Market Intelligence
& Analytics

CRISIL
An S&P Global Company

Solar power market in India

Waaree Energies Ltd.

Final report

October 2024

Consulting

Contents

List of tables

List of figures

1 Overview of economy

Executive Summary:

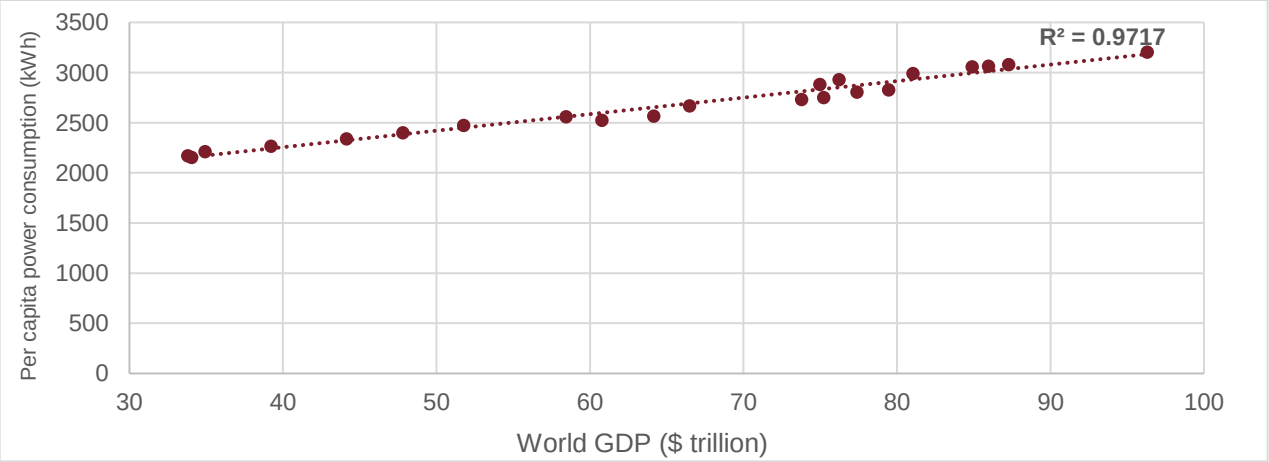
- India is at fifth largest economy in the World as per the estimated GDP for 2023.
- As per IMF, India's GDP growth is estimated to grow at 7.0% in FY2024, highest amongst the top 10 economies.
- CRISIL MI&A Consulting expects India's real GDP to grow 6.8% in fiscal 2025, compared with 8.2% in fiscal 2024.
- CRISIL MI&A Consulting expects CPI inflation to average 4.5% in fiscal 2025 vs 5.4% in fiscal 2024.
- The rupee to average to 84 against the dollar by March 2025 compared with ~83.5 in fiscal 2024.
- The yield on the 10-year benchmark G-sec to decline to 6.8% on average in March 2025 from 7.0% in March 2024

1.1 Overview of global economy

Gross Domestic Product (GDP) is a standard measure of the economic health of a country. If the time evolution of GDP for a nation is plotted against energy consumption, both show a strong correlation. This is especially true for evolving economies where energy access is constrained. As the nation grows, industrialisation and prosperity improve, thereby impacting per capita energy consumption. At some point, for industrialised countries, energy consumption per capita levels off, while GDP may continue to move upwards. Energy intensity grows as investments in the development of energy sector shifts to energy efficiency improvements. However, for developing nations, a direct causality between per capita energy consumption may be established.

With power being a large contributor of end-use energy, power consumption is supposedly a priori of the total energy consumption basket. The plot of per capita power consumption (world average) against world GDP for 2000-2021 shows a strong correlation of 0.9717.

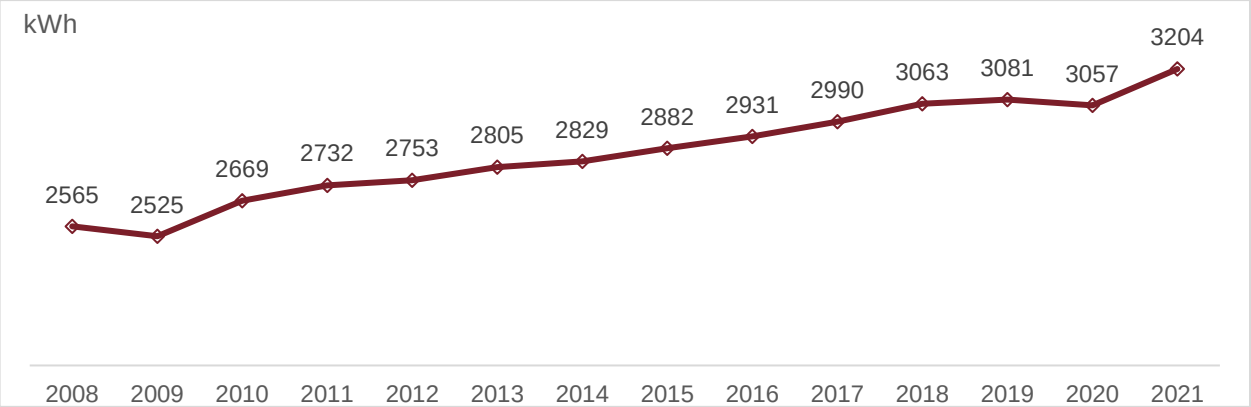
Figure 1: Correlation between GDP and per capita power consumption



Source: World Bank, IMF, EIA, UN, CRISIL MI&A Consulting

Per capita consumption has grown steadily at the global level led by developing nations. In developed nations, although total power usage has moved northwards, consumption on a per capita basis has remained firm owing to efficiency measures. On the other hand, developing nations have shown a strong uptick in per capita power usage as large-scale electrification programmes continue to connect rural areas and living conditions of the population improve. With millions still not connected to the electric grid, the uptick is expected to continue in the short to medium term.

Figure 2: Per capita power consumption: Global



As per the latest data published by EIA;
Source: World Bank, IMF, EIA, UN, CRISIL MI&A Consulting

The global economy is funding energy security and energy transition through a variety of mechanisms, including:

Government spending: Various governments are supporting clean energy by investing in clean energy technologies and infrastructure, as well as in energy efficiency measures aided by various supporting policies to cut reliance on fossil fuels. e.g., the USA planned to spend $2 Tn for clean energy to reduce greenhouse emissions.

Private investment: Various private investors are also keen in investing in clean energy due to the potential for long-term growth and the falling costs of renewable energy technologies.

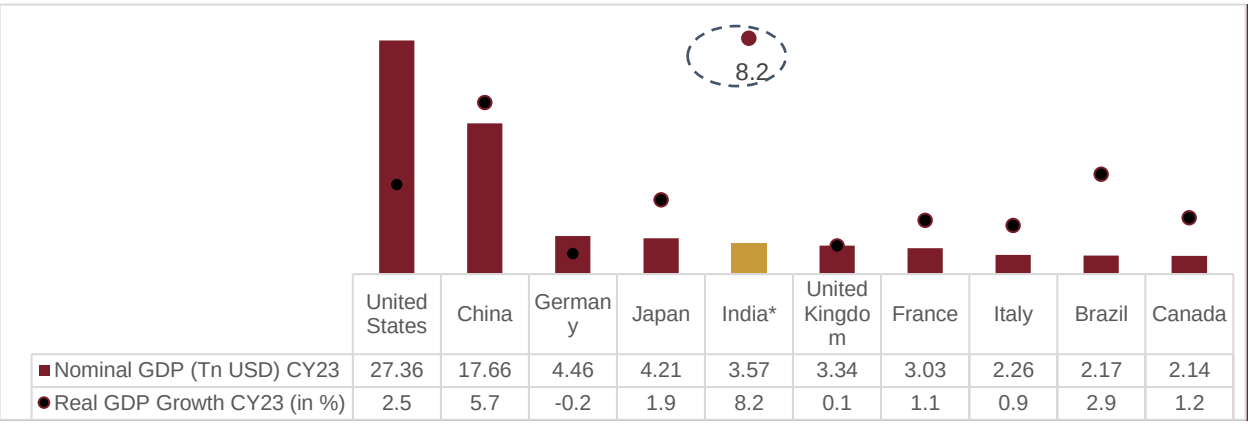
Carbon markets: Carbon markets allow countries and companies to trade emissions certificates. This helps to reduce emissions and at the same time raise revenue to fund more clean energy projects.

International climate finance: Financial assistance is provided by developed countries to developing countries to help them transition to clean energy. Green Climate fund is one example which assists developing countries in adaptation and mitigation practices to counter climate change.

1.2 India's economy against developed countries

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

Figure 3: India's economy ranked 5th in the World

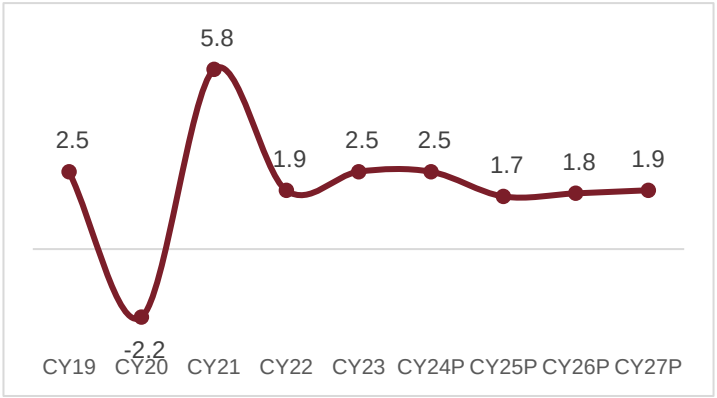


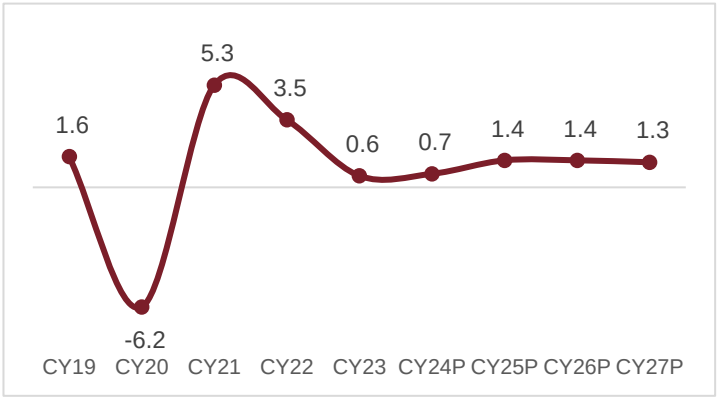
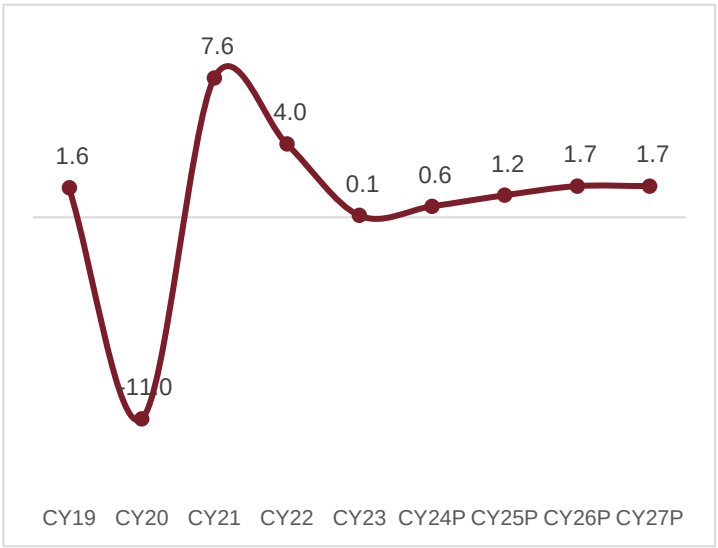
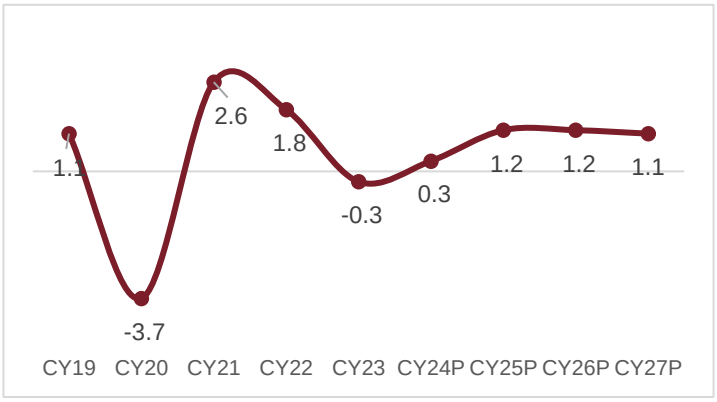
	United States	China	Germany	Japan	India*	United Kingdom	France	Italy	Brazil	Canada
Nominal GDP (Tn USD) CY23	27.36	17.66	4.46	4.21	3.57	3.34	3.03	2.26	2.17	2.14
Real GDP Growth CY23 (in %)	2.5	5.7	-0.2	1.9	8.2	0.1	1.1	0.9	2.9	1.2

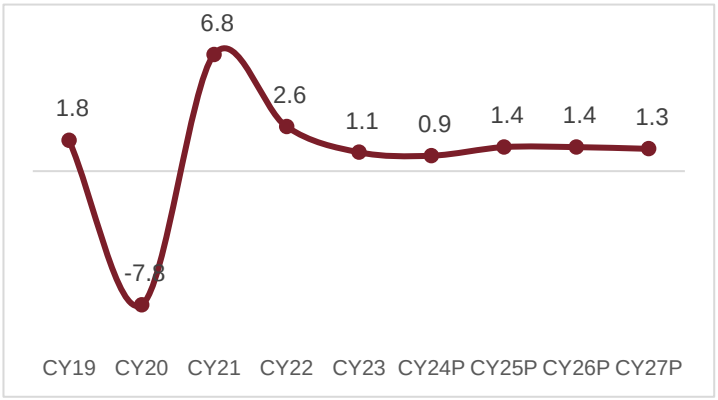
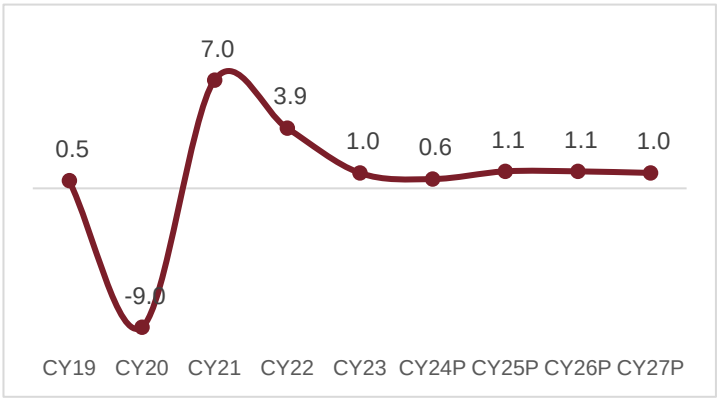
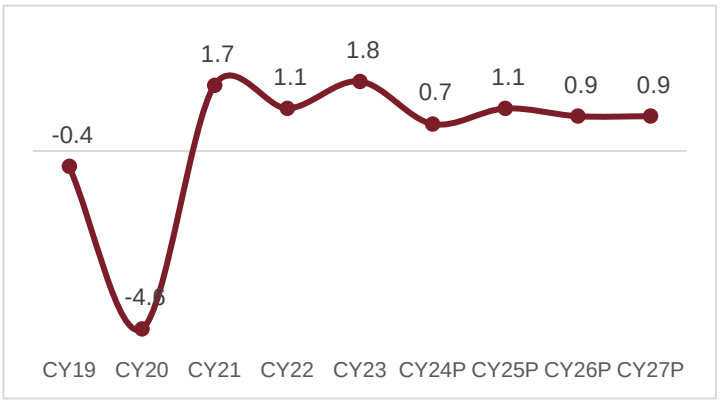
**India-Financial Year; Source: World Economic Outlook Database (July 2024) by IMF; CRISIL MI&A Consulting*

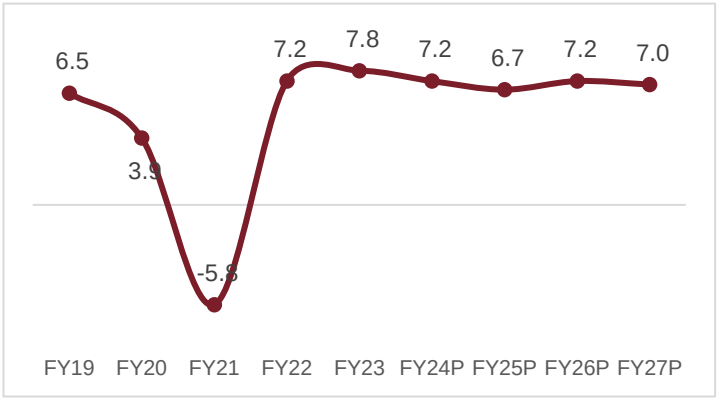
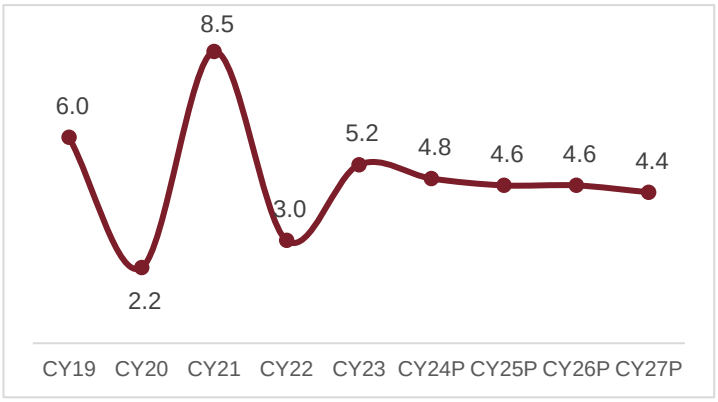
Indian economy has been booming in recent year with GDP increasing at around 6-7% rate. The reasons behind this boom are strong domestic demand, foreign investments, economic reforms, supportive policies, digitalization etc. Indian economy is expected to grow further and is seen as one of the most promising economies in the world due to rise of Indian IT sector, growth of Indian manufacturing sector and infrastructure development.

Table 1: Real GDP growth forecast of major economies

USA	S&P Global expects U.S. real GDP to grow 2.5% in 2024. The U.S. economy continues to outperform its advanced-economy peer group. Growth has averaged almost 3% over the past four quarters, well above the advanced-country average. The drivers of this strong growth have been, in order, the consumption of services, fixed investment and government spending.	

Eurozone	Activity is on the rise, with the May composite purchasing managers' indices firmly above the expansion threshold. The eurozone has exited the recent manufacturing recession, putting it cyclically ahead of the U.S. S&P Global has revised its 2025 GDP growth forecast up to 1.4% from 1.3%. Recent slower growth at the eurozone level reflects in part a faster passthrough of monetary policy, which has led to weaker inflation pressures.	
UK	The S&P Global UK Manufacturing PMI rose to a 26-month high of 52.5 in August from 52.1 in the previous month. The index has been in the expansionary zone for four consecutive months, indicating a sustained recovery in manufacturing. S&P Global forecasts GDP to expand by 0.6% in 2024, before rising to 1.2% in 2025 and 1.7% annually in 2026 and 2027.	
Germany	S&P Global expects Germany's economy to grow by a modest 0.3% in real terms in 2024, as domestic and external demand recover toward the second half of the year. S&P Global has lowered its projections for fiscal deficits over the next several years on an ongoing normalization of energy markets in Europe, the reinstatement of Germany's debt brake rule as of 2024, and lower net spending by some extrabudgetary funds following	

	a constitutional court decision in November 2023.	
France	S&P Global forecasts France's annual real economic growth will average 1.4% in 2024-2026, after an estimated 1.1% in 2023. S&P Global expects the budget deficit will slowly narrow to 3.4% of GDP by 2026, from 4.9% in 2023, with a very modest decline in general government debt as a share of GDP in 2025-2026 and beyond.	
Italy	By 2025, S&P Global projects that Italian real GDP growth will recover to above 1.1%, after a deceleration in 2023-2024. The temporary softening will mostly result from tighter financing conditions; high, albeit declining, inflation; rising private savings; and a decline in external demand.	
Japan	The Japanese economy grew at an annualised (and seasonally adjusted) 2.9% in the second quarter of 2024, after a 2.4% contraction in the first quarter. The rebound was led by a significant pick-up in private consumption (3.7%) and private residential and non-residential investment (7.1% and 3.1%, respectively). On the other hand, government consumption growth moderated (0.4%) and imports grew (6.9%) faster than exports (6.1%).	

India	S&P Global increased forecast for GDP growth in fiscal 2023 (ending in March 2023) 0.2 percentage points to 7.7%. S&P Global now expect fiscal 2024 growth will increase 40 bps relative to its previous forecast of 6.8%. S&P Global expects growth to moderate to 6.8% fiscal 2024, with high interest rates and lower fiscal support tempering demand in the nonagricultural sectors.	
China	S&P Global expects growth in China's GDP will slow to 4.8% in 2024 from 5.2% in 2023. However, for 2024, S&P Global raised its 2024 China GDP growth forecast to 4.8%, from 4.6%, but see a sequential slowdown in the second quarter as the combination of subdued consumption and robust manufacturing investment weighs on prices and profit margins.	

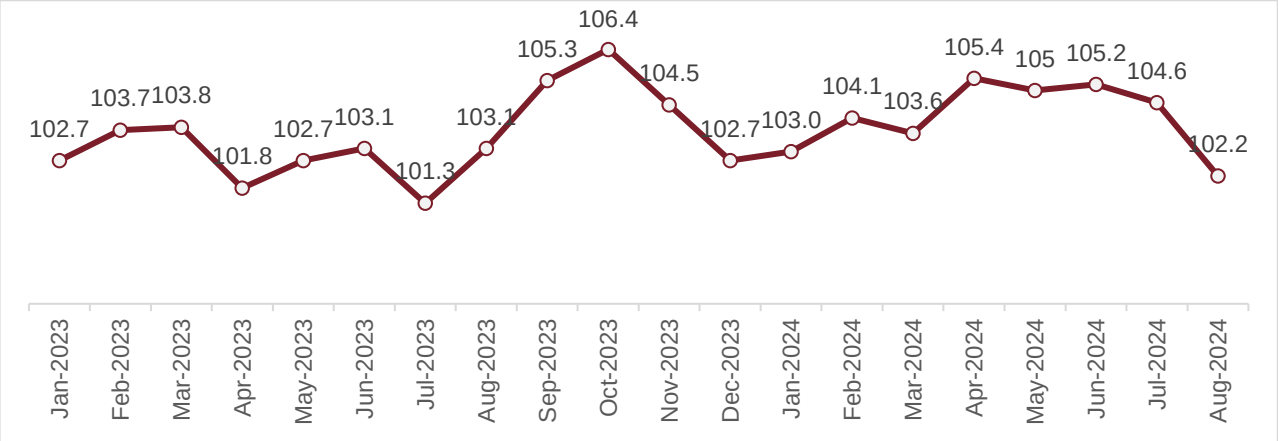
P: Projected

Source: S&P Global Economic Outlook Q3 2024; June 26, 2024; CRISIL MI&A Consulting

1.3 Global currency market and currency movement

The dollar index contracted 2.3% on average to 102.2 in August (its lowest level since December 2023) compared with 104.6 in July. This is the second month in a row that the index has seen weakness. The index gauges the greenback's strength against six other major currencies (the euro, Swiss franc, Japanese yen, Canadian dollar, British pound and Swedish krona). Expectations of rate cuts by the Fed and a softening labour market may have driven down the dollar index.

Figure 4: US Dollar Index



Note: A fall in the index indicates depreciation
Source: Bloomberg, CRISIL MI&A Consulting

CRISIL MI&A Consulting expects the rupee to average to 84 against the dollar by March 2025 compared with ~83 in fiscal 2024. While the current account deficit is expected to remain manageable, it may face some risks amid the uneven global growth scenario and geopolitical uncertainties. That said, India's healthy domestic macros will cushion the rupee.

1.4 Overview of Indian economy

As per data released by the National Statistical Office (NSO) in May 2024, India's gross domestic product (GDP) at constant (fiscal 2012) prices was estimated at Rs 173.82 lakh crore in fiscal 2024 vis-à-vis the first revised estimate for fiscal 2023 of Rs 160.71 lakh crore, which translated into a growth of 8.2% y-o-y. This was higher than the 7.0% growth in fiscal 2023. However, India has overtaken the United Kingdom's economy in terms of size, making it the fifth biggest. In fact, India's GDP growth is estimated to be the highest amongst the top 10 economies.

Table 2:GDP trajectory (% change)

At basic prices	FY19	FY20	FY21	FY22	FY 23E	FY 24E	At basic prices	FY19	FY20	FY21	FY22	FY23E	FY 24E
							GDP	6.5%	3.9%	-5.8%	9.7%	7.0%	8.2%
Agriculture	2.1%	5.5%	3.3%	3.5%	4.7%	1.4%	Private consumption	7.1%	5.2%	-6.0%	11.1%	6.8%	4.0%
Industry	5.3%	-1.4%	-3.3%	14.8%	9.4%	9.9%	Govt. consumption	6.7%	3.4%	3.6%	6.6%	9.0%	2.5%
Manufacturing	5.4%	-2.9%	-0.6%	11.1%	-2.2%	9.9%	Fixed investment	11.2%	1.6%	-10.4%	14.6%	6.6%	9.0%
Mining and quarrying	-0.8%	-1.5%	-8.6%	7.1%	1.9%	7.1%	Exports	11.9%	-3.4%	-9.2%	29.3%	13.4%	2.6%
Services	7.2%	6.3%	-7.8%	9.7%	8.9%	7.8%	Imports	8.8%	-0.8%	-13.8%	21.8%	10.6%	10.9%

E: Estimated (Since FY23 are first advance estimates and FY24 are provisional estimates, shown as estimated))
Source: NSO, CEIC, CRISIL MI&A Consulting

GDP grew 6.7% on-year in the first quarter of fiscal 2025, in line with forecast of 6.8%. The print was a deceleration vs the fourth quarter of fiscal 2024, which saw the economy expand 7.8%. And in the first quarter of fiscal 2024, the economy had grown 8.2%. On the supply side, GVA growth of 6.8% was slightly higher than 6.7% GDP growth. From the demand side, decline in government consumption spending was a drag on GDP growth. And reducing growth in net taxes limited the rise in GDP over gross value added (GVA) growth. That being said, both private consumption and fixed investments picked up in the quarter. From the supply-side, despite healthy growth of 7.0%, manufacturing was slower than in the last quarter fiscal 2024, while agriculture and services improved. However, the improvement in agriculture was relatively modest, which capped the rise in GDP. Nominal GDP moderated as well to 9.7% from 9.9% in the last quarter of fiscal 2024 but was higher than 8.5% in the year-ago quarter

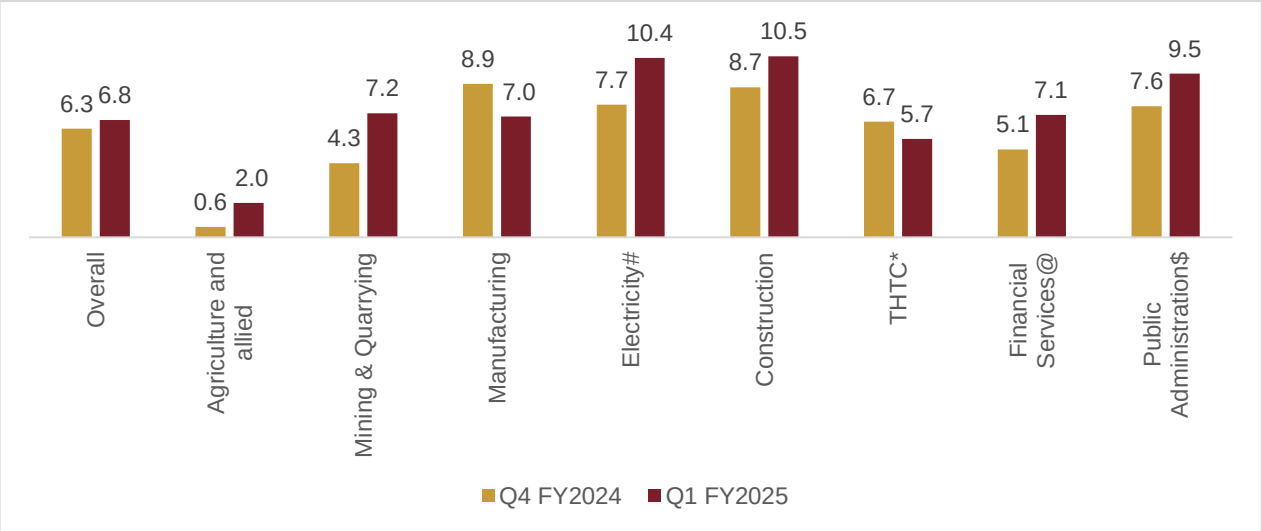
Table 3: Services, manufacturing, and government consumption lead GDP growth

Particulars	Demand Side		Particulars	Supply Side	
	FY23E	FY24E		FY23E	FY24E
GDP	7.0%	8.2%	GVA	6.7%	7.2%
GFCE	9.0%	2.5%	Manufacturing	-2.2%	9.9%
PFCE	6.8%	4.0%	Public Ad+	8.9%	7.8%
GFCF	6.6%	9.0%	Agriculture	4.7%	1.4%
Imports	10.6%	10.9%	Mining	1.9%	7.1%
Exports	13.4%	2.6%	Financial Services	9.1%	8.4%
			Electricity	9.4%	7.5%
			Construction	9.4%	9.9%
			THTC	12.0%	6.4%

Note: GFCE: Government final consumption expenditure, PFCE: Private final consumption expenditure; GFCF: Gross fixed capital formation; GVA: Gross value added; THTC refers to trade, hotels, transport, and communication services; financial services+ refers to financial, real estate and professional services; public ad+ refers to public administration, defence and other services

Source: NSO, CEIC, CRISIL MI&A Consulting

Figure 5: Agriculture & services record stronger growth in Q1; consumption & investments pick up



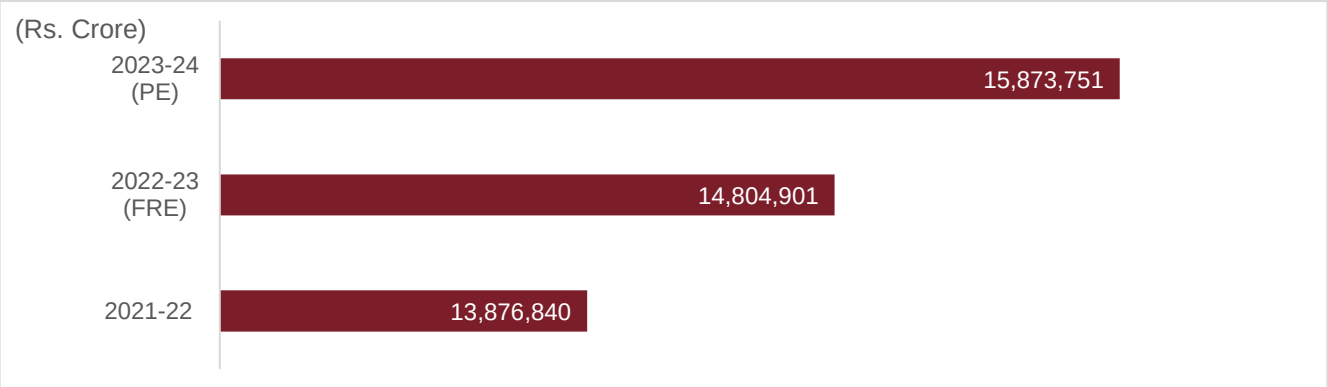
**THTC refers to trade, hotels, transport, and communication services; @Financial services refers to financial, real estate and professional services; # Electricity, gas, water supply and other utility services, $Public administration refers to public administration, defence and other services*

Source: NSO, CEIC, CRISIL MI&A Consulting

1.5 GVA performance

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

Figure 6: GVA at basic prices (Rs. crore)



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

1.6 India's GDP recovered with subsiding of the pandemic

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

After strong GDP print in the past three years, CRISIL MI&A Consulting expects some moderation to 6.8% this fiscal 2025 after a high growth of 8.2% last year, weighed down by high interest rates and low fiscal impulse. However, agriculture and consumption, which were both sluggish last fiscal, are expected to see a revival this fiscal.

