus/(deficit)	**-0.09%**	**-0.06%**	**-0.01%**	**-0.28%**	**-0.57%**	**-0.07%**
Peak Demand (MW)	9,459	10,225	11,193	12,551	13,167	13,237
Peak Met (MW)	9,453	10,207	11,193	12,032	12,293	13,237
Peak Surplus/(deficit)	**-0.06%**	**-0.18%**	**0.00%**	**-4.14%**	**-6.64%**	**0.00%**

Source: CEA, CRISIL MI&A Consulting

4.8.1.2 Demand drivers and restraints

The following figure depicts the various drivers for power demand in Andhra Pradesh.

Figure 99: Drivers for power demand in Andhra Pradesh



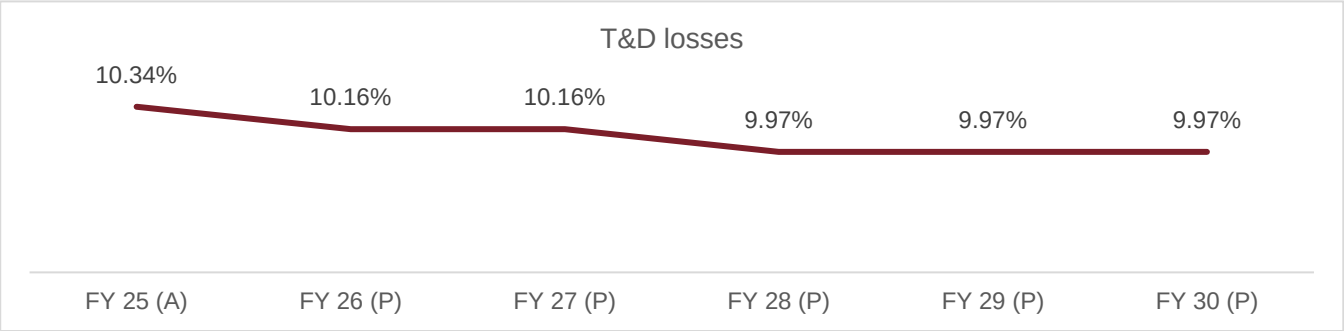
Source: CRISIL MI&A Consulting

Key constraints impacting the demand from discoms is the growth of rooftop solar and energy efficiency measures adopted by the state. Under the PAT scheme, Designated Consumers are identified in the state with a reduction of specific energy consumption as notified in the BEE resulting in a saving of ~9 MTOE. Under the UJALA scheme, Andhra Pradesh has installed ~22 million LEDs till date resulting in a savings of ~3 BU of annual energy.

4.8.1.3 T&D Losses

T&D losses are presently in the range of 10-11% in Andhra Pradesh which is estimated to witness a slight reduction till FY30. The projected T&D losses in the forecast period are given below.

Figure 100: T&D Losses trajectory in Andhra Pradesh



Note: FY 25 approved by APERC
Source: CRISIL MI&A Consulting

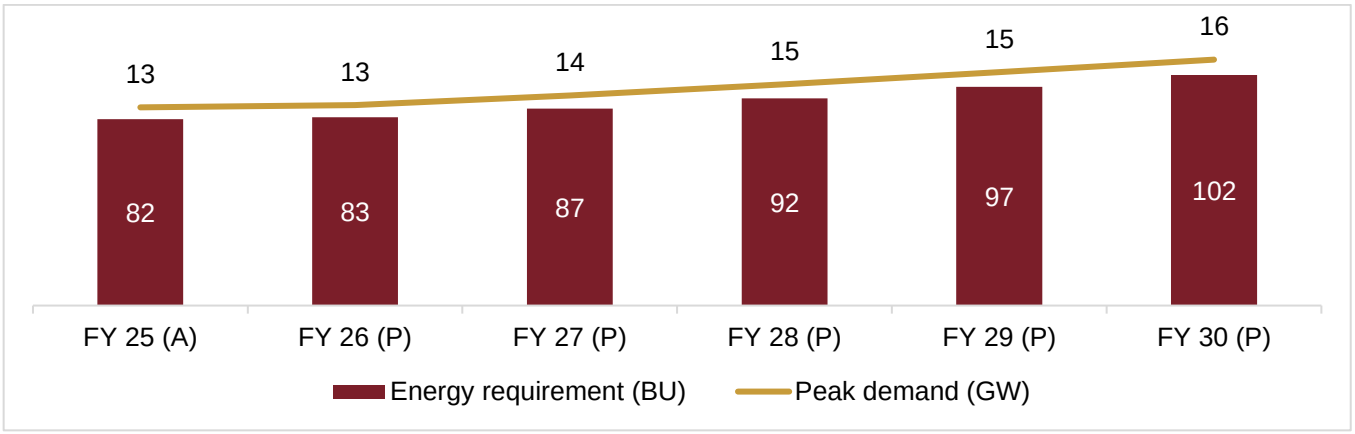
4.8.1.4 Energy requirement

The historic CAGR of energy requirement was 4.7% from FY19 to FY24. The highest growth was in commercial demand followed by the domestic and industry sectors indicating a strong growth in energy requirement due to industrialization and urbanization activities.

The correlation between GSDP and electricity consumption was 98% in the domestic demand. For commercial 87%, agriculture sector 84%, industrial sector 75%, and others 55%. Using appropriate weights, demand has been computed under CAGR and GSDP approaches, and the constrained energy sales are estimated.

Considering the above-mentioned drivers and constraints, un-restricted energy sales have been estimated which are then grossed up to the extent of T&D losses to arrive at the ex-bus energy requirement for Andhra Pradesh. The overall energy requirement is expected to reach 102 BU by FY30.

Figure 101: Total energy requirement and peak demand for Andhra Pradesh



Note: FY 25 approved by APERC
Source: CRISIL MI&A Consulting

Using the Load factor, the ex-bus energy requirement is grossed up to arrive at the peak requirement. Peak demand (ex-bus bar) of Andhra Pradesh is expected to reach ~15-16 GW by fiscal 2030, from 13 GW in fiscal 2025. Demand side management majors by discoms to flatten the load curve, installation of off-grid solar across consumer categories, and use of energy efficient appliances is some of the factors which are expected to restrain the peak demand.

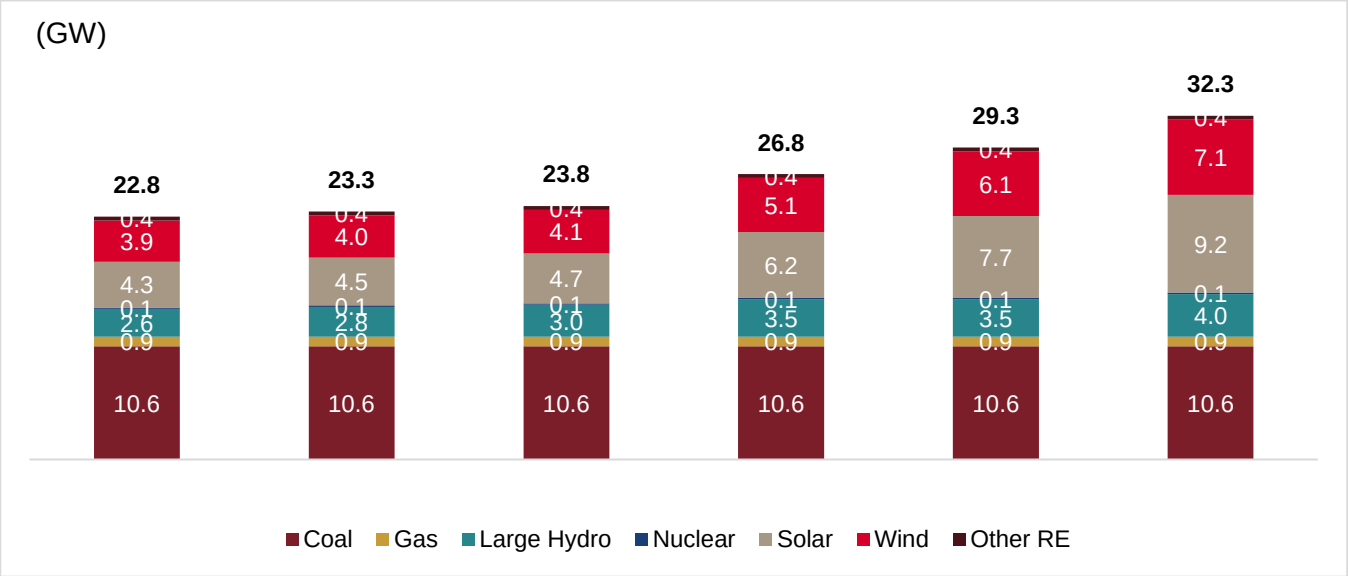
4.8.2 Supply Projections

4.8.2.1 Supply forecast

The total installed capacity of Andhra Pradesh as of fiscal 2025 is estimated at 23 GW due to the growth in renewable energy. Central capacity primarily includes the allocations for coal power of ~1.9 GW and nuclear power of ~0.1 GW. State capacity accounts for ~9 GW which includes thermal capacity of ~6.5 GW and the balance hydro power. The private sector concentration is in the renewable power accounting for ~9 GW. The private sector has also contributed to the thermal capacity of ~2 GW.

Renewable energy additions are expected to drive the installed capacity within the state. The state policies to promote development of large-scale solar park(s) and green corridors for power evacuation and providing land would accelerate development of RE sector in the State. Solar capacities are expected to increase by ~5 GW followed by wind capacities of ~3 GW till FY30.

Figure 102: Projected effective installed capacity incl. share from central projects for Andhra Pradesh (GW)



Note: FY 25 approved by APERC
Source: CRISIL MI&A Consulting

Energy availability is likely to grow at a CAGR of ~4.3% between fiscal 2025 and 2030 driven by ~9-10 GW additions over the same period. Although thermal energy is expected to reduce in the share of energy supplied, it will continue to dominate the energy mix with 65% share. The share of RE in energy supplied is expected to increase to 27% by FY30 from the existing 16% share. Nuclear and gas are expected to have the least share of 1-2% each. Large hydro projects are expected to witness an increase in the share in the energy mix from 4% in FY25 to ~7% in FY30.

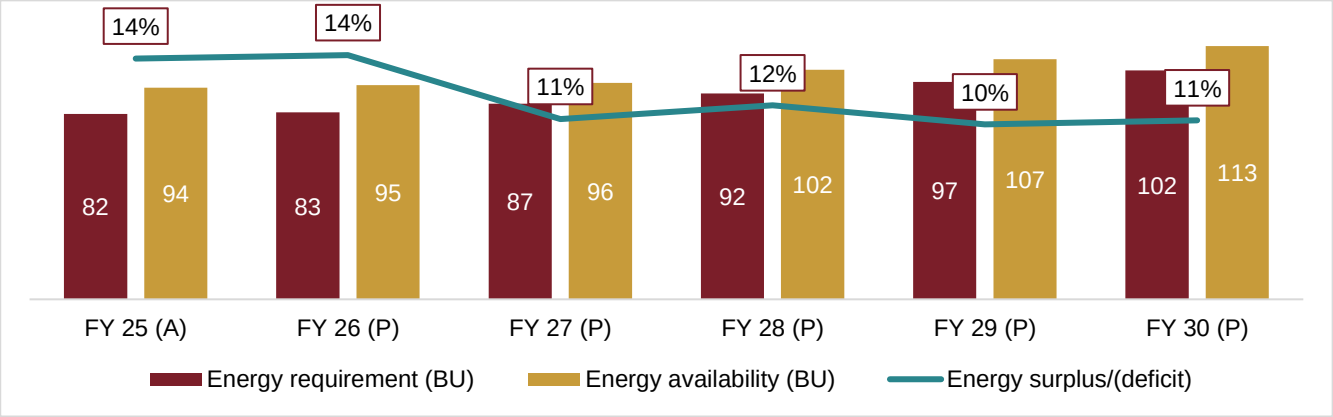
4.8.3 Demand-Supply and surplus/deficit scenario

Discoms to strive to manage availability to maintain system reliability in the event of grid disturbances such as line faults, transformer failures, planned and un-planned outages of generating stations, maintenance shut down,

accidents, equipment failures, etc. Thus, to ride through such events and to ensure smooth grid operations, each discom needs to have adequate contracted capacity which can be scheduled whenever needed.

The state will continue to remain in a surplus position during the forecast period owing to the increase in supply of RE projects of ~8-9 GW and 1-2 GW of large hydro projects. I

Figure 103: Energy requirement and availability projections in Andhra Pradesh



Note: FY 25 approved by APERC
Source: CRISIL MI&A Consulting

4.8.4 Category wise tariff projections

4.8.4.1 Historical variable charges for C&I consumers

The following chart summarises the approved variable charges for commercial and industrial category consumers in Andhra Pradesh.

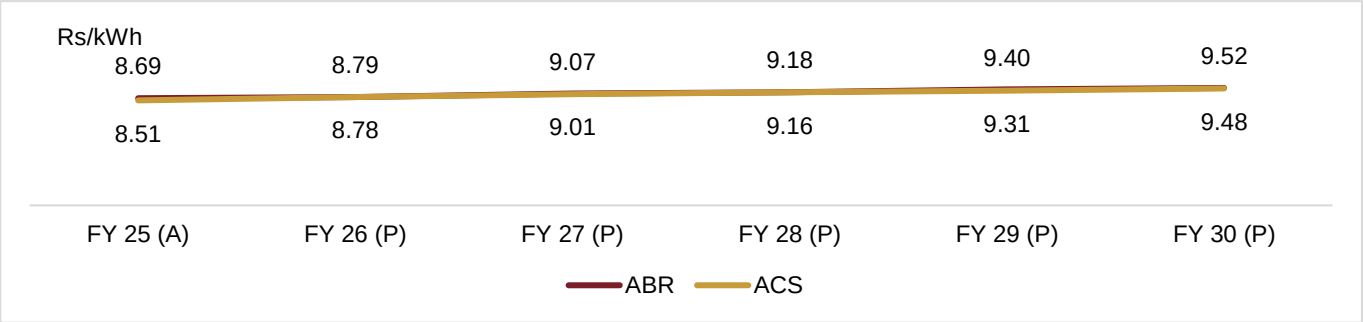
	FY20	FY21	FY22	FY23	FY24	FY25
Industry						
11 kV	6.30	6.30	6.30	6.30	6.30	6.30
33 kV	5.85	5.85	5.85	5.85	5.85	5.85
132 kV	5.40	5.40	5.40	5.40	5.40	5.40
220 kV	5.40	5.40	5.40	5.35	5.35	5.35
Commercial						
11 kV	7.65	7.65	7.65	7.65	7.65	7.65
33 kV	6.95	6.95	6.95	6.95	6.95	6.95
132 kV	6.70	6.70	6.70	6.70	6.70	6.70
220 kV	6.70	6.70	6.70	6.65	6.65	6.65

Source: CRISIL MI&A Consulting

4.8.4.2 ABR and ACS Trajectory

Increase in power purchase costs, O&M and other expenses result in an increase in the overall cost which is expected to increase the tariffs for the consumers. The increase in tariffs is approved by APERC on a periodic basis considering the increase in the costs. During the forecast period, ACoS is expected to increase at a CAGR of 2.2%. Similarly, the ABR is expected to increase at a CAGR of 1.8% to reach Rs. 9.52/kWh by fiscal 2030, to minimize the gap between ABR-ACoS.

Figure 104: ACoS-ABR Gap for Andhra Pradesh

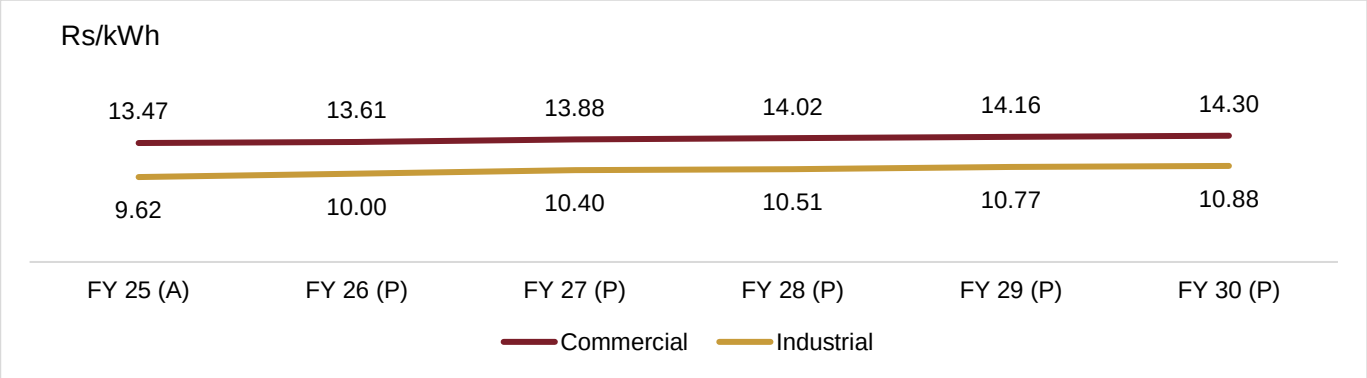


Note: FY 25 approved by APERC
Source: CRISIL MI&A Consulting

4.8.4.3 ABR projections for Commercial and Industrial category

ABR for commercial and industrial sector are expected to grow till fiscal 2030 on account of continued supply of subsidized power to agriculture/domestic consumers. The commercial ABR is expected to increase at a CAGR of 1.2% to reach Rs. 14.30/kWh. Similarly, industrial ABR would witness an increase in CAGR of 2.5% to reach Rs. 10.88/kWh by fiscal 2030.

Figure 105: Commercial and Industrial category ABR for Andra Pradesh



Note: FY 25 approved by APERC
Source: CRISIL MI&A Consulting

4.8.5 Open access charges

The Allocation Matrix for segregation of the ARR between the Wires and Supply Business has been specified in the Wheeling and tariff regulations of APERC. The projected wheeling charges and cross subsidy surcharge for commercial and industrial consumers at 11 kV and 33 kV are provided below.

As per APERC's tariff order, the cross-subsidy surcharge (CSS) is capped at 20% of the tariff applicable to the consumer category. Accordingly, the applicable CSS is computed for commercial and industrial consumers.

Table 21: Summary of key parameters in Andhra Pradesh

Particulars	Units	FY 25 (P)	FY 26 (P)	FY 27 (P)	FY 28 (P)	FY 29 (P)	FY 30 (P)
Peak demand	GW	13	13	14	15	15	16
Overall demand	BU	74	75	78	83	87	92
Energy requirement	BU	82	83	87	92	97	102

Particulars	Units	FY 25 (P)	FY 26 (P)	FY 27 (P)	FY 28 (P)	FY 29 (P)	FY 30 (P)
% energy consumed by C&I users	%	43%	42%	42%	42%	42%	43%
Renewable energy as a % of total energy (incl large hydro)	%	20%	21%	22%	27%	30%	33%
Open access charges							
Wheeling charges – 11 kV	Rs/kWh	1.62	1.71	1.80	1.87	1.95	2.02
Wheeling charges – 33 kV	Rs/kWh	0.58	0.59	0.59	0.60	0.61	0.61
Transmission Charges	Rs/kWh	0.31	0.33	0.34	0.34	0.34	0.35
CSS – 11 kV – Commercial	Rs/kWh	2.69	2.72	2.78	2.80	2.83	2.86
CSS – 11 kV – Industrial	Rs/kWh	1.92	2.00	2.08	2.10	2.15	2.18
CSS – 33 kV – Commercial	Rs/kWh	2.69	2.72	2.78	2.80	2.83	2.86
CSS – 33 kV – Industrial	Rs/kWh	1.60	1.66	1.73	1.74	1.79	1.81

Source: CRISIL MI&A Consulting

4.9 Telangana

4.9.1.1 Historical demand supply position

Energy requirement for Telangana has increased from 66 BUs in FY 2019 to 85 BUs in FY 2024, registering a growth of 4.9% (CAGR). The 5-year CAGR for energy availability was 5.0% leaving negligible deficit Similarly, the peak demand reached to 15.6 GW in FY 2024 from 10.8 GW in FY 2019 with a CAGR of 7.6% against a similar growth of 7.6% (5 yr CAGR) in peak availability leaving NIL deficit 2.4%. Domestic consumption, improved power availability, increased industrialisation, and urbanisation, metro railways are some of the reasons for the increase in demand.

Table 22: Historical power demand supply position for Telangana

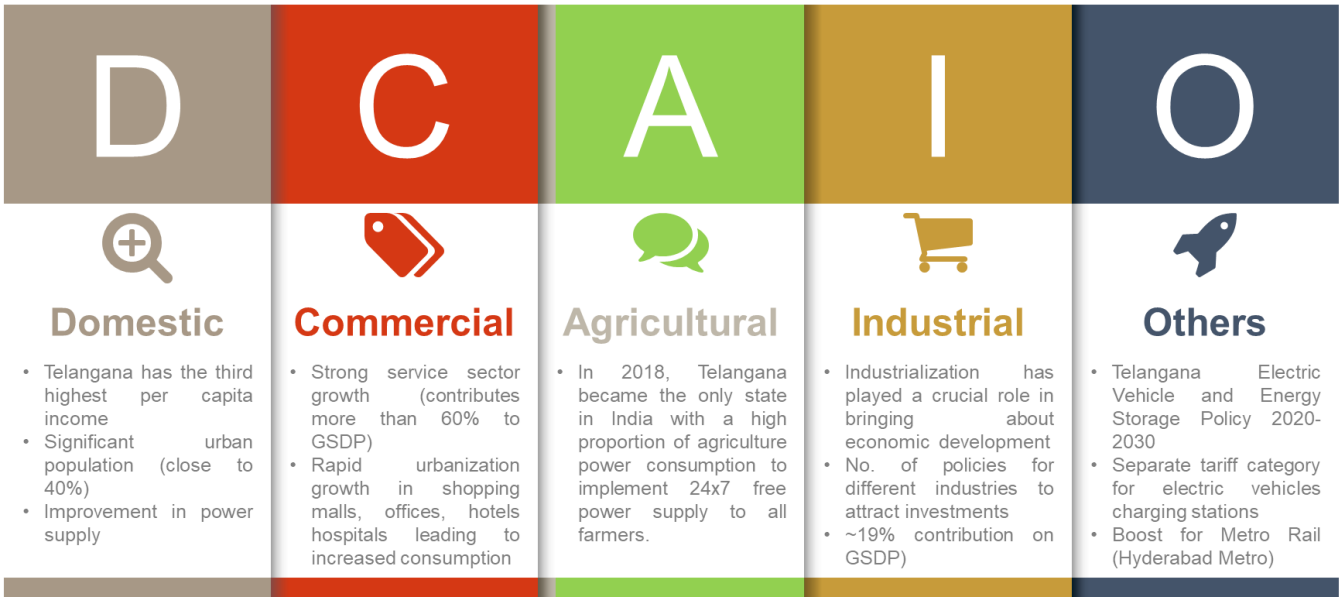
Particulars	FY 19	FY 20	FY 21	FY 22	FY 23	FY 24
Energy requirement (MUs)	66,489	68,306	66,998	70,539	77,832	84,623
Energy availability (MUs)	66,427	68,303	66,994	70,523	77,799	84,613
Energy Surplus/(deficit)	**-0.1%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**
Peak Demand (MW)	10,815	13,168	13,688	14,163	15,497	15,622
Peak Met (MW)	10,815	13,168	13,688	14,160	15,497	15,622
Peak Surplus/(deficit)	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**

Source: CEA, CRISIL MI&A Consulting

4.9.1.2 Demand drivers and restraints

The following figure depicts the various drivers for power demand in Telangana.

Figure 106: Drivers for power demand in Telangana



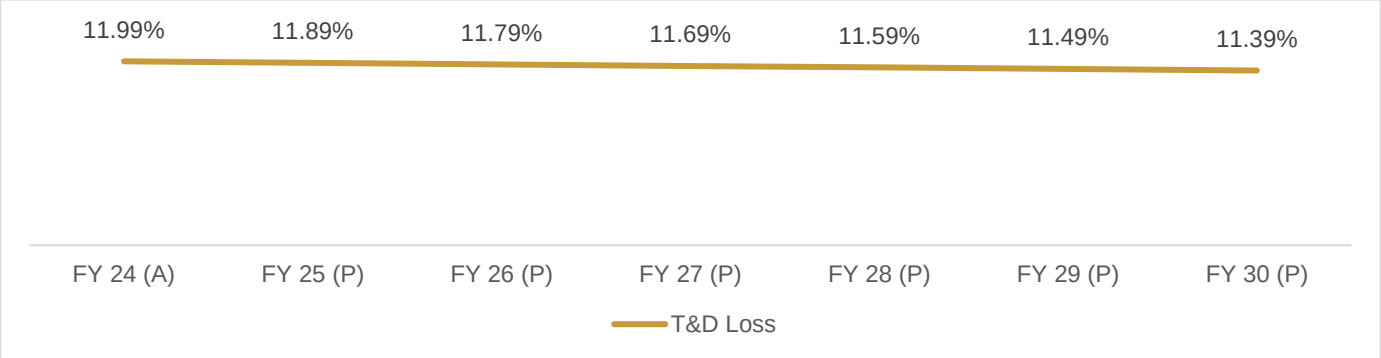
Source: CRISIL MI&A Analysis

Rooftop solar and energy efficiency are some of the key constraints which may affect the demand from Discoms. State government is actively supporting solar rooftop by providing subsidies. As a result, FY 2024 saw significant capacity growth in solar rooftop (~100 MW). Moreover, Perform Achieve and Trade (PAT) scheme, supply of LED bulbs to domestic consumers, strong government push on use of LED etc. have achieved significant energy efficiency.

4.9.1.3 T&D Losses

T&D losses for Telangana Discoms have been reduced significantly. Going forward, investments in network augmentation to drive further reduction in losses. Considering the existing levels, T&D loss reduction beyond 10% is expected to be challenging owing to difficult geographical area coupled with expansion into rural households and agriculture segment. A draft DPR for Smart Prepaid Metering for all existing consumers (excluding Agriculture Consumers) and system Metering under RDSS has been prepared for an amount of Rs.93 billion which is to be approved by Distribution Reforms Committee (DRC) and also by the Telangana State Cabinet in order to obtain final approval by MoP, GoI. PFC and REC have also sanctioned a loan of Rs. 125.7 billion to Telangana discoms under RDSS.

Figure 107: T&D Losses in Telangana



Note: FY 24 and FY 25 approved by TSERC
Source: TGDiscoms, TSERC, CRISIL MI&A Consulting

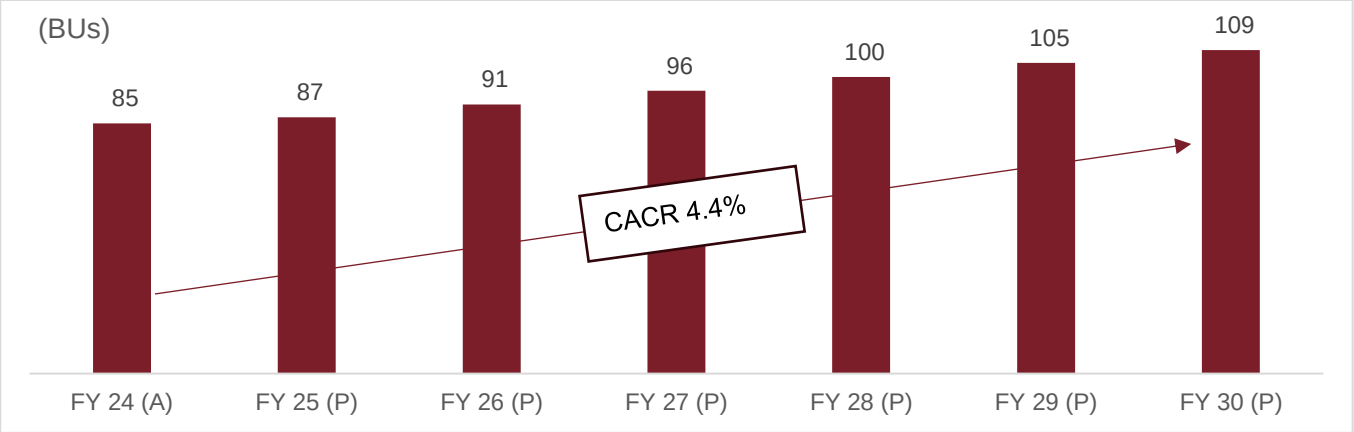
4.9.1.4 Energy requirement

The five-year CAGR for energy consumption in Telangana was 4.9% (FY24 over FY19). The Industrial category experienced a growth of 7.1% whereas the domestic category witnessed a growth of 6.4%. The commercial and agriculture category grown by 4.6% and 3.2% respectively over the said period.

Further, the correlation between GSDP and electricity consumption for domestic category is more than 90%, Industrial 77%, Agriculture 90%, commercial 65% and others 60%. Considering this, the appropriate weights for CAGR and GSDP have been established and accordingly the constrained energy sales have been estimated.

Furthermore, using the demand drivers and constraints, the un-constrained sales for the Telangana Discoms have been estimated which is then grossed up to arrive at the ex-bus energy requirement in Telangana as summarized in following chart. Overall energy requirement (ex-bus bar) of Telangana is expected to reach ~109 BUs by FY 30 driven by residential, industrial and agricultural consumption at a CGAR of 4.4% (FY 30 over FY24)

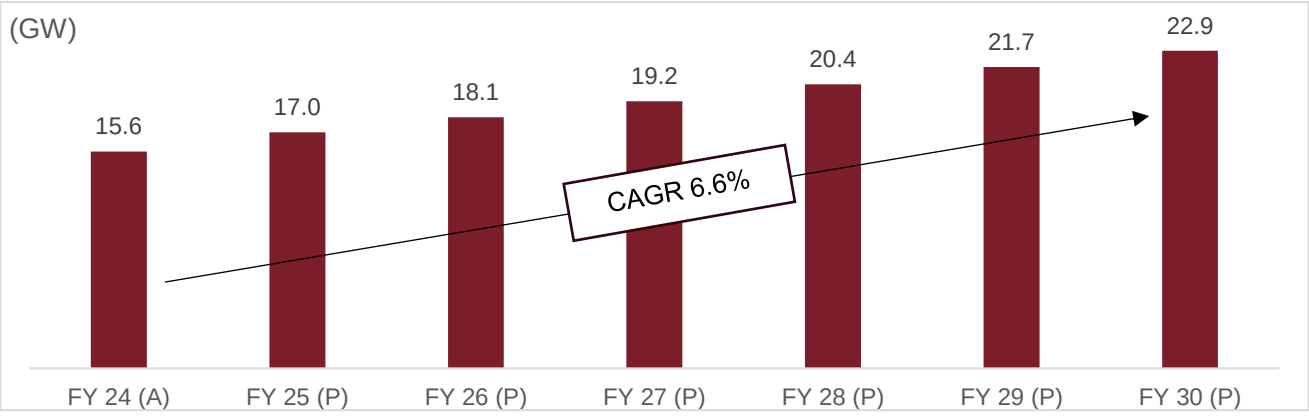
Figure 108: Total energy requirement for Telangana is expected to growth at a CAGR of 4.4%



Note: FY 24 approved by TSERC
Source: TSERC, CRISIL MI&A Consulting

Using the Load factor, the ex-bus energy requirement is grossed up to arrive at the peak requirement. Peak demand (ex-bus bar) of the state is expected to reach ~23 GW by FY30, an increase of ~7 GW over FY 24. Demand side management majors by discoms to flatten the load curve, installation of off-grid solar across consumer categories, use of energy efficient appliances is some of the factors which are expected to restrain the peak demand.

Figure 109: Peak demand projections for Telangana



Note: FY 24 CEA (Actual)
Source: CEA, CRISIL MI&A Consulting

4.9.2 Supply Projections

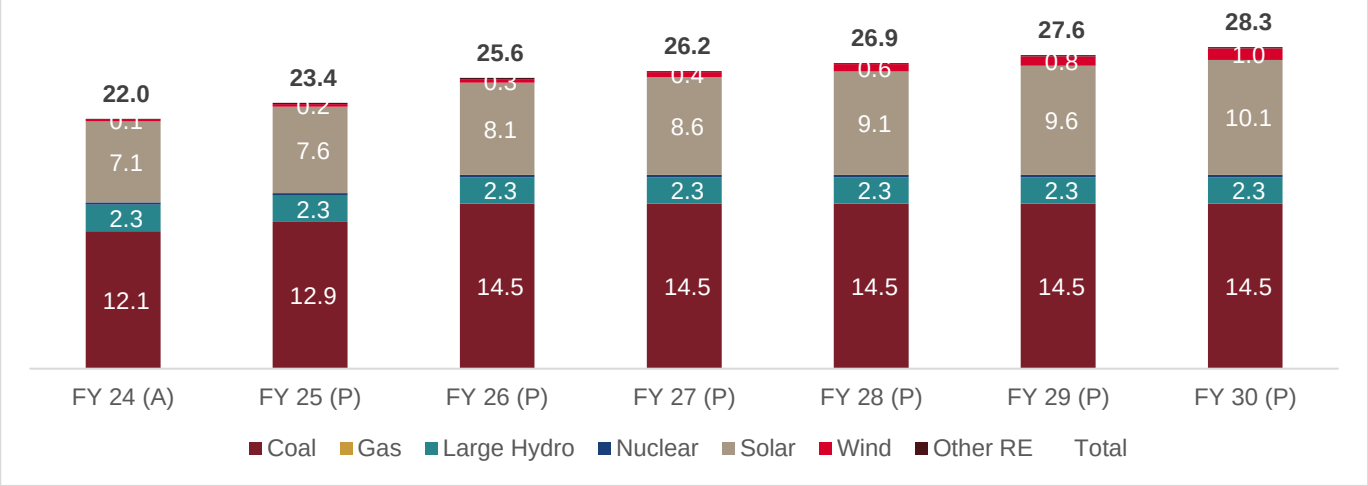
4.9.2.1 Supply forecast

Telangana has witnessed an increase in capacity additions by the private sector (~5.3 GW) over the last 9 years, especially from renewable energy sources. The state share in overall installed base is ~9 GW, which consists of coal and hydro based capacity. The state draws ~3 GW power from central allocations which includes ~0.8 GW gas power and ~0.2 GW of Nuclear power.

Coal based additions are expected to slow down due to the focus on clean energy. Further, increasing fuel costs and reducing cost competitiveness with renewable energy to deter coal-based additions over the long-term. Around 2.4 GW coal-based capacity is expected to get commissioned. Medium term contract from CSPDCL is expected to get closed and remaining 3 units of Yadadri TPS is expected to get commissioned in next 1-2 years. Hydro and gas capacity projects are likely to benefit from rising RE penetration for balancing purposes; but overall share to remain low.

Both solar and wind are likely to dominate capacity due to govt. thrust, incentives, technological advancements and ~3.3 GW expected to be added by 2030.

Figure 110: Projected installed capacity incl. share from central projects for Telangana (GW)



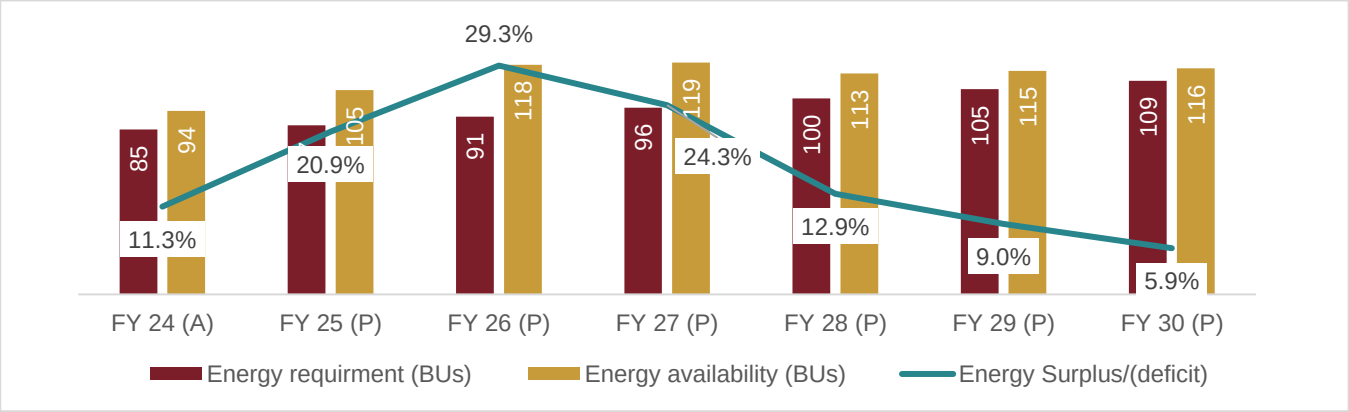
Note: FY 2A based on approved power purchase and share from central stations
Source: TGDiscoms, TSERC, CRISIL MI&A Consulting

Energy availability is likely to grow at a CAGR of ~3.5% between FY24 to FY30 driven by ~6 GW additions over same period. Despite the reduction in share, thermal energy will continue to dominate the fuel mix. Additions in renewable space will drive the share of RE in total supply to ~17% in FY30 as against ~12% in FY24. RE capacity addition will be driven by RPO targets as well as Government thrust on achieving the sustainability goals incl. CoP commitments. The share of energy through nuclear power plants likely to be ~1% and that of hydro power plants ~5%.

4.9.3 Demand Supply and surplus/deficit scenario

Discoms need additional capacity in order to maintain system reliability in the event of grid disturbances such as line faults, transformer failures, planned and un-planned outages of generating stations, maintenance shut down, accidents, equipment failures, etc. As per the power supply position, the State is expected to have surplus energy. However, the surplus is expected to decline to ~6% from the current ~11%. Avenues for generating additional revenue from the sale of surplus power need to explore such as trading and PPAs with other Agencies. Various rebates given to consumers would encourage them to utilise some of the surplus power.

Figure 111: Slowdown in conventional capacity additions to shrink surplus for Telangana



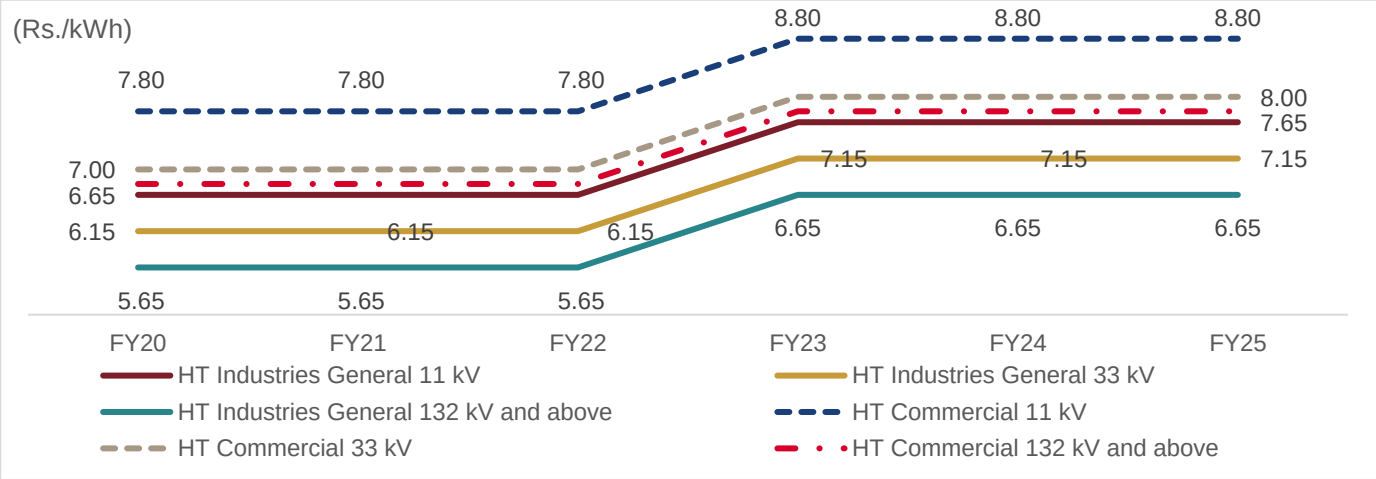
Note: FY 24 based on power purchase approved by TSERC
Source: TSPERC, CRISIL MI&A Consulting

4.9.4 Category wise tariff projections

4.9.4.1 Historical variable charges for C&I consumers

The following chart summarises the approved variable charges for commercial and industrial category consumers in Telangana.

Figure 112: Historical variable charges for commercial and industrial consumers-Telangana

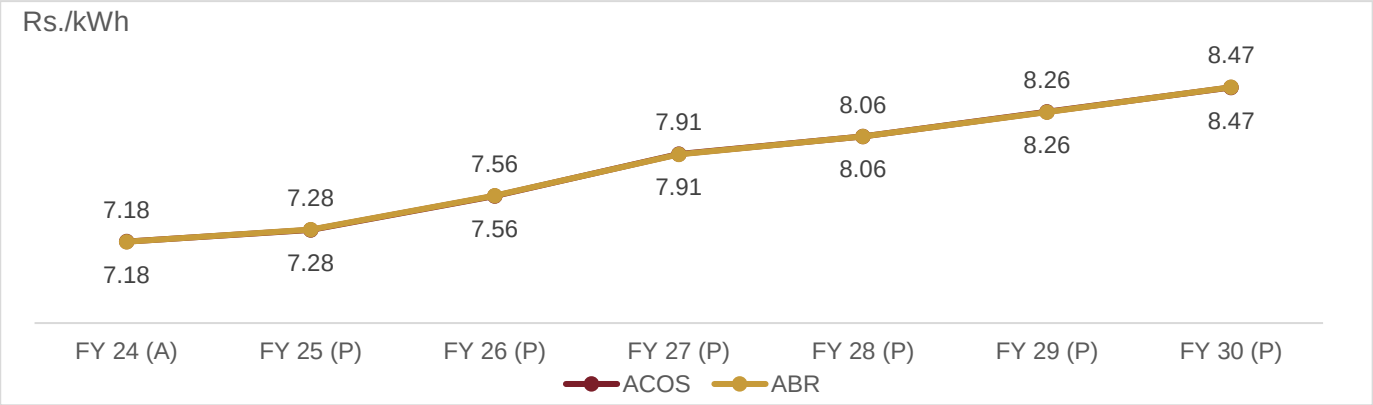


Source: TSERC; CRISIL MI&A Consulting

4.9.4.2 ABR and ACS Trajectory

Considering the increase in power purchase cost and other expenses, regular tariff hikes would be required to bridge the gap. It is pertinent to note that the state has been getting tariffs revisions through annual tariff orders by TSERC except for 1-2 years. Additionally, the State government has been providing tariff subsidies to domestic and agriculture consumers to bridge the revenue gap and provide free power to agriculture consumers. Further, the Power Ministry has urged the banks to be more cautious while issuing loans to State discoms having regulatory assets. Also, to achieve the targets of schemes like RDSS and get financial assistance from the Central Government, the State is expected to go for annual tariff revisions. ACOS is expected to increase at CAGR of ~3.1% during the period of 6 years, with power purchase cost to contribute mostly for such increase. ABR is expected to increase at same pace ~3.1% CAGR between FY 25 and FY 30, resulting in bridging the ABR-ACOS gap.

Figure 113: ACOS-ABR Gap for Telangana (Rs./kWh)

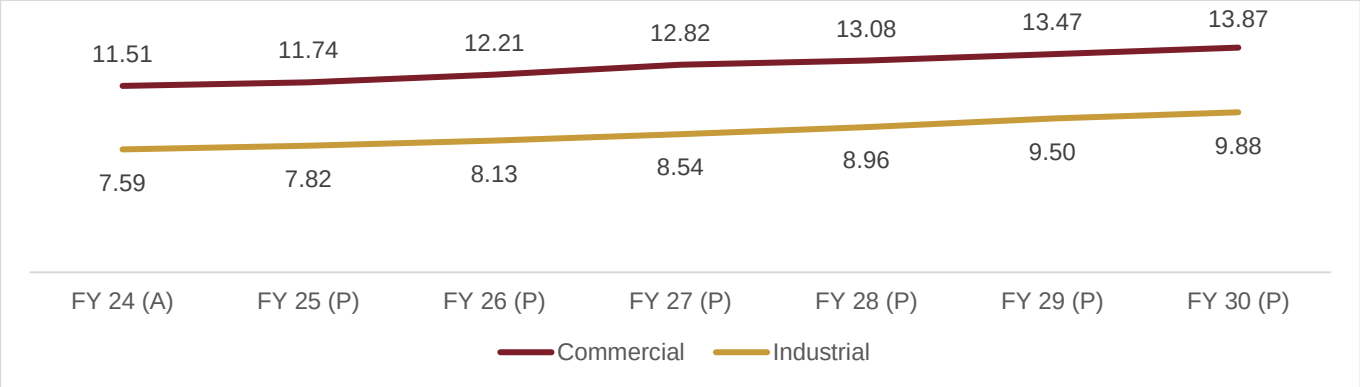


Note: FY 24 approved by TSERC
Source: TSERC, CRISIL MI&A Consulting

4.9.4.3 ABR projections for Commercial and Industrial category

Commercial and Industrial ABRs to rise at moderate pace (3.4% and 4.8% respectively) as state is expected to further stabilise cross-subsidization to balance tariff subsidy burden on account of continued free power to agriculture consumers and lower tariffs for domestic categories.