Investments, a key factor that boosts growth, are expected to moderate as the government focuses on fiscal consolidation. The extent of revival in private investment cycle will determine the investment momentum this fiscal. The other strong segment, urban demand, could moderate as credit conditions tightened this year. Transmission of past rate hikes to broader lending rates remains incomplete. As the wait for rate cuts from the Reserve Bank of India (RBI) prolongs, the transmission is expected to continue, raising the borrowing costs. In addition, the RBI's regulatory measures to clamp down on risky lending will weigh on credit support to consumption.

CRISIL MI&A expects a normalisation of the net indirect tax impact on GDP, after strong growth in the last fiscal. Slower global growth can restrict upside to goods exports owing to normalisation of supply chains and an expected pick-up in volume of trade in calendar 2024. S&P Global expects global GDP growth to slow to 3.3% in 2024 from 3.4% the previous year, weighed by interest rates staying elevated for longer. Any spike in the prices of commodities — particularly crude oil — remains a risk for the country's growth.

Overall, CRISIL MI&A-Consulting expects India's real GDP to grow 6.8% in fiscal 2025, compared with 8.2% past fiscal 2024 estimated by NSO.

Table 4: CRISIL's key projections

	FY18	FY19	FY20	FY21	FY22	FY23	FY24	FY25P
GDP growth (%)	6.8%	6.5%	3.9%	-5.8%	9.7%	7.0%	8.2%	6.8%
CPI (%, average)	3.6%	3.4%	4.8%	6.2%	5.5%	6.7%	5.4%	4.5%
CAD/GDP (%)	1.8%	2.1%	0.9%	-0.9%	-1.2%	-2.0%	-0.7%	-1.0%
FAD/GDP (%)	3.5%	3.4%	4.6%	9.2%	6.7%	6.4%	5.6%	4.9%
Exchange rate (Rs/$ March-end)	65.0	69.5	74.4	72.8	76.2	82.0	83.0	84
10-year G-sec yield (%, March-end)	7.6%	7.5%	6.2%	6.2%	6.8%	7.4%	7.1%	6.7%

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

Source: CSO, RBI, CRISIL MI&A Consulting

1.7 Overview of other demographic factors

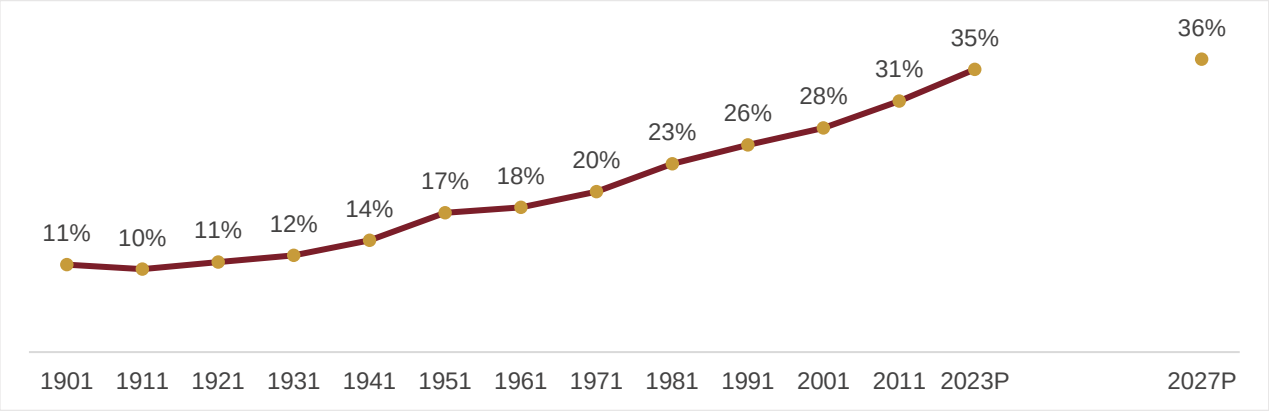
1.7.1 Urbanisation

Urbanisation is one of the big growth drivers, as it leads to rapid infrastructure development, job creation, development of modern consumer services, and mobilisation of savings.

The share of the urban population in India in overall population, which stood at ~31% in 2011, has been consistently rising over the years, and is expected to reach 36% by 2027, spurring increasing consumer demand.

Indeed, urban consumption in India has shown signs of improvement. And given India's favourable demographics, along with rising disposable income, the trend is likely to continue and drive the country's economic growth.

Figure 7: Urban population as a % of total population of India



P: Projected

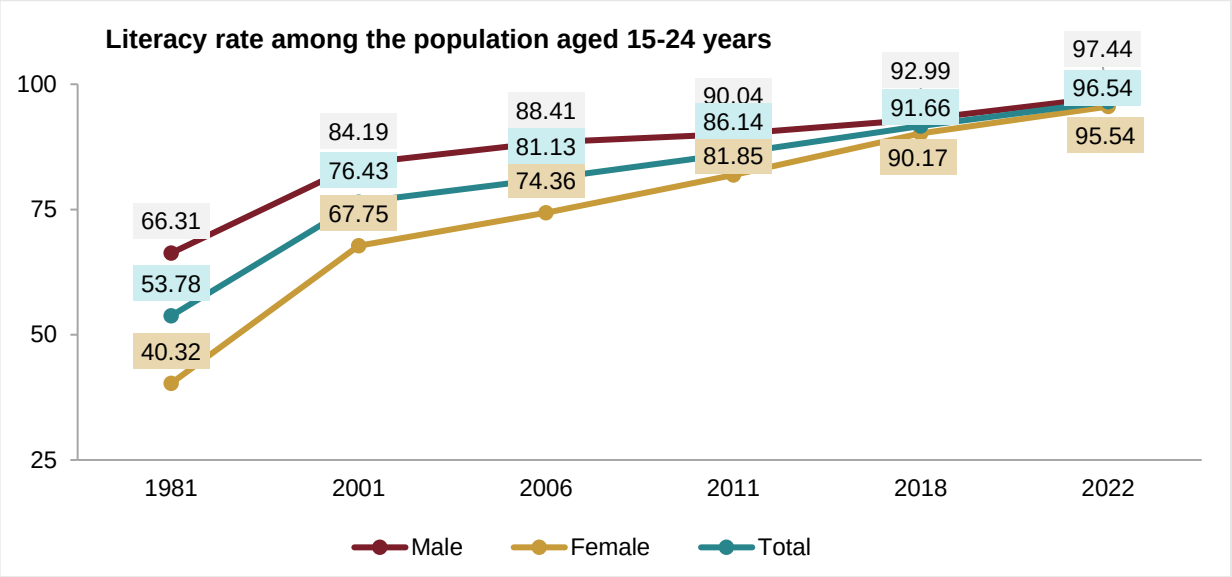
Source: Census 2011, Report of The Technical Group on Population Projections by Ministry of Health & Family Welfare (July 2020), CRISIL MI&A Consulting

1.7.2 Literacy

Literacy rate reflects the socio-economic progress of a country. India has experienced continuous growth in youth literacy rate (aged 15-24 years), which rose from ~54% in 1981 to ~90% in 2015. However, the pace of

growth has decelerated since 2006. This is because the growth in male literacy rate is slowing; the literacy rate for the female population, though, has continued to rise.

Figure 8: Youth literacy rate of India



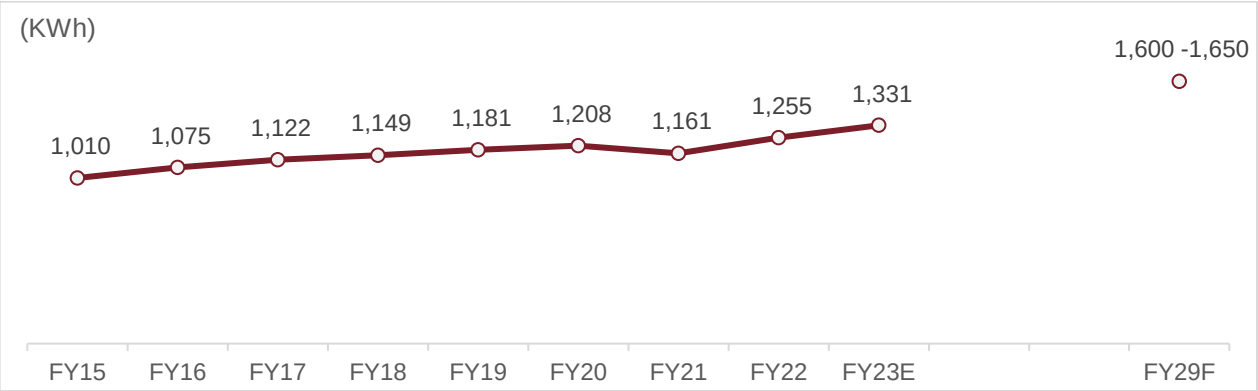
Source: UNESCO, WHO, CRISIL MI&A Consulting

1.7.3 Per capita power consumption

Electricity consumption per person rose to 1,331 kWh in fiscal 2023 (as per CEA's provisional data), from 1,010 kWh in fiscal 2015 at a CAGR of 3.5%, primarily led by large capacity additions coupled with 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.

Between fiscals 2024 and 2029, India's per capita electricity consumption is expected to grow at ~5-7% CAGR. Per capita consumption is expected to gradually improve in the long term as well, as power demand picks up on the back of improvement in access to electricity, in terms of quality and reliability, rising per capital income, increasing EV penetration, railway electrification, on account of intensive rural electrification, resulting in realisation of latent demand from the residential segment, increased penetration of consumer durables. However, there are a few factors which could restrict the growth such as improved energy efficiency, focus on T&D loss reduction, sustainability targets and increasing share of services in GDP. Consequently, CRISIL MI&A-Consulting expects per capita electricity consumption to reach 1,600-1,650 kWh by fiscal 2029.

Figure 9: Per capita electricity consumption-India



E: Estimated; F: Forecast

Source: Central Electricity Authority of India (CEA), CRISIL MI&A Consulting

The per capita electricity consumption remains significantly lower than that of other major as well as developing countries, thereby offering strong organic growth potential.

1.8 Outlook on inflation, interest rates, etc.

1.8.1 Inflation

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 2024, 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.

The fading base effect in vegetable inflation was the primary driver of higher food inflation in August 2024. Vegetable inflation rose to 10.7% in August 2024 from 6.8% in July 2024, though it remained below the June 2024 print of 29.3%. Sequentially, vegetable prices declined 0.5% (seasonally adjusted) on-month. Inflation in tomato stood at -47.9% in August 2024 vs -43% in July 2024. Onion (54.1% Aug-2024 vs 60.6% Jul-2024) and potato (64% Aug-2024 vs 65.8% Jul-2024) inflation remained high but eased relative to the previous month

Foodgrain inflation slowed down to 8.6% in August 2024 from 9.5% in July 2024 displaying broad-based easing across key categories. Cereals inflation eased to 7.3% in August 2024 from 8.1% in July 2024, driven by easing inflation in non-public distribution system rice (9.5% Aug-2024 vs 10.9% Jul-2024). Pulses inflation dropped for the third straight month to its lowest value since September 2023

Edible oil inflation was broadly steady at -0.9% in August 2024 vs -1.1% last month. Sugar inflation dropped to 4.7% in August 2024 from 5.2%, in line with the fall in international sugar prices. A high base drove down inflation in spices to -4.4% in August 2024, a record low.

Fuel inflation (CPI fuel and light) negative

Fuel prices remained in deflation, falling 5.3% on-year in August 2024 vs 5.5% decline in July 2024. Prices of liquified petroleum gas (LPG) declined 24.6% on-year, with government subsidies keeping LPG prices in deflation for the past year. From September 2023, the high base effect is expected to slightly fade as a subsidy

of Rs 200/cylinder was kicked off on August 30, 2023. That said, the additional Rs 100/cylinder subsidy that came into effect in March 2024 should keep LPG inflation negative

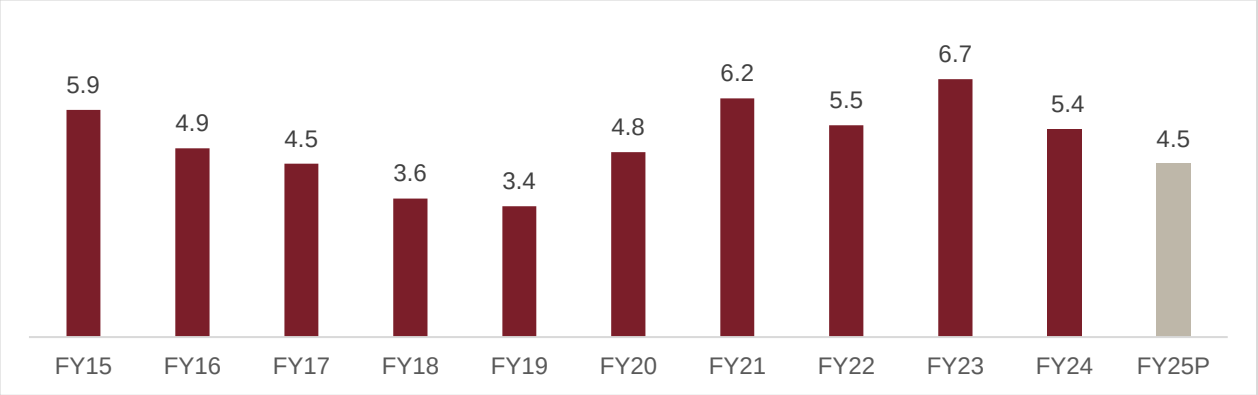
Electricity inflation remained steady at 4.9% in August 2024 (vs 4.8% in July 2024), owing to neutral base effect for the category. Electricity tariffs were hiked sharply from May-July 2023, which has since normalized

Core inflation eases a touch

Core [excluding food and beverages, and fuel and light] inflation eased 10 bps to 3.3% in August 2024. Services inflation (3.6%) was higher than core goods [excluding services, food, and fuel and light] inflation (3%), due to the impact of tariff hikes by major domestic telecom companies. Excluding the impact of the tariff hikes, services inflation remained close to core goods inflation at 3.1%

Inflation in personal care and effects eased for the first time in six months in August 2024(7.9% vs 8.4% in July 2024). However, inflation in the category remains well above other key core categories. Inflation in precious metals, such as gold (19.5% vs 20.8%) and silver (16.6% vs 21.4%) eased in August 2024.

Figure 10: CPI inflation (%, y-o-y)



E: Estimated, P: Projected
Source: NSO, CEIC, CRISIL MI&A Consulting

CRISIL MI&A Consulting expects CPI inflation to broadly ease to 4.5% on-year this fiscal from 5.4%. The monsoon has progressed well and kharif sowing is up compared with the last year, paving the way for easing food inflation

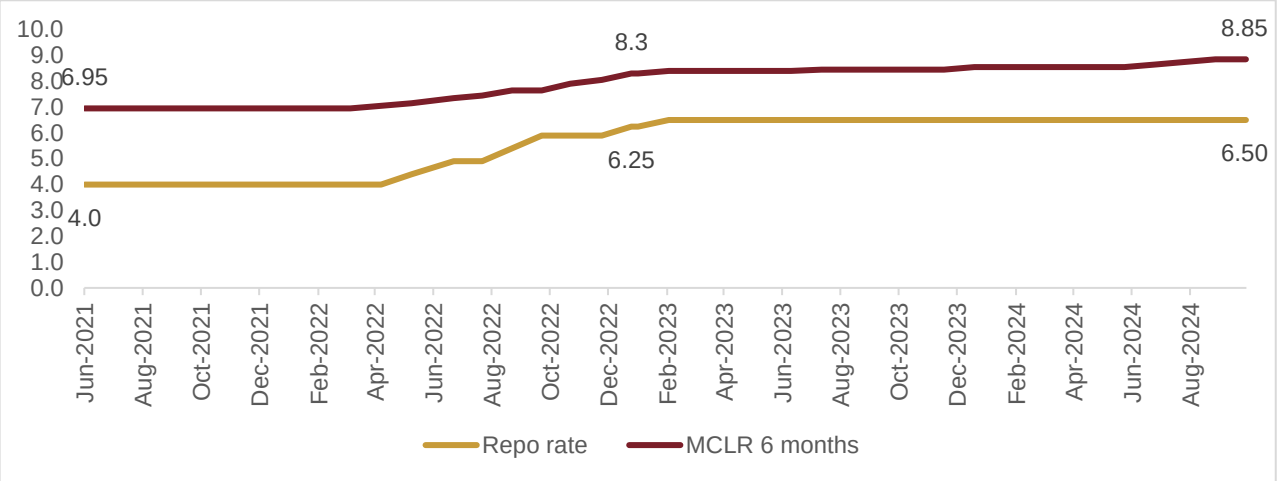
1.8.2 Interest rates

The weighted average call money rate, the operating target for monetary policy, was broadly steady—averaging 6.5%—in line with the repo rate, while other money market rates eased in August 2024 compared with July 2024. The six-month commercial paper rate eased 3 bps to average 7.81%. The 91-day treasury bill rate declined by a shaper 9 bps to 6.62%, its lowest monthly average since February 2023. However, CD (Certificate of Deposit) rates continued to rise

Bank lending rates increased in August, with the one-year marginal cost of funds-based lending rate (MCLR) rising 5 bps to 8.9%. The auto loan rate was broadly steady, rising 1 bp to an average of 9.82%. Deposit rates were unchanged at 6.86%.

Compared with the 250-bps hike in the repo rate in this interest rate cycle, the rise in bank lending rates has been less pronounced. Deposit rates, one-year MCLR and auto loan rate have risen 177 bps, 165 bps and 160 bps, respectively..

Figure 11: Trend in interest rates



Source: RBI, SBI, CRISIL MI&A Consulting

CRISIL MI&A Consulting expects the RBI to initiate rate cuts this fiscal, depending on a durable reduction in food inflation, which has been the primary challenge for the central bank.

Food inflation has softened so far this quarter, supported by a high base. A further drop will depend on a decline in food prices as the high base effect will fade in September. That said, CRISIL MI&A Consulting expects food inflation to ease this fiscal, given good monsoon and improved agricultural outlook.

Non-food inflation is expected to remain benign. Though it faces risks from geopolitical uncertainties, benign commodity prices will keep core prices subdued.

Growth is expected to moderate this fiscal as the government aims to reduce its fiscal deficit. That said, it is expected to remain resilient at 6.8%, higher than the pre-pandemic decadal average of 6.7%, giving the RBI room to delay rate cuts.

CRISIL MI&A Consulting expects the central bank to begin cutting rates from October at the earliest, with the repo rate to reach 6% at the end of this fiscal.

1.8.3 Debt

The yield on the 10-year benchmark G-sec eased for the fourth straight month to its lowest monthly average since March 2022, supported by global and domestic factors. The yield averaged 6.87% in August 2024, down 10 bps on-month.

The following factors led to the decline in G-sec yields:

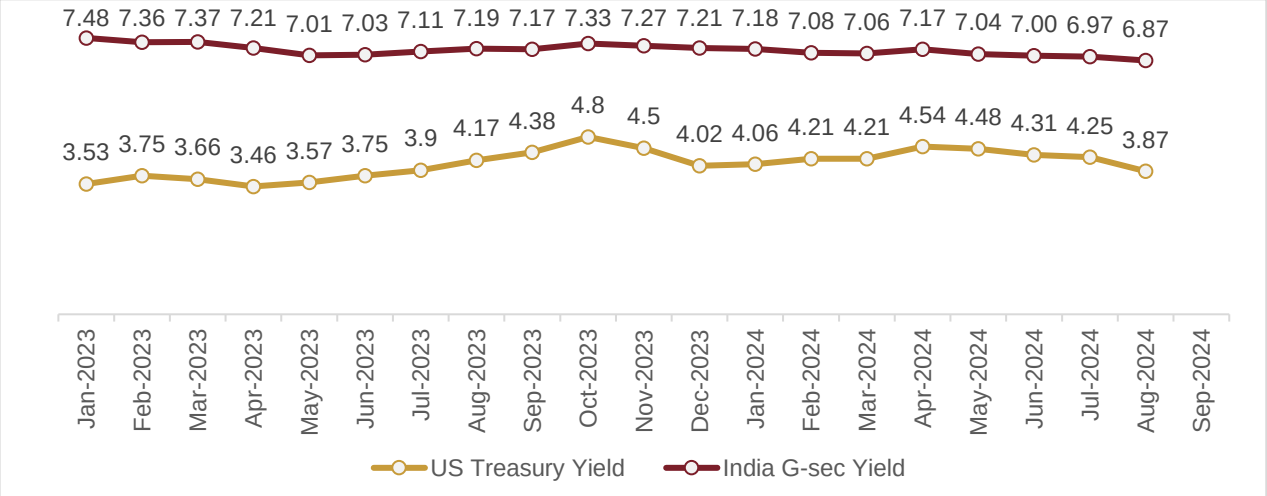
- Demand concerns in the US and China drove down crude oil prices in August 2024. Brent crude oil prices cooled down to $80.9 per barrel in August 2024 from $85.3 per barrel
- The surplus in systemic liquidity rose in August 2024 compared with July 2024. The RBI net absorbed Rs 1.51 lakh crore in August 2024, compared with Rs.1.03 lakh crore in July 2024
- The domestic Consumer Price Index (CPI) data released on August 12,2024, revealed that domestic retail inflation eased sharply to 3.5% in July 2024 from 5.1% in June 2024
- US Treasury yields eased sharply, with the yield on the 10-year note averaging 3.87% in August 2024

- Net foreign portfolio inflows into the Indian debt market remained robust at $2.1 billion in August 2024, but declined relative to the previous month's $2.7 billion

The yield curve remained flattish, as yields eased across the curve by similar quantum.

US Treasury yields moderated sharply in August 2024 as weak jobs market data led to fears about a US recession. The 10-year Treasury note eased 38 bps on average in August 2024, declining to 3.87% from 4.25% in the previous month. The spread between the US and Indian government bond yields widened for the third consecutive month, because of the sharper decline in US Treasury yields.

Figure 12: India G-sec with US treasuries spread widens



Source: RBI, US Department of the Treasury, CRISIL MI&A Consulting

CRISIL MI&A Consulting expects yields to decline this fiscal, because of the following reasons:

- CRISIL MI&A Consulting expects the RBI to initiate rate cuts this fiscal, as inflation is expected to moderate. We expect two rate cuts this fiscal, with the first one in October at the earliest.
- CRISIL MI&A Consulting expects CPI inflation to ease to an average of 4.5% in fiscal 2025 from 5.4% this fiscal. The monsoon has progressed well and kharif sowing is up compared with the last year, paving the way for easing food inflation
- Fiscal deficit is budgeted to decline to Rs 16.1 lakh crore (4.9% of GDP) this fiscal from Rs 16.5 lakh crore (5.6% of GDP) in fiscal 2024. Accordingly, the government's gross market borrowings through dated securities are expected to be Rs 14 lakh crore, 9.2% lower on-year.
- Crude oil prices are expected to remain benign, comforting yields. CRISIL MI&A Consulting expects crude oil prices to remain in the $80-85 per barrel range (revised down from the earlier forecast of $83-88 per barrel) compared with an average of $83 per barrel last fiscal.
- The inclusion of Indian government bonds in global bond indices will contribute to a decline in yields, as the move is likely to increase foreign demand for Indian yields. Bloomberg will be including Indian government bonds in its Emerging Markets Local Currency Index from January 2025, while the JP Morgan Emerging Market Bond Index has already started including the Indian bonds from June 2024. Foreign portfolio investor (FPI) inflows into debt have reached a six-year high.

Overall, CRISIL MI&A Consulting expects the yield on the 10-year benchmark G-sec to decline to an average 6.7% in March 2025 (from 7.1% in March 2024), revised down from earlier forecast of 6.8%. The downward revision is mainly due to a downward revision in the crude oil forecast and sharper rate cuts in the US than previously expected.

1.8.4 Per capita national income

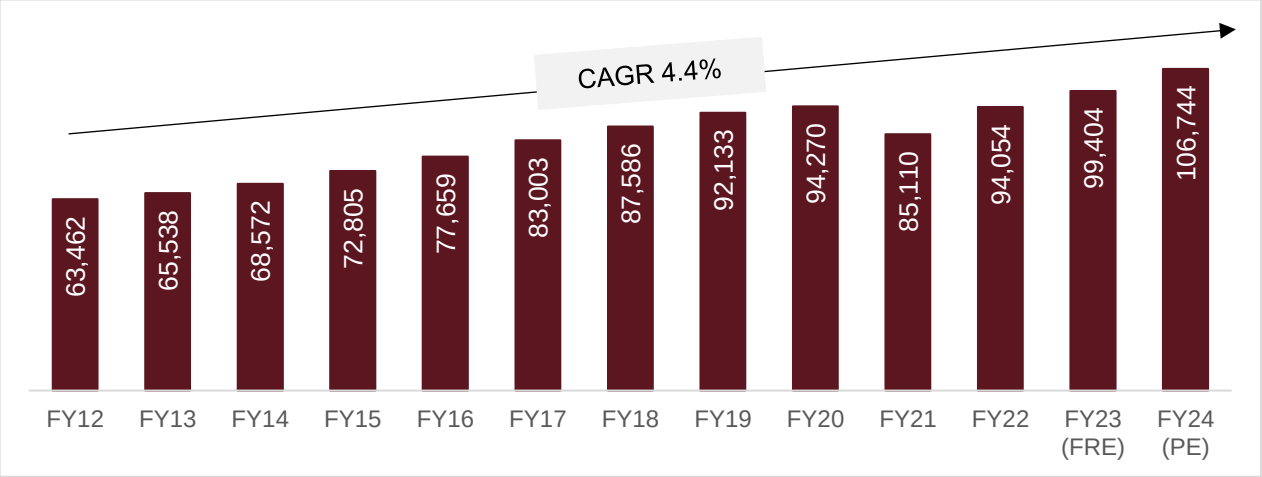
The national income is the total amount of income accrued to a nation from various economic activities during a specified period which is generally taken as a year's time. National income helps to understand the standard of living of the people residing in a nation. It also helps in economical decision making. The more the national income, the more the economic growth.

India's per capita income is expected to rise to Rs 106,744 in fiscal 2024 from Rs 63,462 in fiscal 2012 with a compound annual growth rate of 4.4%. In fiscal 2024, per capita income is expected to rise by 7.4% against 5.7% in fiscal 2023.