Figure 114: Commercial and Industrial category ABR for Telangana (Rs./kWh)



Note: FY24 Approved by MPERC
Source: MPERC, CRISIL MI&A Consulting

4.9.5 Open access charges

Considering the wheeling ARR and losses approved by TSERC for wheeling business and the power quantum to be wheeled, the wheeling charges are estimated for 33 kV voltage.

AS per TSERC tariff Order for fiscal 20024, the CSS is computed as minimum of 20% of ABR of the category and NTP formula. Accordingly, the applicable CSS is computed considering the ABR and NTP Formula. The wheeling losses are expected to remain at around 6% for 33 kV consumers.

Table 23: Summary of key parameters in Telangana

Particulars	Units	FY 25 (P)	FY 26 (P)	FY 27 (P)	FY 28 (P)	FY 29 (P)	FY 30 (P)
Peak demand	GW	17.0	18.1	19.2	20.4	21.7	22.9
Overall demand	BU	76	80	84	89	93	97

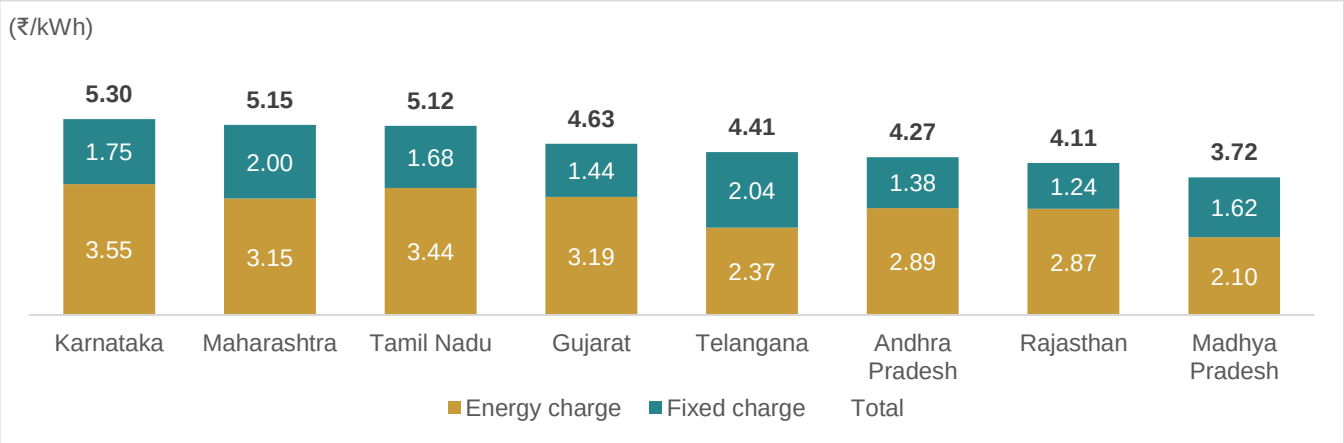
Particulars	Units	FY 25 (P)	FY 26 (P)	FY 27 (P)	FY 28 (P)	FY 29 (P)	FY 30 (P)
Energy requirement	BU	87	91	96	100	105	109
% energy consumed by C&I users	%	36%	36%	36%	36%	36%	36%
Renewable energy as a % of total energy (incl large hydro)	%	18%	17%	18%	20%	20%	21%
Open access charges							
Wheeling charges	Rs/kWh	0.12	0.12	0.13	0.13	0.14	0.15
Transmission Charges	Rs/kWh	0.24	0.23	0.24	0.24	0.25	0.25
CSS Industrial	Rs/kWh	1.83	1.91	2.02	2.04	2.08	2.12
CSS Commercial	Rs/kWh	2.35	2.44	2.56	2.62	2.69	2.77

Source: CRISIL MI&A Consulting

4.10 Analysis on average power purchase cost of the identified states

With large-scale capacity additions of coal-based power, several states entered into PPAs over fiscals 2010-2016 to meet power requirement and bridge the deficit. As a result, coal dominates in the power procurement mix of discoms and their average power purchase cost (APPC) mirrors the cost of coal-based power.

Figure 115: Average power purchase cost in key states for FY2024



Source: State discoms tariff orders, CRISIL MI&A Consulting

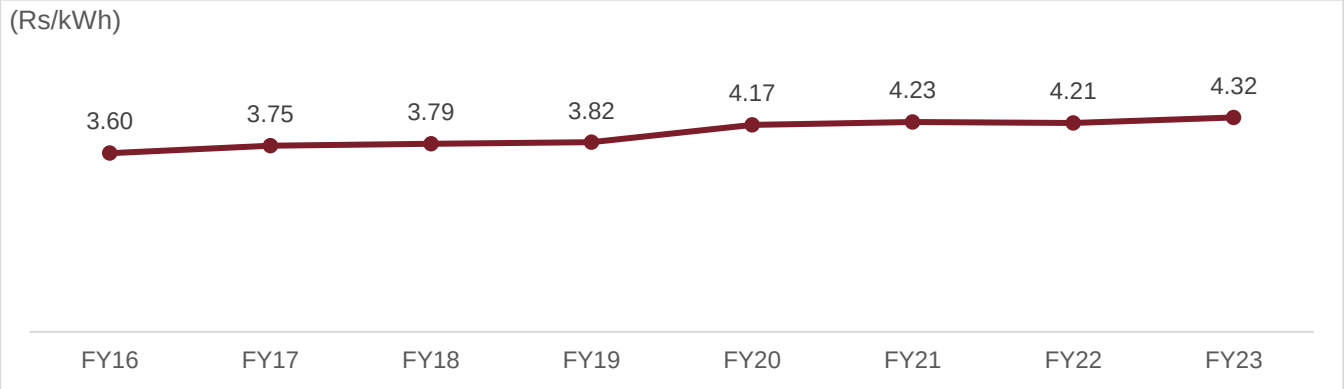
All India power purchase cost during fiscal 2023 was Rs. 5.49 per unit, a rise of 14.8% y-o-y. This rise in power purchase cost was driven by increase in imported coal volume, rise in prices of imported coal due to Russia-Ukraine war and surge in power exchange prices. The weighted average cost of procurement for solar, wind and hybrid project for FY24 is ~ Rs 3.34 per unit.

As can be observed from the chart above, the estimated APPC for fiscal 2024 as per the tariff order of major RE rich states varies between Rs 3.7 – 5.3 per unit. Variable cost is higher in case of plants located in South India such as Karnataka, Tamil Nadu, due to the distance from East India, where key coal bearing states are located, and higher dependence on imported coal. Also, total cost of procurement for coal-based power is Rs 4.4 – 5.6 per unit, factoring in the capital intensity on a per-MW basis and maintenance requirement of plants. These coal-based tariffs are further expected to increase with adoption of stricter environmental norms.

India is expected to add 26-27 GW of coal-based projects in the next 5-7 years and would be the dominant resource in overall energy mix. Hence, any increase in the coal-based tariffs would affect the average power purchase cost to discoms. The government has targeted to curb dependence on imported coal with gradual increase in production and supply of domestic coal.

As shown in the below chart, the tariff of coal-based power plants has increased at a CAGR of 2.6% over the past eight years. Inflation rises the costs of raw materials, labour, energy, and services across the sector, which leads to increased expenses in operations, mining, transportation, and administration, resulting in narrowing of the profit margins and potentially resulting in higher prices.

Figure 116: Historical national level coal based average tariff



Source: NITI Aayog; CRISIL MI&A Consulting

This can affect consumer purchasing power resulting in slowing of economic growth. Businesses may cut investments which might affect the expansion plans.

4.11 Wind-solar hybrid (WSH) projects

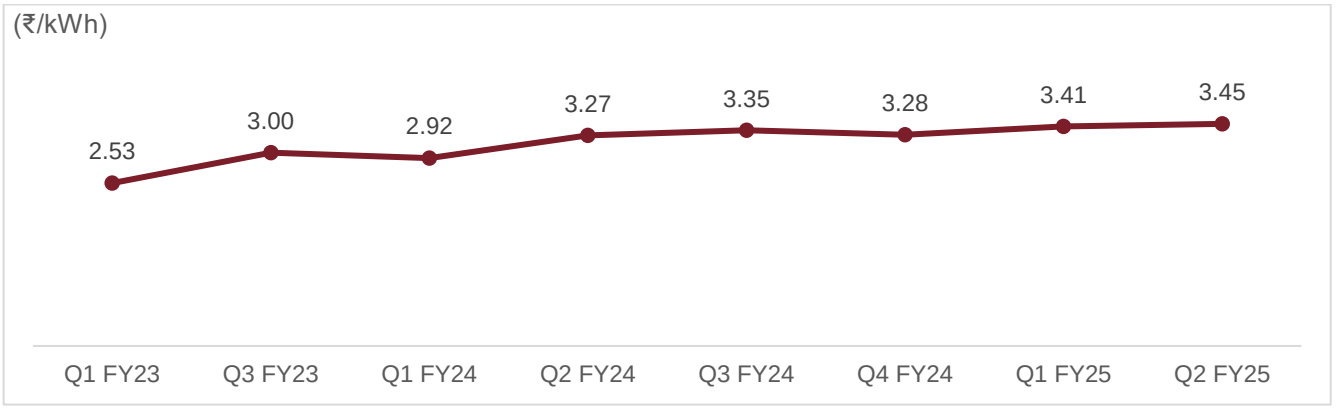
WSH projects have garnered significant interest in recent years, primarily driven by the increasing demand for reliable green power from both corporate consumers and discoms. MNRE also notified the national Wind-Solar Hybrid Policy in 2018 with an aim to reduce RE variability and improve grid stability. Additionally, various state including Gujarat, Andhra Pradesh, and Rajasthan have formulated their own WSH policies.

In August 2023, the MoP issued a tariff based competitive bidding guidelines for procurement of power from grid connected wind-solar hybrid projects. These guidelines are applicable to all upcoming wind-solar hybrid power projects of 10 MW and above capacity for intra-state transmission, and 50 MW and above for inter-state transmission, with or without energy storage. However, at least 33% of the total capacity must be from either wind or solar resources. The revised guidelines include revised bid capacity limits, revised timelines, restrictions on power procurement and penalties for delays.

Some of the key advantages of hybrid projects include improved land and transmission infrastructure utilisation, reduced generation variability and complimentary generation profiles. Standalone solar and wind projects exhibit relatively low CUF. However, the amalgamation of these two technologies leads to a higher CUF, resulting in enhanced overall efficiency of the hybrid plant. Moreover, the cost of co-located solar and wind projects is lower compared to that of their respective standalone counterparts, making them economically attractive. Consequently, tenders conducted for such hybrid projects have yielded competitive tariffs, with prices ranging from Rs 2.5 - 3.5/kWh. These factors collectively contribute to the growing allure and widespread adoption of WSH projects.

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

Figure 117: Recent trend in competitively bid out wind-solar hybrid tariff (weighted average tariffs)



Source: Central & State bidding agencies, CRISIL MI&A Consulting

Hybrid projects also pose some challenges related to land constraints especially related to wind projects since it requires adequate wind sites to meet get optimum CUF. Optimising system size is also challenging as per wind and solar resources at each site and determining the appropriate storage capacity to avoid underutilization during high generation period.

The wind and solar power markets are at a relatively early stage of development in India. The wind and solar energy industries continue to experience improved efficiency and higher electricity output. However, trends in the renewable energy industries are based only on limited data and may not be reliable.

4.12 Expected trend in tariffs of renewable energy projects over the next 5 years

i. Solar energy

Solar power prices are subject to the price of modules. Solar tariffs showed a rapid decline over fiscal 2016-2020, majorly due to declining module prices. Modules account for 57% of the cost of solar energy and these module prices are impacted by the commodities used to manufacture them. Steel is the key commodity used and accounts for a 33% share, followed by Polysilicon (28%), Aluminium (12%) and Copper (8%). Polysilicon prices had increased from ~9 USD/kg to ~38 USD/kg in Aug 2022 due to shortage of raw materials. Since June 2023, the polysilicon prices have dropped to 7-8 USD/kg.

The module prices of mono-PERC declined significantly to USD 0.13/ Wp in December 2023 due to high inventory levels coupled with subdued international demand. Falling component prices and easing supply chain pressure has resulted in falling capital costs to Rs 30-35 million per MWp.

However, from 2023 till mid-2024, the solar tariffs have increased from an average range of Rs. 2.3 – 2.4/kWh to Rs. 2.5 – 2.6/kWh despite significant decline in solar module prices. This is due to the levy of BCD and the ALMM. After the imposition of ALMM for utility-scale solar projects, developers must procure domestically produced solar modules, which are costlier than their global counterparts. Even during the abeyance period of ALMM, the cost of solar module imports was high due to 40% BCD. Currently, most parties in ALMM are Indian manufacturers. Even though prices of solar cells and modules fluctuate significantly, they are currently lower in China than in India.

Currently, the domestic manufacturers use imported cells for solar module manufacturing. The government has proposed the imposition of ALMM on solar cells from April 2026, the prices of domestic modules are expected to be even more expensive, with prices at least 30-40% higher than those using imported cells. Therefore, until sufficient domestic manufacturing capacity is established, the use of domestic modules with domestic cells could lead to a significant increase in domestic tariffs by around Rs. 0.30 - 0.75/kWh. However, with significant cell capacity addition expected by fiscal 2027-28 the domestic module prices would remain below Rs 3/kWh (between 2.7-3.0/kWh). However, global supply chain scenarios, technology advancements (introduction of TopCon, HJT cells with high

efficiency), domestic manufacturing capacity addition, infrastructure issues, land acquisition challenges, prices of commodities would be the key monitorable in the medium term.

There have been recent press reports on studies claiming that the production of polysilicon, a key component of solar modules, relies on the use of forced labour in China's Xinjiang province, which accounts for nearly 45% of global polysilicon production. The USA has banned imports from China's Xinjiang province over forced labour concerns. If such claims of use of forced labour are true and in case India imposes restrictions on the sourcing of solar equipment from China, the availability of such equipment may be adversely affected, and their prices may rise.

ii. Wind energy

Since wind prices are largely driven by commodity prices, they are expected to have an upward trajectory. Wind energy development cost is governed by Nacelle (34%) and BOS (21%). Steel is the major commodity with 31% share in overall wind energy development followed by cast iron (10%) and copper (4%). Renewable energy sources are expected to continue to be competitive compared to fossil fuels with improvement in technology, increased efficiency, and government support.

The rise in commodity prices led to a 14-20% increase in capital costs from Rs 66-67 million/MW in fiscal 2021 to Rs 74-76 million/MW from fiscal 2022 onwards. The capital cost remained stagnant in fiscal 2023 owing to further marginal rise in commodity prices, impacting project viability. However, with gradual cooling global and domestic commodity prices in fiscal 2025 is expected to fall 5-7% to Rs 65-75 million/MW. Currently the two most prevalent choices of turbines available in the market - 2 MW and 3 MW turbine with equipment and EPC. The EPC cost of a 3 MW WTG is about Rs. 75-80 million/ MW. The prices are expected to continue to stay elevated coupled with on-ground execution challenges. However, key commodity prices are expected to stabilise.

The availability of type I wind sites in suitable locations is a cause for concern. There are other sites across states that would also be suitable for wind projects; however, they may be of lower wind density (Type 2 and 3 wind sites), may not have adequate linked grid infrastructure, or may have a paucity of contiguous land parcels. But due to lower availability of Type I wind sites in preferred locations along with congested transmission infrastructure has forced developers to move to type II wind sites. To avoid lower CUF at these sites developers are opting for high hub height wind turbines. Hence going forward, due to such reasons, the wind tariffs are expected to be in the range of Rs 3.2 – 3.4/kWh to factor in the added execution challenges.

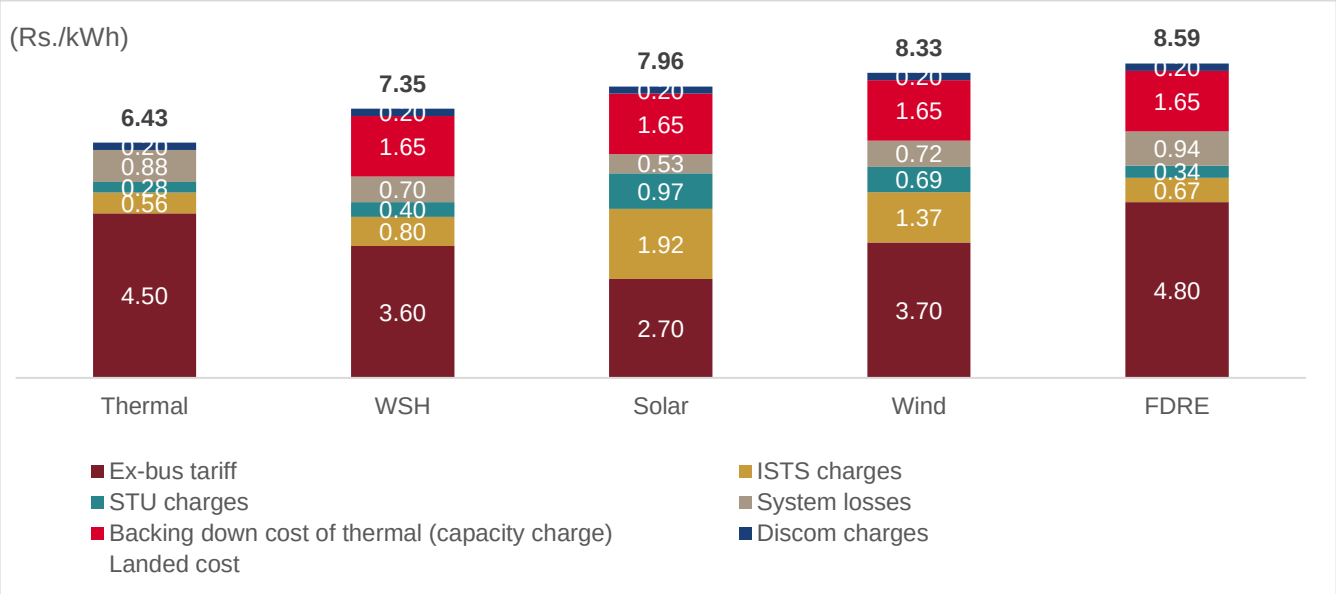
4.13 Outlook on cost of generation of multiple RE source vs cost of delivery

The tariffs for ISTS connected plain vanilla solar and wind projects were observed between Rs 2.5-2.7/ kWh and Rs 3.0 – 3.5/kWh in 2023. Whereas the tariffs for WSH projects are in the range of Rs 3.3 – 3.6/kWh. Tariffs in Rajasthan, Maharashtra, Gujarat, Tamil Nadu and Karnataka are marginally lower than in other states due to availability of resources. The average CUF of solar projects can reach 25% or higher and for wind it could go upto 35% or higher in these regions.

While the ISTS connected ex-bus RE tariff for discoms appears attractive at Rs 2.5 – 3.5/kWh but the cost delivered to the discoms' periphery is significantly higher. This is because several additional costs are incurred during transmission and distribution of RE power. These include ISTS losses, ISTS drawal charges, T&D losses, STU charges, distribution service charges.

The delivered RE cost to discom can range from Rs. 8-8.5/kWh depending upon the ex-bus tariff and other costs which can vary from state to state. Similarly, the average levelised cost of a thermal plant is in the range of Rs 4-4.5/kWh which would also end up giving the landed cost of about Rs. 6.5 – 7/kWh. Hence, for discoms, the landed cost of RE power is at par with thermal despite lower ex-bus tariff and utilisation as compared to conventional source.

Figure 118: Delivered cost to Discom from various sources



Note: The ex-bus tariff of solar, wind, WSH, FDRE are as per the recent auctions; All calculations have been done assuming 1 MWac capacity. Assumed CUF of 25% for solar and 35% for wind. For WSH, 50% capacity of each solar and wind has been assumed with a weighted average CUF of 30%, FDRE project CUF assumed as 72% and thermal PLF as 85% for CGS based plants. ISTS losses considered at 4.0%, State T&D losses considered at 15.5%, STU charges at Rs. 5,800/MW/day and ISTS charges of Rs. 0.35 Mn/MW/Month. Backing down cost of thermal (capacity charge) considered for RE projects to paid by discoms for backed down capacity.

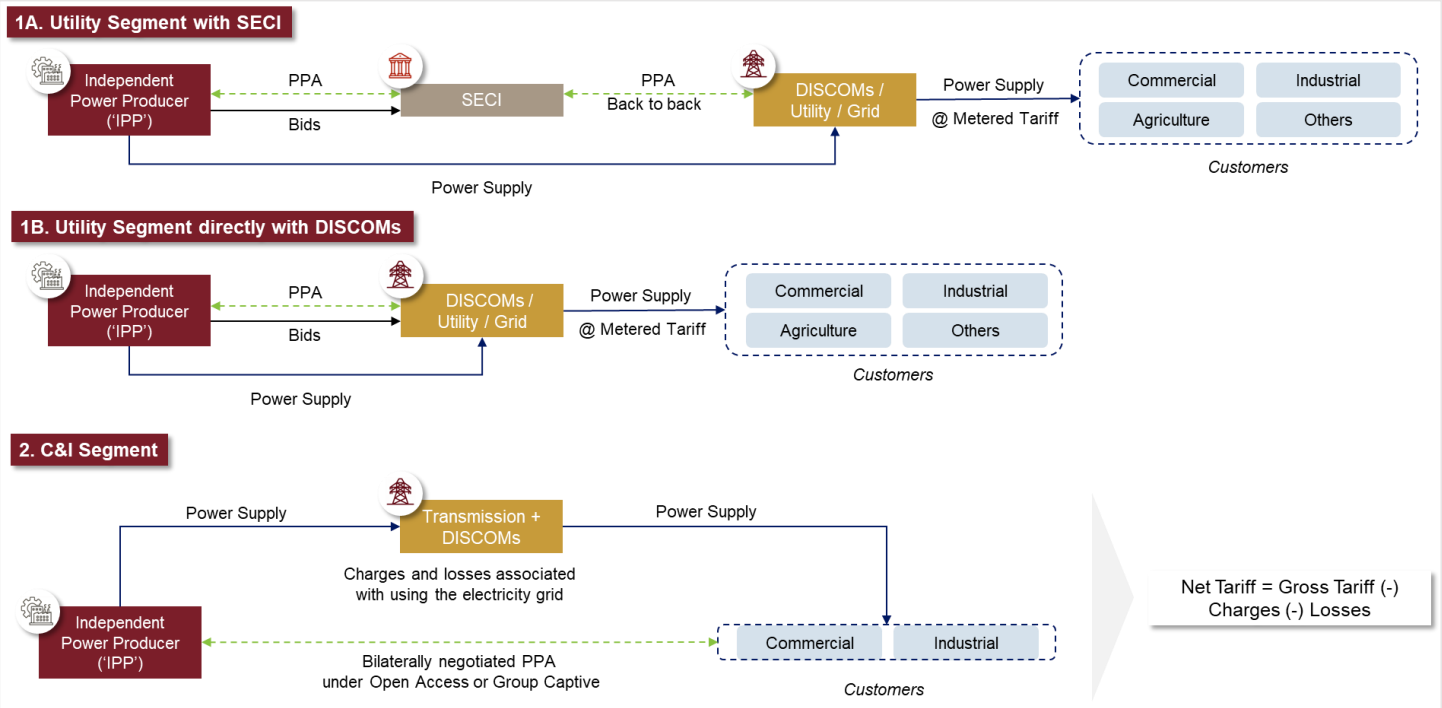
Source: CRISIL MI&A Consulting

5 Overview of open access market

5.1 Options for sale of power

RE generators have several options to supply power to the grid or to the C&I consumers through open access. These options provide generators in India with a range of choices to supply power to the grid or directly to consumers, enabling them to monetize their generation capacity and contribute to a more efficient and sustainable energy market.

Figure 119: Options for power sale



Source: Industry, CRISIL MI&A Consulting

However, supply to C&I consumers through open access segment has distinct advantages over the utility segment as summarised below:

Figure 120: Advantages of C&I segment over the Utility segment

	C&I segment	Utility segment
Electricity consumer	• Electricity sale to C&I consumers under open access or group captive route with tariffs linked to industrial tariffs	• Power supply to state distribution utilities / SECI structured on a fixed tariff with a term of 13 to 25 years
Headroom for growth	• Commercially driven and planned, not dependent on government auction targets	• Growth is dependent on auction wins
Technology	• C&I can optimally utilize excess battery combined with WSH projects to provide firm supply and additional capacity	• Capacity is fixed based on long term Power Purchase Agreements (“PPA”)
Pricing power	• Dependent on discom’s industrial tariff with the option to pass 50% to 100% of the variation depending on type of contract	• Bid based fixed tariff
Customer diversification	• Contract with multiple and diverse set of offtakers	• Contract with a single offtaker for each project
PPA terms	• C&I players have an option to not lock in tariffs or shorter lock in periods of 3 to 5 years	• Bid based PPA’s lock tariffs for long term (mostly for 25 years)

Source: Industry, CRISIL MI&A Consulting

5.2 Current status of RE based open access sale

During FY23, the total C&I consumption in the country was 712 billion units, of which about 84% is industrial consumption and the rest is commercial consumption. The total C&I sales contribute over 49% of India’s electricity consumption. However, over 30% of the total consumption is met through captive power plants. As of fiscal 2023 the total installed capacity of captive based power plants was over 78 GW which has generated 212 billion units. Of this, about 9.0 billion units were produced by RE based power plants. The majority of captive power plants are coal-based plants which contributes about 60% of the total captive based installed capacity. The share of RE capacity is about 7.2 GW which translates into 9% of the total captive based installed capacity. The total open access sale is estimated to be about 230 BU for fiscal 2023.

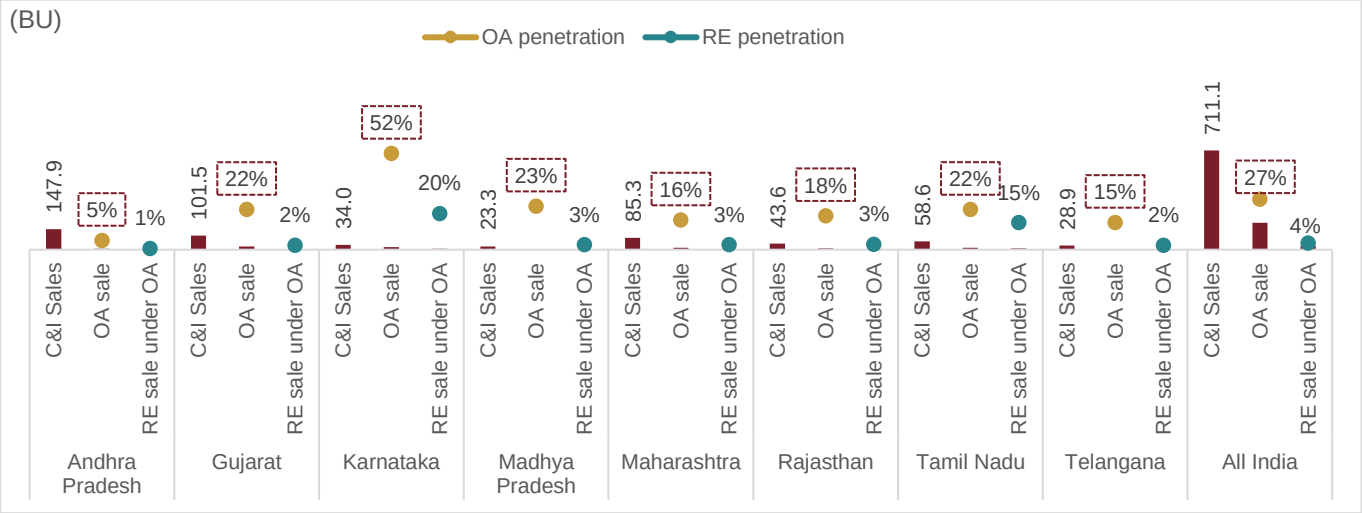
Post fiscal 2017, there has been a notable shift in consumer behavior towards adopting RE based projects for captive consumption due to several factors such as RPO compliance, the escalating cost of conventional fuels, the decreasing trend of RE tariffs, and the attractive incentives offered under open access regulations in some of the states. The share of coal-based capacity has reduced by around 4.8 GW from 51.5 GW to 46.8 GW between fiscal 2020 and 2023. This trend indicates a growing recognition of the benefits and advantages associated with RE sources, as industries increasingly embrace sustainable practices and capitalize on the economic and environmental benefits of RE generation for their own consumption. There is still a significant portion of gas and diesel based captive plants of about 24 GW which could be replaced by RE projects in the medium term.

RE project installations under open access are independent of government tenders and targets. These projects allow C&I consumers to directly approach IPPs to procure RE enabling them to negotiate contracts, ensuring a more flexible and tailored approach to meet their energy needs.

The below graph shows the total C&I consumption at India level and for key states during fiscal 2023. It is evident from the graph that about 27% has been met through open access/captive projects and about 4% of the total C&I

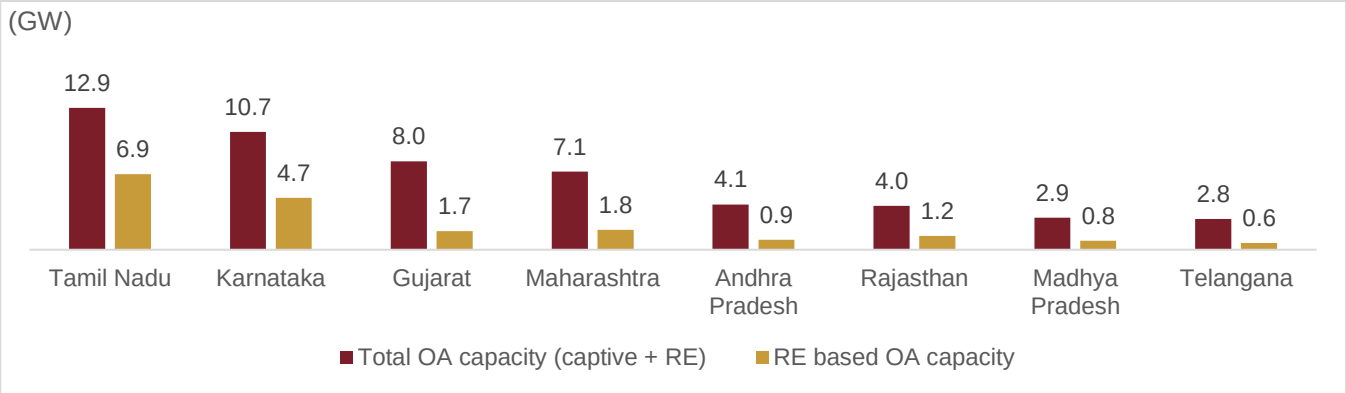
consumption has been met through RE based OA projects. Karnataka and Tamil Nadu are the leading states with over 15% of the C&I demand being met through RE open access projects.

Figure 121: Open access/captive sales in key states for FY23 (penetration as % of total C&I sales)



Source: CEA, CRISIL MI&A Consulting

Figure 122: Open access based installed capacity by Industries as of FY23 in key states

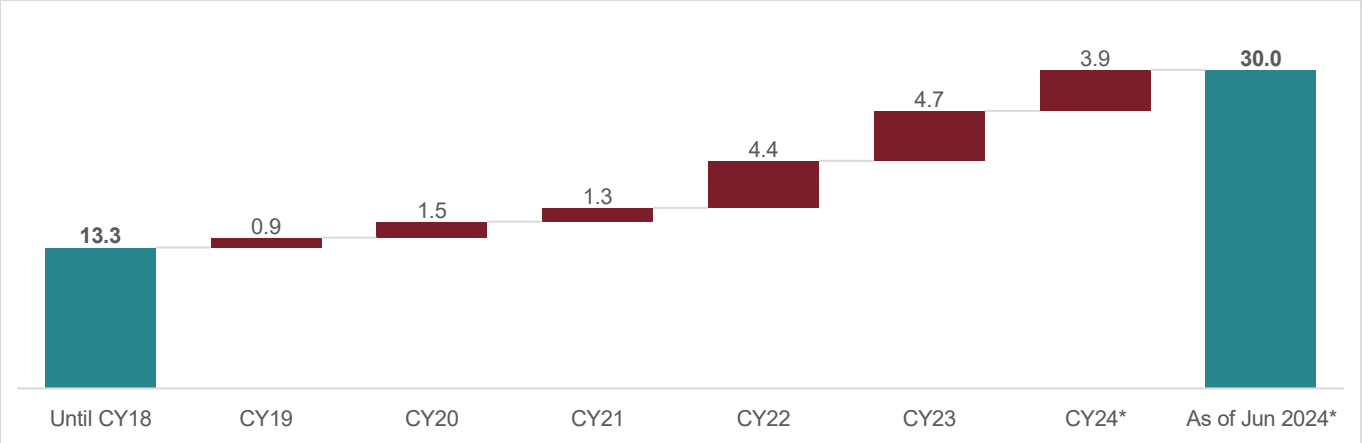


Source: CEA, CRISIL MI&A Consulting

5.3 RE based open access capacity addition in the C&I space

The cumulative open access renewable C&I capacity including solar rooftop installation is ~30 GW as of June 2024, of which utility scale solar and wind OA project accounts for ~27 GW. The remaining 3 GW is from rooftop solar. Among the renewable sources, solar holds the majority share at ~64% (including rooftop solar). This dominance is attributed to its advantages, such as higher accessibility, wider availability of resources, shorter project gestation periods, and reduced construction and operational risks.

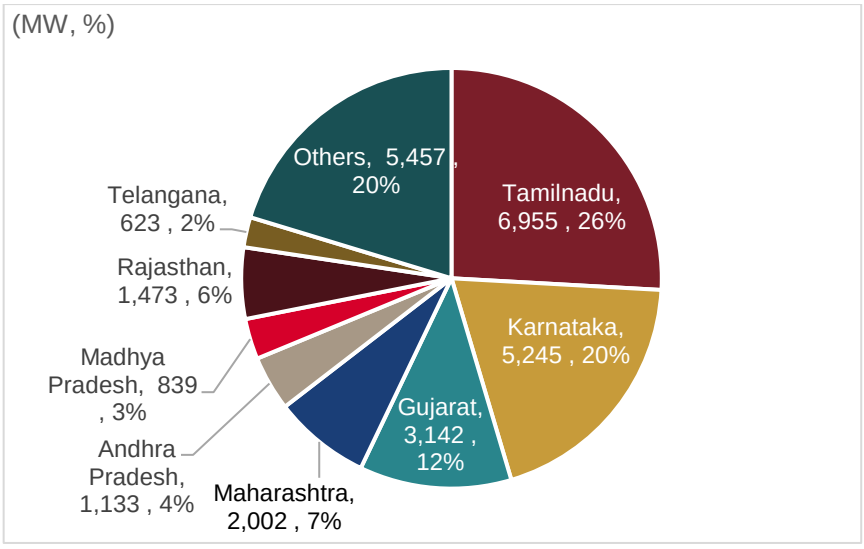
Figure 123: Historical open access RE capacity addition in C&I space (in GW)



**2024 data as of June 2024; Source: CRISIL MI&A Consulting*

A significant portion of this capacity is concentrated in a few states such as Maharashtra, Tamil Nadu, Gujarat, and Karnataka, which together contribute about 65% of the total C&I RE open access capacity. These states are recognized for their high industrialization levels and, consequently, account for a larger proportion of C&I power consumption compared to other states.

Figure 124: Share of RE open access capacity across states as of June 2024



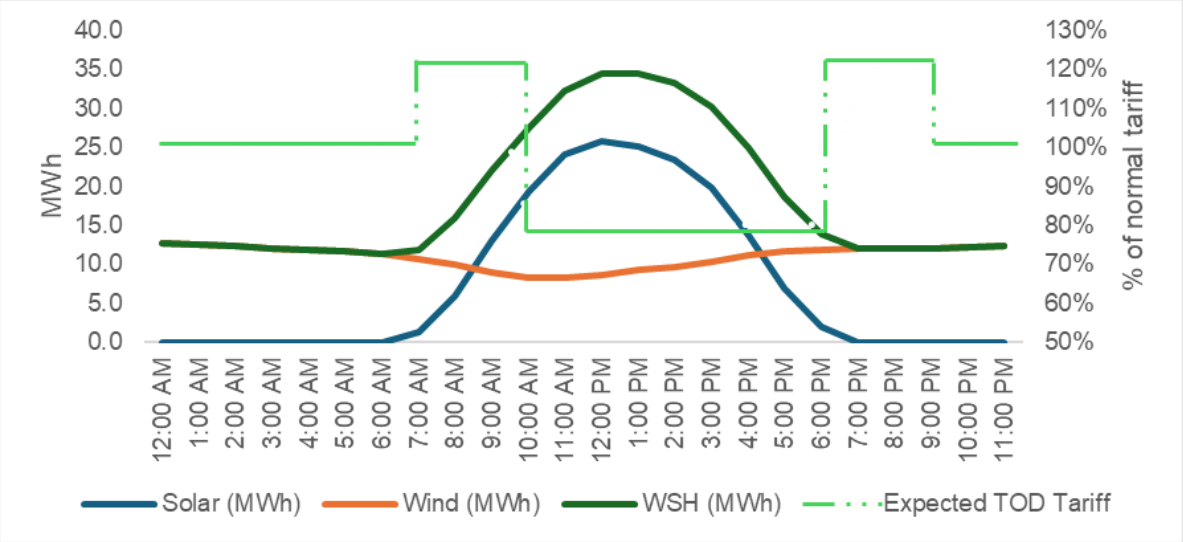
Source: CRISIL MI&A Consulting

The C&I consumers are exhibiting a growing preference for transitioning wind-solar hybrid and RTC energy sources. This inclination is primarily driven by the advantages of wind power supplying energy during peak hours and diversified output profile of different sources helping corporates in achieving higher renewable penetration. Furthermore, with the recent introduction of Electricity Amendment Rule, 2023 wherein the ToD tariff regime has been specified and a specific provision has been made to set the tariffs for solar hours at 20% lower than the normal tariffs. As a result, C&I consumers may be reluctant in procuring standalone solar power at higher tariffs, as they would realize comparatively lesser revenue during the solar hours due to the lower tariffs imposed for solar energy consumption. Moreover, a noticeable trend is emerging as more states are shifting away from annual banking mechanisms towards monthly banking arrangements. In light of this, consumers are increasingly opting for the adoption of hybrid solutions, which offer distributed energy generation capabilities throughout the day.

5.4 Generation profile of solar and wind project

Solar energy is limited to daylight hours, with peak production during midday (between 10 am to 2 pm). Wind energy is more variable but can be generated throughout the day, with potential peaks during nighttime and early morning hours depending on local wind patterns. On the other hand wind-solar hybrid project benefit from the complementary nature of solar and wind generation, providing a more stable and predictable energy supply throughout the day. The combination of both the RE sources increases the overall CUF, making hybrid project's ability to produce electricity at both high solar and wind periods, along with more consistent output makes it valuable for balancing supply and demand in the grid.

Figure 125: TOD tariff movement with respect to solar and generation profile



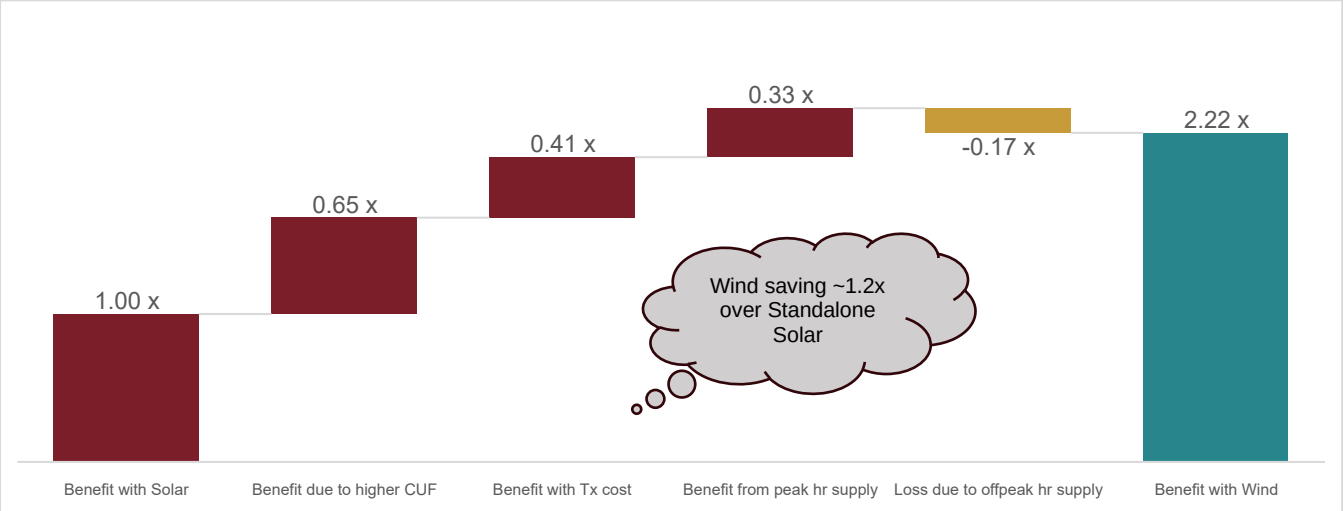
Source: CRISIL MI&A Consulting

Solar energy peaks during midday (between 10 am to 2 pm). This period coincides with higher electricity demand, resulting in higher utility tariff for C&I consumers during peak hours. Similarly, in the evening the peak demand starts from 6pm to 10 pm when the wind energy generation starts to peak. The C&I consumers can benefit from combination of solar and wind component that can supply power during these hours of the day, avoiding high cost associated with discom tariffs.

The WSH project per MW offers higher generation to customer vis-à-vis standalone solar and wind projects leading to higher savings for consumers. It leverages the strength of both wind and solar, ensures more consistent power supply. It has a higher CUF as compared to standalone projects. This means the energy generation assets are used more efficiently, lowering the cost per unit of energy. If both the projects are co-located it can optimise land use and reduce environmental footprint.

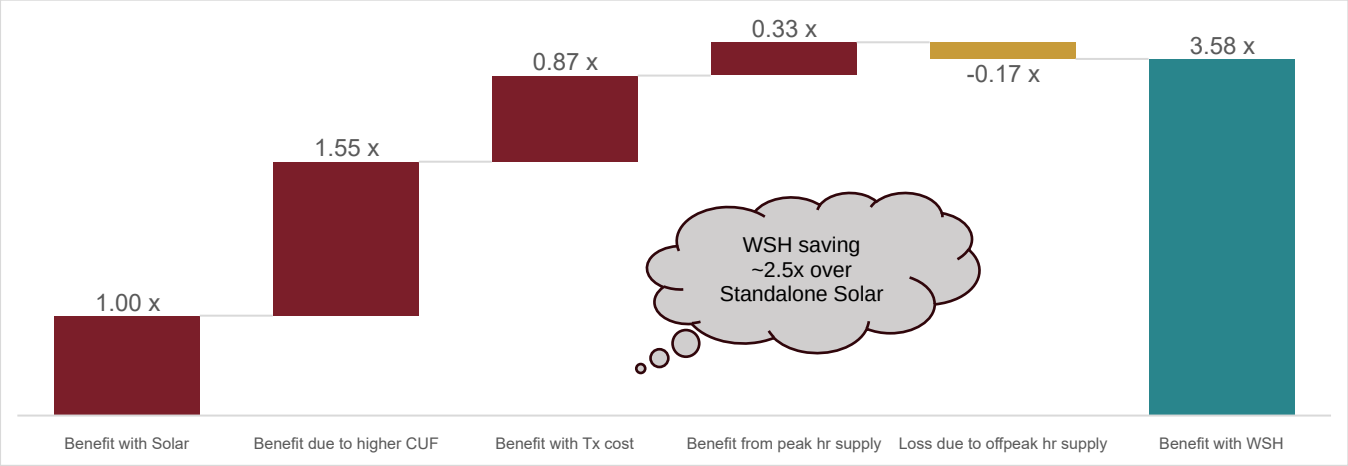
In a WSH or a wind project, higher consumer saving can be realised as compared to standalone solar projects due to factors such as higher generation, reduced transmission charges. Additionally, hybrid project can generate more power during peak hours when electricity prices are higher. Combining all these factors, this significantly increases the consumer savings.