Some of the reasons for India's poor national income are its large population, largely agrarian economy, lack of industrial development as well as difference in socioeconomic conditions across the

states. However, recent fiscal measures, emphasis on manufacturing through 'Make in India' and various packages for economic revival have helped India to grow faster. Opportunities for employment, increased private consumption along with positive consumer sentiments are expected to support higher GDP growth and per capita national income in future.

Figure 13: All-India per capita NNI at constant prices

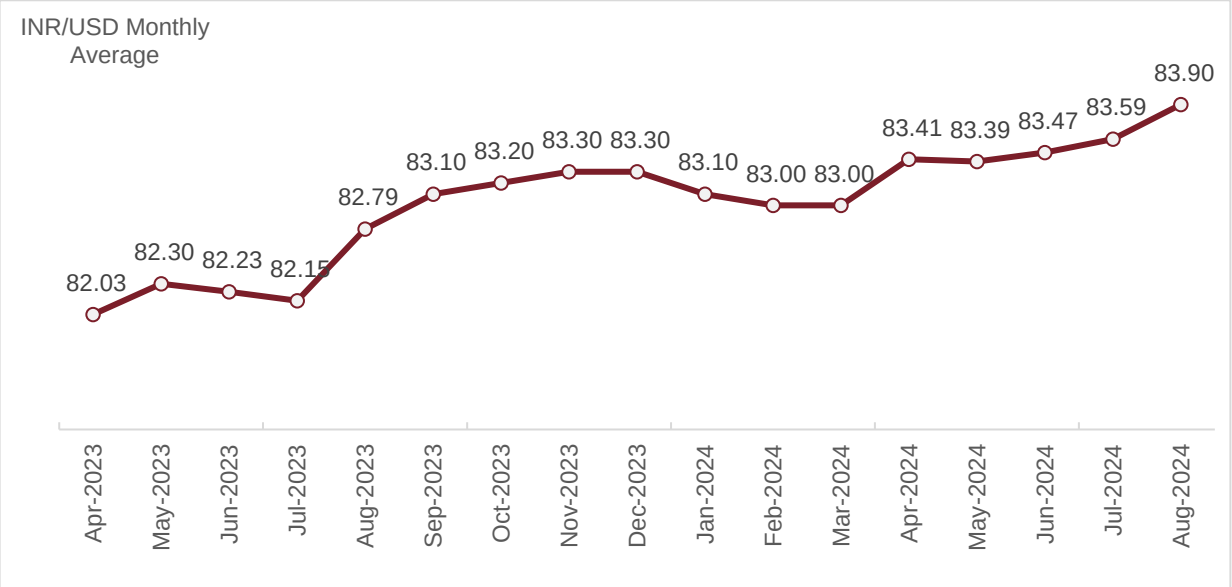


Note: FRE – First Revised estimates; PE – Provisional estimates
Source: RBI, Economic Survey 2022-23; CRISIL MI&A Consulting

1.8.5 Currency

The rupee averaged 83.9/$ in August 2024 compared with 83.6/$ a month earlier. The dollar index weakened to 102.2 in August 2024 from 104.6 in July, the trade deficit was wider ($29.7 billion from $23.6 billion) led by higher imports while August saw lower FPI inflows. The rupee depreciated 1.3% on-year, against a 4.1% on-year fall in August 2023. So far in 2024, the rupee has been one of the better performing emerging market currencies, seeing only a 0.9% decline, on average, against the dollar..

Figure 14: Rupee remains stable



Source: Financial Benchmarks India Pvt Ltd, CEIC, CRISIL MI&A Consulting

CRISIL MI&A Consulting expects the rupee to average 84 against the dollar by March 2025 compared with 83 in fiscal 2024.

1.9 *Aatmanirbhar Bharat* Abhiyan

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

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 5: Sector-wise focus of *Aatmanirbhar Bharat*

Sector	Government spend	Key schemes
Renewable energy	~Rs 1,30,000 crore	• Rs 4,500 crore Production Linked Incentive Scheme 'National Programme on High Efficiency Solar PV Modules'. This was further increased by Rs 19,500 crore in the budget for fiscal 2023, taking it to Rs 24,000 crore; in Tranche I 8.7 GW and in Tranche II 39.6 GW capacity were allocated for domestic solar module manufacturing capacity under PLI. • PM Surya Ghar Muft Bijli Yojna: This scheme has a proposed outlay of Rs. 75,000 Crore and aims to light up

Sector	Government spend	Key schemes
		1 crore households (rooftop solar) by providing up to 300 units of free electricity every month. • Public procurement (Preference for 'Make in India') to provide for purchase preference (linked with local content) in respect of renewable energy (RE) sector • Implementation of Pradhan Mantri Kisan Urja Suraksha Utthan Mahabhiyan (PM KUSUM) scheme; MNRE, in November 2020, scaled up and expanded the PM KUSUM scheme to add 30.8 GW by 2022 with central financial support of Rs 34,422 crore. The scheme has been extended till March 31, 2026 • Approved Models & Manufacturers of Solar Photovoltaic Modules (Requirement for Compulsory Registration) Order, 2019 • List of manufacturers and models of solar PV modules recommended under ALMM Order • Scheme of grid connected wind-solar hybrid power projects • Basic customs duty (BCD) of 25% on solar cells and 40% on modules, respectively, effective April 1, 2022
Power distribution companies (discoms)	~Rs.97,000 Crore	• Rs 1.35 lakh crore liquidity infusion for discoms via Power Finance Corporation/ Rural Electrification Corporation (PFC/ REC) against receivables • Rebate for payment to be received by generation companies (gencos) to be passed on to industrial customers • Revamped distribution sector scheme (RDSS) to help discoms improve their operational efficiencies and financial sustainability by providing result-linked financial assistance; outlay of Rs 3,03,758 crore over 5 years i.e., fiscals 2022 to 2026. The outlay includes an estimated Government Budgetary Support (GBS) of Rs 97,631 crore.
Agriculture procurement and sales	Rs 4,000 crore	• Amendment in the Essential Commodities Act for deregulation of sales of agriculture produce, including field crops, onion, and potato • Working capital limit of Rs 6,700 crore sanctioned for procurement of food grains to state government entities • Rs 3,500 crore allocated for the distribution of 5 kg rice/wheat and 1 kg pulses to 8 crore non-card holder migrants • Rs 500 crore allocated under Operation Greens for facilitation of sales of horticulture produce through 50% subsidy on storage and transport
Agri-allied	Rs 72,500 crore	• Additional allocation of Rs 40,000 crore for Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA)

Sector	Government spend	Key schemes
		• Rs 20,000 crore for fisherman over the next five years under Pradhan Mantri Matsya Sampada Yojana • Rs 13,343 crore for eradication of foot and mouth disease in Indian livestock population • Rs 15,000 crore for Animal Husbandry Infrastructure Development Fund (AHIDF) • Rs 4,000 crore for enhanced cultivation of herbal and medicinal plants • Rs 500 crore for the Indian apiculture industry • Rs 10,000 crore for formulation of micro food enterprises
Mining	Nil	• Expected to offer 500 mineral blocks, including 50 coal • Promoting commercial coal mining (ordinance to remove captive end-use restriction passed in January 2020); government to expedite policy formulation and auction process • Government to allow composite exploration/auction of coal bed methane reserves for extraction • Rebate offered on revenue sharing quantum to incentivise early operationalisation/ higher produce • Provision of Rs 50,000 crore for evacuation infrastructure
New Energy	Rs. ~38,800 Crore	• Rs 18,100 crore under PLI scheme for Advanced Chemistry Cell (ACC) Battery Storage in India launched in October to achieve 50 GWh manufacturing capacity • Green Hydrogen Policy launched in February 2022 to facilitate production of green hydrogen/green ammonia • PLI scheme on green hydrogen manufacturing with an initial outlay of Rs 19,744 crore with an aim to boost domestic production of green hydrogen

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

2 Overview of global solar and Indian power market

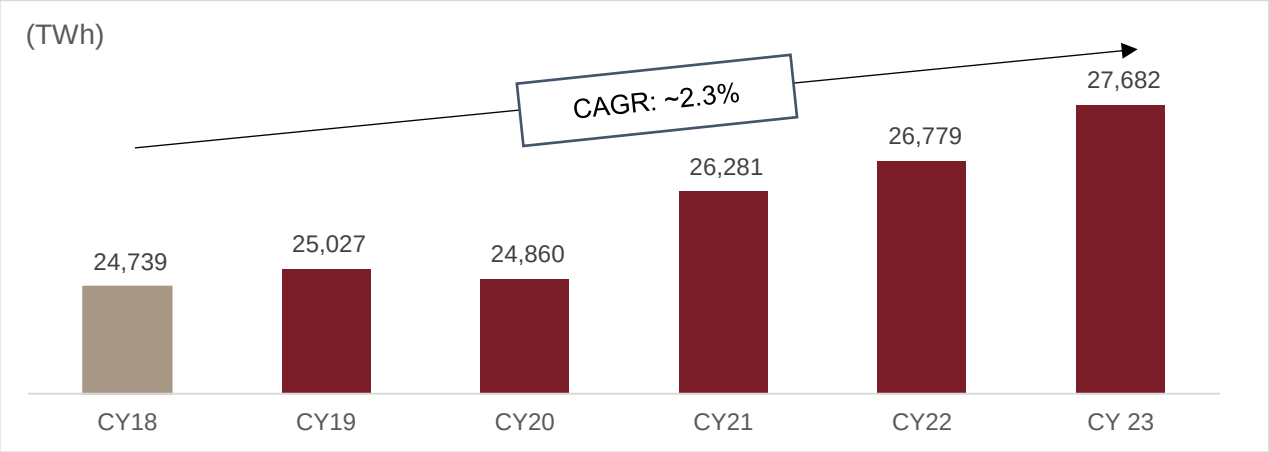
Executive Summary:

- Electricity Demand rose by almost ~3.4% in 2023 compared with the 2.3% average growth rate seen over the period 2019 to 2023.
- Renewables and nuclear energy will provide more than 90% of the new electricity needed over the next three years.
- China accounts for more than 45% of the growth in renewable generation in the period 2023-2025, followed by the EU with 15%.
- Globally ~347 GW of solar PV capacity was added in 2023, taking the installed capacity to 1,411 GW, which is a ~33% increase over the previous year.
- China continues to dominate the solar PV market, accounting for about 43% of the global installed capacity, while key European countries control about 18% of the total solar PV installed capacity.
- As per IEA analysis, the cumulative Solar PV capacity is expected to triple to 2,733 GW by 2028, surpassing hydropower in 2024, natural gas in 2026, and coal in 2027 to become the largest installed electricity capacity worldwide.
- India's power demand to log a healthy growth of 5.0-6.0% CAGR between fiscals 2024 and 2029.India's power generation is expected to grow at 5.5–5.7% CAGR between fiscals 2024 and 2029.In India, the share of renewable capacity (including large hydro and BESS) from 33% in fiscal 2024 to ~50% in fiscal 2029. The share of coal would reduce to 36% from 49% currently over the same period.
- CRISIL MI&A Consulting expects investments of Rs 24.5-25.5 trillion in the power sector over the next five years

2.1 Overview of the Global Energy demand

Global electricity demand grew by ~3.4% (+903 TWh) in 2023, similar to the average growth of 2.3% in the last five years (CAGR from CY19 to CY23). Last year's increase was largely driven by demand increases in major economies. Three of the major economies namely China, US and India accounted for more than 90% of global demand growth. Electricity demand saw an increase of ~6% in CY21 the biggest annual increase since 2010 indicating a rebound in many economies following the pandemic. The war in Ukraine has caused energy prices to skyrocket, economic growth to slow, and inflation to rise. The cost of electricity generation increased around the world due to higher fuel prices, which led to a decrease in electricity consumption in many regions. Despite the worsening crisis, the global demand for electricity remained relatively stable, increasing by almost 3.4% in 2023 from 2022 registering a CAGR of 2.3% from CY19 to CY23 as mentioned in the chart below.

Figure 15: Overview of global energy consumption



Source: IEA, CRISIL MI&A Consulting

As per IEA, Renewables and nuclear energy will dominate the growth of global electricity supply over the next three years, together meeting on average more than 90% of the additional demand. China accounts for more than 45% of the growth in renewable generation in the period 2023-2025, followed by the EU with 15%. The substantial growth of renewables will need to be accompanied by accelerated investments in grids and flexibility for their successful integration into the power systems. The increase in nuclear output results from an expected recovery in French nuclear generation as more plants complete their scheduled maintenance, and from new plants starting operations, largely in Asia.

Global electricity generation from both natural gas and coal is expected to remain broadly flat between 2022 and 2025. While gas-fired generation in the European Union is forecast to decline, significant growth in the Middle East will partly offset this decrease. Similarly, drops in coal-fired generation in Europe and the Americas will be matched by a rise in Asia Pacific. However, the trends in fossil-fired generation remain subject to developments in the global economy, weather events, fuel prices and government policies. Developments in China, where more than half of the world's coalfired generation occurs, will remain a key factor.

2.2 Key factors for demand growth in the identified countries

1. USA

The US is the largest economy in the world in nominal terms and the second largest in PPP terms. It is a highly developed and industrialised nation. Amid a globalising market and economic boom, the country grew rapidly, and stock markets boomed. Although the dotcom bubble and housing market bust bled the economy, it has grown ever since.

US coal-fired power generation capacity has been steadily declining in recent years as utilities and plant owners retire coal-fired units in an effort to reduce greenhouse gas emissions and due to economic competition from gas and renewable energy resources. According to S&P Global Market Intelligence data, ~16.0 GW was shuttered permanently in the U.S. in 2022, up 50.7% from the 10.6 GW retired in 2021. Power generators have shut down 86.2 GW of coal capacity since 2015, an average of 10.8 GW per year. The falling price of renewable energy, a boom in low-priced natural gas production, and clean air and water regulations have long pressured the declining U.S. coal sector. Counting only plants with announced retirement years, U.S. coal generating capacity will fall to below 100 GW as soon as 2037, down from about 283 GW at the end of 2015. Many of those retirements are frontloaded, with particularly large drop-offs expected in 2025, 2027 and 2028.

Each state has a separate incentive and obligatory mechanism to boost solar power in the form of net metering and purchase of RECs. State policies direct the obligatory power purchased from renewable and have constant upgradation of targets for the purchase. This is resulting in increased adoption of renewable generation. In addition, rooftop installations with net metering have been widely adopted. State mandates for renewable electricity have fueled the growth of utility-scale projects; the largest of these are materialising in western US, particularly in California, Arizona and Nevada. States of California, Arizona, North Carolina, New Jersey and Nevada are leading the country's solar PV installations.

In January 2018, the US imposed 30% anti-dumping duty on Chinese solar panels. In March 2018, the US also imposed 25% import tariff on solar cells and modules from China. As a result, imports of Chinese panels declined, and prices of domestically produced panels increased. The Office of the US Trade Representative has exempted bifacial and some other types of solar panels from the levy of 25% newly imposed safeguard duty. In February 2022, the USA Government extended tariffs on imported solar cells and panels for another four years (upto 2026), but with several changes to existing provisions. Exemption given to bifacial solar panels from the duty extension shall be continued and the allowable import quota for solar cells increased from 2.5 GW to 5 GW.

The US is expected to add more than 67 GW of renewable generation in 2024 as policy and economics drive an energy transition that has grid operators keyed in on clearing clogged interconnection queues., according to an S&P Global Market Intelligence analysis. More than 56 GW of solar generation (incl. Utility scale, Distributed Systems and concentrated), alone is projected to come online in 2024, continuing to spur a trend of renewables domination buoyed by state regulation and federal incentives, according to an analysis of S&P Global Market Intelligence data. Nearly 11 GW of wind generation is expected to come online in 2024, while planned energy storage additions will ramp up to 21 GW, the analysis showed. As per IRENA Renewable Capacity Statistics, the USA added around 24 GW of Utility scale Solar PV Capacity.

2. Canada

As of December 31, 2022, Canada had an installed capacity of more than 19 GW of utility-scale wind and solar energy. Overall, the wind, solar and energy storage sectors grew by 10.5% this year. Canada added more than 1.8 GW of new generation capacity in 2022, significantly larger than last year's growth (1 GW in 2021). Solar energy grew by 25.9% (810 MW) in 2022, to a new total installed capacity of nearly 4 GW. More than a quarter of Canada's current solar capacity was installed in 2022. Alberta accounts for almost all this growth, with 759 MW of 771 MW. Saskatchewan installed 10 MW, Nova Scotia 2 MW, and Yukon 0.1 MW this year. As of December 31, 2022, Ontario had more than 1.9 GW of installed solar PV capacity.

As per Canada RE Association, the industry added 2.3 GW of new installed capacity in 2023, including more than 1.7 GW of new utility-scale wind, nearly 360 MW of new utility-scale solar, 86 MW of new on-site solar, and 140 MW / 190 MWh of energy storage. Canada has a total installed capacity of more than 21.9 GW as on 31st January 2023, including 20.4 GW of utility-scale wind and solar energy, 1.2 GW of on-site solar and 356 MW / 539 MWh of energy storage nationwide.

Canada Energy Regulator, the share of coal-fired power generation is expected to decline from 16% in 2005 to less than 1% in 2040. Over the past few years, the federal government has put in place strict emissions requirements that will require coal-fired power plants to be shut down at the end-of-life or retrofitted with carbon capture and storage technology. These retiring coal-fired power plants will be replaced by renewable and low-carbon energy sources.

The Government of Canada has established a target to achieve 90% non-emitting electricity generation by 2030. Through regulations to accelerate the phase out of conventional coal-fired electricity generation, expected cumulative GHG reductions are 94 million tonnes (2019 – 2055). These regulations will achieve 12.8 million tonnes of emissions reductions in 2030.

The Emerging Renewable Power Program provides up to $200 million to expand the portfolio of commercially viable RE sources available to provinces and territories as they work to reduce greenhouse gas (GHG) emissions from their electricity sectors. Emerging renewable projects face higher risks, costs and more regulatory issues than projects using established RE sources. This programme mitigates the risk of emerging renewable power projects through federal government funding, allowing emerging renewables to play a larger role in Canada's electricity supply mix. The programme will establish new industries in Canada by supporting renewable power technologies that are:

- Already established at the commercial level abroad, but not yet in Canada
- Demonstrated in Canada, but not yet deployed at the utility scale

The Pan-Canadian Framework on Clean Growth and Climate Change has been developed to meet emission-reduction targets, boost economic growth, and build resilience to a changing climate.

The Government of Canada will work with the provinces and territories to:

- Phase out coal-fired electricity by 2030
- Set performance standards for natural gas-fired electricity generation
- Invest in clean energy
- Invest in energy storage and smart grid technologies to build a modern electricity system.

3. European Union (EU)

The EU is a political and economic union of 27 member states located primarily in Europe. The United Kingdom (UK) withdrew from the EU on January 31, 2020.

Since the implementation of the Renewable Energy Directive in 2009, there has been a notable increase in the share of renewable energy sources in overall energy consumption across Europe. From 2010 to 2021, the share of renewables in energy consumption rose from 12.5% to 21.8%.

Among European countries, Sweden currently leads in terms of the highest share of renewables in energy consumption, with an impressive figure of 62.6%. Finland follows closely with a share of 43.1%, and Latvia ranks third with a share of 42.1%.

In July 2021, the European Commission put forth a proposal for the revision of the Renewable Energy Directive as part of the 'Fit for 55' package aiming to align the European Union with the objectives of the European Green Deal. The new target proposed in the revision raised the share of renewables to 40%, an increase from the previous target of 32%.

The EU proposed the REPowerEU plan in May 2022 to end its reliance on Russian fossil fuels by 2027 by increasing the share of renewables in final energy consumption to 45% by 2030.

On March 30, 2023, a provisional agreement was reached among the European Union institutions regarding the binding target for renewable energy for the year 2030. The agreement sets a minimum target of at least 42.5% for the share of renewable energy in the EU's energy consumption by 2030. However, there is an ambitious aim to reach a target of 45%.

4. Africa

Africa is the second most populous continent in the world, behind Asia. It covers 6% of the world's geographical surface area and is home to more than 1.2 billion people. However, it continues to lag, with rampant poverty, illiteracy and poor human development indices. Prolonged policy paralysis has curbed development in the region.

Several African economies depend on international capital markets and debt financing to sustain investments and growth. Also, the continent's major exports are commodities. With the global boom in commodity prices coming to an end, prices of many of Africa's exports, such as gold, oil, and coffee, have fallen significantly.

Together these factors have had a bearing on Africa's current account position. Many countries have responded by lowering government spending and recurrent expenditures. However, to contain the rise in debt levels, sustained fiscal consolidation is necessary.

Africa has abundant RE resources. From traditional hydro power, it is now moving towards solar (both off-grid as well as grid connected). With rapid decrease in costs, solar PV can be the solution for electrification of unelectrified areas. Various countries from the continent with good solar potential, have started to take policy initiatives, adopt targets and formulated regulatory frameworks to increase penetration of solar PV. Off-grid solar solutions have played a major role in providing energy access to millions of people in Sub-Saharan Africa. Policymakers, private investors and end users alike have embraced off-grid solar products as an affordable and sustainable solution for electricity access.

The Integrated Resource Plan 2019, prepared by the Department of Mineral Resources and Energy, South Africa, has set targets of 11.5 GW for wind, 8 GW for solar PV and 600 MW for CSP by 2030, including addition of 5.6 GW in solar PV and 8.2GW of wind capacities over 2025-2030.

Africa possesses abundant solar resources, with approximately 60% of the world's best solar resources located on the continent. However, despite this immense potential, Africa currently has only 1% of its electricity generated from solar photovoltaic (PV) capacity.

Solar energy in Africa is already the most affordable source of power in many regions, and its cost competitiveness is expected to increase further in the coming years. By 2030, solar power is projected to outcompete all other energy sources across the continent.

In the Sustainable Africa Scenario, which focuses on sustainable development and clean energy, renewables, including solar, wind, hydropower, and geothermal, are anticipated to account for over 80% of new power generation capacity added by 2030. This highlights the significant role that renewable energy, particularly solar, will play in Africa's energy transition and the expansion of its power generation infrastructure.

5. Middle East

The Middle East is a transcontinental region centered in Western Africa. Saudi Arabia is the largest nation in the group, while Bahrain is the smallest. The nations in the group are disproportionate in terms of wealth with countries like Gaza and Yemen being very poor and countries like Qatar and United Arab Emirates (UAE) being wealthy. Some nations like Saudi Arabia and Kuwait are highly dependent on oil and oil-related exports, while other countries like Cyprus, Israel and Turkey have a diverse economic base. The Middle East's economic performance has been skewed over the years.

The OPEC+ alliance had announced oil output cuts, meaning that major MENA energy producers would sell less oil in the near term than during a large part of 2022. Brent oil prices are expected to drop from about USD102 per barrel in 2022 to USD87-88 per barrel in 2023 and 2024, reducing the petrodollar inflows into MENA oil-exporting countries when compared to 2022. Lower energy revenues will translate into less firepower to kick-start new ventures and embark upon fixed investment spending for MENA economies, having adverse repercussions on real GDP growth momentum.

With solar power tariffs reaching grid parity, solar power has been gaining significance in the Middle East region. Considerable population growth and increased industrialisation and developments have put stress on the existing power network, which has helped affordable renewable solutions find a comfortable place in the region. Various government policy supports as well as requirement of use of maximum RE sources, will drive the solar market in the region. However, delay in the commissioning of solar projects is a major worry.

Oman is working to increase its use of renewable energy. The country's Vision 2040 plan aims to increase the share of renewable energy in the country's electricity generation mix from 1% today to 20% by 2030 and to 35-39% by 2040.

In Oman, the main procurement activities for power projects in 2022 include: (1) completion of Manah Solar I & II IPPs procurement; and (2) procurement commencement of MIS Solar IPP 2025, Duqm Wind IPP 2025, Jalaan Bani bu Ali Wind IPP 2025, Dhofar II Wind IPP 2026, and Waste to Energy IPP. Beyond 2022, future procurement initiatives include additional RE IPPs, and potentially a Power 2024 and 2028 procurement rounds.

The UAE has set a target of achieving net-zero emissions by 2050. To support this goal, the UAE aims to install 14 GW of clean energy capacity by 2030. Saudi Arabia has set a similar target of reaching net-zero emissions by 2060. To support its transition towards cleaner energy sources, Saudi Arabia plans to install 58 GW of renewable energy capacity by 2030. Bahrain has also committed to achieving net-zero emissions by 2060. As part of its efforts, Bahrain aims to have renewables account for 10% of its power generation by 2035. Qatar aims to reduce its emissions by 25% by 2030. To contribute to this goal, Qatar plans to have renewables responsible for 20% of its power generation by 2030.

These targets and goals reflect the commitment of these countries in the region to transition to more sustainable energy systems and mitigate climate change by reducing greenhouse gas emissions and increasing the share of renewable energy in their respective energy mixes.

6. China

In China, solar PV capacity addition dropped to ~30 GW in 2019 from 44 GW in 2018. However, with ~50 GW addition, the country led solar PV installations in 2020 and 2021, with ~35% of the installation happening in the country in both years. However, in 2022, China bounced back and added ~87 GW (~37% of total global installed capacity). The total capacity increased 28 per cent y-o-y to 393 GW in 2022 making China the leader in the solar PV market as compared to a growth of 21 per cent from ~306 GW in 2021. Government policies, falling costs, increased awareness of climate change, technological advances are some of the reasons for significant capacity additions in China.

In 2021, China has decided to stop subsidies for new solar power stations and distributed solar projects by commercial users. This is in the backdrop of faster development; availability of cheaper panels and competitive rates close to coal-fired capacity. Electricity generated from the new projects will be sold at local benchmark coal-fired power prices or at market prices, w.e.f. August 1, 2021. However, local governments are encouraged to develop localised policy instruments supporting all types of renewable projects.

China continued to add significant amounts of solar capacity in the coming years, as it strives to meet its ambitious renewable energy targets. China added a whopping 217 GW of solar capacity during CY2023 which is ~60% of the global solar capacity additions. This would mean China would continue to remain one of the largest solar markets going forward however, its pace would slacken compared to its previous growth.

7. Japan

The Government of Japan has formulated the Strategic Energy Plan to show the direction of Japan's energy policy under the Basic Act on Energy Policy. Under the plan, renewables should account for 36-38% of power supplies in 2030, double 2019’s level and well above its previous 2030 target for 22-24%.

In Japan, installed solar PV capacity grew significantly 10% on-year to ~69.8 GW by the end of 2020. The country added ~6.6 GW of solar PV capacity in 2020. With addition of ~4.6 GW in 2022 and ~4.4 GW in 2021, the installed capacity stood at ~78.8 GW by the end of 2022. Growth in PV installations has been driven by the introduction of feed-in tariffs in July 2012. Moreover, a significant increase in utility and commercial installations also led to healthy growth.

In May 2022, Ministry of the Environment and the Association for the Advancement of Environmental Technology Promotion announced that they would support the introduction of solar power generation equipment that utilizes farmland, reservoirs, and waste disposal sites. Disposal site) Utilization business subsidy" started public offering. The subsidy rate was 1/2 of the target expenses, and the maximum subsidy amount was 300 million yen. The first public offering period was until June 17th. The second public offering was from June 27th to July 27th. Facilities eligible for subsidies include solar power generation facilities, stationary storage batteries (for business/industrial use and household use), private lines, energy management systems (EMS), and power receiving and transforming facilities.

In January 2023, Japan's Agency for Natural Resources and Energy (ANRE) released an interim summary detailing a dual strategy to promote the production and utilization of clean hydrogen and ammonia. This strategy consists of two key initiatives. According to IRENA, Japan reached a cumulative installed PV capacity of 87 GW at the end of 2023. During 2023, the country deployed around 4 GW of new solar capacity.

The first initiative is the Supply Chain Subsidy, which aims to support international hydrogen and ammonia supply chains. Through this subsidy scheme, financial assistance is provided to facilitate the development and operation of supply chains involved in the production, transportation, and distribution of clean hydrogen and ammonia on a global scale.

The second initiative is the Clusters Support scheme, designed to promote the utilization of hydrogen and ammonia within industrial clusters in Japan. This support program focuses on providing assistance and incentives for the implementation of hydrogen and ammonia technologies and infrastructure within designated industrial areas. The goal is to foster the integration of clean energy solutions, specifically hydrogen and ammonia, into various industrial processes, thus reducing carbon emissions and promoting sustainable practices.

These two-pronged approaches reflect Japan's commitment to advancing the adoption of clean hydrogen and ammonia as part of its overall energy transition and decarbonization efforts.

8. Australia

The Australian RE industry has added significant capacity in the past six-seven years. In 2017, just 17% of the country's electricity came from renewables. Now, Australian renewable energy industry accounted for 35.9 per cent of Australia's total electricity generation in 2022, up from 32.5 per cent in 2021. Rooftop solar once again led the charge for Australian renewable energy in terms of capacity added, with 2.7 GW added throughout 2022. With 1.4 GW of new capacity added, wind came in second place. This growth is driven by auctions as well as FiT offerings. Various provincial governments have also come up with their own schemes such as interest-free loans.

As per the Federal Government of Australia, its RE Target aims to achieve at least 33,000 GWh (or 23.5%) of total electricity from RE sources. The RE Target has two schemes: Large-scale RE Target and Small-scale RE Scheme. The former encourages investment in large RE power plants through financial incentives in the form of tradable certificates, while the latter encourages small users to install small-scale systems.

In January 2021 the Renewable Energy Target of 33,000 gigawatt hours of additional renewable energy was met on a 12-month rolling basis. In 2016, Australian Clean Energy Regulator estimated that for the 2020 target to be reached the total new capacity of renewable energy power projects required to be committed through to the end of 2018 was 6,000 megawatts (MW). Due to a higher proportion of solar projects in the pipeline than expected, it estimated that 6,400 MW would now be required to reach the target. In 2023, there was a substantial change in the policy landscape for renewables, including

- Australia joined the global renewables and energy pledge on 3 December 2023. The pledge is to triple the world's installed renewable energy capacity by 2030 and to double the global average annual rate

of energy efficiency improvements. Australia joined at the 28th meeting of the Conference of the Parties (COP28) to the United Nations Framework Convention on Climate Change (UNFCCC).

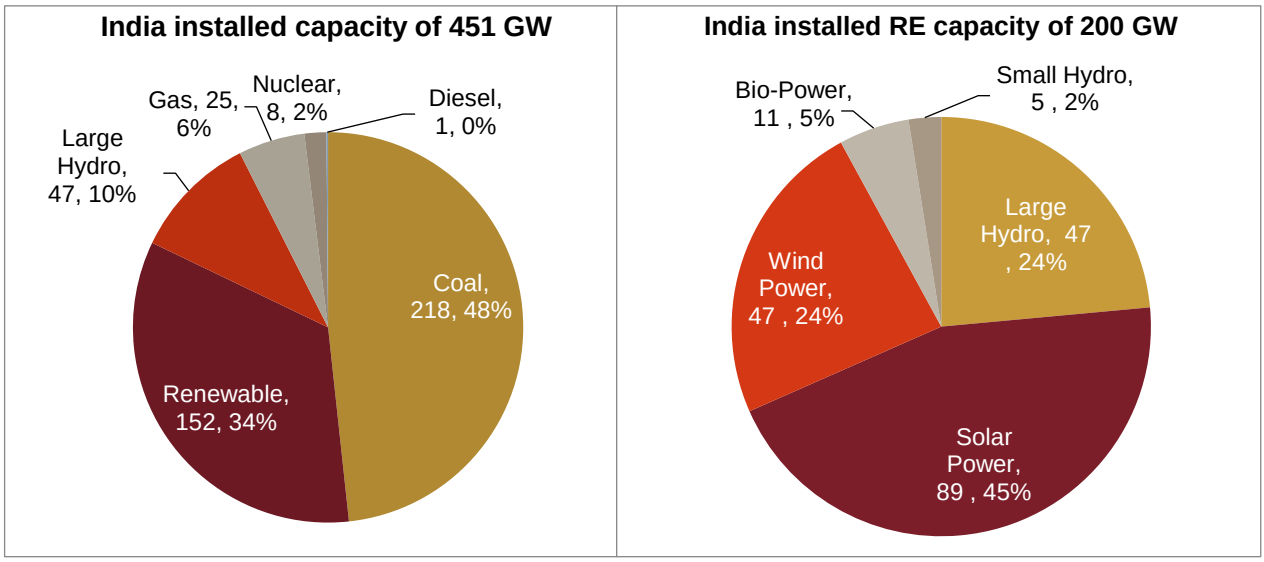
- In November 2023, the Australian Government expanded the Capacity Investment Scheme (CIS) to 32 GW nationally. The CIS covers new renewable energy, storage and other capacity for the grid. The first auction will be held in April to May 2024. Additional projects may reach FID driven by the CIS in 2024.
- In December 2023, the Department of Climate Change, Energy, the Environment and Water (DCCEEW) published the annual climate change statement 2023.

2.3 Review of Indian power demand-supply scenario

2.3.1 Power supply mix

The total installed generation capacity at the end of August 2024 was 451 GW, of which ~99 GW of capacity was added over fiscals 2018-24. The overall installed generation capacity has grown at a CAGR of 6.0% over fiscals 2014– 24. Coal and lignite-based installed power generation capacity has maintained its dominant position over the years and accounts for ~48% as of August 2024. However, RE installations (including large hydroelectric projects), have reached ~200 GW capacity as on August 2024, compared with 63 GW as of March 2012, constituting ~44% of total installed generation capacity as of date. This growth has been led by solar power, which rapidly rose to ~89 GW from 0.9 GW over the same period.

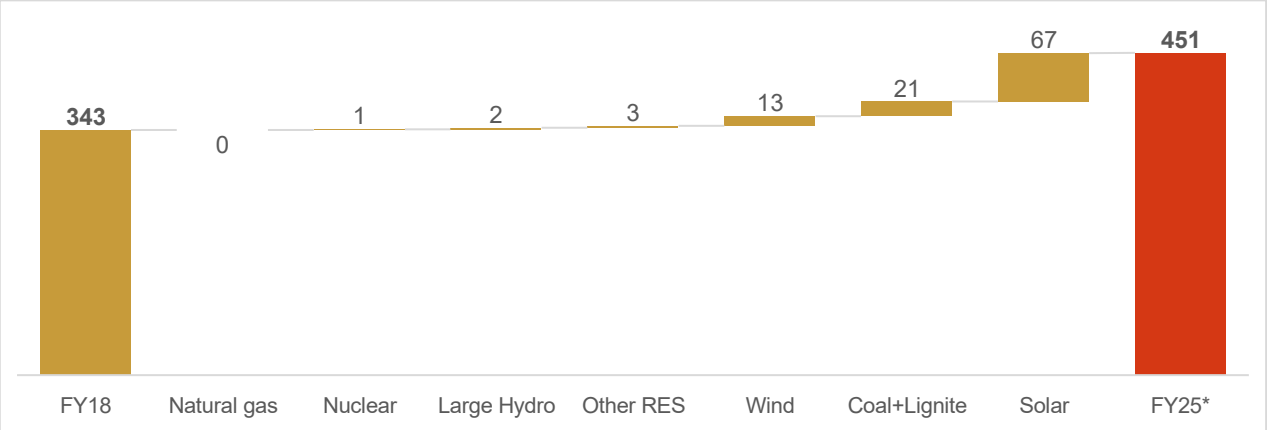
Figure 16: Details of source wise installed capacity as of August 2024 (GW, % share)



Source: CEA, CRISIL MI&A Consulting

The Electricity Act, 2003 and competitive bidding for power procurement, implemented in 2006, encouraged the participation of private market participants that have announced large capacity additions. As a result, capacities of ~142 GW (fiscals 2014-24) were added by the private sector, which accounted for 85.0% of the total additions. Moreover, a strong government thrust on RE and decreasing tariffs (with falling capital costs and improving efficiency) also supported RE capacity additions. Investments from foreign funds participating in fundraising activities into the sector have also enabled growth.

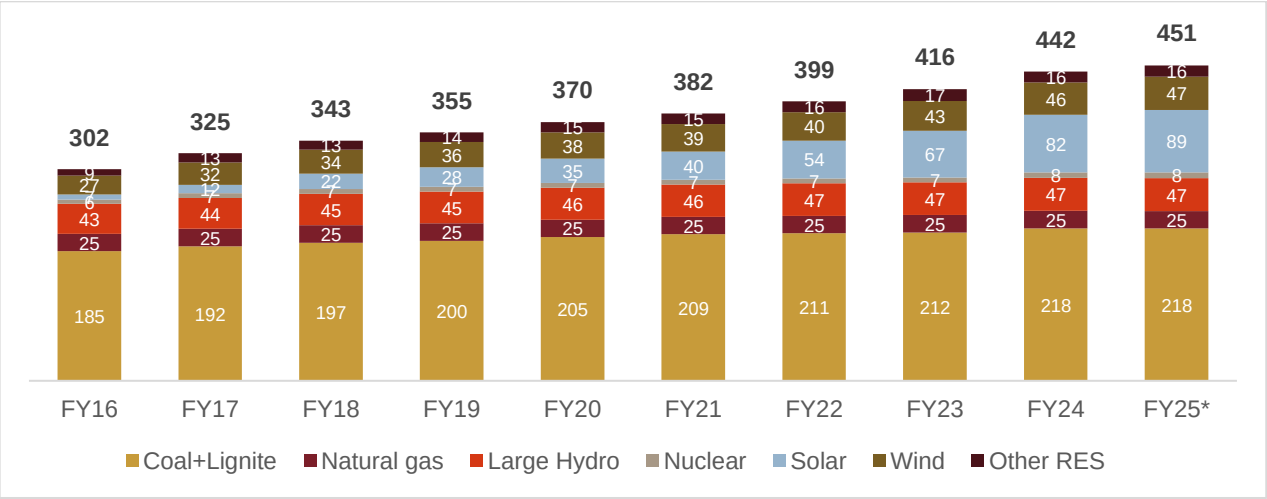
Figure 17: Evolution of all India installed generation capacity (GW)



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

In 2014, the GoI set a target to achieve 175 GW of RE in India by December 2022, with a focus on solar energy (100 GW) and wind energy (60 GW), in addition to other RE sources such as small hydro projects, biomass projects and other renewable technologies (~15 GW).

Figure 18: Fuel-wise installed capacity in past 10 years (GW)



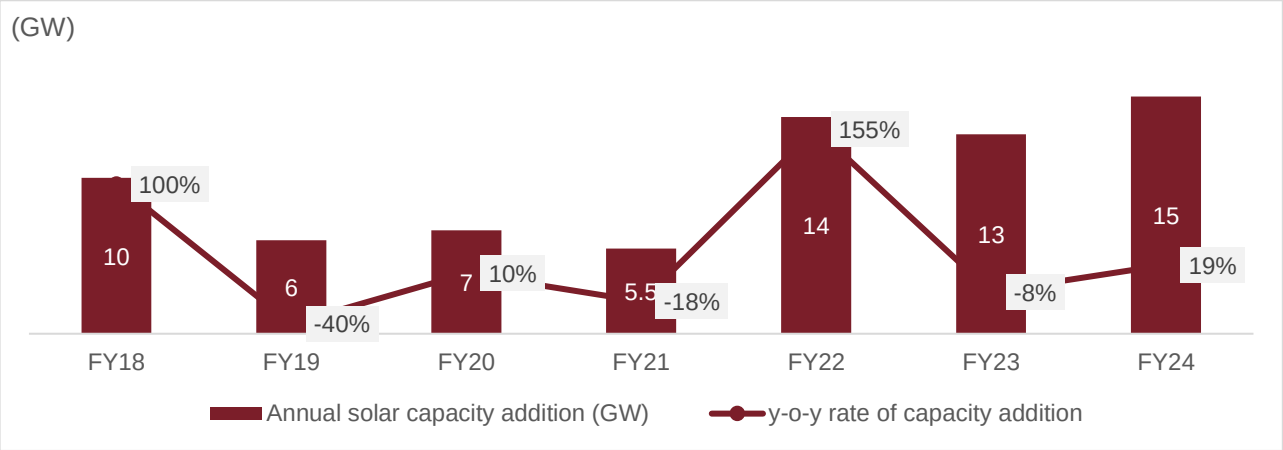
**FY25 data as of August 2024; Other RE sources: Incl. small hydro, biomass/bagasse and waste to energy*
Source: CEA, CRISIL MI&A Consulting

2.3.2 Impact of COVID-19 on capacity addition

The central government enforced a nationwide lockdown in March 2020. During the lockdown, several restrictions were placed on the movement of individuals and economic activity came to a halt. India could install only 82% and 55% of its annual RE capacity addition targets in fiscals 2018 and 2019 — based on the overall 175 GW addition target by fiscal 2022. As of January 2020, 67% of the target for fiscal 2020 had been achieved and the overall capacity of 121 GW was achieved at the end of December 2022, resulting in ~69% of 175 GW target.

Further, COVID-19 affected capacity addition targets for various sources of power owing to the halt in construction activities, disruption in the global supply chain and shortages in key components leading to delays in execution of projects.

Figure 19: Annual addition in solar capacity installation

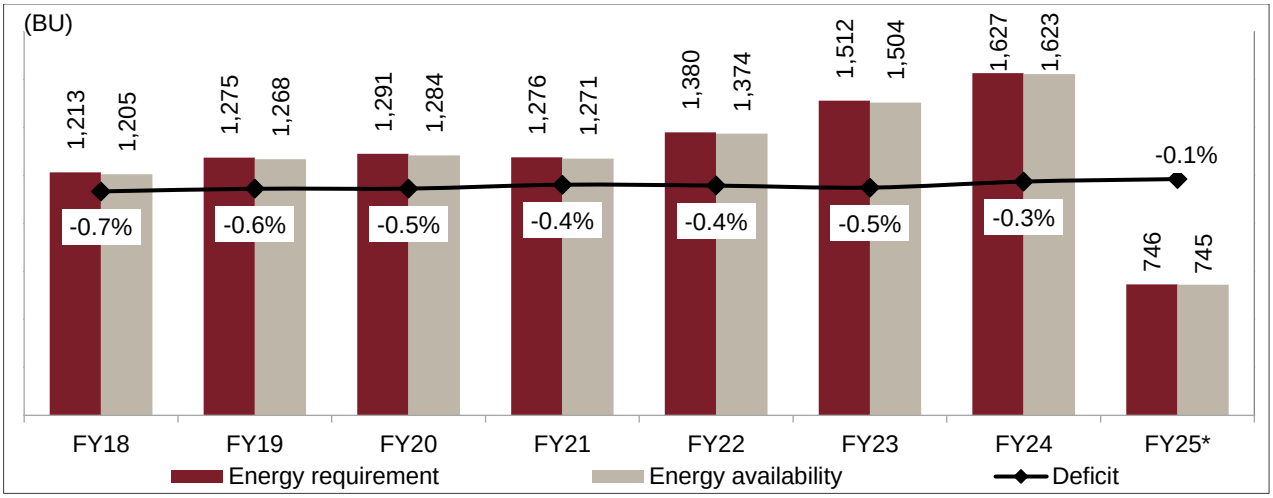


Source: CEA, CRISIL MI&A Consulting

2.3.3 Review of power demand-supply gap

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

Figure 20: Aggregate power demand supply (in billion units, or BUs)

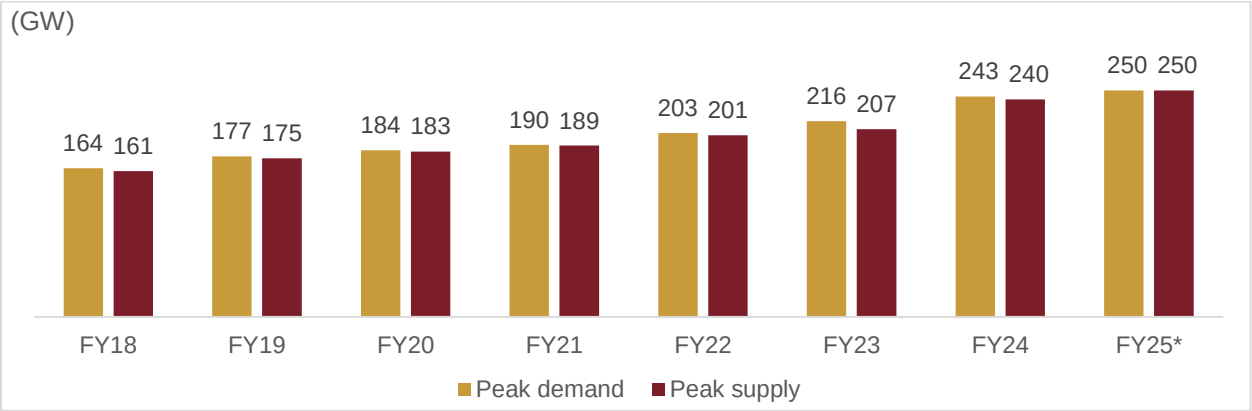


FY25 data as of August 2024; Source: CEA, CRISIL MI&A-Consulting

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

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

Figure 21: Peak power demand and supply



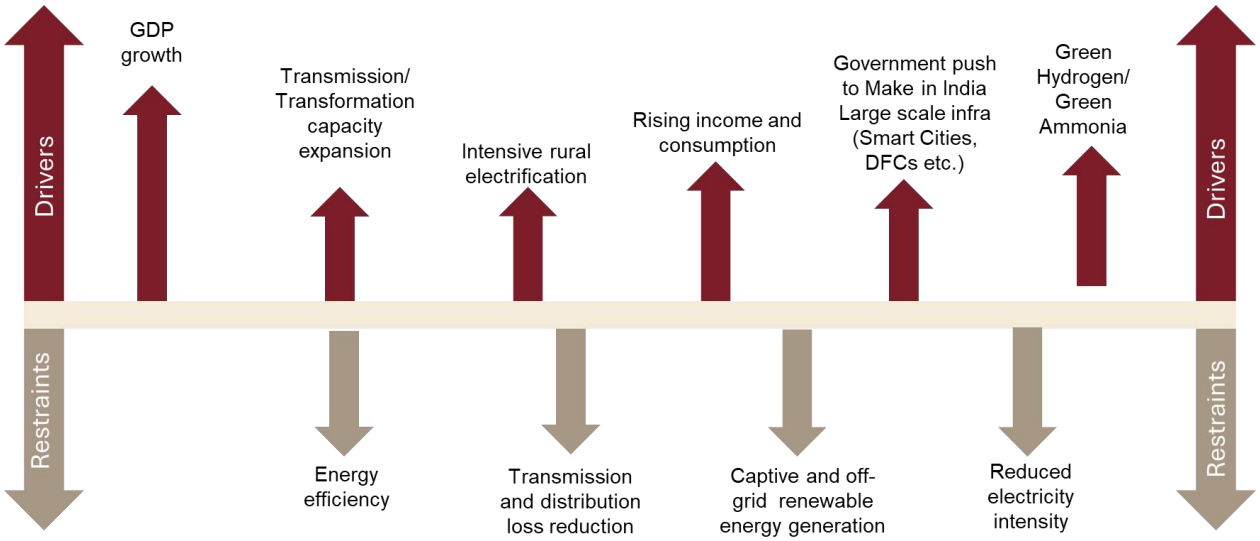
FY25 data as of August 2024; *Source: CEA, CRISIL MI&A-Consulting*

2.4 Demand-supply outlook for India

2.4.1 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 an average GDP growth of 5.8% over the past decade. The trickle-down effect of government spending on infrastructure through the National Infrastructure Pipeline, expansion of the services industry, rapid urbanisation, and increased farm income from agriculture-related reforms are key macroeconomic factors that are expected to foster power demand. Significant policy initiatives such as 24x7 power for all, Sahaj Bijli Har Ghar Yojana (SAUBHAGYA) scheme to provide electricity connections to all households, green energy corridor to facilitate evacuation of RE power, green city scheme to promote the development of sustainable and eco-friendly cities, production linked incentive (PLI) scheme and low corporate tax rates among others are expected to further support power demand in the country.

Figure 22: Factors influencing power demand



Source: CRISIL MI&A

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 carbon emitter by 2030. Therefore, Government aimed to achieve 100% electrification of Indian Railways by fiscal 2025. This leads to incremental power demand of around 23 billion units (BUs) on average every year between fiscal 2025 to 2029. Further, Metro rail has seen substantial growth in India in recent years, and the rate of growth is set to double or triple in the coming years with multiple cities seeking metro rail services to meet daily mobility requirements. As of May 2024, 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.

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 the 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 RDSS. 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 decentralized distributed generation, a reduction of 2-3% in base demand from the grid is expected with the addition of 32-33 GW of rooftop capacities are expected by fiscal 2029. Industries are expected to add ~3-4 GW of captive capacity over the next five years, adding on average 290-300 BUs of demand over the period which may lead to a reduction in demand from the grid.

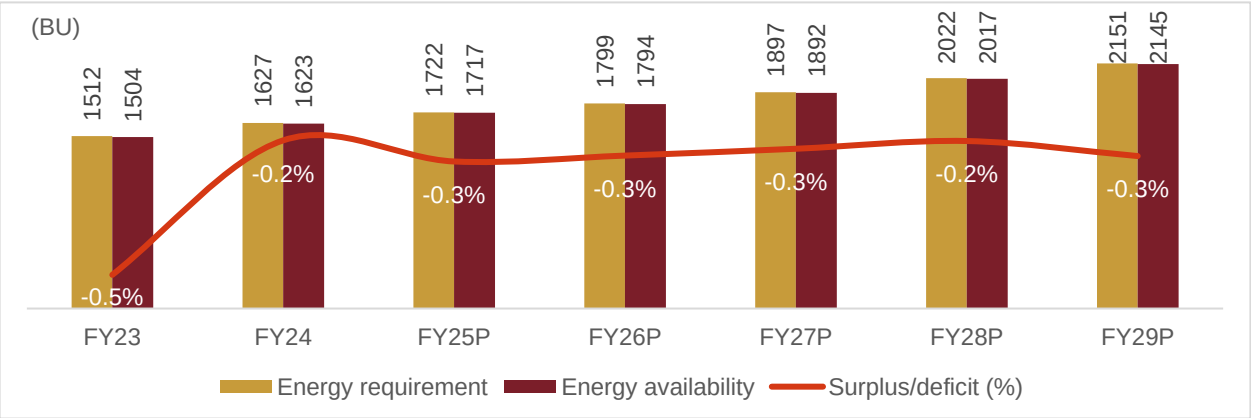
2.4.2 Energy demand-supply forecast

Energy demand to clock 5-7% CAGR over fiscals 2024 to 2029, significantly higher than the 4.5% CAGR over the past 5 years between fiscal 2018-2023. CRISIL MI&A Consulting expects all-India deficit to be in the range of 0.25-0.30% in fiscal 2025 to reduce moderately to 0.25-0.27% by fiscal 2029 on account of increasing renewable capacity additions, transmission line augmentation, and improvement in distribution infrastructure but also countered by a strong growth in base and peak power demand.

Extreme seasonal vagaries, sustained buoyancy in economic activities along with robust industries activities accelerated power demand. Infrastructure-linked capex, strong economic fundamentals along with expansion of the power footprint via strengthening of T&D infrastructure, coupled with major reforms initiated by the GoI for improving the overall health of the power sector, particularly that of state distribution utilities, are expected to improve the quality of power supply, thereby propelling power demand. CRISIL MI&A Consulting expects power demand to log a healthy 5.0-7.0% CAGR between fiscals 2024 and 2029, with the growth trajectory sustaining above the long-term historical growth rate of 5% over the next six years.

Further, the power generation is expected to grow at 5.5 – 5.7% CAGR between fiscals 2024 and 2029. The energy availability across fuels has grown at 5.0% CAGR between fiscals 2018 and 2024, reaching 1,623 BU in fiscal 2023. Despite improvements, underserviced regions (mainly northern, north-eastern, and eastern) are also a key reason for expected continuation in pan-India deficit in the medium term despite an oversupply situation in terms of generation. The government is expected to improve connectivity within these regions, with inter-regional transmission capacity of the National Grid at 116,540 MW as on March 2024, aiding in reduction of the deficit.

Figure 23: Energy demand outlook (fiscals 2023-29)



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

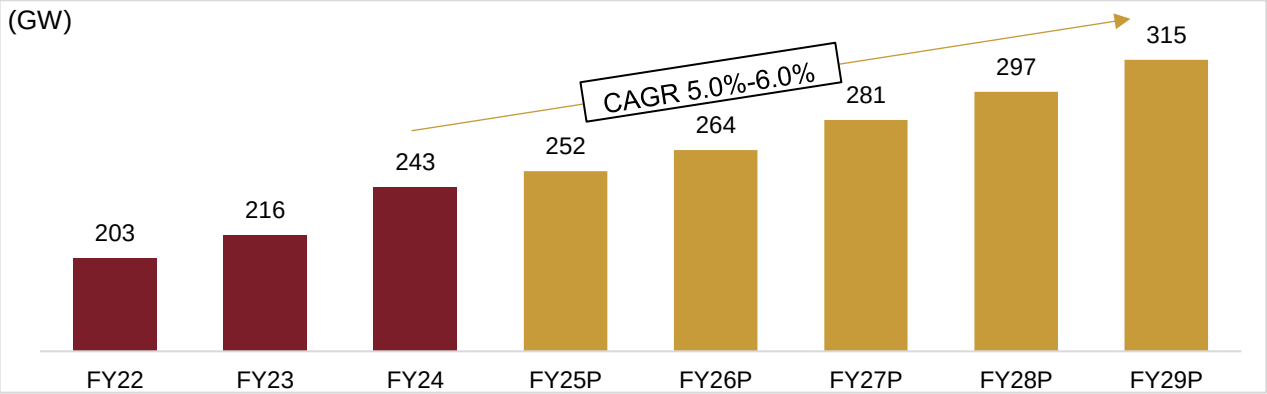
Power demand has breached pre covid levels across all states. C&I segments have also staged sharp recovery after nosediving during pandemic. Broad-based recovery across states will push demand to increase by 1.4 times over the next five years. Growing population, increasing number of connections, 24X7 power supply initiatives by the government and rapid urbanization are some of the primary triggers which will support growth in power demand. Reopening of offices coupled with increased investment in realty sector is also expected to benefit highly commercialized states like Tamil Nadu and Karnataka. Demand uptick in highly industrialized states like Haryana, Punjab, Gujarat, Tamil Nadu is expected to emanate from increasing manufacturing and industrial activity. Several incentive schemes like Production linked incentive (PLI) announced by the government to boost domestic production is expected to further give impetus to manufacturing sector which will in turn increase power demand. Besides this, providing power at subsidized rates in some states, free power to

farmers in states like Andhra Pradesh and Telangana, additional demand from upcoming railway electrification and metro projects are expected to boost power demand in these states as well.

2.4.3 Peak demand outlook

Peak demand has outpaced base demand in several instances. While base demand has grown at a CAGR of nearly 5% over fiscals 2019-24, peak demand has grown at 7%. Even in fiscal 2021 which was marred by the COVID-19 pandemic, base demand entered into negative territory and fell 1.2%, while peak demand grew 3% to 190 GW, which was about half of the country's installed capacity, from almost 184 GW in the prior year. The constant rise in peak demand can be attributed to economic growth, seasonal vagaries, and the increasing daily average temperature India experienced over the last decade leading peak demand to touch 224 GW in June 2024. Peak demand is expected to grow annually at ~5.3% over fiscal 2024-29 to nearly 314 GW by fiscal 2029 with expected persistent high temperatures, rising urbanisation, economic growth and infrastructure push leading to higher power consumption.

Figure 24: Peak demand outlook (fiscals 2021-29)



F: Forecast
Source: CEA, CRISIL MI&A Consulting

2.4.4 Expected capacity installation by fiscal 2029

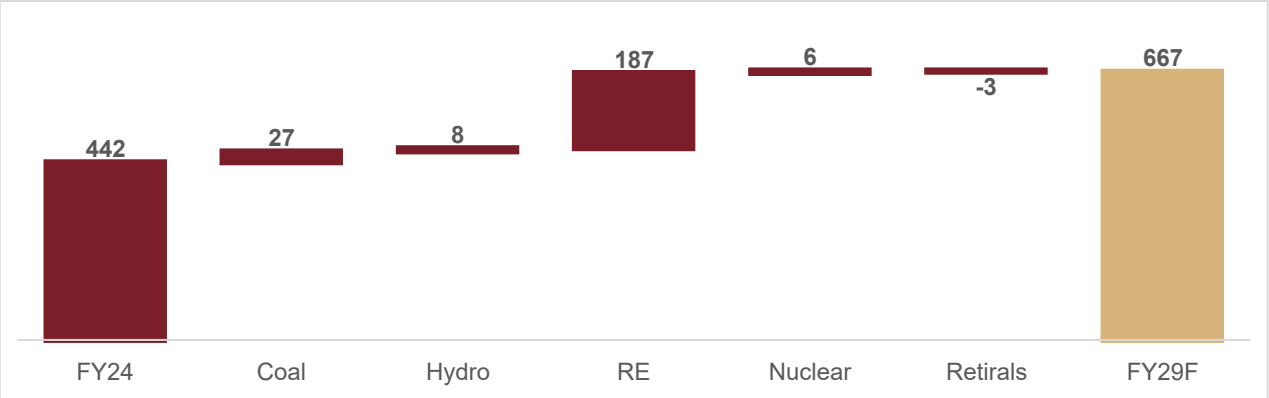
India's installed generation capacity, which stood at 356 GW at the end of fiscal 2019 has reached to ~442 GW in fiscal 2024 and ~451 GW in fiscal 2025 (as of August 2024) on the back of healthy renewable capacity additions (including solar, wind, hybrid, and other renewable sources) even as additions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

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

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

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

Figure 25: All India installed capacity addition by fiscal 2029 (in GW)



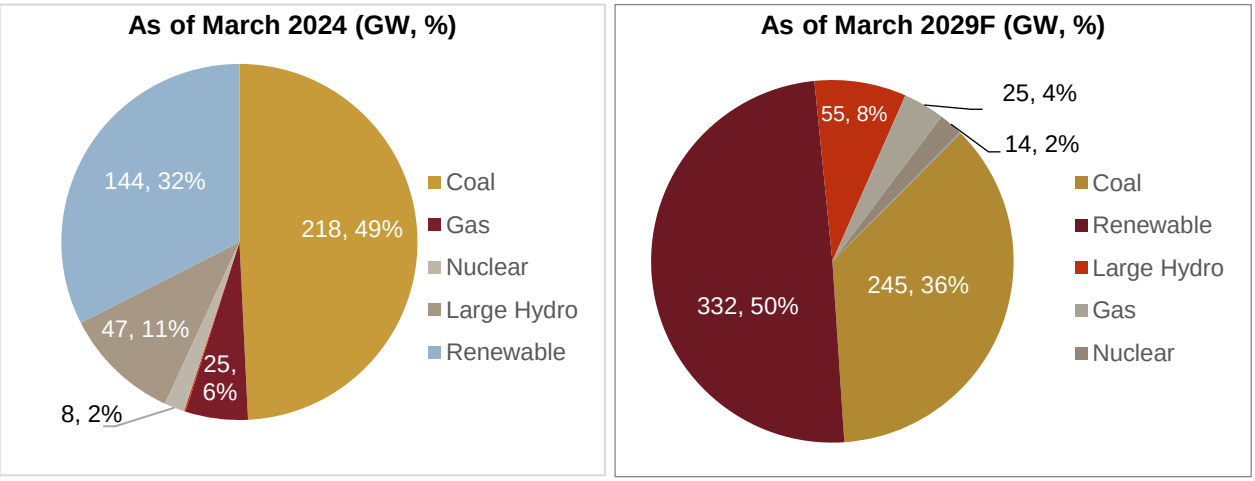
Source: CEA, CRISIL MI&A Consulting

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

By fiscal 2029, RE capacity (excl. large hydro) of over 330 GW is expected driven by various government initiatives, favourable policies, competitive tariffs, innovative tenders, development of solar parks and green energy corridors, etc. RE capacity is estimated to account for about 50% of the installed capacity of 660-670 GW by fiscal 2029.