Figure 126: Consumer savings from wind project compared to standalone solar project



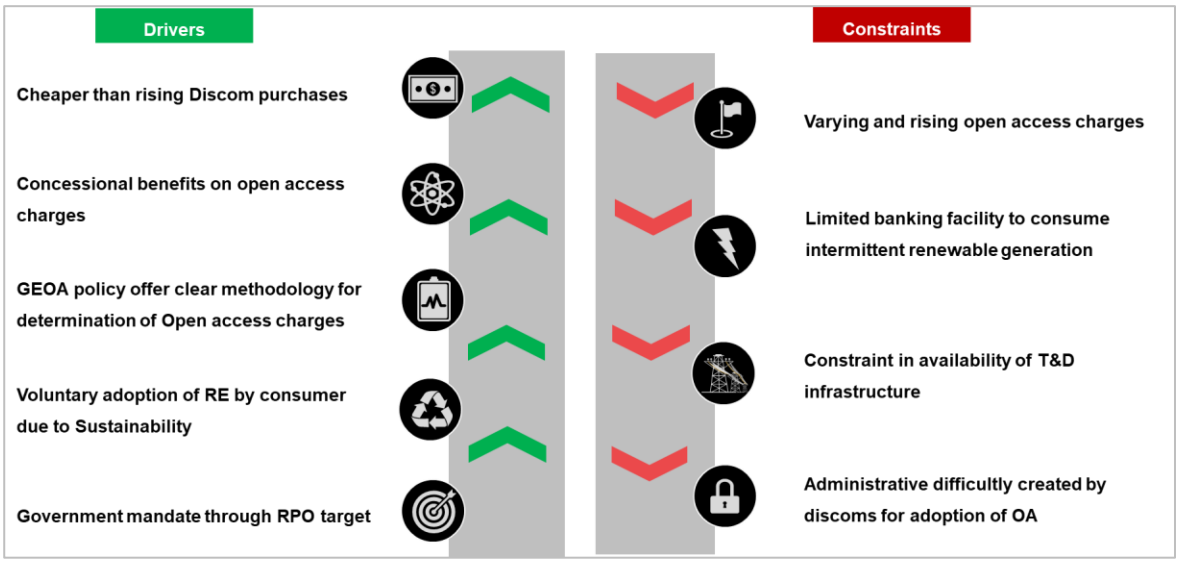
Source: CRISIL MI&A Consulting

Figure 127: Consumer savings from WSH project compared to standalone solar project



Source: CRISIL MI&A Consulting

5.5 Drivers and constraints for open access market

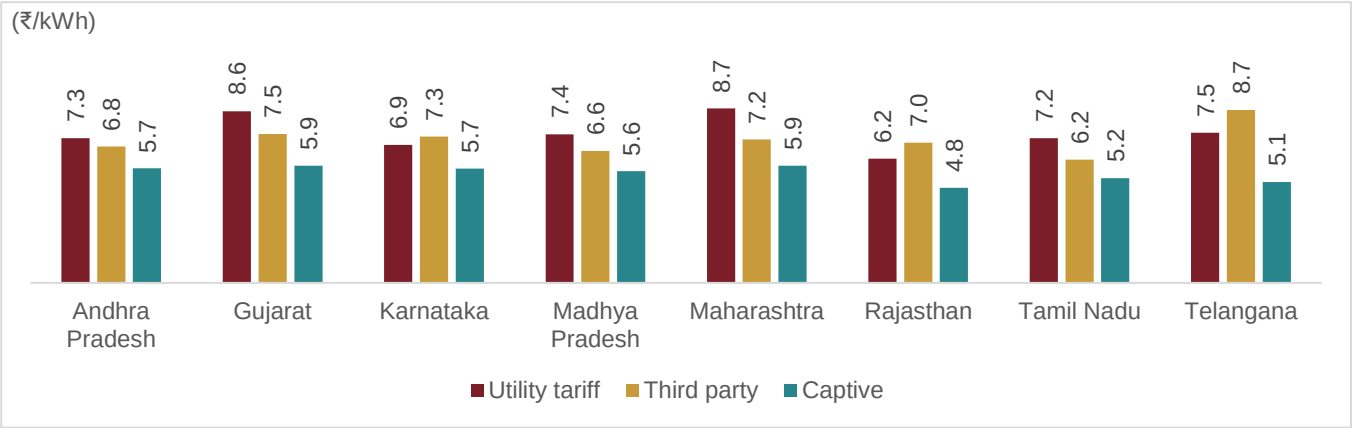


Source: CRISIL MI&A Consulting

5.5.1 Landed cost of RE open access vs grid tariff in identified states

The utility tariff for C&I consumers is significantly higher than other consumer categories and this trend is expected to continue in future. On the other hand, the landed RE tariff, which accounts for the levelized cost of RE projects and other open access charges to the consumers, has become increasingly competitive due to advancements in technology, higher CUF, lower cost of finance and supportive government policies and regulations for open access consumers. As demonstrated in the chart below, assuming a levelized tariff of Rs. 3.5/kWh for key states, the difference becomes evident, offering businesses a compelling incentive to opt for sustainable and cost-effective RE solutions. In fact, it can be inferred from the below chart that the open access tariffs are still more competitive than variable utility tariffs even after removal/reduction of incentives for open access charges in majority of the states.

Figure 128: Utility vs open access landed tariff for Industrial consumer for FY2024



Note: Base tariff of Rs 3.5/kWh is considered for industrial consumer connected with Discom at 33 kV. The open access charges are as per Tariff Orders for FY2024. The landed tariff includes prevailing exemptions/concessions applicable for OA charges.

Source: SERC Tariff Orders, CRISIL MI&A Consulting

Considering the various charges recovered from third party open access consumers, discoms certainly benefit for providing open access versus continuing supply to C&I consumers. Discoms are not required to pay transmission costs for units not supplied. The concerned open access consumer/developer as the case may be pays the

transmission charges to Transco for consumed units. Discoms recover CSS and ASC for loss of cross subsidy and stranded assets due to open access. Further, due to backing down of higher variable cost sources, Discoms save more than cheaper marginal sources. Also, being connected to the grid, the open access consumers continue to pay the fixed charges. Thus, there is net gain to Discoms in case of third party RE open access.

5.5.2 Voluntary adoption of RE gaining rapid traction by corporates to meet sustainability goals

Several large electricity-intensive industries exist in sectors such as steel, cement, chemicals, textiles, automobile, glass and other industrial products. While several large corporations – utilising open access power or captive generation from conventional fuels – are mandated to meet RPO targets, their voluntary compliance is gradually rising.

On a broader scale, one of the main drivers behind the increase in Indian corporate PPAs in RE is the predominant reliance on coal in the country's electricity grid, resulting in high tariffs. Moreover, RE sources are now widely accessible and affordable in India, particularly solar energy due to significant advancements. Now many corporates are entering into wind-solar hybrid with and without storage to maximise the use of RE throughout the day.

Additionally, given the growing significance of sustainability and climate consciousness, there is a focus on robust Environment, Social, and Governance (ESG) standards and forthcoming green taxonomies, which may also extend to unlisted companies.

Furthermore, GoI's decisive shift toward renewable energy, driven by ambitious climate targets set under the Paris Agreement, has led to the implementation of various green policies and regulations. These include the recent modifications to the open access and REC regime in 2022, creating an environment that encourages and incentivizes the adoption of green practices.

Procuring electricity through open access using RE not only helps reduce costs, but also cuts carbon footprint and aids in meeting sustainability goals. Several corporations are gradually setting out long-term goals for net zero carbon emissions for their own production and across their value chain, including suppliers, supply chain and distributors. In fact, the global list of RE 100 companies also features a few Indian companies.

Consequently, the number of corporate PPAs in the renewable energy sector has surged and is expected to continue with evolving policy, regulations and business models.

5.5.3 Strong investor interest to support growth in the open access market

Several developers focused on the open access market have managed to attract marquee global investors. Investor interest has not only been from a specific investor class but has been witnessed across investor categories. Global IPPs, PE funds, Impact funds as well as multi-lateral agencies – have extended financing to such developers. This clearly indicates the potential of the open access market in India.

With rising awareness about climate change, several corporates in India are voluntarily procuring RE with an objective to operate sustainably. This provides a further impetus to RE.

5.6 Review of Green open access policies in identified states

High C&I grid tariff across states and falling RE generation cost augur well for the open access business model. However, most of the states have either discontinued or reduced the exemptions/ concession on open access charges. Some states such as Gujarat and Rajasthan are providing some benefits for hybrid projects under their respective state policies to promote adoption of hybrid projects. However, the RE projects that were commissioned during the period when open access charges rebates/concessions were introduced under the open access regulations would continue to enjoy such benefits until its expiry. Any changes made to the open access charges

incentives are usually implemented prospectively and are applicable to new projects which may affect the future open access transactions. The policy benefits in some of the key states are given in Section 3.3.3 of the Report.

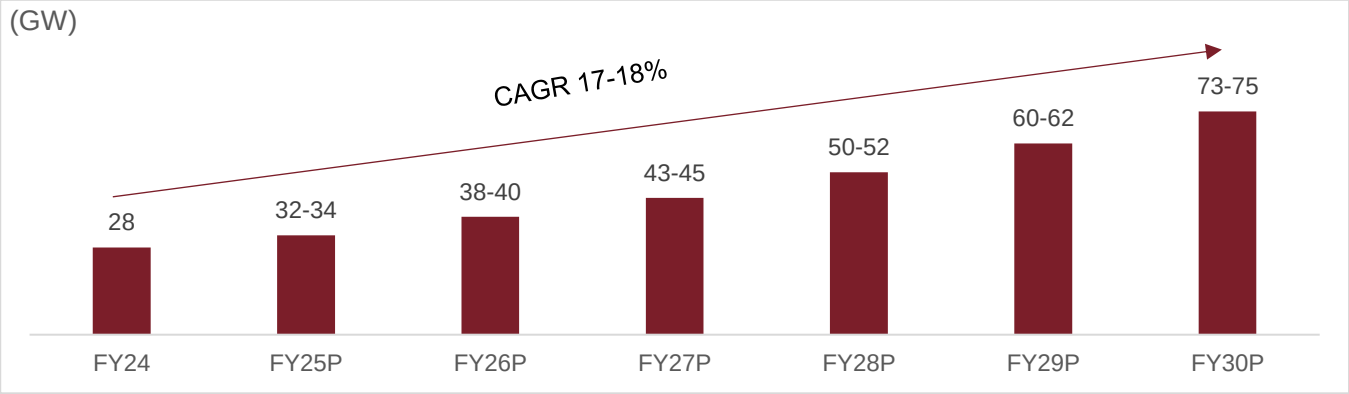
CSS and additional surcharge will not be levied in case of a captive generating plant consuming electricity for its own use. Many states either reduced or withdrew exemptions and concessions related to open access and annual banking provisions. Some of these changes may affect open access capacity additions in these states over the near term. However, these changes are expected to address concerns about uncertainty over short-term incentives and provide greater visibility for long-term cash-flow projections for open access based RE projects. In fact, it also reduces dependence of the RE based open access business model on government support and thrives on its inherent competitiveness. Moreover, there exists an arbitrage between landed cost of open access power (through the group captive model) and grid tariffs. This helps C&I consumers reduce costs and enhances competitiveness. At the same time, it also offers IPPs an opportunity to diversify their portfolio away from ailing discoms.

Further, several global IPPs and private equity, impact funds, multilateral agencies have recently invested in Indian renewable energy companies with strong focus on open access transactions in C&I segments. This clearly indicates growing interest of global players in open access in C&I market in India which is expected to grow at healthy pace over the medium term.

5.7 C&I RE capacity addition outlook

CRISIL MI&A-Consulting expects an installed capacity of about 75 GW of C&I driven RE capacity by fiscal 2030. About 45-50 GW is expected to be added between fiscal 2025-30. The capacity addition of 14-16 GW of open access capacity is expected from wind projects to deliver RTC power. About 18-20 GW from solar projects (large scale projects), 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. Further, 10-12 GW of rooftop solar projects (under the capex and opex mode) is expected to be commissioned by fiscal 2030, led by industrial and commercial consumers under net/gross metering schemes of various states. Moreover, are also expected to be commissioned for C&I projects.

Figure 129: Expected installed RE capacity outlook in C&I market



P: Projected; Source: CRISIL MI&A Consulting

5.8 Review of emerging business models for C&I players

Currently, different types of business models are being implemented by RE Project developers for open access. Different types of PPAs include:

Variable discount PPAs: As per the PPAs, the power is sold to customers at agreed PPA tariff computed by adjusting a customer benefit amount defined under the PPA from the variable tariff charged by Discoms of the

customers' area. The PPAs also have a provision for periodic change in the customer benefit linked to corresponding change in variable tariff and open access charges. For example, in case of some of the PPAs, 50% of the increase or decrease in variable tariff is passed on to the customer through a corresponding increase or decrease in customer benefit on an annual revision basis. The variable tariffs and open access charges are approved by the SERCs through periodic tariff orders.

Fixed discount PPAs: In fixed discount arrangement, the customer benefit remains the same irrespective of the change in the variable tariffs as well as open access charges. The applicable PPA tariff is determined by deducting the agreed customer benefit from the prevailing variable tariff on monthly basis.

Bus bar tariff arrangement: In case of the bus bar tariff arrangement, the PPA tariff is at the delivery point and all the open access charges are on account of the consumer.

Electricity (Amendment) Rules 2022 have capped the CSS on open access at 20% of the average cost of supply (ACOS). Most of the open access projects are priced at a discount on discom tariff for the particular consumer category. The discom tariff for the particular consumer category is linked to ACOS. Therefore, a 20 paise per unit increase in CSS would mean an increase of Rs. 1.00 per unit in discom tariff. i.e. a clear advantage of 80% for open access projects offering discount on discom tariff.

Moreover, there are different types of emerging business models emerging in the open access which are summarised below:

RTC power including storage – RE-RTC supply has gained momentum in recent years due to benefits such as reliable supply of power, optimisation of solar and wind with complimentary profile. The RE RTC can be customized for the industries depending upon their load pattern. With Reduction in cost of storage technologies, it is expected that RE-RTC will become cost competitive with other standalone renewable technologies.

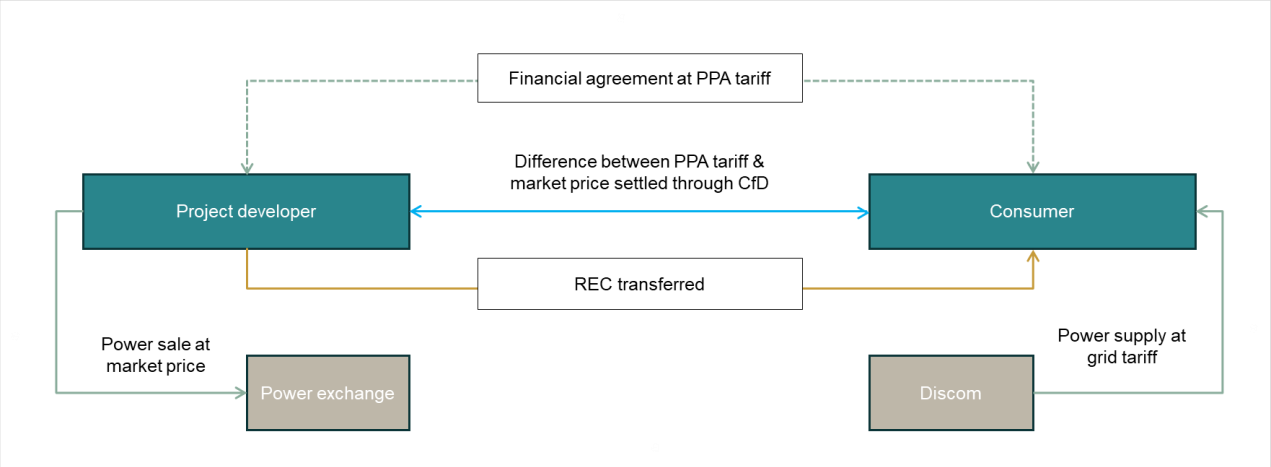
Green power trading - In a bid to help obligated entities meet RPO targets and offer an alternative to IPPs to sell green power, the CERC approved the GTAM. This was supported by stabilisation in RE technology, falling price and availability of sophisticated tools for forecasting and scheduling RE. The GTAM platform would also enable IPPs to sell 'surplus' RE and avoid any potential back-down or curtailment by discoms. Further, after the success of GTAM, the government has recently launched GDAM. These market segments will create additional sale avenues to the existing IPPs and encourage other merchant power plants to set up more RE capacity.

ISTS connected OA projects - This market is growing strongly on the back of multiple drivers including a waiver from ISTS charges coupled with streamlined transmission connectivity approval process. The route offers scale and cost benefits particularly for larger consumers and those with distributed operations across multiple states. Exemption from ISTS charges is worth savings of about Rs 1.00-1.50/ kWh. The ability to set up larger projects at a single location with lower land cost and higher radiation results in further cost savings of about Rs 0.30-0.50/ kWh over intra-state projects. While consumers must bear incremental ISTS losses of about Rs 0.15/ kWh, the ISTS route is financially attractive across all states but only for projects commissioned by June 2026 (at least 75% ISTS charge waiver).

Since notification of CERC Connectivity and General Network Access (GNA) Regulation in October 2022, there has been a surge in ISTS connectivity applications from project developers – as of October 2023, over 10 corporate-focused developers including AM Green, Serentica and Aditya Birla have applied for ISTS connectivity for total 7.8 GW renewable capacity.

Virtual Power Purchase Agreement (VPPA) - VPPAs are more flexible in their structure than physical PPAs as the corporate buyer and power producer do not have to be connected to the same electricity network. It is a contract for difference. In this mechanism, RE developers sell their power in wholesale market while transferring the green attributes of power to VPPA consumers. In return, consumer guarantees a fixed price (strike price) with positive and negative adjustments based on based on difference of open market price vs. strike price. The entire transaction is financial and would not require actual physical transfer of power from generator to consumer.

October 2021, the Supreme Court passed the order wherein CERC was granted authority over all physical delivery-based forward contracts, while the regulation of financial derivatives was entrusted to SEBI. Consequently, any VPPA will be subject to joint regulation by both CERC and SEBI. As a result, investors, power producers, and consumers could now explore the benefits of such innovative power purchase mechanisms, leading to potential advancements in the adoption of RE sources is expected to further boost demand for corporate PPAs through the open access route.



Source: CRISIL MI&A Consulting

The market is experimenting with variants of VPPAs. A variant to the typical VPPA framework includes an agreement for the RECs which will be sold directly to the consumer at a mutually agreed price and brown power will be sold on power exchange without CfD.

In September 2023, Cleantech Solar started commercial operation of its VPPA. The solar project has been registered under the International REC (I-REC) mechanism, and the renewable attributes (I-RECs) from this project are being purchased by a leading FMCG company under a virtual PPA.

Energy storage as a service - ESS is swiftly gaining prominence as one of the major components in RE projects. BESS is often coupled with solar rooftop by C&I consumers. This may provide several benefits. “Solar rooftop + BESS” systems in C&I segment are usually in behind-the-meter (BTM) configuration. During the day, whenever the solar generation is more than the required load demand, the excess energy is stored in the BESS system. With states having ToD tariff structure, BESS can be utilized such that consumer uptake energy from BESS during peak tariff hours. BESS during peak load periods will reduce the peak load, ultimately helping in reduction of energy charges.

Carbon offsets – By adopting RE, the industries can reduce their carbon footprint. Any reduction in carbon footprint can be traded by receiving carbon credits. This can be sold in the voluntary carbon market. Buyers of these credits are typically companies looking to compensate for their own emissions which they cannot reduce directly. This provides a revenue stream for C&I players.

5.9 Potential risks and challenges in open access projects

Contractual challenges:

- **Mismatch between PPA and loan tenure** – Typically the duration of long term PPA in C&I is of 10-15 years, while loan taken for the project might have a longer duration. The lenders may be hesitant to favourable loan terms if there is a significant tenor mismatch, potentially leading to higher interest rates. However, PPA tariff for supply of green power is generally at discount to Discom’s tariff selling black power. Therefore, demand for green power should always be there.

- **Contract standardisation** – The government tenders usually have a standardized PPA which is a part of RfP document. However, in open access projects, PPAs are often customized based on mutually agreed terms between the parties after negotiation, leading to variety of terms and conditions. This can lead to inconsistencies in contractual terms and when any dispute arises, the lack of standardization can complicate the resolution process.
- **Contract enforcement –** It arises from the challenges associated with ensuring that all parties adhere to the terms of the PPA. However, inconsistent contractual terms, misinterpretation of any regulatory provision or ambiguity in policies and regulation can affect the enforcement of PPAs.

Operational challenges:

- **Performance risk** – RE sources are inherently variable. Unpredictable fluctuations in wind speed and solar irradiance due to extreme weather events lead to variations in power output which can affect the forecasted revenue for the period. Moreover, any unexpected breakdowns or faults can also lead to longer downtimes and reduced power generation.
- **Grid curtailment risk –** Integrating RE project into the grid in a RE rich state can pose challenges related to congestion, forcing grid operator to curtail power to avoid overloading the network. Moreover, intermittent supply of RE can also affect grid stability. Standalone solar is more prone to grid curtailment vis-à-vis wind or WSH since all solar projects peak at the same time which is not a case with wind.

Regulatory challenges:

- **Variable open access charges –** The open access charges are variable in nature; most of the state discoms are gradually increasing their open access charges which make it less attractive for the C&I consumer. Increase in open access charges can significantly increase the cost of RE power for a buyer. However, these charges being regulated cannot be increased on an ad hoc basis. The transmission and wheeling charges have remained consistent, albeit few exception in most of the states. Cross subsidy surcharges is capped at 20% of the ACoS rate to industries and waived for group captive customers, full waiver of additional surcharge if fixed charges being paid by the consumer and not applicable for group captive customers. However, for projects offering fixed discount over discom tariff, any increase in CSS is advantageous. For a 20 paise per unit increase in CSS, an increase of Rs. 1.00 per unit in discom tariff would be required which results in a clear advantage of 80%.
- **Addition of new open access charges** - There are various new charges other than the open access charges that have been introduced by many states on open access consumers. For example, in Gujarat, the hybrid policy of 2018 applied multiple wheeling charges of Re 0.05 per kWh on hybrid projects. In Madhya Pradesh, the Harit Urja Tax has been introduced in a new renewable energy policy at the rate of Re 0.10 per kWh. Some states have introduced grid support/parallel operation charges to captive power plants.
- **Captive project status -** Captive projects are more attractive than 3rd party open access projects. Most C&I consumers are opting for captive open access and due to this Discoms are incurring revenue losses. Group captive customers need to abide by group captive guidelines as per the Electricity Act 2005 and compliance is tested at the end of the year. The Supreme Court issued a judgement on 09 Oct 2023 clarifying multiple aspects of the Electricity Rules 2005 relating to captive/group captive plants and captive users.

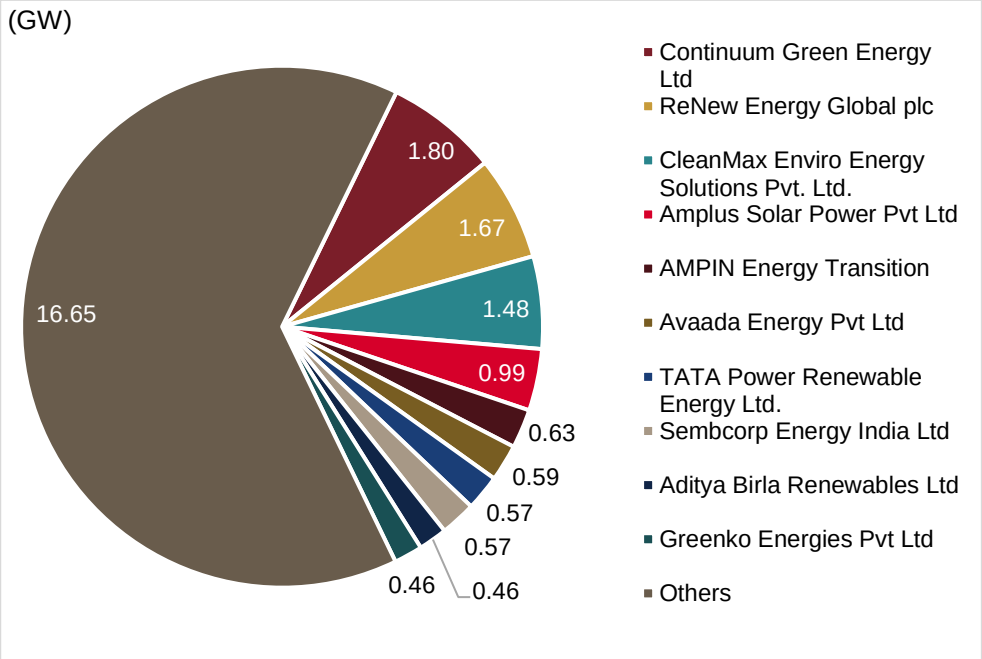
5.10 Competitive landscape

5.10.1 Leading RE IPPs in C&I space

The demand for clean energy in the C&I segments is witnessing a remarkable surge, driven by falling tariffs and an increasing focus on sustainability initiatives. In response to this burgeoning demand, IPPs are stepping up to seize the opportunity. They are keen to build open access business to diversify offtake risk away from Discoms, improve financial returns (aggressive bidding for utility scale projects) and reduce lumpiness associated with utility scale

projects (large project sizes, longer project development cycles). Hence, they are proactively tailoring their offerings to cater to the specific needs of C&I customers, providing them with custom-made RE solutions. Almost all major IPPs are looking to develop WSH projects because of strong consumer demand.

Figure 130: Share of leading project developers in C&I space as of March 2024



Source: CRISIL MI&A Consulting

Continuum Green Energy was one of the first to sell wind energy to consumers in 2012 from their 18 MW wind farm in Gujarat, and it was also one of the pioneers in establishing a large co-located WSH farm of 226.80 MW in Tamil Nadu in 2021. Continuum Energy's 199.70 MW Bothe project in Maharashtra, commissioned in 2014, was one of the largest single sites developed in-house by an IPP at that time. This was followed by the in-house development of the 170.00 MW Ratlam wind farm site in Madhya Pradesh in 2015. Many renewable energy developers who have traditionally focused on solar projects are still developing their skills in operating and managing wind energy projects. This gives Continuum Green Energy an advantage in developing WSH projects in India.

As of June 30, 2024, Continuum Green Energy had PPAs with more than 170 diversified, good credit quality C&I consumers for green energy supply, and in terms of C&I-focused capacity among renewable energy producers in India. The Company holds a significant ranking (1st as of March 2024) amongst its immediate peers. C&I consumers account for the largest share of total electricity consumption in India at 50% in fiscal 2024 and pay the highest electricity tariff.

The IPPs in the C&I RE space in India offering clean energy solutions to diverse verticals including manufacturing, aerospace & defence, automotive, FMCG, pharma, food processing, retail chains, educational institutes, hospitals & healthcare, office buildings, shopping malls, etc. Some of the major companies are as follows:

Table 24: Key players in C&I open access

Players	Brief description
AMPIN Energy Transition	Headquartered in India, have presence across key C&I consumer segment such as automobiles, FMCG, heavy industries, cement & steel, pharma & healthcare, data centres and govt. institutions. It has a portfolio of over 3.8 GW including about 1.2 GW of C&I open access capacity. It offers solar, wind, WSH, BESS and Energy Management solutions.
Amplus Solar Power Pvt Ltd	It is part of PETRONAS group, Malaysia and is headquartered in India. It offers RE solutions to C&I customers by setting up on-site and off-site solar projects. It has a portfolio of over 1.9 GW.

Players	Brief description
Avaada Energy Pvt Ltd	Headquartered in India. It has implemented C&I projects over 700 MW and are engaged with domestic and multi-national entities for open access.
CleanMax Enviro Energy Solutions Pvt. Ltd.	Headquartered in India, have presence across automotive, education, pharmaceuticals, FMCG, and IT. It has an operating portfolio of over 1.2 GW. It is backed by investors like Augment Infrastructure, a US-based fund manager, Danish Investment Fund and UK Climate Investments.
Cleantech Solar Group	Headquartered in Singapore and operate across India and Southeast Asia focusing on long-term investments within the C&I customer segments. It has an overall capacity of over 750 MW under open access solar, wind, WSH and rooftop solar energy solutions.
Continuum Green Energy Ltd.	Headquartered in India, with a focus on C&I consumer segment offering utility-scale wind and WSH projects. It has a portfolio of over 4 GW. It is backed by North Haven Infrastructure Partners, a US $4 bn Global Infrastructure Investment Fund managed by Morgan Stanley Infrastructure Partners.
Fourth Partner Energy Pvt. Ltd.	Headquartered in India and operates in Bangladesh, Indonesia, Vietnam and Sri Lanka. Have a portfolio of over 1.4 GW. Offers solar, wind, hybrid, RTC and BESS solutions to C&I consumers.
Hero Future Energies Pvt. Ltd.	Offers behind the meter ESS, distributed and utility scale solar solutions to C&I consumers.
ReNew Energy Global plc	ReNew Green Solutions is the B2B vertical of ReNew Power to provide customisable green energy solutions to C&I segment. It has a portfolio of over 1.65 GW
TATA Power Renewable Energy Ltd.	It offers utility scale as well as rooftop solar solutions to large corporates and small businesses

Source: Company websites, Industry reports, CRISIL MI&A Consulting

5.10.2 Peer comparison

Table 25: Key players active in RE C&I segment

Parameter	Continuum Green Energy Ltd.	ReNew Energy Global plc	Adani Green Energy Ltd.	CleanMax Enviro Energy Solutions Pvt. Ltd.	TATA Power Renewable Energy Ltd.	Hero Future Energies Pvt. Ltd.
Years in Business (As on 31/03/2024)	~15 Yrs	~14 Yrs	~9 Yrs	~13 Yrs	~17 Yrs	~12 Yrs
Operational/Shortly operational (Installed capacity) (GW) as on 31st March 2024	Wind: 1.5 Solar: 0.8	Solar:4.0 Wind:4.3	Solar:7.4 Wind:1.4 WSH:2.1	Solar: 0.5+ Wind:0.1+	Solar:3.5 Wind:1.0	Solar: 1.18 Wind: 0.6
Under construction/ Development capacity (GW) as on 31st March 2024	2.2 GW	Solar:3.3 Wind:1.8	Solar:16.8 Wind:2.4 WSH:2.7	0.6+	Solar:1.0 Hybrid: 4.5	Solar: 0.73 Wind: 0.51
Solutions offered	IPP Corporate PPA Green credit energy solutions	IPP Corporate PPA Green credits Energy management RTC/Storage Solar PV manufacturing	IPP Corporate PPA RTC/ Storage Solar Park development	CPP, third-party open access	IPP; Corporate PPA; RTC/Storage Rooftop solar Solar PV manufacturing	IPP; RTC/ Storage; Corporate PPA

WSH: Wind solar hybrid; RTC: Round the clock

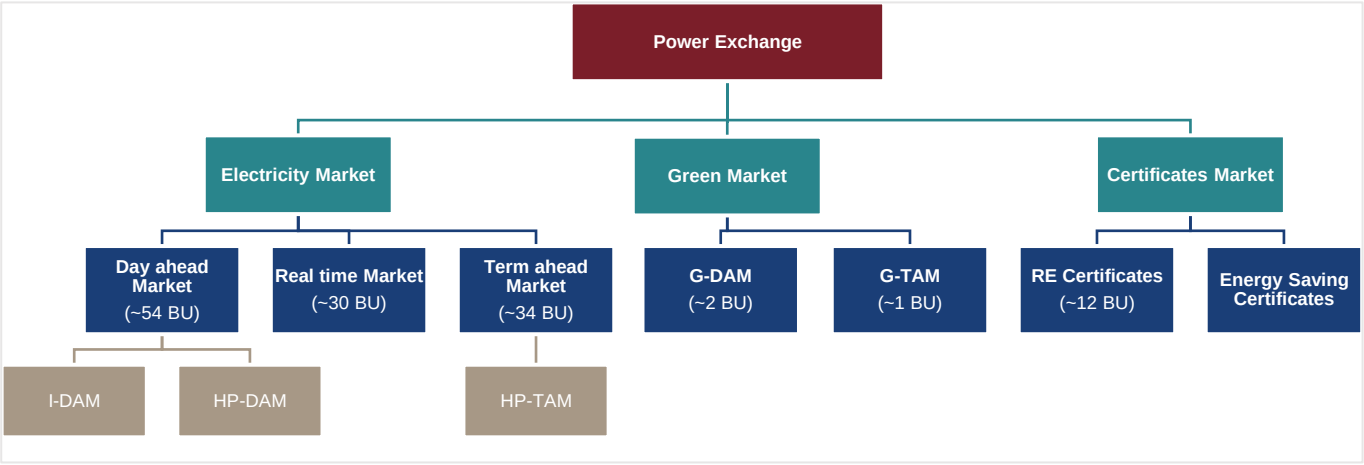
Source: Company websites, CRISIL MI&A Consulting

6 Merchant power price forecast

6.1 Overview of products/ options available on exchanges

The power exchange market can be broadly classified as under

Figure 131: Overview of products on the power exchange

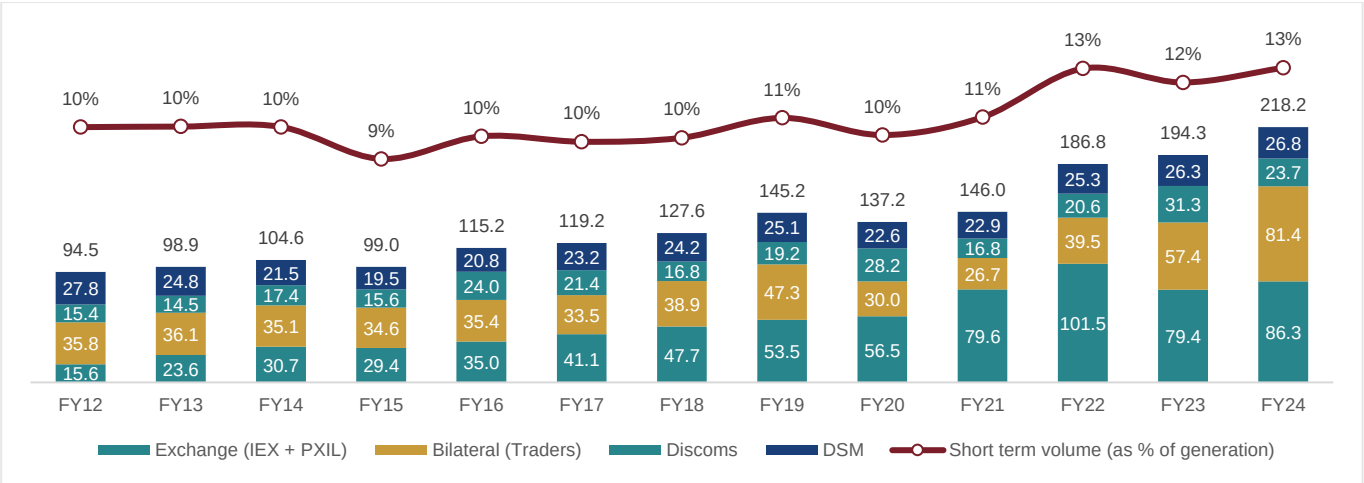


Source: CERC Market Monitoring Report, CRISIL MI&A Consulting

Cross-border electricity trade, which commenced in April 2021 at IEX, aimed at integrating the South Asian Power market, enabling countries like Nepal, Bhutan and Bangladesh to participate in DAM and TAM. Additionally, long-duration contracts of up to 3 months were launched in FY 2022.

In March 2023, IEX introduced the High Price Day Ahead Market (HP-DAM) for high variable cost generators who were unable to participate in DAM due to the price ceiling of Rs12/kWh.

Figure 132: Short-term market volumes (FY12 - FY24)



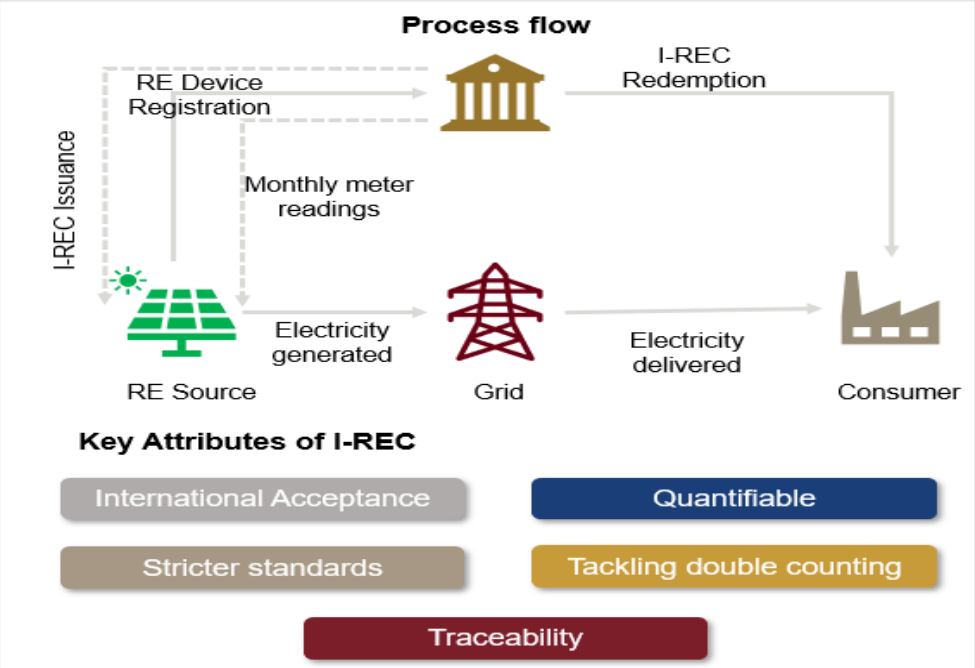
Note: Exchange volumes include DAM, RTM, and GDAM
Source: CERC, CRISIL MI&A Consulting

The short-term market volume grew at a CAGR of ~7% from FY12 to FY24. However, power procurement through medium/long- term PPAs continue to be the preferred mode among power distribution companies. Share of short-term volume, as a percentage of power generation has stayed in the range of 10%-14% over the past 10 fiscals.

With improvement in market liquidity, power transactions through exchanges increased from 16.5% in FY12 to ~40% of short-term transactions in FY24.

International Renewable Energy Certificate: International Renewable Energy Certificate (I-REC) is an unbundled Energy Attribute Certificate. I-RECs are administered by the (I-REC Standard. I-RECs are issued by specific agencies registered with the I-REC Standard for RE generation. Green Certificate Company (GCC) is the authorized issuer of I-RECs in India. I-RECs enable the purchaser to claim the environmental attributes of RE. Each I-REC represents 1 MWh of RE produced having a unique ID to prevent double counting, double issuing, and double claiming of underlying attributes.

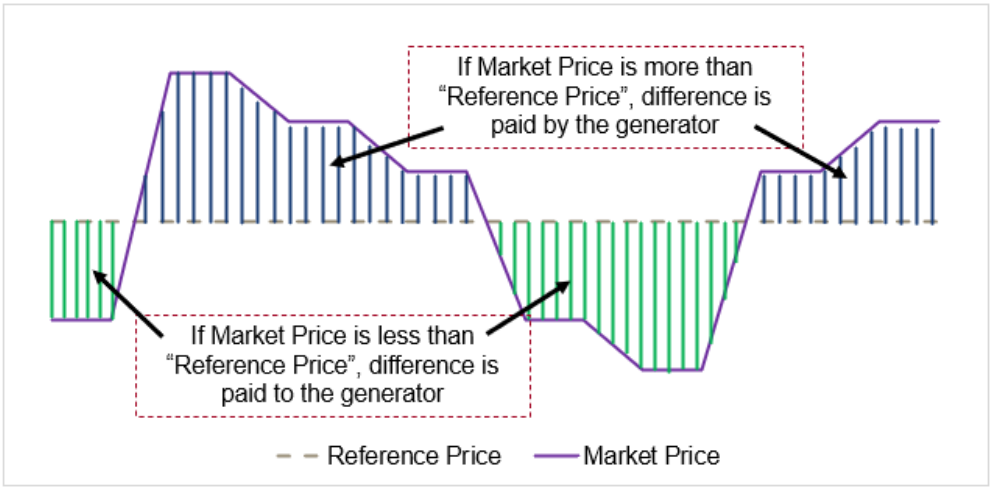
Figure 133: Process flow for I-RECs



Source: Industry, CRISIL MI&A Consulting

Contract for difference (CfD): Under CfD, power is traded and scheduled at Power Exchange at market prices. However, the generator gets assured revenue through a 'Contract for Difference' (CfD).

Figure 134: Pictorial depiction of CfD



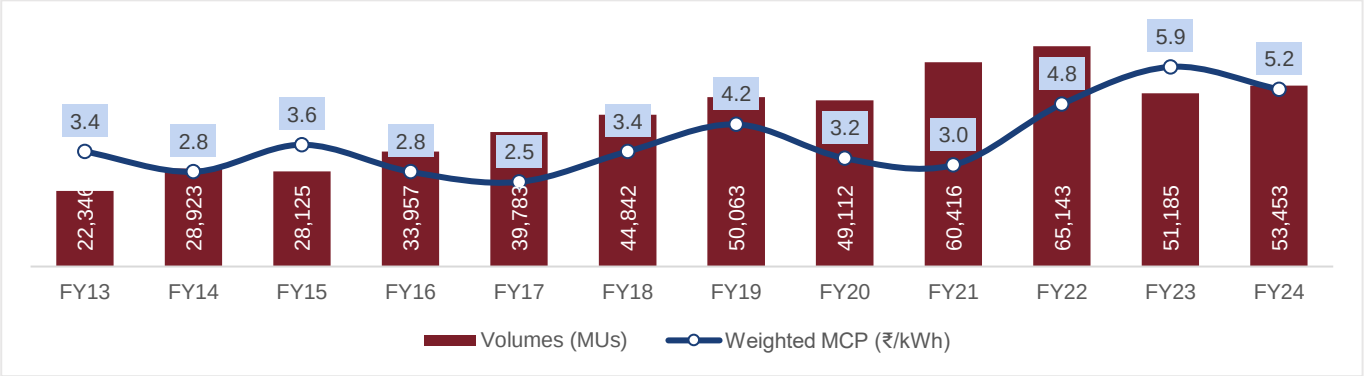
Industry: CRISIL MI&A Consulting

6.2 Price trend of different products

Day Ahead Market: Day Ahead Market (DAM) serves as a physical electricity trading market for trading 15-minute contracts in 24 hours of the next day. Prices and quantum of electricity to be traded are determined through an anonymous double-sided auction bidding process. Further, SLDC gives clearance to buyers and sellers subject to network availability and ABT (Availability Based Tariff) meters.

Figure 135: DAM trading process flow

Figure 136: Weighted average prices and volumes traded in DAM



Source: CERC Market Monitoring Report, CRISIL MI&A Consulting

The weighted MCP for DAM was highest during FY23 at Rs.5.9/kWh. The volume of yearly DAM transactions grew by 139% since 2013 and for FY24 stands at 53,453 MU. The overall share of DAM trades out of total exchange trades remained above 60%. However, it has decreased over FY21 and FY22 due to introduction of new products like RTM, G-DAM and GTAM

High Price Day Ahead Market: High Price Day Ahead Market (HP-DAM) is a recently launched segment of the Indian Energy Exchange (IEX) where power utilities (gencos and discoms) can trade expensive electricity generated from imported coal-based plants, gas-based plants, and renewable energy with battery storage. For the price below the ceiling tariff of Rs.10/unit, I-DAM market is available while for the power priced between Rs.10/unit and Rs.20/unit, HP-DAM has been introduced. HP-DAM has reduced the burden of earlier I-DAM ceiling tariff of Rs.12/unit on the generators which have high power generation cost.