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

Figure 26: Source wise details of installed capacity



Renewable includes solar, wind, biomass/bagasse, small hydro and waste-to-energy
Source: CEA, CRISIL MI&A Consulting

2.5 Review of global solar PV capacity additions

2.5.1 Outlook 2023-2028: global solar capacity additions

The global energy crisis is driving renewable installations worldwide, with total capacity growth set to almost double in the next five years, overtaking coal as the largest source of electricity generation. Some of the key drivers for this shift are reducing RE generation costs, favourable policies, improved emphasis on energy security and access, and socio-economic benefits. The last decade saw a remarkable evolution in solar PV industries, including higher installations, signification reductions in tariffs, and technological advancements.

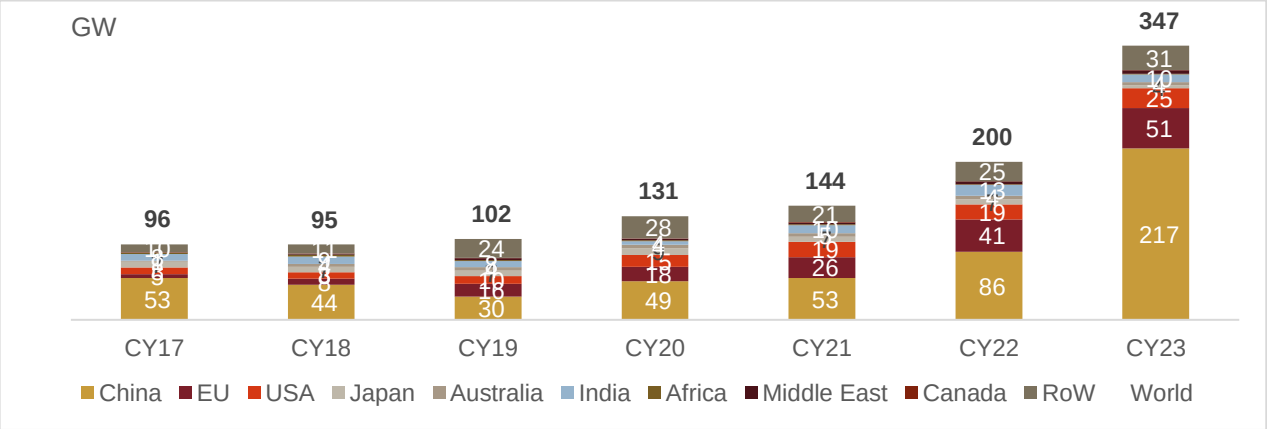
Concerns over climate change are at the heart of the energy shift towards RE and its increasing utilisation will be key for decarbonisation. Various initiatives, such as Kyoto Protocol, Paris agreement, Conference of Paris (COP) 21, COP26, RE 100, ISA, and subsequent favourable policy interventions, have helped strengthen the RE segment. The transition towards RE is a critical part of meeting the goals of the Paris Agreement, which aims to limit the rise in global average temperatures to well below 2 degrees Celsius and ideally below 1.5 degrees Celsius above pre-industrial levels.

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

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

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

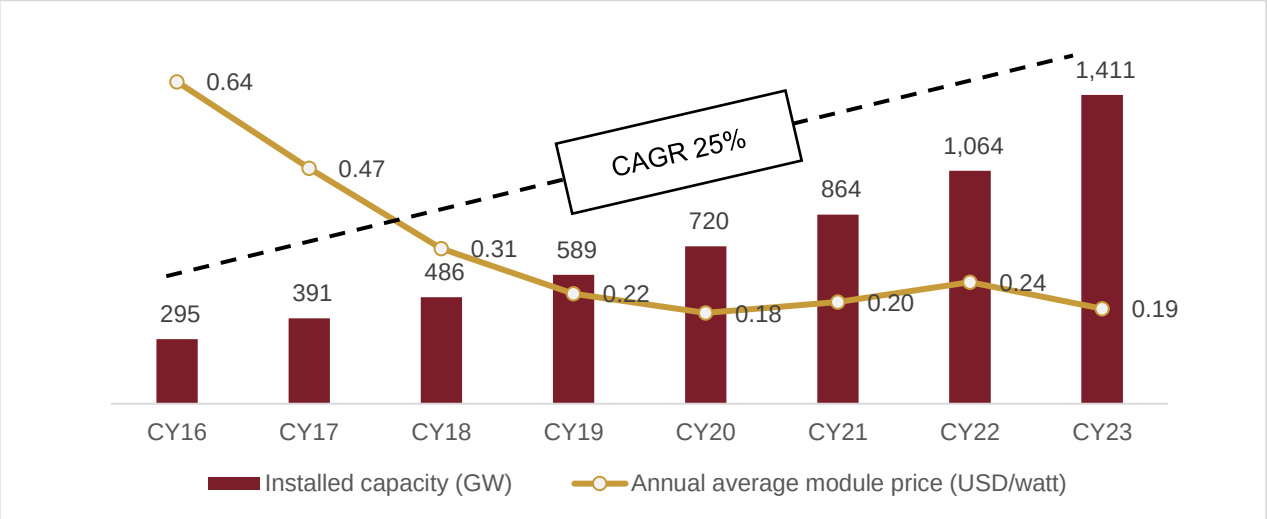
Figure 27: Annual solar capacity additions in major economies



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

Continuous innovation and economies of scale have helped drop in Module prices. With significant fall in module prices, solar PV became one of the most preferred electricity generation technology leading to substantial capacity additions.

Figure 28: Global solar PV installed capacity registered ~25% CAGR between 2016 and 2023



Source: IRENA, CRISIL MI&A Consulting

Table 6: Solar PV capacity additions and installed base (2023)

Country	Installed capacity (MW)	Capacity additions (MW)
China	609,351	216,889
EU	254,868	51,114
USA	137,725	24,844
Japan	89,077	4,011
Australia	32,609	3,725
India	72,767	9,719
Africa	12,353	792
Middle East	17,882	4,534
Canada	5,884	445
RoW	178,623	30,791

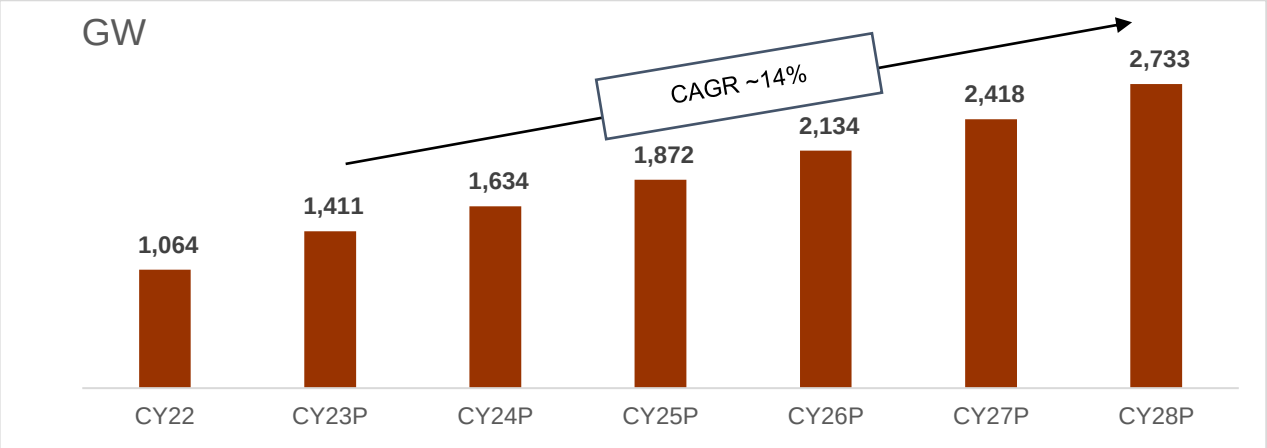
Source: IRENA, CRISIL MI&A Consulting

China continues to dominate the solar PV market, accounting for about 43% of the global installed capacity, while key European countries control about 18% of the total solar PV installed capacity.

2.5.2 Global solar outlook (CY2023-2028)

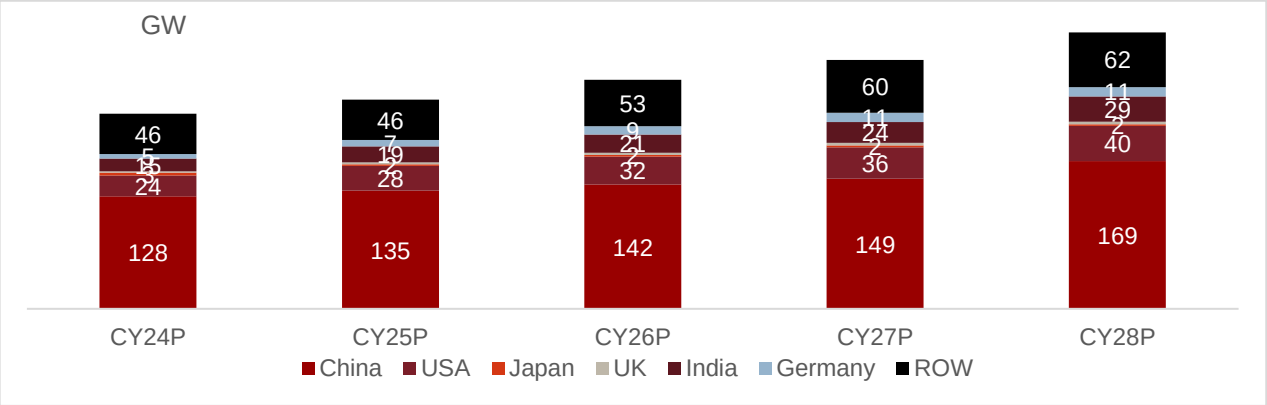
The IEA predicts that the global cumulative solar PV capacity would triple by 2028, surpassing natural gas by 2026 and coal by 2027. Although the current commodity super-cycle may have pushed investment costs up, utility-scale solar PV continues to be the most cost-efficient option for most countries. Emerging solar technologies, such as distributed solar PV and rooftop solar, are also set for rapid growth due to higher retail electricity prices and growing policy support to help consumers save on their energy bills.

Figure 29: Projected growth in global installed capacity base in solar PV over CY23-28



(P): Projected
Source: IRENA, IEA Renewables 2023, CRISIL MI&A Consulting

Figure 30: Projected annual solar capacity additions in major economies



Utility Scale PV systems, (P): Projected
Source: IEA Renewables 2023, CRISIL MI&A Consulting

International Solar Alliance has committed to invest $1 trillion by 2030 in solar industry. This will result into installation of 1,000 GW of solar energy capacity. The market is driven by various positive influences such as falling costs of solar energy technologies, the increasing awareness of the risks of climate change, and the growing demand for energy security. Increasing adoption of rooftop/decentralised solar applications, growth of utility scale solar coupled with energy storage solutions and advancements in solar and energy storage technologies will drive investments in the sector.

As per IEA analysis, the cumulative Utility scale Solar PV capacity is expected to triple to 2,198 GW by 2028, surpassing hydropower in 2024, natural gas in 2026, and coal in 2027 to become the largest installed electricity capacity worldwide. Solar PV continued to grow at a rapid pace despite being impacted by Covid-related disruptions, supply-chain bottlenecks, and commodity super-cycle. The Russia-Ukraine conflict expedited clean energy transitions, with energy security emerging as an additional factor not just for the EU, but for the whole world. The REPowerEU plan targets 45% share of renewables in final energy consumption by 2030.

China, the US, and India are expected to double their renewable capacity expansion over the next five years, accounting for two-thirds of global growth. The IRA provides long-term policy visibility for solar PV projects by extending tax credits until 2032. India and the US are also focusing on solar PV manufacturing, with investment

in the segment expected to reach ~USD 25 billion over 2022-2027. The governments of India and the US are offering PLIs and manufacturing tax credits to attain cost parity with the lowest-cost manufacturers in China.

China is forecast to invest ~USD 90 billion between 2022-2027 in solar PV manufacturing. However, if countries continue to limit imports and favour domestically produced PV products, China's share in global PV manufacturing could fall to 60-75% by 2027. The global supply of solar PV could potentially exceed the expected demand, significantly reducing the plant utilisation factors to half the current levels in China.

China is expected to add ~128 GW of solar PV in 2024. By the end of 2024, solar PV will have surpassed hydropower to gain the largest portion of installed renewable capacity in China. China, as per its 14th Five-Year Plan released in June 2022, aims to achieve 33% renewables and 18% wind and solar PV in electricity generation by 2025. The Chinese government also introduced a new target, requiring 50% of all large public buildings and new buildings in industrial parks to have rooftop PV installations.

The US is expected to add ~24 GW solar PV capacity in 2024. IEA forecasts the RE capacity to increase 75% to ~280 GW from 2022 to 2027, with solar PV and wind accounting for nearly all renewable expansion. Out of 50 states, 37 have renewable portfolio standards and goals supporting expansion. Distributed PV could see rapid deployment in the US, propelled by the extension of tax credits and attractive economics resulting from net-metering rules in some states.

Distributed solar PV is gaining traction in Europe, backed by FiT or self-consumption, with remuneration for excess generation promoting uptake. The REPowerEU strategy of reaching 45% share of renewables by 2030 will require ~600 GW of solar PV by 2030, and several major countries have revised their targets to meet this goal. Germany raised its 2030 renewable electricity target to 80% from 65%, aiming for 350-GW installed solar PV and wind by 2030 compared with 191 GW earlier. The UK proposed a 2030 PV target, and Portugal announced plans to meet its 2030 target by 2026.

Japan is expected to add ~3 GW of solar PV capacity in 2024. IEA predicts the renewable capacity in Japan to increase 44 GW (+30%) over 2022- 2027, led by solar PV and wind. The country aims to transition from FiTs to feed in premiums (FIPs) to spur utility-scale PV growth. The government is also identifying preferential areas for solar PV execution and encouraging corporate PPAs to drive distributed solar PV.

India is forecast to almost double its renewable power capacity over 2022-2027, with solar PV accounting for three-quarters of this growth. At COP26, India announced its targets of achieving net zero by 2070 and 500 GW of non-fossil installed capacity by 2030. The country also mandated higher RPO in July 2022 for discoms. India is also focusing on domestic manufacturing of solar PV and aims to expand its module manufacturing capacity to ~70 GW by 2030.

Substantial solar PV capacities of ~223 GW are expected to be added in 2024, driven by China, the US, and India. Other emerging markets in Africa, Latin America, Southeast Asia, and the Middle East have also started to grow past the ~1 GW level, further supporting future growth outlook. The key markets include Southeast Asia (Malaysia, Vietnam, Indonesia, and the Philippines, among others), the Latin American region (Brazil, Venezuela, and Chile, among others), and the MENA region (Egypt, the UAE, Saudi Arabia), which are increasingly focusing on renewable.

2.6 Major export destinations for Indian solar modules

Although India has been importing around 80% of its solar module requirement, it is worthwhile to note that exports in fiscal 2020 saw a massive increase of 75% over fiscal 2019 levels. However, during fiscal 2021, exports reduced by around 65% due to restrictions imposed globally amid the COVID-19 pandemic.

It is also pertinent to note that India used to export much higher value of solar modules (fiscal 2011 ~USD 512 million). Indian manufacturers derived over 90% of their revenues through exports, given limited opportunity in the domestic market. However, post that, China rapidly expanded its cell and module capacities and emerged

as a strong threat to India. Higher scale and backward integration helped improve China's cost-competitiveness, compared with India. Availability of equipment-linked financing further restricted potential for Indian exports.

In fiscal 2014, exports rose to USD 283 million, as anti-dumping and countervailing duties (average of 47.7%) were imposed on modules and cells imported from China. Further, the EU levied high import duties of 45-50% on Chinese modules. As an alternative to this, they introduced the minimum import price (MIP) mechanism, whereby Chinese manufacturers had to abide by a floor price and import quotas to avoid the high import duties. MIP restricted bulk export orders by Chinese players, which benefited Indian suppliers. A sharp rupee depreciation further aided growth in exports from India for the period.

A decline in capacity additions (to 7 GW in fiscal 2014 vis-à-vis 22 GW in fiscal 2011) from European nations due to a reduction in FiTs and subsidies pulled down exports, particularly in fiscal 2015. However, in fiscal 2016, the export of solar modules rose, albeit modestly, driven by the doubling of solar module exports to European nations such as the UK, the Netherlands, Italy, Spain, and Germany.

In fiscal 2017, exports decreased again to USD 69 million on account of a fall in demand from the UK and other European nations. Capacity additions slowed down as the UK added only 2 GW of capacities in calendar year 2016, with players like Wuxi Suntech, Yingli, JASolar, and Jinko Solar being main suppliers. Exports to the US also contracted 35% as indigenous module manufacturers strengthened capacities with cell and module production rising 24% and 29%, respectively, as Chinese players face high tariffs in the market.

Exports picked up in fiscal 2018, at USD 141 million, exceeding exports of USD 69 million in fiscal 2017. This was owing to a steep rise in exports to the USA, as a petition was filed by US manufacturer Sunviva, against all imports of solar modules. This caused a rush by US solar project developers to import modules before the duty got reimposed. Additionally, the European region witnessed increased demand, where distributed generation projects spurred installations in Belgium, the unlicensed solar market led to increasing installations in Turkey, and several large ground-mounted PV projects drove installations in Italy. Africa is also emerging as a key export market as multilateral aid for the region also focuses on renewable energy, especially distributed solar, as a key source of energy for the under-developed parts. For instance, in October 2017, International Finance Corporation (IFC), a World Bank arm, provided a USD 653 million debt package to finance the building of 13 solar power plants near Aswan in Egypt, planned to be part of the largest solar park in the world.

Exports have weakened in fiscal 2019, falling ~14% from USD 121 million in fiscal 2018 to Rs 141 million; this could also be due to a high base. Demand has shifted to the US market from the EU over fiscals 2018 and 2019, due to the tariff exemption granted to India under the new anti-dumping measures against imported modules from around the world since January 2018. However, key European markets have seen a fall in demand after a strong fiscal 2018. However, exports were supported by sporadic demand from smaller markets spread across Eastern Europe, Africa, and Asia.

Even as Indian dependence on imported solar modules and cells continues, exports for fiscal 2020 increased to USD 213 million from USD 121 million (increase of 76%) from fiscal 2019. However, due to COVID-19 disruptions, exports declined to USD 77 million in fiscal 2021. Nevertheless, the exports grew in fiscal 2022 by ~45% due to the opening of economy and restoration of normalcy in most parts of the World.

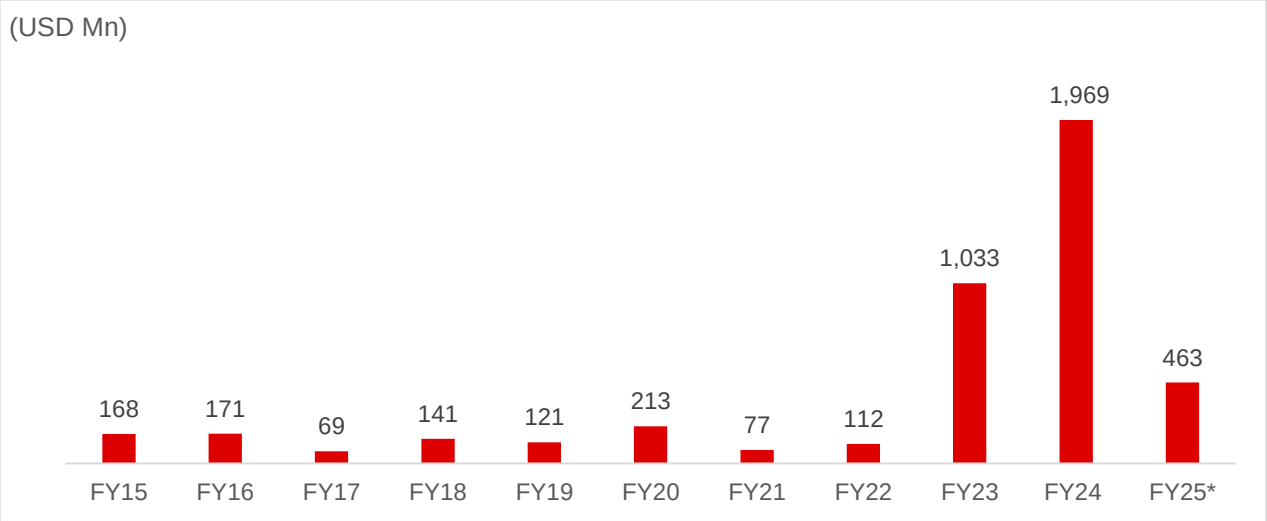
During the fiscal 2023, India has experienced a significant surge in solar module exports. This increase can be attributed primarily to the restrictions imposed by other countries on Chinese goods, including solar modules. These restrictions have created opportunities for Indian manufacturers to fill the gap in the global market and meet the demand for solar modules. As a result, India has witnessed a notable boost in its solar module exports, contributing to the growth of its solar industry and strengthening its position as a global player in the renewable energy sector.

US enacted the Uyghur Forced Labor Prevention Act (UFLPA) in December 2021 with June 21, 2022 as effective date. Implementation of ULFA has supported India’s solar module exports. The ULFA prohibits importation of goods into the United States manufactured wholly or in part with forced labor in the People's

Republic of China, especially from the Xinjiang Uyghur Autonomous Region, or Xinjiang. This has provided an opportunity for alternative sources such as India for demand for solar modules.

With its strong solar manufacturing capabilities and being a reputed supplier of high-quality solar modules, India benefitted to a large extent because of this shift. Indian solar module manufacturers have been able to capitalize the opportunity created by ULFA by expanding production capacities as well as meeting the stringent requirements for exporting to the US market. Resultantly, India's export to US have been surged significantly after implementation of ULFA and exports to US have seen substantial increases in fiscal 2022.With more focus on sustainability and its plans for expansion of solar capacity, the trend of export to US is expected to continue.

Figure 31: Export of cells and modules from India in value terms



**Till June 2024*

Source: Ministry of Commerce; Data for HS Code 85414011; FY 21-22 (HS Code 85414011+85414012): FY 23 onwards (HS Code 85414300 +85414200); CRISIL MI&A Consulting

Until recently, India had the same HS code for solar cells whether they were assembled as modules/panels – 85414011. In the Union Budget 2020, the Ministry of Finance segregated the HS codes as following:

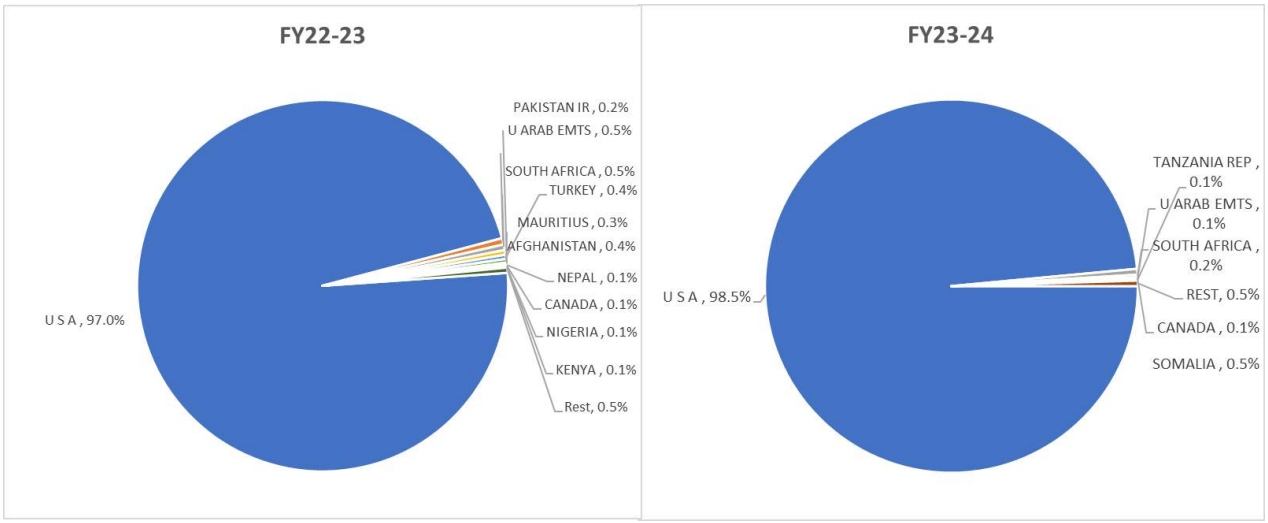
85414011 - Solar cells (not assembled); 85414012 - Solar cells (assembled in modules or made up into panels)

854143- Photovoltaic cells assembled in modules or made up into panels; 85414200- Photovoltaic cells not assembled in modules or made up into panels; 85414300-Photovoltaic cells assembled in modules or made up into panels

From April 2021, separate data 85414012 is available; however, historical data is not available for said code.

During fiscal 2023, USA accounted for ~97% of the exports of solar modules (in value terms), followed by UAE, South Africa, Afghanistan and Turkey. Also, during fiscal 2024 , US accounted for ~99% of the total exports of solar module followed by Somalia and South Africa.

Figure 32: % Share of export of solar modules (in value terms USD Mn)



Source: Ministry of Commerce; FY 22-23-22 (HS Code 85414011+85414012); FY 23-24: (HS Code 85414300+ 85414200); CRISIL MI&A Consulting

There are buyers for Indian Modules in international markets, however compared to Chinese manufacturers, the volume is very low. Also, majority of Indian module manufacturers cater maximum to domestic market unlike Chinese which export majority of their production. USA is expected to be the major export destination for India. Future demand will also be driven by the EU, Africa, and Gulf Countries due to healthy additions of solar capacity.

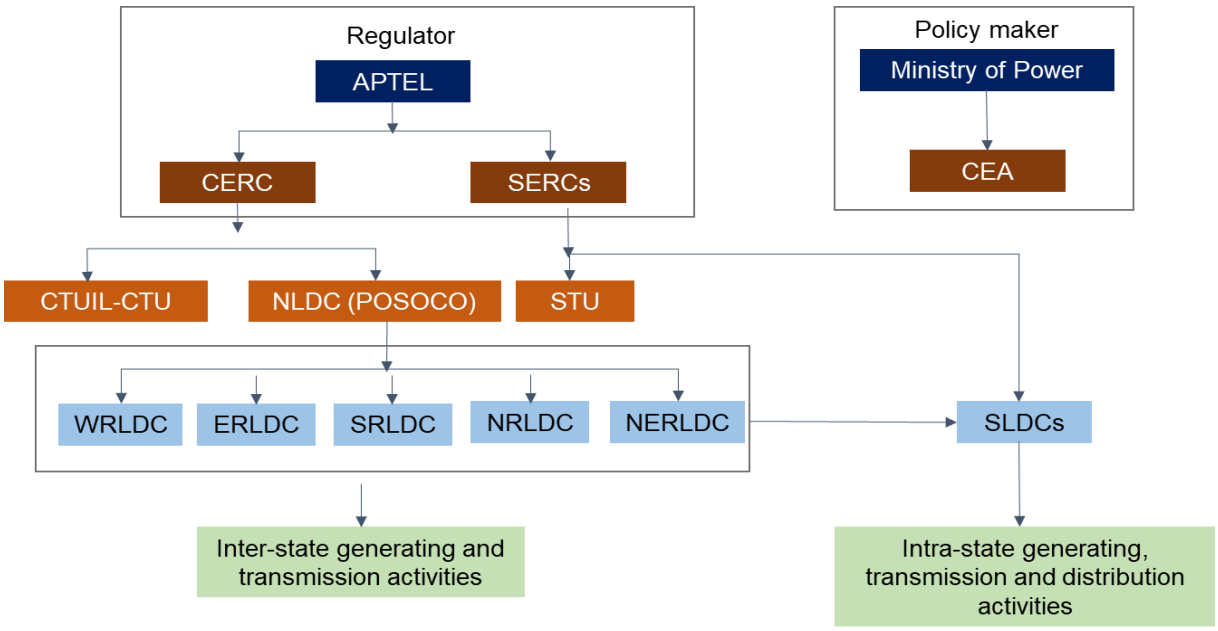
2.7 Review of the Indian power sector

2.7.1 Evolution and structure

India's power sector is highly diversified, with sources of power generation ranging from conventional (coal, lignite, natural gas, oil, hydro and nuclear power) to viable, non-conventional sources (such as wind, solar, and biomass and municipal waste). Transmission and Distribution infrastructure has expanded over the years for evacuation of power from generating stations to load centres through the intra-state and inter-state transmission system (ISTS).