Real Time Market: Real Time Market (RTM) is a newly launched market, commenced operations in FY21. In this product, every new auction session is of 30 minutes (48 times a day) and power is to be delivered after 4-time blocks (or 1 hour after gate closure of the auction). Price and quantum of electricity traded is determined via double-sided closed auction bidding. It is classified into two bids – Single and block. In Single bids, there are 15-minute bids for different price and quantity pairs and partial execution of bids is possible. Under Block bids, there are any 15-min block or series of 15-min blocks during the same day where partial execution is not possible.

Figure 137: RTM trading process flow

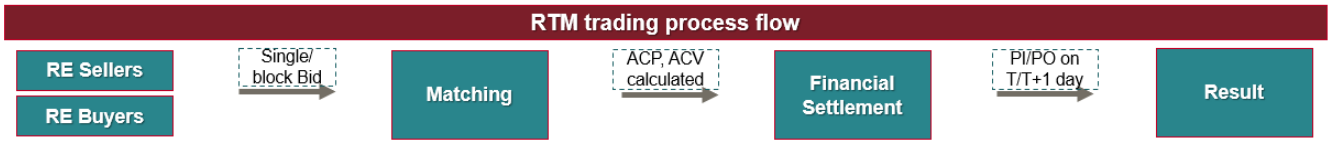
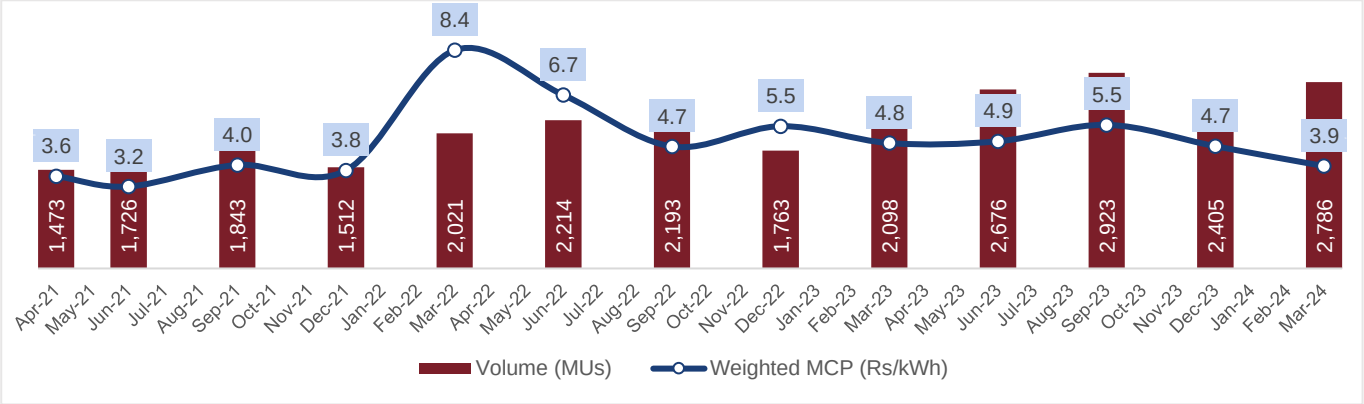


Figure 138: Weighted average prices and volumes traded in RTM



Source: CERC Market Monitoring Report, CRISIL MI&A Consulting

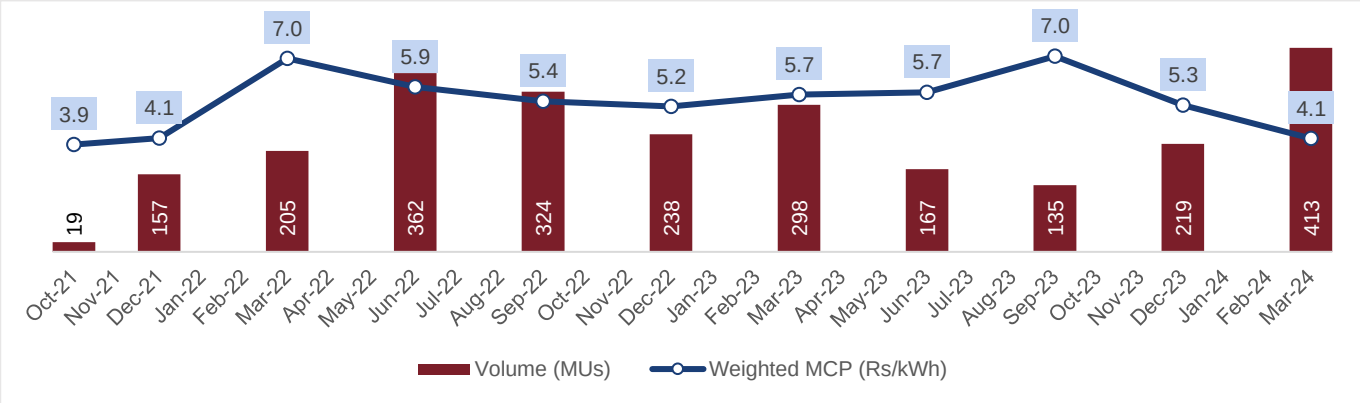
IEX Real Time Market commenced in June 2020. The weighted MCP for RTM varied from Rs. 2.6 to Rs. 9.1 per unit, peaking in April 2022. Over FY22 and FY23, higher volumes of trade were observed during monsoon months. RTM trades, which had 10-20% share for past months in FY21 and FY22, achieved over 30% market share in the ongoing fiscal.

Green Day Ahead Market: Green Day Ahead market (G-DAM) is a marketplace for trading renewable power on a day-ahead basis. RE Generators, Discoms subject to issuance of NoC/Standing clearance by RLDC/SLDCs containing type of RE source along with other details viz maximum quantum in accordance with the applicable regulations are eligible to act as sellers. RE Generators registered under REC mechanism are not eligible to be sellers. Entities which are eligible to procure power through Open Access shall be eligible to participate in G-DAM as buyers.

This market involves double sided anonymous auction bidding wherein there are separate quantity limits for sellers in each category, i.e. Solar, Non-Solar and Hydro. Participants at either premium or discount price can use 'Order Carry forward (OCF)' at the time of placing bid to carry forward uncleared bids to conventional DAM

Figure 139: GDAM trading process flow

Figure 140 : Weighted average prices and volumes traded in G-DAM



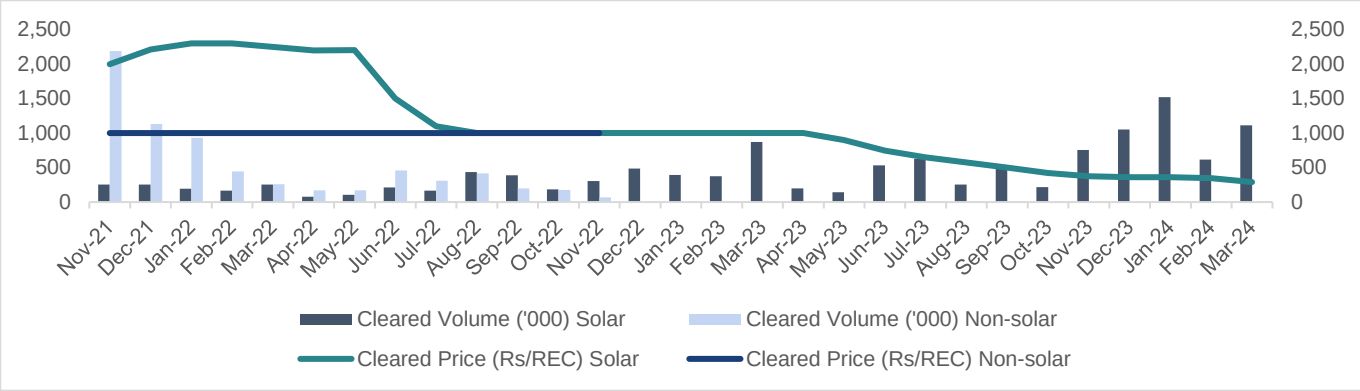
Source: CERC Market Monitoring Report, CRISIL MI&A Consulting

Renewable Energy Certificates: Renewable Energy Certificates (REC) enable buyers to meet RPO obligations without purchasing green power. 1 REC is equivalent to 1MWh energy generated from renewable energy sources. Trading is done through a closed double-sided auction on the last Wednesday of every month. Sellers include RE generators and distribution companies whereas buyers include discoms, OA consumers, Captive consumers, voluntary entities (NGOs, individuals, corporates).

Carbon credit trading system: Under this system, the Government allocates fixed number of credits to each entity. Those that are within emission limits can sell their extra credits to excess emitters or back to the market. It also requires establishing a minimum share of non-fossil fuels to be consumed by various industries. Implementation of a carbon market will help regain traction for REC market as a mechanism for corporates to fulfill climate commitments.

Post the implementation of CERC Terms and Conditions for Renewable Energy Certificates for Renewable Energy Generation) Regulations, 2022 in May 2022, all renewable energy projects are eligible to receive RECs in case they are selling power through power exchanges in the day-ahead market.

Figure 141: REC Trading



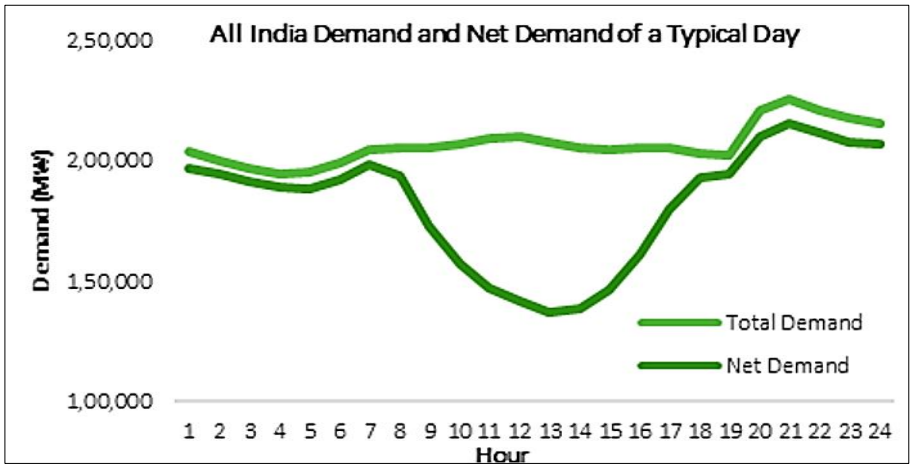
**Note: New "REC" contract introduced as per CERC's "REC Regulations 2022"*
Source: CERC Market Monitoring Report, CRISIL MI&A Consulting

IEX resumed Renewable Energy Certificate trading in November 2021, after being paused in June 2020 Solar REC prices declined from Rs.2,000 to Rs.1,000 per unit, matching non-solar REC prices. Solar REC monthly trading volumes grew at a CAGR of 8% since November 2021. Solar and non-solar REC contract was deactivated from December 2022, and a new contract named "REC" was made available. Further, with the introduction of ToD tariff regime which comprises separate tariffs for peak hours, solar hours and normal hours is applicable from 1st April 2024, where the tariffs during the solar hours would be cheaper than normal hours. Solar generation creates a

midday peak in supply, pushing down prices during those hours. The penetration of solar energy would be significantly higher than other RE sources during daytime leading to ramp down of net-load of non-RE generation as solar-energy generation fills in during the daylight hours as shown in below Figure. The issue arises when the solar generation drops to zero during evening, which is mostly a peak-demand time.

Therefore, there is a need for market-based fast ramping technologies to deal with the anticipated steeper duck curve (due to gradual increase of solar energy penetration into the grid) to serve the power demand and balance the system. Here wind energy can address the challenge to reduce evening ramp-up rate. The wind generation peaks in the evening and thus reduces the duck curve impact on the grid.

Figure 142: All India typical demand curve

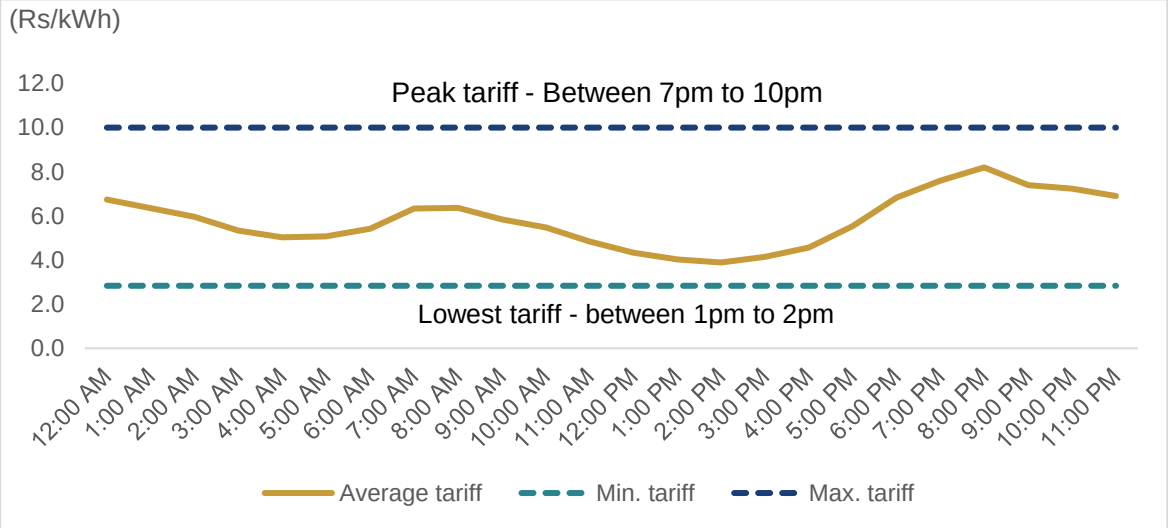


Total demand: Total electricity demand during the hour; Net Demand: total demand less dispatched wind and solar PV capacity during the hour
Source: CEA, CRISIL MI&A Consulting

In the chart shown below, it is evident that the electricity rates are at their peak during evening peak hours between 7pm to 10 pm and lowest during afternoon hours between 1pm to 2-m in most of the conditions when solar is at its peak generation. The wind energy generation coinciding with the demand peak in the evening can benefit as wind energy would become more valuable to meet the demand gap, potentially pushing up merchant prices during those hours resulting in high realisation thereby improving the financial viability of wind projects under ToD tariff regime. In GDAM market, the prices during solar hours to witness a discount to average GDAM prices on account of increased supply and ToD requirements. However, it is expected that in the long-term when a significant volume of BESS would be deployed in the system, the surplus solar energy during peak daylight hours would be used to charge such energy storage systems which is expected to create a balance between availability of solar energy during solar hours in power exchanges and demand.

Solar generation typically peaks at the same time across the country. In contrast, wind generation is highly dependent on local wind conditions, which can vary significantly by region and time of day. This variability in wind patterns with sites spread across different parts of the country can benefit by selling power at different time of the day, when wind is stronger in one region and weaker in another. This can allow the developer to capitalize on varying electricity prices throughout the day in the merchant market.

Figure 143: A typical daily graph of GDAM market



Source: IEX, CRISIL MI&A Consulting

6.3 Demand and supply curve projection

Demand for power exchange volumes is impacted by multiple factors such as:

Shift from long-term PPAs: Fresh PPA announcements by discoms have fallen sharply due to a decrease in deficit and poor financial health. Between FY 2013 to 2022, only 5 discoms have conducted case-I bids, aggregating ~9 GW, to enter new long-term PPAs. Discoms are shifting towards short-/medium-term PPAs to lower cost of procurement instead of engaging in long-term contracts, at least in the conventional generation segment. Presently, there is ~21 GW of capacity without long-term PPAs that has been already commissioned.

Rising Open Access consumption: There is an estimated rise in open access consumers transacting on power exchanges.

Transmission System Capacity Augmentation Plans: As of March 2024, India has 485,544 ckm of Transmission Lines with MVA: MW ratio of 2.8. As per the "Transmission System for Integration of over 500 GW non fossil fuel-based Capacity by 2030", the Ministry of Power envisages substation capacity addition of 433,575 MVA with transmission line addition of 50,890 ckm for integrating 537 GW renewable capacity. According to CRISIL estimates, to further prevent RE curtailment, 47% loading of transmission lines is to be maintained for such high RE capacity addition.

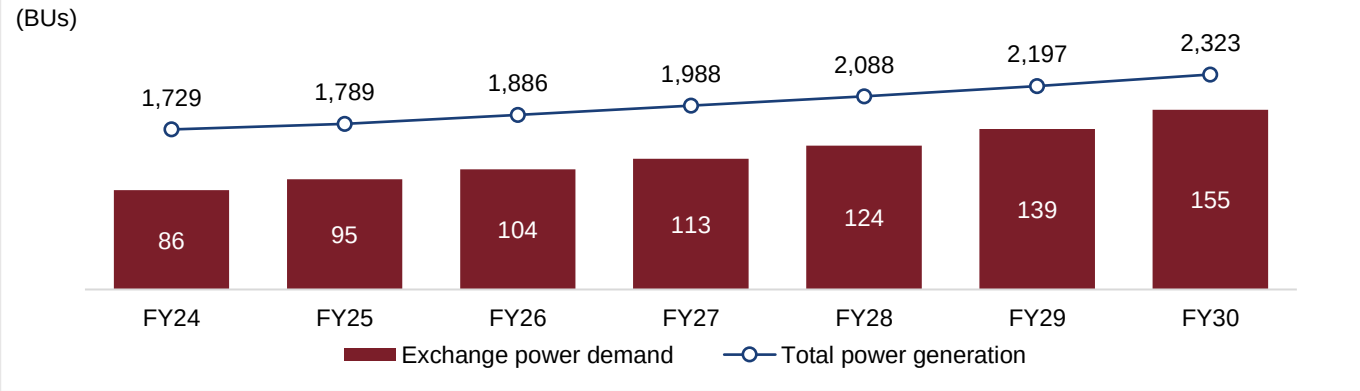
Table 26: Key drivers of short-term power market in India

Factors	Short-to-medium term impact
Demand growth	Power demand to rebound over medium term led by infrastructure investment push by government
Seasonality factors	Seasonality in demand supply balance across states provides opportunity for short term trading
Supply growth	Constrained conventional capacity additions, especially coal will result in reduction in un-tied up capacity available in the short-term market
Phasing out of coal-based power plants	Phasing out of old, inefficient thermal capacities by state and central entities will result in rise in short term demand
Phasing of long-term contracts	Long term contracting is unlikely to resume owing to reluctance of utilities to enter in to fixed cost obligations

Factors	Short-to-medium term impact
Power procurement cost optimization by large consumers	Large C&I consumers to optimize their overall power procurement costs via short term power purchase on exchanges at lower cost
Coal production and supply	Domestic coal production is set to increase in the near future led by commercial coal mining & ramp by CIL Thus, improving capacity utilization of power plants contracted by states
Transmission	Augmentation of ISTS network, rising TBCB investments in transmission to reduce network congestion to negligible levels
State open access policies	State-level procedural issues and high cross-subsidy surcharge expected to remain, and restrict exchange volume
Open access registry	Initiatives such as this would provide a transparent mechanism for consumers to seek open access.
Other trading options	Exchange to play dominant role in day ahead, traders in term ahead. Tighter DSM regime can push discoms to move to day ahead and intra-day markets
DEEP platform	Initiatives like DEEP to restrain some growth from which exchanges could have benefited
Financial health of discoms	With implementation of revamped distribution sector scheme, discoms financial health is expected to improve leading to increase in power procurement by discoms
Overall view	Exchange volume expected to maintain its share in short term and total power. But in absolute terms, volume expected to witness slower growth

6.4 Potential demand to be met from PPAs and that from power exchanges

Figure 144: Power exchange transactions volume FY24-FY30



Source: CRISIL MI&A Consulting

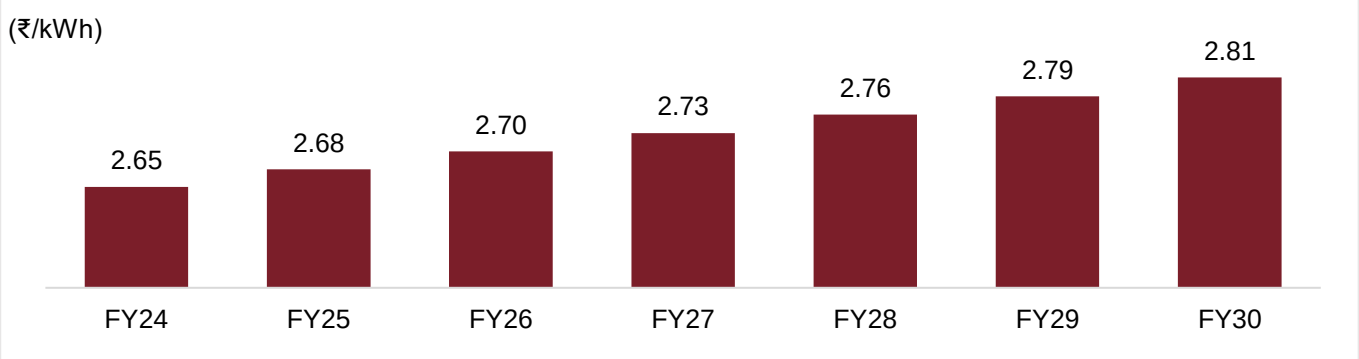
Exchange Volumes have been estimated considering regression with monthly power demand & supply volumes as there was high correlation in past. External market development expected in future will drive exchange transactions. Key developments relate to proposal of MBED model, competition with new players filing for exchange license, introduction of new products in exchanges dedicated for RE players (GTAM, G-DAM, RTC), phasing out of long-term contracts (PPAs) to favour short-term exchange-based transactions.

Factoring the regression analysis and impact of external market developments, exchange volumes are expected to grow at a CAGR of 10% between FY24 and FY30

As a result, transactions on exchanges are estimated to grow to ~155 BU in FY30, occupying a share of ~7-8% of total power generation, up from the present share of ~5 to 6% in FY24.