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

Figure 33: 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; SRDLC - Southern Regional Load Despatch Centre; 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

The Ministry of Power (MoP) works in close coordination with the CERC and CEA. While the CERC's role is more of a regulator for approving tariffs of central utilities, approving licenses, etc., the CEA is primarily a technical advisor focused on planning, i.e., estimating power demand and generation and transmission capacity.

2.7.2 Key policy and regulatory reforms in support of RE growth

The development of grid interactive renewable power has essentially taken off with the Electricity Act 2003, which mandates the SERCs to promote cogeneration and generation of electricity from renewable energy (RE) sources by providing suitable measures for connectivity with the grid and sale of electricity and fix certain minimum percentages for purchase of renewable power in the area of each distribution licensee. In June 2008, a National Action Plan on Climate Change (NAPCC) was announced, which included eight major national missions, with the one on solar energy the Jawaharlal Nehru National Solar Mission (JNNSM) being central. The JNNSM was launched in January 2010, with a target of 20 GW grid solar power. In June 2015, this target was increased to 100 GW by 2022 and a cumulative target of 175 GW of RE capacity addition by 2022 was set which included 100 GW from solar, 60 GW from wind, 10 GW from bio-power, and 5 GW from small hydropower.

Furthermore, the GoI has committed in the COP 26 summit to reduce its emission to net zero by 2070. To achieve the said target India updated its intended nationally determined contributions (NDCs) in August 2022, for the period up to 2030. India set an ambitious target of achieving 500 GW of non-fossil fuel-based capacity addition, 50% of energy needs from non-fossil fuels, reduction of emissions by 1 billion tonnes between 2021 and 2030 and emissions intensity of the GDP by 45% by 2030. This is expected to provide further impetus to the renewable energy segment.

In the past 5 years, the government has taken several initiatives to promote RE in the country:

- Permitting **foreign direct investment** (FDI) up to 100% under the automatic route

- **Waiver of ISTS charges** for inter-state sale of solar and wind power for projects to be commissioned by June 30, 2025
- Declaration of **trajectory for renewable purchase obligation (RPO)** wherein trajectory for RPO for wind, hydro purchase obligation (HPO) and other RPOs has been laid down up to fiscal 2030
- Setting up of **ultra-mega renewable energy parks** to provide land and transmission to RE developers on a plug-and-play basis
- Laying of new transmission lines and creating new sub-station capacity for evacuation of renewable power under the **Green Energy Corridor (GEC)** Scheme
- **Standard bidding guidelines** for tariff based competitive bidding process for procurement of power from grid-connected solar PV and wind projects
- **Generation-based incentive** (GBI) is being provided to the wind projects commissioned on or before March 31, 2017
- **Electricity (Promoting Renewable Energy through Green Energy Open Access) Rules, 2022** in order to further accelerate the RE programme with the end goal of ensuring access to affordable, reliable, sustainable and green energy for all
- **Letter of credit** (LC) or advance payment to ensure timely payment by distribution licensees to RE generators
- **National Green Hydrogen Mission** for the development of green hydrogen production capacity of at least 5 million tonne per annum (mtpa) with an associated RE capacity addition of about 125 GW in the country
- **Issued Transmission System plan for integration of over 500 GW** RE capacity by 2030 which include 8,120 ckm of high voltage direct current (HVDC) transmission corridors (+800 kV and +350 kV), 25,960 ckm of 765 kV AC lines, 15,758 ckm of 400 kV lines and 1,052 ckm of 220 kV cable at an estimated cost of Rs 2.44 lakh crore. It also includes transmission system required for evacuation of 10 GW offshore wind located in Gujarat and Tamil Nadu at an estimated cost of Rs 0.28 lakh crore.
- **Issuance of bidding trajectory for renewable power bids** aims to achieve a target of 280 GW solar capacity (of the 500 GW of installed capacity from non-fossil sources) by 2030. The bids for 40 GW of solar energy capacity per annum, of the total trajectory of 50 GW RE capacity are to be issued each year from fiscal 2024 through fiscal 2028
- **The viability gap funding for Battery storage** proposed in the budget for fiscal 2024 with capacity of 4000 MWh. An outlay of Rs 3,500 crore is expected by the central government to support the VGF. Central government also issued guidelines to promote pump storage projects.

2.7.3 Distribution reforms planned by the government to revive the sector

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

- *Rs 3 trillion RDSS aiming to improve operational and financial parameters of discoms* — In Union Budget 2021-22, the GoI announced the RDSS with an outlay of Rs 3.04 trillion, partly funded by the GoI to the tune of Rs 976 billion, aimed at reducing financial stress across discoms. The package, slated to be distributed over the next five years, will subsume other schemes (DDUJY and IPDS) under its ambit. As has been the case with the *Aatmanirbhar Bharat* discom liquidity package, PFC and REC will be the key nodal lenders for disbursal of funds to discoms. The 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 key criteria proposed in the scheme are explained below.

Figure 34: Key criteria of RDSS

Parameter	Target/objective under RLRDS	Current status	Potential and impact
ACS-ARR	National target of zero by fiscal 2025	Avg. ACS-ARR gap has increased from Rs 0.55 per unit in fiscal 2017 to Rs 0.77 per unit in fiscal 2022 due to worsening in fiscal 2021. Exception states were Gujarat, UP, Rajasthan, Andhra Pradesh and Maharashtra, which saw ACS ARR reduction in fiscal 2022 over fiscal 2017	Stringent cost-cutting through shift towards cheaper sources of power such as RE, efficient management of operating costs, capital support through equity infusion and access to low-cost debt is required to be combined with timely tariff hikes in order to achieve the target. Weaker states are likely to remain laggards, however efficient states such as Gujarat Maharashtra and Andhra Pradesh could lead the pack, offsetting performance of weak states.
AT&C losses	National target of 12-10% by fiscal 2025	AT&C losses of states under consideration reduced from 23.2% in fiscal 2017 to 20.7% in fiscal 2022, incentivized by UDAY reforms and improvement in billing and collection efficiency. However, certain states such as Telangana, and Madhya Pradesh have seen an increase in losses. The losses for these states after increasing to 24.2% in fiscal 2021 due to pandemic impact on collection efficiency in fiscal 2021, are likely to moderate to 13-14% by fiscal 2027.	Improvement in billing efficiency through strengthening of distribution network, installation of smart meters, and theft reduction, as well as increase in collection efficiency through pro-consumer payment mechanisms, incentivising timely payments, and improving collection systems could be instrumental in meeting the target. Weaker states such as Uttar Pradesh, Bihar, Madhya Pradesh and Andhra Pradesh, will have to exhibit substantial improvement for achieving the target

Parameter	Target/objective under RLRDS	Current status	Potential and impact
Tariff Reforms	Cost-reflective tariff to ensure profitability	Historically, tariff hikes have not been in line with increase in power purchase costs (PPC), resulting in under-recovery of costs for state discoms and affecting their profitability	Cost-reflective tariffs could ensure fair recovery of costs through increased revenue, resulting in improved profitability. However, higher tariffs could translate to increased cost burden on consumers, particularly industrial and commercial categories that are already paying higher tariffs due to cross-subsidisation.
Direct Benefit Transfer (DBT)	Direct transfer of the subsidy to end-consumers	Currently, subsidy is transferred by state governments to respective discoms for power supplied to subsidised consumer categories, typically agri. consumers, with subsidy received-to-booked ratio at 99% in FY22 for states under consideration. However, certain states such as Madhya Pradesh, Karnataka and Telangana are known to have weaker performance than peers. The ratio is expected to remain stable at over 99% considering RDSS mandate of compulsory payment of pending subsidy.	DBT is expected to shift financial burden from discoms to consumers and state governments, with subsidised consumers having to pay designated tariffs, even as state govt. has to make timely direct transfers to concerned consumers. However, states with weaker finances could falter in payments, which could trigger defaults by subsidised consumers, thereby impacting collection efficiency and profitability of respective discoms.
Working capital rationalization	Payables days to Creditors for the year under evaluation to be equal to or less than the projected trajectory	Payables to power gencos remain abysmally high due to weak financial position of state discoms, largely on account of stretched receivables from consumers, particularly economically weaker sections and government departments. Funds disbursed under Atmanirbhar Bharat discom liquidity package have aided repayments to gencos in fiscal 2021 and fiscal 2022, however payables persist at alarmingly high levels.	Timely payments by consumers are essential to improve liquidity position of state discoms', which, in turn, can reduce payables days, thereby improving working capital cycle. Increasing collection efficiency and successful implementation of DBT could be crucial for the same.

Parameter	Target/objective under RLRDS	Current status	Potential and impact
Hours of Supply (Rural)	Govt. aiming for 24*7 power for all under a parallel program	Rural areas received power supply for an average ~20 hours daily across India as of June 2022.	Reducing leakages in distribution network through timely infrastructure upgrades as well as improving billing and collection efficiency in rural consumers could facilitate achievement of the target.
DT metering and Smart metering	Non-Agri. and Agri. DT metering to be completed by June 2023 and March 2025 respectively Smart metering to be completed by March 2025	DT metering in urban and rural areas has reached 99% and 68% as of July 2021, whereas smart metering has reached ~10%.	100% DT metering and smart metering could enable accurate and timely tracking of power consumed, thereby increasing billing efficiency of discoms, consequently reducing their AT&C losses.
Corporate Governance and Compliance	Discoms to publish audited annual accounts by December-end of following fiscal year for the first two years of the scheme, and by September-end from third year onwards Tariff orders to be issued by SERCs by April 1 of new fiscal year	Audited annual accounts are typically published by state discoms after a lag of at least 12 months, whereas tariff orders are issued by SERCs 4-6 months after commencement of a new fiscal year.	Timely filing of tariff orders and annual accounts could ensure efficient implementation of new tariff schedule as well as improve overall governance standards and compliance of discoms.

Source: MoP, CRISIL MI&A Consulting

- The letter of credit (LC) mechanism was also implemented in August 2019. This order mandated discoms to issue LCs or provide payments upfront before purchase of power. However, the success of this scheme has been limited so far, due to various loopholes utilised by discoms and the lower bargaining power of independent power producers (IPPs).
- In June 2022, the MoP notified Late Payment Surcharge and Related Matters Rules, 2022, to tackle the mounting payables to generation companies and transmission companies. The rules provisioned for converting discoms' outstanding dues to these companies into equated monthly instalments (EMIs) for gradual liquidation of these dues. Further, to promote timely payment of current power bills, the power supply would be regulated for discoms that fail to clear their bills one month after the due date of payment or two-and-a-half months after the presentation of the bill by the generating company.

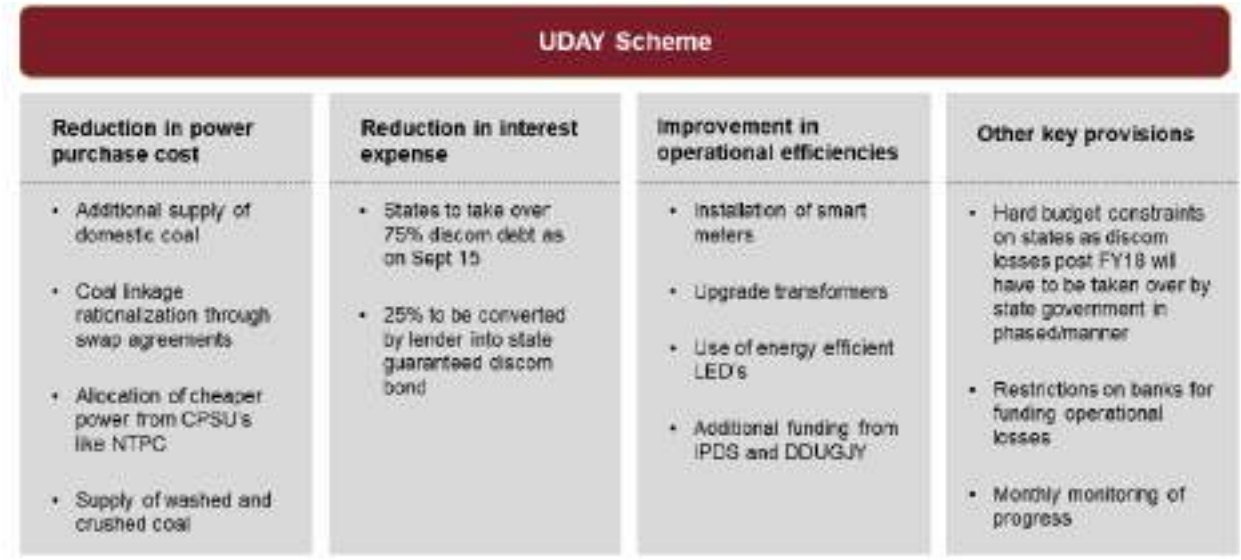
2.7.4 Current state of discom financial health

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

Distribution is the final and critical link in the power sector value chain. However, the financial position of the distribution sector has significantly deteriorated over the past decade owing to irregular tariff hikes, high aggregate technical and commercial (AT&C) losses, and delays in subsidy payments by state governments. This has adversely impacted power offtake by discoms and led to delays in payments to generation companies. Both the financial and operational performance of discoms started to improve post implementation of Ujwal DISCOM Assurance Yojana (UDAY), but the situation reversed and worsened again once the scheme ended in March 2019.

Under the UDAY scheme, states took over 75% of discom debt as on September 30, 2015, over a period of two years – 50% in fiscal 2016 and 25% in fiscal 2017. The balance 25% was to be converted by lenders into loans or bonds at an interest rate not more than the banks' base rate plus 10 basis points. Alternatively, this debt could be fully/partly issued by the discoms as state guaranteed bonds at prevailing market rates, which were to be equal to or less than the banks' base rate plus 10 bps. The scheme envisaged reduction of the cost of power through measures such as additional supply of domestic coal (at notified prices), coal linkage rationalisation through swap agreements, supply of washed and crushed coal, and supply of cheaper power from NTPC and other central public sector units (as part of central allocation of power to states), if available through a higher plant load factor. Implementation was mixed with policy-level support but limited traction on the ground. While coal linkage rationalisation under the SHAKTI scheme did benefit several projects, and domestic supply also improved, the effect has been temporary or partial.

Figure 35: Synopsis of UDAY scheme



Source: CRISIL MI&A Consulting

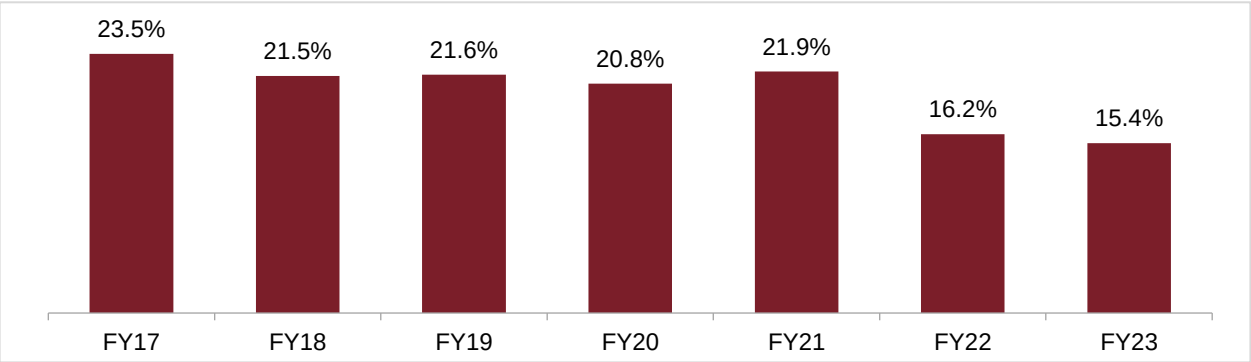
Improvements in operational efficiency

Operational efficiency improvements were planned through smart metering, upgradation of infrastructure (including transformers), and use of energy-efficient LED bulbs, pumps, and other heavy electric equipment. Through GoI schemes such as Integrated Power Development Scheme (IPDS) and Deen Dayal Upadhyaya Gram Jyoti Yojana (DDUGJY), additional/priority funding (depending on achievement of operational milestones) was being made available to target reduction in AT&C losses. However, the earlier target of 15% by the end of fiscal 2019 from ~23.7% in fiscal 2016 was not achieved.

But in fiscal 2023 AT&C losses were reduced to 15.4% due to improvement in collection efficiency. ACS-ARR gap has fallen to Rs 0.30 per unit in fiscal 2023 increase over fiscal 2022 level of Rs 0.10 per unit.

All India AT&C losses in fiscal 2021 was at 21.9% which decreased to 15.4% in fiscal 2023 due to improvement in collection and billing efficiencies. Collection efficiency improved from 92.77% in fiscal 2021 to 97.27% in fiscal 2023.

Figure 36: AT&C loss trajectory (%)



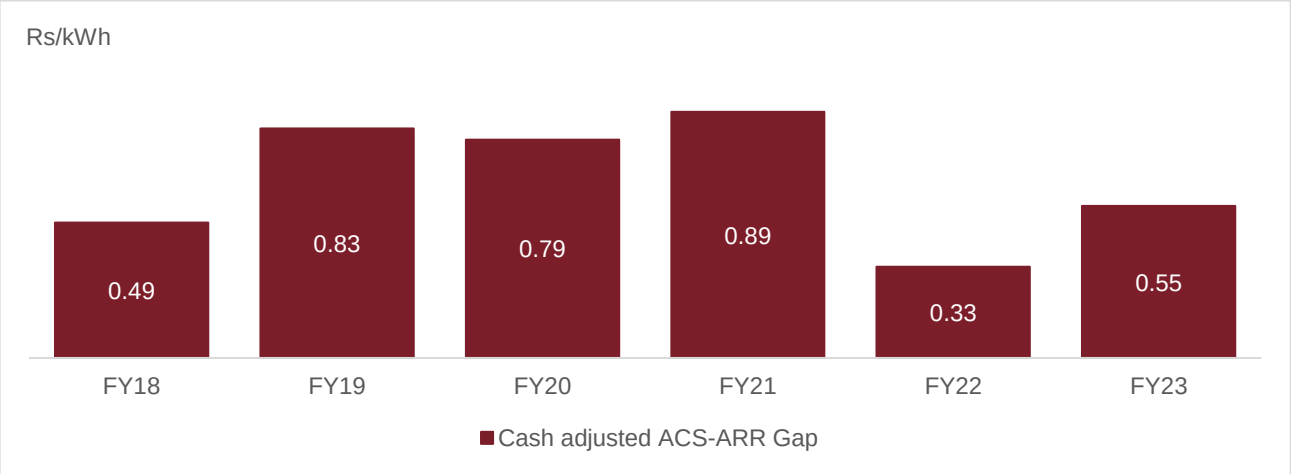
P: Provisional

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.

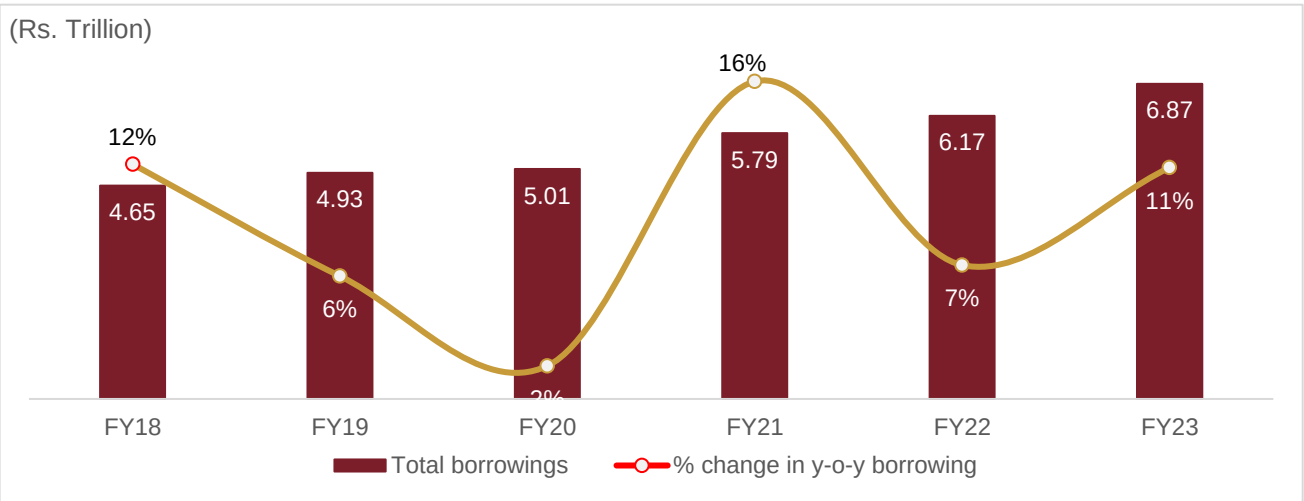
Figure 37: ACS-ARR gap



PFC has not provided figures for FY23
Source: PFC, CRISIL MI&A Consulting

The power distribution sector suffers from high trade payables with days payable averaging 160 days nationally, as opposed to the benchmark of 45 days specified in LPS Rules, 2022. With the sector making losses and facing liquidity crunch, reducing trade payables remains challenging. Payables for purchase of power (no. of days) improved from 168 days sale as on March 31, 2022 to 128 days sale as on March 31, 2023.

Figure 38: Total borrowings for discoms



Source: MoP, PFC, CRISIL MI&A Consulting

2.7.5 Financial position of transmission and distribution (T&D) sector entities

Distribution companies

As per the Report on Performance of Power Utilities for fiscal 2023 by PFC, the aggregate losses for distribution utilities increased from Rs 26,947 crore in 2021-22 to Rs 57,223 crore in 2022-23. Aggregate losses on tariff

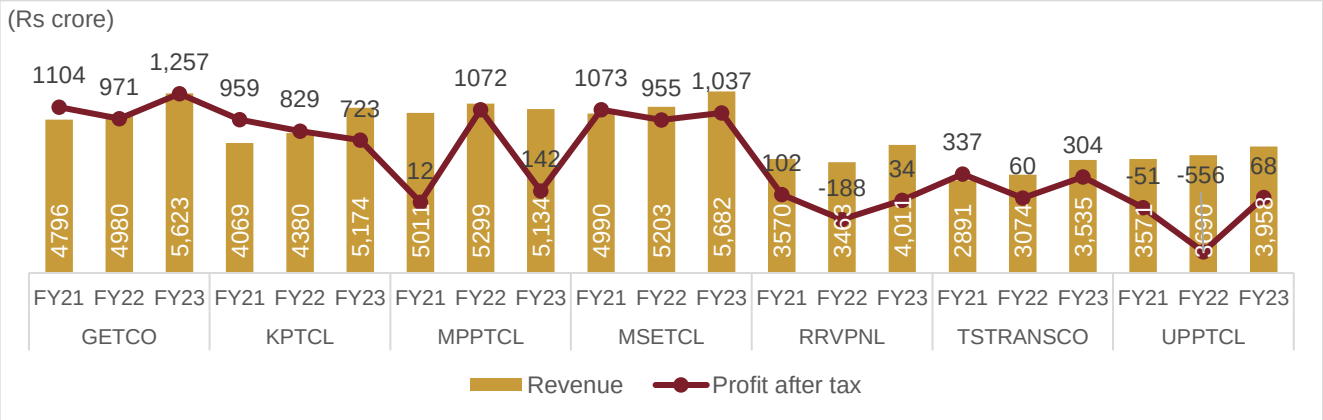
subsidy received excluding Regulatory Income and Revenue Grant under UDAY for loan takeover increased substantially from Rs 13,766 crore in 2021-22 to Rs 67,189 crore in 2022-23. Gap on tariff subsidy billed basis widened from Rs 0.20 per kWh in 2021-22 to Rs 0.39 per kWh in 2022-23. Gap on tariff subsidy received excluding Regulatory Income and Revenue Grant under UDAY for loan takeover deteriorated from Rs 0.10 per kWh in 2021-22 to Rs 0.46 per kWh in 2022-23. Cash Adjusted Gap also deteriorated from Rs 0.33 per kWh in 2021-22 to Rs 0.55 per kWh in 2022-23. Total borrowings by distribution utilities increased from Rs 6,14,853 crore as on March 31, 2022 to Rs 6,84,379 crore as on March 31, 2023. Overall AT&C losses for distribution utilities improved from 16.23% in 2021-22 to 15.37% in 2022-23. Billing efficiency improved from 86.13% in 2021-22 to 87.00% in 2022-23.

The trade receivables for SECI improved to 46 days in fiscal 2023 compared to 57 days fiscal 2021 whereas for NVVN, the trade receivables increased to 156 days in fiscal 2023 compared to 81 days fiscal 2021. Rajasthan discoms did not pay NVVN a certain amount related to delay in inter-state scheduling (LTA) of power generated and outstanding dues towards dispute in trading margin. These matters were pending as on 31st March 2022.

Transmission companies

As per the Report on Performance of State Power Utilities for fiscal 2023 by PFC, profit of transmission utilities increased from Rs 3,835 crore in 2021-22 to Rs 5,548 crore in 2022-23. 16 out of 19 transmission utilities registered profit in 2022-23. Net worth for transmission utilities increased from Rs 99,680 crore as on March 31, 2022 to Rs 1,01,925 crore as on March 31, 2023.

Figure 39: Performance of state power transmission utilities for FY23



Source: PFC's Report on Performance of State Power Utilities for FY23; CRISIL MI&A Consulting

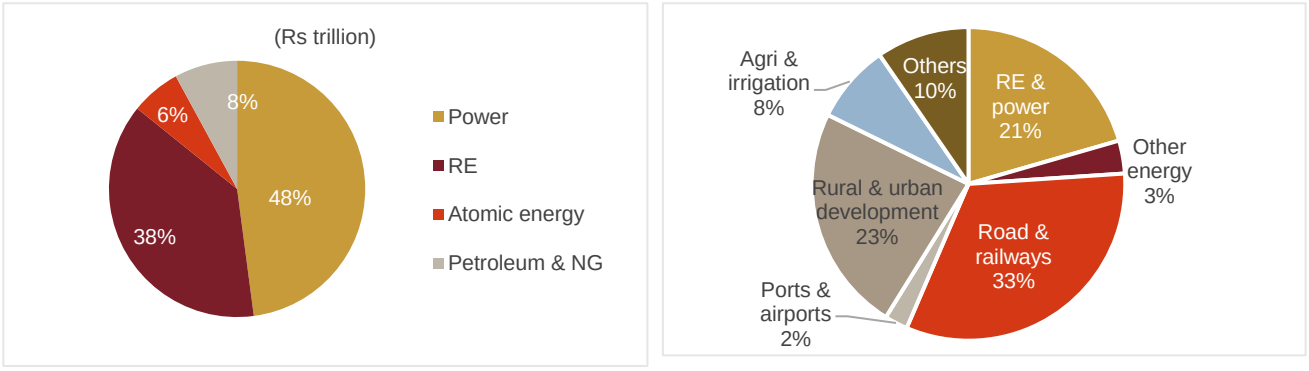
2.7.6 Proposed investments in the power sector

National infrastructure pipeline

The National Infrastructure Pipeline (NIP) is a roadmap to boost infrastructure across India and showcase investment opportunities in the domestic infrastructure sector, improve project preparation and attract investments into the country. The NIP aims to raise investments for key greenfield and brownfield projects across all economic and social infrastructure sub-sectors on a best-effort basis.

A total investment of ~Rs 102 lakh crore has been proposed between fiscals 2020 and 2025 out of which around 24% has been allocated to the energy sector. The allocation of projected capital expenditure is as follows:

Figure 40: Proposed investment in energy sector under NIP & the share of key infrastructure sectors

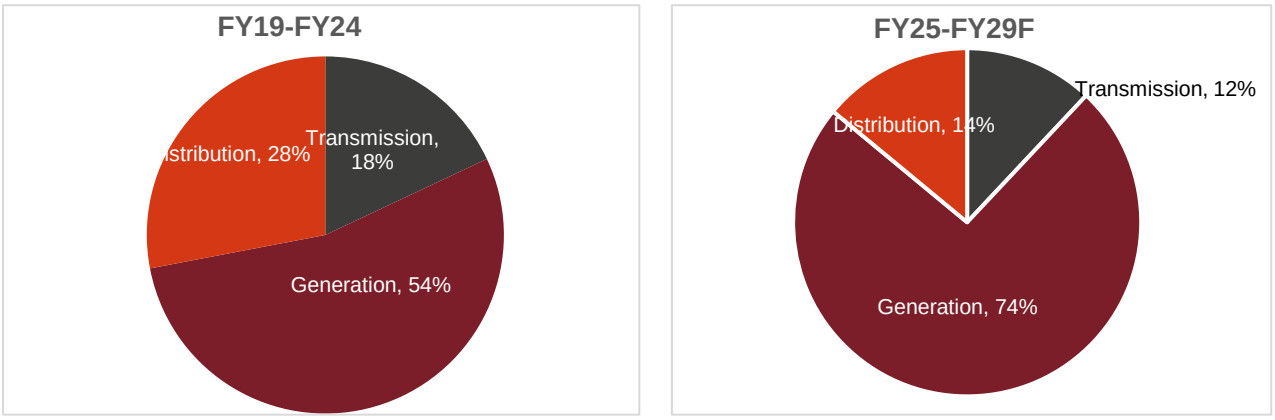


Source: CEA, CRISIL MI&A Consulting

Investments in generation, transmission, and distribution infrastructure

The total investments in the power sector between fiscal 2019-24 was about INR 14.7 trillion. CRISIL MI&A-Consulting expects investments of INR 24.5-25.5 trillion in the power sector over fiscal 2025-29. Generation segment investments are being driven by capacity additions with robust growth in RE installations followed by distribution investments led by the RDSS scheme.

Figure 41: Segment-wise break-up of total investments-dominance of the generation segment (Rs Trn, %)



F: Forecast; CRISIL MI&A Consulting

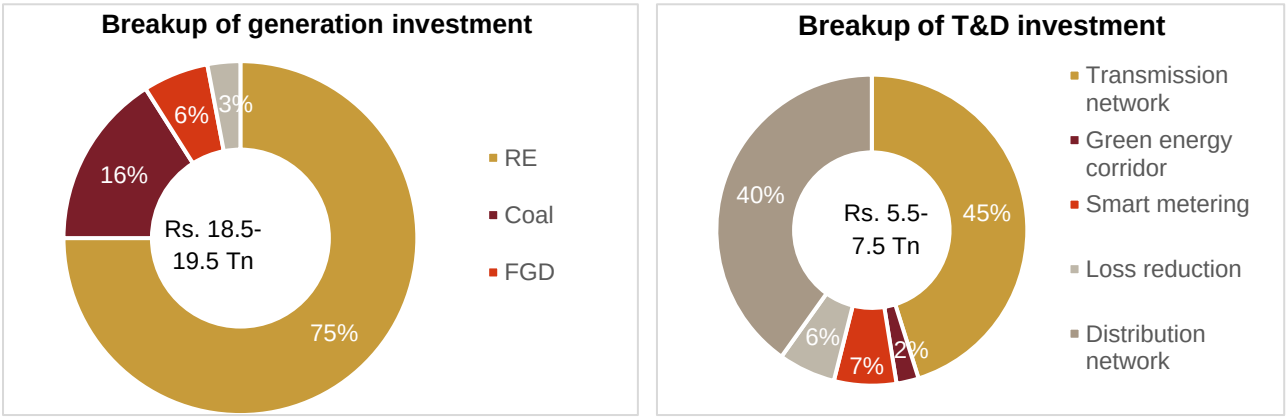
Investments in the generation segment are expected to double from INR ~7.9 trillion (over fiscals 2019-2024) to ~INR 18.5-19.5 trillion (over fiscals 2025-29). Capacity addition from RE sources is expected to be 215-225 GW from fiscals 2025 to 2029 (including large hydro and ESS), and 25-27 GW from coal-based plants sources over the same period. Investments in RE capacity, which are expected to double over the next five years, in line with capacity additions, will constitute over 70% of overall generation investments.

To achieve the RE generation target, strong transmission infrastructure is needed so as to integrate large scale RE capacities into the grid. This is expected to lead to transmission investments of INR 2.5-3.5 trillion between fiscals 2025-2029 from ~INR 2.6 trillion between fiscals 2019-2024 led by upcoming ISTS projects.

The distribution segment is expected to attract investments worth INR 3-4 trillion over fiscals 2025 to 2029 vis-à-vis ~INR 3.3 trillion between fiscal 2019-2024. This would be driven by the government's thrust on the RDSS scheme entailing an outlay of INR 3.04 trillion for state discoms, to be allocated until fiscal 2026. INR 2.52 trillion worth of DPRs have been sanctioned by nodal agencies (PFC and REC) as of December 2023. While the amount is sanctioned, disbursement under the scheme will be contingent upon the work undertaken that was proposed under the DPR. Fulfilment of the conditions, which primarily involve operational efficiency parameters,

strengthening of distribution infrastructure, and regulatory compliance, will entail significant investments in the distribution segment.

Figure 42: Breakup of investments (FY25F-FY29F)



Source: CRISIL MI&A Consulting

2.7.7 Overview of the sector's key challenges and risk factors

Low power offtake by discoms and credit risk

Despite significant availability of power (as reflected in low plant load factors (PLFs) of coal-based plants of ~59% in fiscal 2022), offtake by discoms in various Indian states is low on account of their weak financial position. In fact, some discoms opt for load shedding instead of buying power as they face revenue under-recovery (a gap between average cost of supply (ACS) and average revenue realised (ARR), also called ACS-ARR gap). The national average of under-recovery was Rs 0.48 per kWh in March 2023 (as per UDAY portal). Also, counterparty credit risk arising from the weak financials of discoms is an underlying risk as reflected in high receivables of gencos.

Financial health of generators

Private sector coal-based plants without long-term power purchase agreements (PPAs) are stranded due to low offtake. Their overall PLFs in fiscal 2023 stood at ~56.64%, marginally higher than 53.48% in fiscal 2022. Their financial position has deteriorated, with declining sales, reduced net margins and a rise in the gearing ratio. With their financial health remaining weak despite the implementation of UDAY, discoms are not expected to sign fresh long-term PPAs over the medium term owing to excess tie-ups in the past. Thus, the debt servicing ability of private players is expected to remain weak and affect projects that are operational and under construction.

Fuel availability

For thermal plants, which form 80% of installed capacity of conventional energy, fuel accounts for a large proportion of operating costs at 75-80%. Over fiscals 2011-14, domestic coal availability was a major issue as total non-coking coal production grew a mere 1.7% owing to stringent environmental regulations. This partly contributed to a decline in PLFs from ~75% in fiscal 2011 to ~56% in fiscal 2023. Also, players were compelled to rely more on expensive imported coal which adversely impacted returns of players. Despite increasing coal production, insufficient rake availability led to inadequate coal dispatches to plants, who were reeling under increased power demand. However, going forward, coal-based plants will be increasingly utilised for flexible operations to service rising peak demand, particularly those plants commissioned over the past decade and those in the commissioning pipeline.

On the gas front too, there are challenges. Availability of domestic gas reduced sharply after production from Reliance Industries' KG-D6 field plummeted. Over the years, government support for gas-based generation in

terms of gas supply assurance has dwindled, thereby leaving gas-based plants, which typically operate on domestic gas, short on fuel supply. The same is reflected in PLFs of gas-based plants remaining stagnant at 22-23% over fiscals 2017-21, with private sector plants operating at an even lower PLF of 15.6% in fiscal 2021. In fiscal 2022, gas PLFs fell further to 16.5%, with PLFs of private capacities languishing at ~11% during the fiscal.

Timely execution of projects

Power projects are highly capital intensive and have a long gestation period. Therefore, completion of projects in a time bound manner is very critical for developers to avoid huge time and cost overruns. In the past, thermal power projects witnessed significant cost overruns on account of delays in getting clearances, land acquisition and achieving financial closure. In fact, certain projects saw cost overruns as high as ~70% resulting in total project expenditure escalating to Rs 75 million per MW from an initial estimate of Rs 45 million per MW.

Hydro power projects have also been crippled due to execution challenges. Securing necessary approvals (environmental and forest clearances); land acquisition; relocation of project-affected people; inadequate infrastructure for power evacuation; and other logistical issues have constantly hampered the pace of project execution in the sector. Moreover, any delays in commissioning of projects further raises the cost of the project. This, in turn, escalates the power tariff, thereby increasing the power purchase cost of discoms, making them reluctant to buy electricity from such projects.

Changes in emission norms

Coal-based plants need to adhere to emission norms prescribed by the Ministry of Environment, Forest & Climate Change (MOEF&CC). There is additional capital expenditure associated with the equipment to be installed for keeping emissions below prescribed levels. Thus, any revision in such norms has a cost impact on the generators.

In December 2015, the government notified the revised standards for coal-based thermal power plants in the country, aimed at minimising pollution and limiting water usage. E.g., upgrade of electrostatic precipitators (ESP); installation of FGD plants and modification of combustion systems; and upgrade of cooling towers to reduce specific water consumption would escalate the capital cost of coal-based plants by Rs 1.5-2.0 million per MW, that too if adequate land is available for expansion. If land is not available, the cost could rise further. Although capital expenditure incurred towards these modifications can be passed on to discoms, it requires approval from the respective regulatory commission and the PPA clause should also allow it.

Regulatory and policy issues

After the cancellation of coal block allocation in September 2014, a number of plants were stalled due to lack of fuel. Although the latest coal linkage policy notified in May 2017 – SHAKTI – aims to resolve this bottleneck, it has added a clause for providing discounts on existing PPA tariffs which would hurt project returns. Also, denial of compensatory tariff on account of international price changes, cancellation of PPA bids by Uttar Pradesh, backing down of wind and solar generation despite their ‘must-run’ status, and re-negotiation of PPAs are some of the key risks affecting the generation sector.

2.7.8 Assessment of key off-taker entities

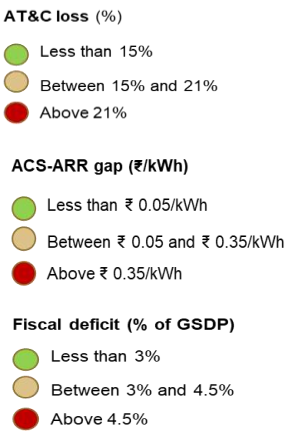
Distribution utilities

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

Figure 43: Most state entities within moderate-to-weak band

Bucketing of state utilities

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



Source: PFC, CRISIL MI&A-Consulting

Strong states have performed better in operational parameters

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

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

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

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

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

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

Solar Energy Corporation of India (SECI)

SECI is 100% owned by the GoI and is a critical institution in ensuring success of the government's RE plans and global climate change commitments; thus, strong government support will continue. SECI is also a Category I Trading Licensee from CERC to carry out power trading on a pan-India basis. SECI was accorded the status of Miniratna Category-I Central Public Sector Enterprise (CPSE) on April 10, 2023.

Some of the key advantages for SECI are availability of surplus funds, including free cash balances and cushion available in payment security fund. Encumbered cash balances for providing grants/subsidies/VGF ensure availability of adequate funds, indicating a strong liquidity position. Healthy cash accruals and a debt-free status augur well for SECI's credit profile, and the LC mechanism and tripartite agreement further safeguard SECI.

Some of the potential risks are as follows:

- CERC, in November 2019, put the onus on both parties to mutually decide trading margins. This could impact SECI's profitability and is a key monitorable
- Further, SECI is in the process of setting up greenfield projects, starting from 10 MW, across India, which could expose it to execution-related risks such as time and cost overrun and funding risk.

Table 7: Key financial indicators for SECI

Particulars	Unit	FY18	FY19	FY20	FY21	FY22	FY23
Operating income	Rs million	11,582	32,351	46,257	54,429	72,848	1,07,951
EBITDA	Rs million	891	1,786	2,087	2,271	3,153	3,800
PAT	Rs million	647	1,294	1,789	1,777	2,403	3,156
EBITDA margin	%	7.7	5.5	4.5	4.2	4.3	3.5
PAT margin	%	5.6	4.0	3.9	3.3	3.3	2.9
RoCE	%	25.2	40.2	37.2	30.9	22.2	18.0
Debt/net-worth	Times	-	-	-	-	-	-
Debt/EBITDA	Times	-	-	-	-	-	-
Cash, cash equivalent	Rs million	16,015	16,741	17,620	15,915	25,219	29.980
Interest coverage ratio	Times	137	67	67	63	77	47
Trade receivables	Days	41	80	93	57	49	46
Trade payables	Days	80	46	36	31	23	16

Note: Values given as '-' are nil; Source: Annual reports, credit rating reports, CRISIL MI&A Consulting

Credit rating history

Mar 2018	Jun 2019	Jan 2020	Jan 2021	Aug 2021	Jul 2022	Sep 2023
AA+ (positive)	AA+ (positive)	AA+ (stable)	AA+ (stable)	AAA (positive)	AAA (stable)	AAA (stable)

NTPC Vidyut Vyapar Nigam Limited (NVVN)

NVVN was incorporated in 2002, as a wholly owned subsidiary of NTPC to undertake trading of electricity. NVVN holds a category-I license and is one of the national nodal agencies for trading in solar power generated under JNNSM Phase-I and for cross border sales. NTPC along with its subsidiaries sells power to NVVN, which is further sold by NVVN to various utilities and discoms.

NVVN has a strong promoter company NTPC and is a critical institution in ensuring success of government's RE plans in line with JNNSM and global climate change commitments; thus, strong government support to continue. It has a healthy business risk profile owing to its status as a nodal agency for Phase-I (JNNSM) and for cross-border sales. Also, NVVNL has a sound relationship with distribution companies and IPPs. These strengths are partially offset by exposure to counterparty risks and the regulated and competitive nature of the power trading industry.

The company enjoys a healthy financial risk profile because of the absence of any long-term debt and comfortable liquidity. The financial risk profile is expected to remain healthy, despite moderate capital expenditure (capex) requirements in the e-mobility segment, while there is no major capex requirement in the trading business.

Potential risks include trading margin capped by the CERC for electricity trading limits revenues of trading companies. The risk gets further enhanced due to some private players offering lower trading margin than CERC capped trading margin. NVVNL is in the process of setting up of ground mounted projects of ranging from 10 to 50 MW across India, which could expose it to execution related risks like time & cost overrun, funding risk.

Table 8: Key financial indicators for NVVNL

Particulars	Unit	FY18	FY19	FY20	FY21	FY22	FY23
Operating income	Rs million	50,630	45,320	44,430	40,370	38,995	44,402
EBITDA	Rs million	952	1020	261	1098	1210	1,305
PAT	Rs million	612	660	180	920	1503	1,759
EBITDA margin	%	1.88	2.25	0.59	2.72	3.10	2.94
PAT margin	%	1.21	1.40	0.40	2.28	3.85	3.96
RoCE	%	30.0	28.9	6.5	29.9	37.9	32.28
Debt/Net worth	times	-	-	0.4	0.2	-	0.21
Debt/EBITDA	times	-	-	0.6	0.9	-	1.16
Cash, cash equivalent	Rs million	2,530	1,450	530	5,891	5,272	4,067
Interest coverage ratio	times	97	40	53	18	61	15
Trade receivables	days	58	86	93	81	136	158
Trade payables	days	79	74	69	92	116	159

Note: Values given as '-' are nil

Source: Annual reports, credit rating reports, CRISIL MI&A Consulting

Credit rating history

Feb 2016	May 2017	Aug 2018	Nov 2019	Feb 2021	Jan 2022	Nov 2023
AA+ (stable)	AA+ (stable)	AA+ (stable)	AA+ (stable)	AA+ (stable)	AA+ (stable, withdrawn)	AA+ (stable)

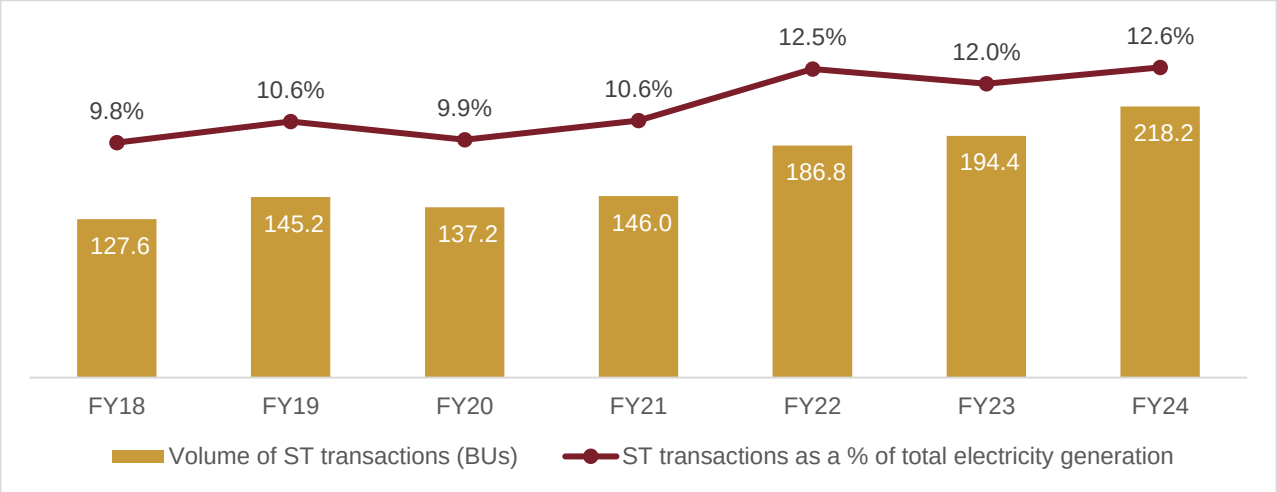
Credit rating of the Company was withdrawn in January 2022 due to receipt of no-objection certificate from bankers

2.8 Trend in short-term power transactions

2.8.1 Short-term power market in India

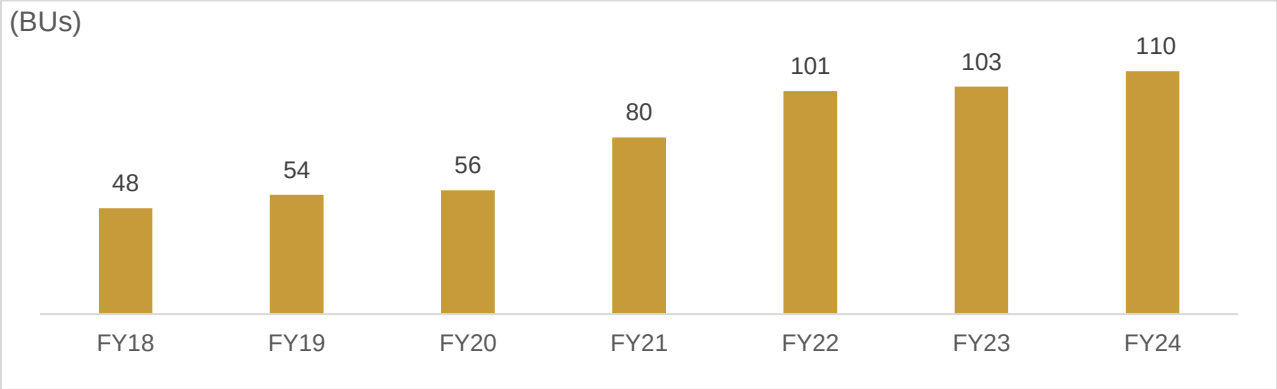
Total volume of short-term transactions of electricity increased from 65.90 BUs in fiscal 2010 to its all-time high of 218 BUs in fiscal 2024. Over the period (fiscal 2018-24), volume of short-term transactions of electricity increased at a higher rate (CAGR of 8.5%) than total electricity generation (CAGR of 4.7%). The volume of short-term transactions of electricity as a percentage of total electricity generation varied from 10% to 12.5% between fiscals 2018 and 2024.

Figure 44: Volume of short-term transactions



Source: CERC, CRISIL MI&A Consulting

Figure 45: Transactions through power exchanges

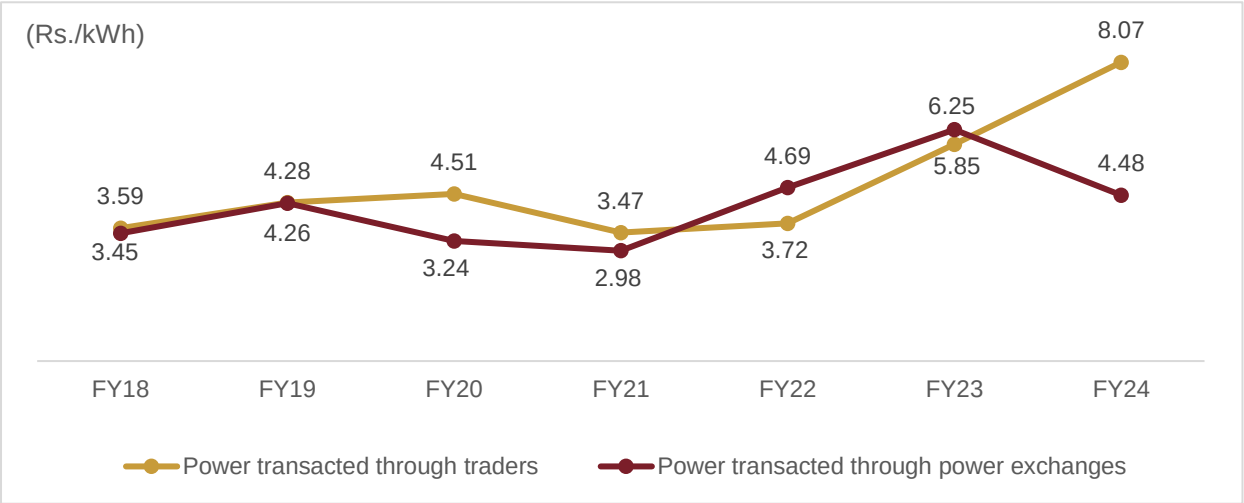


Source: CERC, CRISIL MI&A Consulting

2.8.2 Average price of electricity transacted

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

Figure 46: Weighted average tariff of short-term transactions



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

Source: CERC, CRISIL MI&A Consulting

Congestion for volume of electricity transacted through power exchanges reduced to a great extent since grid integration (integration of NEW Grid and SR Grid) in December 2013, which resulted in a declining trend in both the power exchanges from fiscal 2014.

3 Energy transition and impact on solar energy

Executive Summary:

- Global RE initiatives have been significantly boosting the adoption of renewable energy
- To achieve the COP26 targets, India has started various innovative initiatives such as tender trajectories, green hydrogen policy, proposed mandatory green hydrogen purchase etc.
- According to the IEA's latest World Energy Investment report, approximately USD 2.8 trillion is slated for global energy investments in 2023; of this amount, over USD 1.7 trillion expected to go for clean technologies
- Implementation of China plus One Strategy and US government's Inflation Reduction Act of 2022 may lead to a spike in demand for Indian solar PV modules in the US market.

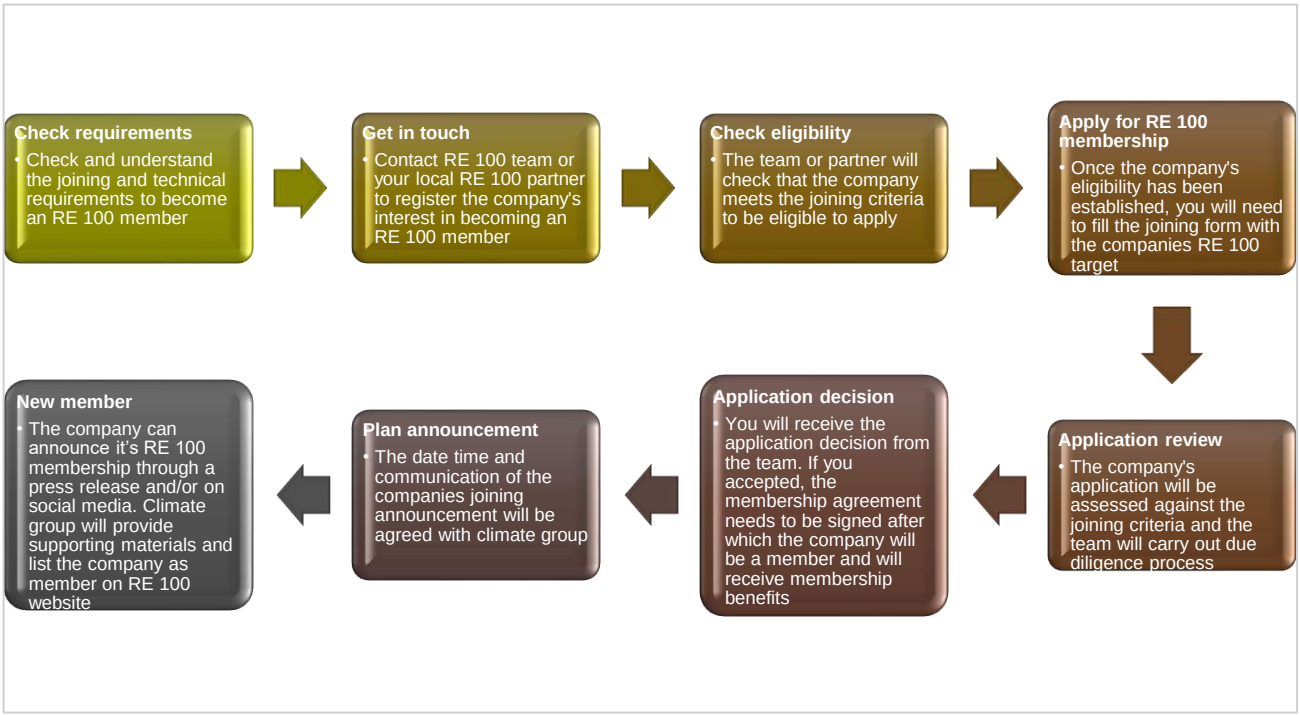
3.1 Key global initiatives for promoting renewable energy

3.1.1 RE 100

RE100 is a collaborative, global initiative of influential businesses committed to 100% renewable electricity, working to massively increase demand for, and delivery of, renewable energy. RE100 is brought by the Climate Group in partnership with CDP, as part of the We Mean Business coalition.

Various progressive companies are opting for 100% renewable energy and optimising the benefits of cost reduction and enhanced reputation. By doing so, they are also encouraging the global market for renewable energy and helping reduce emissions.

Figure 47: Joining Process to become a member of RE100



Source: RE100, CRISIL MI&A Consulting

Table 9: RE100 Joining Criteria

Particulars	Criteria
Mission	RE100's mission is to accelerate change towards zero carbon electricity grids globally by 2040.
Annual electricity demand	1. Significant annual electricity demand to be committed to RE100 of at least 0.1 TWh / 100 GWh / 100,000 MWh. 1.1. Companies with smaller consumption may be considered for membership in exceptional circumstances due to an 'influential' profile, based on one or more of the following characteristics: 1.1.1. Key player in a RE100 priority region 1.1.2. Key player in their industry/RE100 target sector 1.1.3. Willing to be involved in policy advocacy in RE100 priority regions 1.1.4. Globally or nationally recognised and trusted brand and/or major multi-national company (Fortune 1000 or equivalent) 1.1.5. Other consideration of clear international or regional influence that is of benefit to RE100's aims
Public commitment	2. Make a public commitment to sourcing/or having already sourced 100% renewable electricity throughout their entire operations, publicly declaring a target year. The company must have a renewable electricity strategy that includes credible deadlines for achieving 100% RE. RE100 targets must meet or exceed the following minimum ambition path to 100%: • 60% by 2030 • 90% by 2040 • 100% by 2050 Companies are responsible for choosing their own target year based on assessment of their global operations
Entire operations	3. RE100 defines entire operations as the electricity consumption which underlies, according to the Greenhouse Gas Protocol 3.1. All Scope 2 emissions associated with purchased electricity: and 3.2. All Scope 1 emissions associated with the generation of electricity by the company, for the company's consumption (this excludes use of fossil fuels for transport, the production of heat, or other uses not involving electricity production) 3.3. All companies operating within the brand or company group, including operations that are >=50%owned by the brand or company group 3.4. RE requirements for franchises and part-ownership
Group level	4. Companies must join the campaign at the group level. However, an exception can be made if a subsidiary company: 4.1. Has clear separate branding from the parent company, AND 4.2. Has an electricity consumption greater than 1 TWh/year
Annual reporting	5. To track the overall progress of the initiative and ensure its credibility, RE100 members are required to report their data annually via the CDP Climate Change Questionnaire. Companies are obliged to provide country level reporting were prompted in the CDP Climate Change Questionnaire.

Particulars	Criteria
Public claim	6. Members wishing to publicly claim that they have met their RE100 target or an RE100 interim target must submit data to RE100 for the initiative to assess. The data can be the member's response to the CDP Climate Change Questionnaire as part of an annual reporting cycle, or can be data submitted through the RE100 Spreadsheet for an on-demand assessment outside of the annual reporting cycle

Source: RE100, CRISIL MI&A Consulting

RE100 annual disclosure report 2022 presents analysis of reporting to CDP by 334 RE100 member companies in the 2022 CDP disclosure cycle (out of 355 that were requested to report).

Key findings:

- The energy crisis of 2022 and policy responses to it demonstrated that renewable energy is needed now more than ever, but governments need to reduce barriers for corporate buyers.
- Asian markets remain the most challenging, but strong corporate engagement means almost two thirds of new RE100 membership comes from within the region.
- The average target year of the RE100 initiative for companies aspiring to 100% renewable energy has been pushed back, during a year marked by a mounting energy crisis and ongoing barriers to renewable energy procurement.
- Despite these challenges, RE100 member companies now report consuming 49% renewable electricity in 2021, up from 45% in 2020, and 41% in 2019.