6.5 Assessment of source wise variable cost of generation

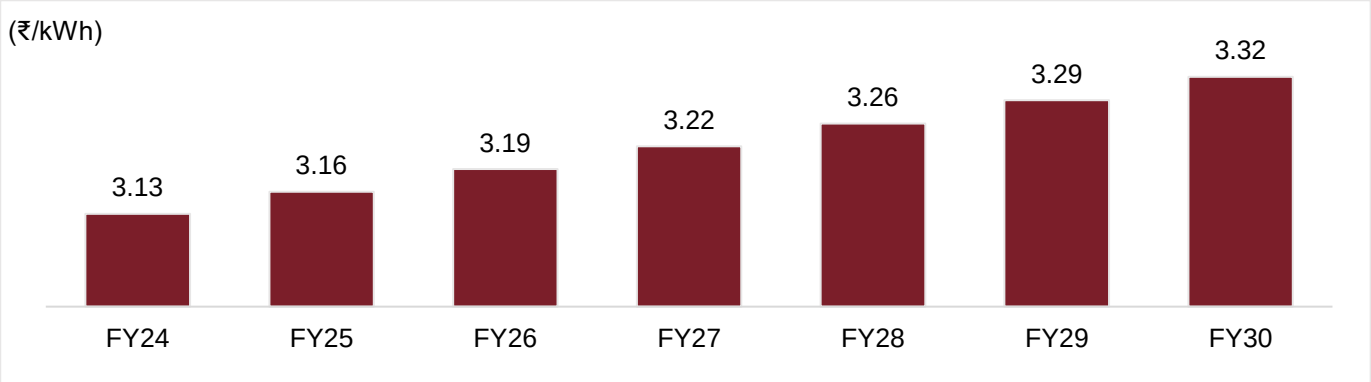
Figure 145: Solar power price forecast (Rs./kWh)



Source: Industry Reports, CRISIL MI&A Consulting

Polysilicon prices have increased from ~9 USD/kg to ~37 USD/kg from 2020 till date due to shortage of raw materials. In the long run, it is expected to witness a falling trend thereby bringing down the levelized tariffs. However, commodity prices are expected to showcase an increasing trend impacting the solar tariffs. Tariffs for new solar installations are expected to reach ~Rs.2.8/kWh till FY30 based on the offsetting impact of commodity prices, and polysilicon prices.

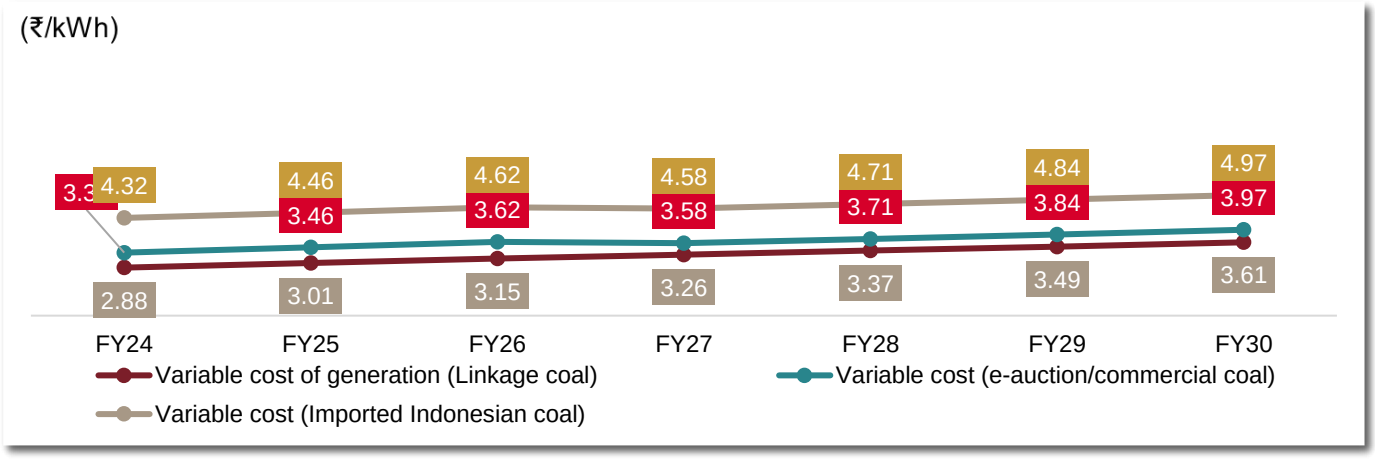
Figure 146: Wind power price forecast (Rs./kWh)



Source: Industry Reports, CRISIL MI&A Consulting

Wind tariff is largely driven by commodity prices which are expected to have an upward trajectory. Tariffs for new wind installations are expected to remain in the range of ~Rs3.2/kWh to ~Rs3.3/kWh till FY30 considering the compensating impact of technological advancement and rising commodity prices till FY30.

Figure 147: Conventional generation power price forecast (Rs./kWh)



Source: Industry reports, CRISIL MI&A Consulting

Coal prices have increased drastically in fiscal 2022 and 2023 owing to the international coal price upsurge considering Russia-Ukraine conflict creating higher demand for coal from European countries. Similarly, coal imports to India increased on account of increased industrial activities in the country after COVID-19 affected previous fiscals. This resulted in higher prices for coal-based power in FY23. Furthermore, coal-based power is likely to witness an upward trajectory during the forecast period with increasing cost of transportation and mining. Non-coking coal prices (grade G11) are expected to be in the range of Rs. 1600-1700 per tonne by FY30. Hydro power generation is likely to have a high tariff towards the end of the forecast period. Gas based variable tariffs are likely to escalate at 2% considering the current economic and geopolitical conditions.

6.6 Potential transmission constraints

CERC (Sharing of Inter-state transmission and losses) Regulations, 2020 allows waiver off inter- state transmission charges (ISTS charges) for renewable energy capacities installed by 30 June 2025. However, renewable capacities commissioned after 30 June 2025 will be subject to ISTS charges which might put them in a disadvantageous position with regards their participation through open access route. However, the treatment of ISTS charges (INR 0.40-0.60 per kwh at present) to be levied on power purchased through exchanges from projects commissioned post June 30, 2025 is not clear and guidelines from CERC will be a key monitorable.

6.7 Estimation of average power exchange price forecast at a national level

The threshold price is estimated to be the price at which electricity is traded in the short-term market. In turn, it will govern the maximum price a discom or an OA consumer will be willing to pay for procuring electricity from the long-term market, subject to technical feasibility (transmission constraints, open access constraints, etc.).

Coal, which is responsible for the majority of power transacted on exchanges, is expected to continue to remain the top resource for electricity transactions even in FY30. However, RE sources like solar and wind, which constituted only 3% of transactions in FY24, are estimated to rise to 15% by FY30. This is attributed to the recent introduction of products like G-DAM, GTAM and RECs which promote RE-based transactions on the exchange. Hydropower based transactions are estimated to increase till FY30, however, its overall share in the power mix would marginally fall.

Figure 148 : Annual weighted average power exchange price forecast over FY24-30

Note: FY22 to FY24 are actuals
Source: CRISIL MI&A Consulting

Coal based power generation dominated the power traded through exchanges with over 88% share of the total power traded in fiscal 2023 while the domestic coal supply was unable to meet the demand from the merchant power producers resulting in higher electricity power of the trade electricity. On the other hand, FY23 witnessed an elevated power exchange tariff. Imported coal-based power witnesses a huge rise in price due to soaring coal prices. Prices are expected to recover in FY24 owing to the correction of the elevated coal prices.

Overall, weighted average exchange tariff to increase from Rs 4.69/kWh in FY22 to Rs 4.77/kWh in FY30, rising at a CAGR of 0.2%.

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 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 RE 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:

- 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.

8 Competitive analysis

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 Adani Green Energy Limited (Adani), ReNew Energy Global PLC (ReNew), ACME Solar Holdings Limited (ACME), and NTPC Green Energy Limited (NGEL). These players also have a sizeable quantum of capacity under consideration/development.

Table 27: Landscape of leading project developers

Metrics Analysis	Unit	Continuum Green Energy Limited				Adani Green Energy Limited				ReNew Energy Global PLC			
		Q1FY25	FY24	FY23	FY22	Q1FY25	FY24	FY23	FY22	Q1FY25	FY24	FY23	FY22
Operating Metrics													
Installed capacity (Closing)													
Solar	MWac	284.38	271.88	130.00	55.00	9,373.00	9,373.00	6,955.00	4,763.00	4,574.00	4,159.00	3,765.00	3,688.00
Wind	MWac	1,162.90	1,141.30	887.50	706.60	2,266.00	2,266.00	1,836.00	647.00	4,081.00	4,071.00	3,898.00	3,780.00
Other projects	MWac	NA	NA	NA	NA	NA	NA	NA	NA	1,332.00	641.00	318.00	99.00
Total	**MWac**	**1,447.28**	**1,413.18**	**1,017.50**	**761.60**	**11,639.00**	**11,639.00**	**8,791.00**	**5,410.00**	**9,987.00**	**8,871.00**	**7,981.00**	**7,567.00**
Installed capacity (Closing)													
Solar	MWdc	431.14	409.95	183.80	78.80	12,987.00	12,987.00	9,663.00	6,440.00	NA	NA	NA	NA
Wind	MWdc	1,162.90	1,141.30	887.50	706.60	2,266.00	2,266.00	1,836.00	647.00	NA	NA	NA	NA
Other projects	MWdc	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total	**MWdc**	**1,594.04**	**1,551.25**	**1,071.30**	**785.40**	**15,253.00**	**15,253.00**	**11,499.00**	**7,087.00**	**NA**	**NA**	**NA**	**NA**
Installed capacity (Opening)													
C&I projects	MWdc	1,016.55	593.30	399.20	371.20	NA	NA	NA	NA	NA	NA	NA	NA
Other projects	MWdc	534.70	478.00	386.20	386.20	NA	NA	NA	NA	NA	NA	NA	NA
Total	**MWdc**	**1,551.25**	**1,071.30**	**785.40**	**757.40**	**15,253.00**	**11,499.00**	**7,087.00**	**NA**	**NA**	**NA**	**NA**	**NA**
Installed capacity (Closing)													
C&I projects	MWdc	1,059.34	1,016.55	593.30	399.20	NA	NA	NA	NA	NA	NA	NA	NA
Other projects	MWdc	534.70	534.70	478.00	386.20	NA	NA	NA	NA	NA	NA	NA	NA
Total	**MWdc**	**1,594.04**	**1,551.25**	**1,071.30**	**785.40**	**15,253.00**	**15,253.00**	**11,499.00**	**7,087.00**	**NA**	**NA**	**NA**	**NA**
Generation exported (mn kWh)													
C&I projects	mn kWh	549.41	1,451.15	1,022.81	922.93	NA	NA	NA	NA	NA	NA	NA	NA
Other projects	mn kWh	314.04	1,066.02	810.26	725.52	NA	NA	NA	NA	NA	NA	NA	NA
Total	**mn kWh**	**863.46**	**2,517.18**	**1,833.07**	**1,648.45**	**7,356.00**	**21,806.00**	**14,880.00**	**9,426.00**	**5,807.00**	**19,037.00**	**17,114.00**	**14,146.00**

Metrics Analysis	Unit	Continuum Green Energy Limited				Adani Green Energy Limited				ReNew Energy Global PLC			
		Q1FY25	FY24	FY23	FY22	Q1FY25	FY24	FY23	FY22	Q1FY25	FY24	FY23	FY22
Average Plant Load Factor (PLF)													
Wind	%	29.54%	24.96%	24.01%	25.51%	36.20%	29.40%	25.20%	30.80%	28.40%	28.00%	27.00%	26.40%
Solar (on DC capacity)	%	18.01%	14.73%	18.45%	17.49%	NA	NA	NA	NA	NA	NA	NA	NA
Average Plant Availability	%	98.14%	97.97%	97.83%	98.35%	NA	99.70%	99.60%	NA	NA	NA	NA	NA
Average Internal Grid Availability	%	98.20%	96.34%	98.95%	99.13%	NA	NA	NA	NA	NA	NA	NA	NA
Average External Grid Availability	%	99.81%	99.66%	99.71%	98.99%	NA	NA	NA	NA	NA	NA	NA	NA
Average Grid Availability	%	NA	NA	NA	NA	NA	99.50%	99.40%	NA	NA	NA	NA	NA
Financial Metrics													
Revenue from operations	INR mn	4,203.05	12,948.39	9,702.98	9,011.50	28,340.00	92,200.00	77,760.00	51,330.00	22,988.00	83,870.00	81,329.00	64,104.00
Total Income	INR mn	4,394.20	13,788.50	11,125.46	9,639.59	31,220.00	104,600.00	86,170.00	55,770.00	24,903.00	96,531.00	89,309.00	69,195.00
Net revenue from operations	INR mn	3,908.28	12,123.92	9,091.87	8,649.01	28,340.00	92,200.00	77,760.00	51,330.00	22,988.00	83,870.00	81,329.00	64,104.00
EBITDA	INR mn	3,276.50	10,113.12	8,373.11	7,556.48	28,880.00	88,260.00	58,310.00	39,550.00	19,548.00	73,231.00	64,397.00	43,243.00
Operating EBITDA	INR mn	3,085.35	9,273.01	6,950.64	6,928.39	26,000.00	75,860.00	49,900.00	35,110.00	17,633.00	60,570.00	56,417.00	38,152.00
EBITDA Margins (% of Total income)	%	74.56%	73.34%	75.26%	78.39%	92.50%	84.38%	67.67%	70.92%	78.50%	75.86%	72.11%	62.49%
Operating EBITDA Margins (% of Net revenue from operations)	%	78.94%	76.49%	76.45%	80.11%	91.74%	82.28%	64.17%	68.40%	76.71%	72.22%	69.37%	59.52%
PAT	INR mn	(1,117.03)	(5,979.82)	(3,671.47)	(750.77)	6,290.00	12,600.00	9,730.00	4,890.00	394.00	4,147.00	(5,029.00)	(16,128.00)
Net Borrowings to Total Equity	times	(33.54)	(61.60)	23.32	7.72	NA	3.11	6.92	19.36	4.91	4.68	3.84	2.45
Days of Receivables Outstanding	Days	48.08	45.59	84.94	NA	NA	27.37	76.10	91.08	77.52	68.78	115.25	260.85
Net revenue from operations / Installed capacity (Opening)	INR mn / MWdc	NA	11.32	11.58	11.42	NA	8.02	10.97	NA	NA	NA	NA	NA
Operating EBIT ROCE	% p.a.	NA	12.42%	13.09%	NA	NA	11.97%	16.22%	17.15%	NA	10.12%	9.47%	6.72%
Operating EBITDA ROCE	% p.a.	NA	19.20%	19.71%	NA	NA	15.97%	21.93%	22.62%	NA	14.26%	13.19%	10.51%

Metrics Analysis	Unit	Acme Solar Holdings Limited				NTPC Green Energy Limited			
		Q1FY25	FY24	FY23	FY22	Q1FY25	FY24	FY23	FY22
Operating Metrics									
Installed capacity (Closing)									
Solar	MWac	1,340.00	1,340.00	1,459.00	1,159.00	2,825.00	2,825.00	2,561.00	1,395.00
Wind	MWac	NA	NA	NA	NA	100.00	100.00	50.00	50.00
Other projects	MWac	NA	NA	NA	NA	NA	NA	NA	NA
Total	**MWac**	**1,340.00**	**1,340.00**	**1,459.00**	**1,159.00**	**2,925.00**	**2,925.00**	**2,611.00**	**1,445.00**
Installed capacity (Closing)									
Solar	MWdc	1,826.00	1,826.00	NA	NA	NA	NA	NA	NA
Wind	MWdc	NA	NA	NA	NA	NA	NA	NA	NA
Other projects	MWdc	NA	NA	NA	NA	NA	NA	NA	NA
Total	**MWdc**	**1,826.00**	**1,826.00**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
Installed capacity (Opening)									
C&I projects	MWdc	NA	NA	NA	NA	NA	NA	NA	NA
Other projects	MWdc	NA	NA	NA	NA	NA	NA	NA	NA
Total	**MWdc**	**1,826.00**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
Installed capacity (Closing)									
C&I projects	MWdc	NA	NA	NA	NA	NA	NA	NA	NA
Other projects	MWdc	NA	NA	NA	NA	NA	NA	NA	NA
Total	**MWdc**	**1,826.00**	**1,826.00**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
Generation exported (mn kWh)									
C&I projects	mn kWh	NA	NA	NA	NA	NA	NA	NA	NA
Other projects	mn kWh	NA	NA	NA	NA	NA	NA	NA	NA
Total	**Mn kWh**	**NA**	**NA**	**NA**	**NA**	**1,697.47**	**5,712.48**	**3,862.77**	**1,967.53**
Average Plant Load Factor (PLF)									
Wind	%	NA	NA	NA	NA	28.67%	19.78%	23.58%	23.66%
Solar (on DC capacity)	%	NA	NA	NA	NA	NA	NA	NA	NA
Average Plant Availability	%	99.36%	99.41%	99.23%	99.69%	NA	NA	NA	NA
Average Internal Grid Availability	%	NA	NA	NA	NA	NA	NA	NA	NA
Average External Grid Availability	%	NA	NA	NA	NA	NA	NA	NA	NA
Average Grid Availability	%	99.46%	99.40%	99.37%	99.30%	NA	NA	NA	NA
Financial Metrics									

Metrics Analysis	Unit	Acme Solar Holdings Limited				NTPC Green Energy Limited			
		Q1FY25	FY24	FY23	FY22	Q1FY25	FY24	FY23	FY22
Revenue from operations	INR mn	3,096.40	13,192.50	12,949.04	14,879.02	5,784.42	19,625.98	14,497.09	9,104.21
Total income	INR mn	3,400.14	14,662.67	13,613.73	15,627.26	6,074.19	20,376.57	14,575.27	9,182.43
Net revenue from operations	INR mn	3,096.40	13,192.50	12,949.04	14,879.02	5,784.42	19,625.98	14,497.09	9,104.21
EBITDA	INR mn	3,020.96	12,362.12	12,390.62	13,151.46	5,419.64	18,215.29	13,174.34	8,027.10
Operating EBITDA	INR mn	2,717.22	10,891.95	11,725.93	12,403.22	5,129.87	17,464.70	13,096.16	7,948.88
EBITDA Margin (% of Total income)	%	88.85%	84.31%	91.02%	84.16%	89.22%	89.39%	90.39%	87.42%
Operating EBITDA Margin (% of Net revenue from operations)	%	87.75%	82.56%	90.55%	83.36%	88.68%	88.99%	90.34%	87.31%
PAT	INR mn	13.89	6,982.27	(31.74)	620.10	1,386.11	3,447.21	4,564.88	947.42
Net Borrowings to Total Equity	times	3.89	2.66	3.85	3.56	2.32	1.98	1.09	4.37
Days of Receivables Outstanding	Days	79.14	84.97	166.11	199.91	56.28	99.51	56.60	34.94
Net revenue from operations / Installed capacity (Opening)	INR mn / MWdc	NA	NA	NA	NA	NA	NA	NA	NA
Operating EBIT ROCE	% p.a.	NA	8.28%	7.36%	5.56%	NA	10.29%	14.76%	NA
Operating EBITDA ROCE	% p.a.	NA	11.55%	12.55%	9.94%	NA	16.29%	22.66%	NA

Source: Company, Company websites, Annual Reports, Filings, CRISIL MI&A Consulting
Note: NA: Not available

Definitions:

- *Installed capacity (Closing) (in MWac): Represents the aggregate megawatt rated capacity of renewable power plants on the AC side that are commissioned and operational as of the reporting date*
- *Installed capacity (Closing) (in MWdc) : Represents the aggregate megawatt rated capacity of renewable power plants on the DC side that are commissioned and operational as of the reporting date*
- *Installed capacity (Opening)(in MWdc): Represents the aggregate megawatt rated capacity of renewable power plants on the DC side that are commissioned and operational as of the previous reporting date*
- *Generation exported (mn kWh): Electricity unit generated in million kWh*
- *Average Plant Load Factor (PLF): Average plant load factor is calculated as total generation by fully operational project capacity divided by maximum generation from fully operational project capacity during the period of operation in the portfolio during the period*
- *Average Plant Availability: Average Plant availability is calculated as weighted average of Plant Availability by fully operational project capacity in the portfolio during the period*
- *Average Internal Grid Availability: Average Internal Grid Availability is calculated as weighted average of Internal Grid Availability by fully operational project capacity in the portfolio during the period*
- *Average External Grid Availability: Average external grid availability is calculated as weighted average of External Grid Availability by fully operational project capacity in the portfolio during the period*

- *Revenue from operations: Revenue from operations for the given year/ period*
- *Total income: Total income is the income earned including Revenue from operations and other income*
- *Net revenue from operations: Net revenue from operations is calculated as revenue from operations less transmission, open access and other operating charges*
- *EBITDA: EBITDA is calculated as profit /loss after tax plus tax expenses plus finance costs plus depreciation and amortisation expenses plus exceptional items*
- *Operating EBITDA: Operating EBITDA is calculated as EBITDA minus other income*
- *Operating EBIT: Operating EBIT is calculated as Operating EBITDA less depreciation and amortisation expense*
- *EBITDA Margin (% of Total income): EBITDA Margin is calculated as EBITDA divided by Total income*
- *Operating EBITDA Margin (% of Net revenue from Operations): Operating EBITDA Margin is calculated as Operating EBITDA divided by net revenue from operations*
- *PAT: PAT represents the profit / loss for the financial year or during given period*
- *Days Receivable Outstanding: Days Receivable Outstanding is calculated as closing trade receivables divided by billed revenue (Revenue from operations plus opening unbilled revenue minus closing unbilled revenue for the year/ period) multiplied by 365 for yearly or 91 for June quarter calculations*
- *Net Revenue from Operations / Installed Capacity (Opening): Net revenue from Operations divided by Installed Capacity (Opening) in MWdc*
- *Operating EBIT ROCE: Operating EBIT ROCE is Operating EBIT divided by opening capital employed less capital work-in-progress, less capital advances less current and non-current cash and bank balances less current and non-current investments*
- *Operating EBITDA ROCE: Operating EBITDA ROCE is Operating EBITDA divided by opening capital employed less capital work-in-progress, less capital advances, less current and non-current cash and bank balances less current and non-current investments*
- *Net Borrowings: Net Borrowings is calculated as current and non-current borrowings minus Cash and cash equivalents and Bank balances other than cash and cash equivalents*
- *Net Borrowings / to Total Equity: Net Borrowings to Total Equity ratio has been calculated as Net Borrowings divided by total*

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