3.1.2 The International Solar Alliance

The International Solar Alliance (ISA) was conceived as a coalition of solar-resource-rich countries (which lie either completely or partly between the Tropic of Cancer and the Tropic of Capricorn) to address their special energy needs. The ISA will provide a dedicated platform for cooperation among solar-resource-rich countries, through which the global community, including governments, bilateral and multilateral organisations, corporates, industry, and other stakeholders, can contribute to help achieve the common goal of increasing the use and quality of solar energy in meeting energy needs of prospective ISA member countries in a safe, convenient, affordable, equitable, and sustainable manner.

ISA has been conceived as an action-oriented, member-driven, collaborative platform for increased deployment of solar energy technologies to enhance energy security and sustainable development, and to improve access to energy in developing member countries. The ISA has 122 sunbelt countries that lie between the two tropics as its prospective member countries. At present, 115 countries are signatories to the ISA Framework Agreement, of which 93 countries have submitted the necessary instruments of ratification to become full members of the ISA.

The interests and objectives of the ISA

As guided by the framework agreement of the ISA, the interests and objectives of the ISA are as follows:

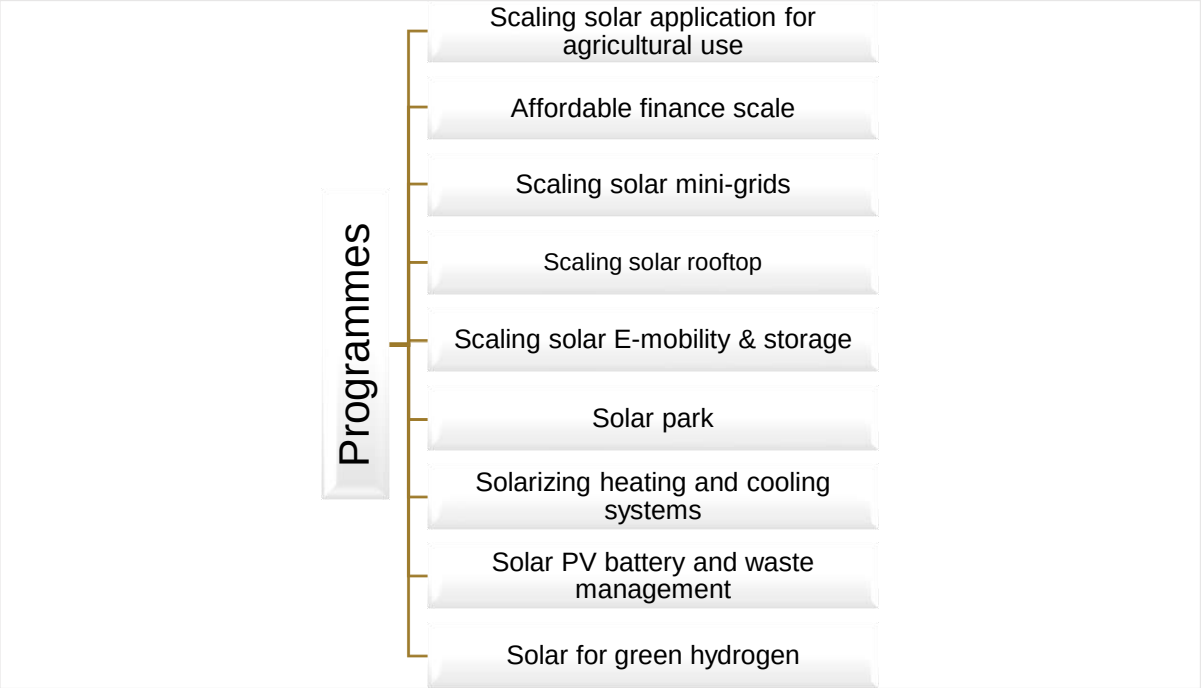
– To collectively address key common challenges to scale up solar energy applications in line with their needs

– To mobilize investments of more than USD 1 trillion by 2030.

– To take coordinated action through programmes and activities launched on a voluntary basis, aimed at better harmonisation, aggregation of demand, risk and resources, for promoting solar finance, solar technologies, innovation, R&D, capacity building etc.

- Reduce the cost of finance to increase investments in solar energy in member countries by promoting innovative financial mechanisms and mobilising finance from institutions
- Scale up applications of solar technologies in member countries
- Facilitate collaborative R&D activities in solar energy technologies among member countries.
- Promote a common cyber platform for networking, cooperation, and exchange of ideas among members countries

Figure 48: Key Programmes by ISA



Source: ISA, CRISIL MI&A Consulting

Brief about the programmes by the ISA

1. **Scaling solar application for agricultural use (SSAAU)**
   The SSAAU Programme mainly focusses on decentralized solar applications in rural settings. The key technologies covered under this programme include Solar Powered Irrigation Systems, Solar Drying, Solar Home/ Street Lighting Systems, Solar Chilling and other off-grid applications. To make the projects viable and affordable, the ISA has aggregated demand from various countries to substantially reduce system costs. The ISA Secretariat undertook a global tendering process, through M/S Energy Efficiency Services limited (EESL), for conducting an International Competitive Bid (ICB) for Price Discovery and for Project Management Consultancy (PMC) for Solar Water Pumping Systems (SWPS). The ICB was floated on 16th May 2019 by EESL and discovered about 47 percent lesser prices compared to the prevailing prices in Africa.

2. **Affordable finance scale**
   The Solar Risk Mitigation Initiative (SRMI), launched at the COP24 by the World Bank (WB) and the Agence Francaise de Développement (AFD) in support of the International Solar Alliance (ISA), aims at supporting the development of bankable solar programs in developing countries leveraging private sector investments. The World Bank has also committed 337 million USD Risk Mitigation Fund for 23 member countries in off

grid sector (ROGEP) in Africa in partnership with ISA. The European Investment Bank (EIB) has started working on a 60 million Euros grant project to create a concessional financial facility and risk mitigation Fund to promote off grid applications in Africa.

3. **Scaling solar mini grids**

   The objective of the program is to cater to the energy needs of ISA member states in identified areas with unreliable or no grid(s), and in island member states having abundant potential to tap solar energy.
   The key focus areas of the programme are:
   - Demand Aggregation
   - Policy and Regulatory Support
   - Technical assistance to member countries
   - Development of bankable projects
   - Facilitation of affordable finance

4. **Scaling solar rooftop**

   Objective of programme- To facilitate, and pool resources for scaling up of Rooftop Solar (Off-Grid and Grid-Connected) in ISA member countries
   - Targeted Users Segments for Solar Rooftop
     - Government & Institutional Buildings
     - Commercial & Industrial Buildings
     - Residential premises
   - Key activities
     - Demand Aggregation
     - Policy and Regulatory Support
     - Development of Business Models
     - Technical assistance to member countries
     - Development of bankable projects
     - Facilitation of affordable finance

5. **Scaling solar E-Mobility & storage**

   The objective of the ISA's programme on 'Scaling Solar E-Mobility & Storage' is to support creation of enabling ecosystem for large scale deployment of energy storage systems and to scale up uptake of solar energy in E-mobility sector in ISA member countries.

   Under this programme, ISA focuses broadly on two key solutions- Vehicle Integrated Photovoltaic (VIPV) and solar power enabled vehicle charging stations. VIPV refers to integrating solar panels on the roof or on the body of vehicles like motorbikes, passengers 3-wheelers, 3-wheelers cargo, passengers 4-wheelers, buses, trucks, boats etc. Under solar power charged charging stations, ISA plans to focus on battery charging stations, grid connected and stand-alone EV charging stations. Grid connected charging stations are capable of providing grid balancing services. ISA will analyze this particular use case in its member countries.

6. **Solar park**

   The programme of solar parks aims at development of large-scale solar power projects under the solar park concept in cluster/group of ISA member countries.

7. **Solarizing heating and cooling systems**

The main objective of the program is to solarize the growing thermal demand from commercial, industrial, and residential sectors. One of the initial areas of focus for this program is the development of solar powered food cold chains for safer and longer preservation of food - significantly reducing post-harvest food loss and potentially doubling farmers' income. Such climate resilient cold chain infrastructure can reduce approximately 19-21 GtCO2e GHG emissions by 2050.

8. **Solar PV battery and waste management**
   The objectives of the programme are threefold:
   - To reduce the amount of solar and battery waste
   - To re-use components whenever possible
   - To recycle the solar and battery waste

   The creation of enabling ecosystems for sustainable solar and battery waste management will be encouraged in ISA member countries or at a more regional level.

9. **Solar for green hydrogen**
   The objective of this programme is to accelerate Green Hydrogen production and utilization in ISA Member Countries. Given the immense cost potential held by the technology when produced with solar energy, it is imperative that stakeholders around the world, including the Least Developed Countries (LDCs) and Small Island Developing States (SIDS), keep abreast with the developments in the emerging green hydrogen space. As and when the technology gets commercialized, the countries should be able to replicate these projects on a fast-track basis.

Significance of the International Solar Alliance (ISA)

In 2015, the ISA was targeted to serve 121 sun-rich countries lying between the Tropic of Cancer and the Tropic of Capricorn. Most of these countries were poor, having insignificant presence of solar capacity. Subsequently, in 2018, the ISA membership was opened for all member countries of the United Nations. The Paris Declaration establishes the ISA as an alliance dedicated to the promotion of solar energy among its member countries. The major objectives of the organisation include deployment of 1000 GW of solar capacity and mobilisation of USD 1000 billion of investment in the solar energy sector by 2030.

The ISA model is independent of member commitments. It helps to get private investments in member countries to encourage solar developments. Due to higher costs of finance and overall economic as well as geo-political situation, private investors are not inclined towards these countries. Also, lack of government policies and technical know-how affects investment opportunities. The ISA aims to reduce the risks by aggregating demand for small projects within or across countries, thereby reducing capital costs.

3.1.3 Green Grids Initiative – One Sun One World One Grid

In a big boost to accelerate global adoption of solar energy, United States of America (USA) has joined the ISA as a member country. The U.S became the 101st country to sign the framework agreement of the ISA to catalyze global energy transition through a solar-led approach.

The One Sun One World One Grid (OSOWOG) is a globally interconnected power grid project aimed at seamless sharing of renewable energy resources among countries for mutual benefits and global sustainability. MNRE is the programme support agency for the OSOWOG Initiative, ISA the nodal implementing agency, and the World Bank the strategic advisory and funding agency.

The idea for OSOWOG initiative was put forth by the Indian Prime Minister at the First Assembly of the ISA in October 2018. He had called for connecting solar energy supply across borders. In May 2021, the United Kingdom and India agreed to combine forces of the Green Grids Initiative and the One Sun One World One Grid initiative and jointly launch GGI-OSOWOG at the COP26 summit at Glasgow in November 2021.

Indian Prime Minister has launched the Green Grids Initiative—One Sun One World One Grid (GGI-OSOWOG), the first international network of global interconnected solar power grids, jointly with Prime Minister of UK at COP26.

OSOWOG will not only reduce storage needs but also enhance the viability of solar projects. The OSOWOG will not only reduce carbon footprints and energy cost but also open a new avenue for cooperation between different countries and regions. This will be a very innovative, transformational initiative which will enable to meet the targets of the Paris Agreement. The end objective of this is to develop a global ecosystem of interconnected renewable energy resources that are seamlessly shared for mutual benefits and global sustainability.

3.1.4 COP 26

The 2021 United Nations Climate Change Conference (COP26) was the 26th United Nations Climate Change conference, held at Glasgow, Scotland during Oct-Nov 2021 and a draft agreement was circulated with respect to climate change action. The 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 percent by 2030, from 2005 level
- To achieve about 50 percent 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 ~15-20% of its power requirement from renewable energy. Similarly, the estimated energy requirement of India will be around 2325 BUs by March 2030. 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 of 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.

Since the adoption of the decision, an amount of around USD 700 million has been pledged by several countries. The United Arab Emirates (UAE) has announced its commitment of USD 100 million to the loss and damage Fund. Other countries making notable pledges included United Kingdom committed GBP 40 million for the Fund and GBP 20 million for other funding arrangements, Japan committed USD 10 million, United States of America committed USD 17.5 million and European Union (including Germany) committed 225 million. The following table summarizes the nationally determined contributions (NDCs) under the Paris Agreement by key economies.

Table 10: Comparison of NDCs (COP21 and COP26)

Country	NDCs (COP21)	NDCs (COP26)	Revised NDCs Submission date
India	• To reduce the emissions intensity of its GDP by 33 to 35% by 2030 from 2005 level. • To achieve about 40% cumulative electric power installed capacity from non-fossil fuel-based energy resources by 2030 • To create an additional carbon sink of 2.5 to 3 billion tonnes of CO2 equivalent through additional forest and tree cover by 2030	• To put forward and further propagate a healthy and sustainable way of living based on traditions and values of conservation and moderation, including through a mass movement for 'LIFE'– 'Lifestyle for Environment' as a key to combating climate change [UPDATED]. • To reduce Emissions Intensity of its GDP by **45%** by 2030, from 2005 level [UPDATED]. • 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) [UPDATED]. • To create an additional carbon sink of 2.5 to 3 billion tonnes of CO2 equivalent through additional forest and tree cover by 2030.	26/08/2022
China	• Achieve the peaking of carbon dioxide emissions around 2030 and making best efforts to peak early • Reduce carbon dioxide emissions per unit of GDP by 60-65% from the 2005 level • Increase the share of non-fossil fuels in primary energy consumption to around 20% • Increase the forest stock volume by around 4.5 billion cubic meters on the 2005 level	• Aims to have CO2 emissions peak before 2030 and achieve carbon neutrality before 2060. • To lower CO2 emissions per unit of GDP by over 65% from the 2005 level. • To increase the share of non-fossil fuels in primary energy consumption to around 25%. • To increase the forest stock volume by 6 billion cubic meters from the 2005 level. • To bring its total installed capacity of wind and solar power to over 1.2 billion kilowatts by 2030.	28/10/2021
USA	• Reducing its net GHG emissions by 50-52% below 2005 levels in 2030 • 100% carbon pollution-free electricity by 2035	Revised NDCs not submitted	22/04/2021

Country	NDCs (COP21)	NDCs (COP26)	Revised NDCs Submission date
Japan	• Reduction of 26.0% by fiscal 2030 from fiscal 2013 levels (25.4% reduction compared with fiscal 2005 levels).	• To reduce its greenhouse gas emissions by 46% in fiscal year 2030 from its fiscal year 2013 levels • Long-term goal of achieving net-zero by 2050. • Japan will continue efforts in its challenge to meet the goal of cutting its emission by 50%.	22/10/2021
Australia	• Reduce GHG emissions by 26-28% below 2005 levels by 2030	• To reduce greenhouse emissions by 43% below 2005 levels by 2030 • Target of net zero emissions by 2050	16/06/2022
EU	• Reduce EU GHG emissions by at least 55% by 2030, compared with 1990 levels	• In 2023 the Council of the European Union and the European Parliament formally adopted all the essential elements of the legislative framework necessary to implement the “Fit for 55”, and the agreed legislation3 has been published in the official Journal of the European Union. • According to the Commission´s estimates, the “Fit for 55” legislative framework, when fully implemented, could enable the EU and its MS to overachieve the EU´s net domestic reduction of greenhouse gas emissions target of at least 55% compared to 1990 by 2030.	19/10/2023
Canada	• To reduce emissions by 40-45% below 2005 levels by 2030 • To reduce emissions to net-zero by 2050	Revised NDCs not submitted	12/07/2021

Source: NDC Registry (Interim) UNFCCC; CRISIL MI&A Consulting

3.1.5 COP 28

The 28th Session of the UN Climate Change Conference (COP 28) was held in Dubai, United Arab Emirates from 30th November 2023 to 13th December 2023.

The major outcome from COP 28 included the decision on Outcome of the First Global Stocktake, ratcheting up global climate ambition before the end of the decade. These global efforts will be taken up by the countries in a nationally determined manner taking into account the Paris Agreement and their different national circumstances. Another major outcome of COP 28 is the agreement on the operationalization of the Loss and Damage Fund and its funding arrangements. The decision was adopted by consensus by all Parties including India.

Since the adoption of the decision, an amount of around USD 700 million has been pledged by several countries. The United Arab Emirates (UAE) has announced its commitment of USD 100 million to the loss and damage Fund. Other countries making notable pledges included United Kingdom committed GBP 40 million for the Fund and GBP 20 million for other funding arrangements, Japan committed USD 10 million, United States of America committed USD 17.5 million and European Union (including Germany) committed 225 million euros.

The purpose of the Fund is to assist developing countries that are particularly vulnerable to the adverse effects of climate change in responding to economic and non-economic loss and damage associated with the adverse effects of climate change, including extreme weather events and slow onset events.

3.2 Energy transition and energy security led investments

Investment in clean energy is growing much faster than investment in fossil fuels, as concerns about the affordability and security of fossil fuels have been amplified by the global energy crisis. This is driving the momentum behind more sustainable energy sources.

According to the IEA's latest World Energy Investment report, approximately USD 2.8 trillion is slated for global energy investments in 2023. Of this amount, over USD 1.7 trillion is expected to go for clean technologies, encompassing renewables, electric vehicles, nuclear power, grids, storage, low-emissions fuels, efficiency improvements, and heat pumps. The remaining portion, which is just over USD 1 trillion, will be allocated to investments in coal, gas, and oil sectors.

Between 2021 and 2023, there is a projected 24% increase in annual clean energy investments, primarily driven by renewables and electric vehicles. In contrast, fossil fuel investments are expected to rise by 15% during the same period.

Solar energy is at the forefront, leading the way in low-emissions electricity technologies. These technologies are anticipated to constitute nearly 90% of the total investment in power generation.

Clean energy investments have witnessed significant growth in recent years, benefiting from various factors. Periods of robust economic expansion and fluctuating fossil fuel prices have played a crucial role in bolstering these investments. The volatility in fossil fuel prices has raised concerns about energy security, especially in the aftermath of Russia's invasion of Ukraine. These circumstances have further propelled the focus on clean energy alternatives.

Enhanced policy support has played a vital role in driving clean energy investments. Major actions like the US Inflation Reduction Act and various initiatives in Europe, Japan, China, and other regions have been instrumental in promoting and incentivizing investments in clean energy technologies. These policy measures have created a conducive environment for businesses and investors to prioritize and allocate resources towards sustainable and low-emissions energy solutions.

3.3 Energy transition and increasing thrust on solar equipment manufacturing

The development and deployment of new clean energy technologies is essential to reducing greenhouse gas emissions to net zero in the coming decades. The world's energy demand is increasing, and over 80% of primary energy needs are still met by fossil fuels. Burning fossil fuels releases greenhouse gases, primarily carbon dioxide (CO_2), which can cause global warming and other climate change impacts. Methane (CH_4) is a greenhouse gas that is released into the atmosphere from agricultural activities, such as livestock farming and rice cultivation, as well as from leaks in natural gas pipelines and other infrastructure.

Policies that help mitigate climate change can encourage the use of renewable energy in a variety of ways, including setting emissions targets, phasing out fossil fuels, and increasing the cost of fossil fuels relative to renewables. Renewable energy sources and energy efficiency are essential components of a successful climate change mitigation strategy.

Governments around the world have pledged to slow global warming by reducing greenhouse gas emissions. Some of the most notable include:

- The Kyoto Protocol: An international agreement that called for industrialized nations to reduce their greenhouse gas emissions significantly.
- The Paris Agreement: A climate accord adopted in 2015, aims to limit global warming to well below 2 degrees Celsius above pre-industrial levels.

There has been significant progress in the development of global energy and CO_2 emissions policies over the past three years. Some of the key changes include China aims to have CO_2 emissions peak before 2030 and achieve carbon neutrality before 2060. More and more countries are committing to net-zero emissions by 2050. These moves are consistent with the Paris Agreement's recognition that developed countries have a greater responsibility and ability to act on climate change.

As investors and companies seek to understand and manage climate risks, businesses are adapting to the energy transition. Energy transition is the shift from fossil fuels to renewable energy sources as the primary source of energy for the global economy. The transition to renewable energy is being driven by technological advances and a growing public awareness of the need for sustainability. The energy transition is a response to structural changes in the energy sector, and it aims to reduce greenhouse gas emissions by decarbonizing the energy system. The rise of renewable energy sources, the electrification of transportation and industry, and advances in energy storage are all important factors driving the energy transition.

The energy transition is a long-term process that requires countries to develop and implement energy strategies that are tailored to their specific needs and circumstances. These strategies should focus on the deployment of appropriate energy technologies that can help countries achieve net-zero emissions.

The International Energy Agency (IEA) defines energy security as the uninterrupted availability of energy sources at an affordable price. Energy security has many aspects: long-term energy security mainly deals with timely investments to supply energy in line with economic developments and environmental needs. On the other hand, short-term energy security focuses on the ability of the energy system to react promptly to sudden changes in the supply-demand balance.

Energy security is important for businesses and households, as it allows them to operate and function without disruption. Energy security is also important for national security, as it can help to protect a country from external shocks, such as oil embargoes. Reliable access to energy is essential for businesses to operate, industries to thrive, and economies to grow. When energy supplies are unreliable, businesses and consumers may have to pay more for energy, which can hurt their bottom lines and make it difficult to afford essential goods and services.

Following are some of the key initiatives that can help in achieving energy security:

- Diversification of energy sources: Access to a variety of energy sources will lessen reliance on a particular source.
- Ensuring reliable energy infrastructure: Robust and reliable network for transport and distribute energy.
- Developing energy efficiency: Efficient use of energy will lead to savings and less requirement of energy
- Investing in renewable energy: Investing in cheaper renewable sources can reduce the dependence on fossil fuels.

Energy security, sustainable development, and wellbeing are the three main drivers of energy policy throughout the world. These drivers are often interrelated, and they can be seen as different aspects of the same goal: ensuring that people have access to reliable, affordable, and clean energy. Global investment in solar energy is growing rapidly, and this trend is expected to continue in the near future. For an increasing number of countries around the world, solar power is now the most affordable way to generate new electricity.

IEA in its World Renewable Energy Market Outlook 2023 and 2024 projected that solar PV installations will reach 650 GW per year by 2030 under its Net Zero by 2050 scenario. The solar industry is now discussing the possibility of installing twice as much solar capacity by 2030 as the IEA projects, and the manufacturing capacity needed to achieve this is already being developed.

In 2023, there has been a global surge in investment and innovation in decarbonization technologies. Governments have provided massive subsidies to stimulate new factories and accelerate the deployment of solar, wind, batteries, electric vehicles, and other clean energy technologies. The United States has made a significant investment in clean energy through the Infrastructure Investment and Jobs Act, but China still has a decade's head start in the race to decarbonize.

Over the past decade, China has become the global leader in solar PV manufacturing, as manufacturing capacity has shifted away from Europe, Japan, and the United States. Today, China’s share in all the manufacturing stages of solar panels (such as polysilicon, ingots, wafers, cells and modules) exceeds 75%.

India's photovoltaic (PV) manufacturing capacity has been on the rise in recent years, driven by government policies and growing demand for solar power. In recent years, there has been a significant increase in the number of domestic PV manufacturing companies in India. This is due in part to government policies that have made it more attractive for companies to manufacture PV cells and modules in India. In order to compete in the global market, Indian PV manufacturers are increasingly focusing on manufacturing high-efficiency cells and modules. This requires the use of advanced technology and manufacturing processes. The growth of India's PV manufacturing capacity is expected to continue in the coming years, as the country seeks to meet its ambitious renewable energy targets.

India is a major player in the global solar module manufacturing industry, with a capacity that is second only to China. The near- to mid-term outlook for the solar module manufacturing sector is very positive, as evidenced by the recent announcement of expansion plans by several leading manufacturers.

CRISIL MI&A Consulting expects solar PV manufacturing capacity to reach ~125 GW by fiscal 2029 with ~25% being integrated till the polysilicon stage. The cell manufacturing capacity is expected to reach ~55 GW by fiscal 2029. With this, India is poised to become a major player in the upstream solar PV manufacturing value chain, with a significant presence in the production of cells, ingots/wafers, and polysilicon.

Major solar PV importers around the world are diversifying their supply chains by developing alternative sources of supply in countries other than China. This is an effort to reduce their reliance on China and to protect themselves from potential supply chain disruptions. This has worked favorably for Indian solar PV Industry.

Implementation of China plus One Strategy and US government's Inflation Reduction Act of 2022 has led to a spike in demand for Indian solar PV modules in the US market. The European market has also seen a surge in demand

for solar PV modules due to the need for energy security in the wake of the Ukraine war. The growing demand for solar PV modules from major importers around the world has created a huge opportunity for Indian manufacturers. As these importers diversify their supply chains, they are increasingly looking to India as a reliable source of high-quality solar PV modules. This is good news for the Indian solar industry, as it will help to boost exports and create jobs.

4 Policy push driving solar energy

Executive Summary:

- Global policy push has accelerated the adoption of renewable energy, making it a more affordable and accessible option for everyone.
- As part of its commitment to supporting the transition to a low-carbon economy, global players stopped insuring or investing in coal
- The US Inflation Reduction Act has allocated ~$400 Bn for clean energy which will lead to critical implications for climate change, trade, security, and foreign policy
- China plus one strategy encouraging Industries to reduce their dependence on China and diversify their supply chains
- India would require around 60 GWh of Li-ion capacity by 2025 and 120 GWh by 2030.
- Government of India has approved the PLI Scheme 'National Programme on Advanced Chemistry Cell (ACC) Battery Storage' for achieving manufacturing capacity of 50 GWh of ACC for enhancing India's Manufacturing Capabilities with a budgetary outlay of Rs 18,100 crore.
- Green Hydrogen Policy expected to lead to increased investment in the green hydrogen sector, development of new green hydrogen technologies and increased demand for renewable energy
- As per NITI Aayog, India may witness a 20 GW electrolyser demand by 2030
- Incentive scheme for Electrolyser manufacturing under SIGHT program expected to have a transformative effect on the Green Hydrogen ecosystem in India

4.1 Global policy push

Country	Policy Component	Details
China	Tax Incentives	Preferential 15 per cent corporate tax rate applicable to High and New Technology Enterprises (HNTE) and a 50 per cent deduction for qualifying R&D expenditure. Additionally, HNTE can also claim a two-year tax holiday followed by a 12.5 per cent corporate tax rate for 3 years.
Japan	Feed-in-tariff	The latest feed in tariffs unveiled in February 2022 are set at $0.096/kWh for 10-50 KW; $0.087/kWh for 50kW-250kW PV projects & above 250 kW to compete in auctions.
UK	Contract for Difference (CfD)	A policy which enables a contract between an RE generator and the 'Low Carbons Contract Company' (LCCC). The LCCC pays the generator the difference between the 'strike price' and the 'reference price'. The 'Strike price' is a pre-determined set under the contract depending on the costs incurred in investing in RE technology and the 'reference price' is the average price of electricity in the Great Britain power market. If strike price is

Country	Policy Component	Details
		above the reference price the LCCC will compensate the generator and vice versa.
UK	Renewables Obligation Scheme (prior to March 2017)	The RO that came into effect in 2002 in England and Wales, and Scotland, places an obligation on UK electricity suppliers to source an increasing proportion of the electricity they supply from renewable sources. Operators can trade ROCs with other parties. ROCs are ultimately used by suppliers to demonstrate that they have met their obligation.
Germany	RE Auctions replace FiT regime	Feed-in-tariff regime replaced by annual auctions of RE sources. 600 MW of solar to be auctioned each year effective from 2017.
Germany	KfW Renewable Energies Program	KfW funding program to fund installation costs up to 100 per cent for various RE power installations.
USA	Business Energy Investment Tax Credit	A tax incentive provided by the federal government on solar installations including lighting systems. The rebate amount is 26% for two years till Jan 1, 2023 & 22% credit till 1 Jan 2024. For projects beginning construction on or before 1 Jan 2024 and not commissioned till 1 Jan, 2026, the tax credit will be 10%. Also, recently US president has proposed to extend the tax credit for 10 years.

4.2 Global Players stopped insuring or investing in coal

As part of its commitment to supporting the transition to a low-carbon economy, Axis Capital, leading insurance company in USA, has further strengthened their existing fossil fuels underwriting and investment policies, first announced in 2019, as follows:

Effective January 1, 2022, AXIS Capital has restricted insurance for both coal and tar sands projects and companies. According to the new policy, AXIS will not provide insurance or facultative reinsurance for new thermal coal or tar sands extraction and pipeline projects and their dedicated infrastructure. AXIS will also not provide new insurance or facultative reinsurance to companies that generate 20% or more of their revenues from thermal coal plants or mines, generate 20% or more of their power from thermal coal, or holding more than 20% of their reserves in tar sands. AXIS will not underwrite new insurance or facultative reinsurance contracts, or provide investment support, for projects generating 20% or more of their revenues from energy exploration, production or transportation activities conducted within the Arctic National Wildlife Refuge. In October 2021, the Company has bolstered its existing policy by committing to phasing out thermal coal business from its insurance, facultative reinsurance, and investment portfolios, ending all such activities no later than 2030 in OECD countries and the EU and 2040 globally. It has also included thermal coal developers within the scope of its policy. The policy continues to include provisions in support of renewable energy projects and companies that are transitioning business models away from thermal coal and oil sands. These measures are in addition to the previously announced restrictions on activities in the Arctic National Wildlife Refuge.

Allianz is committed to limiting global warming to 1.5°C. To drive this transition, Allianz has set ambitious climate and environmental targets, and collaborates with international organizations, companies and civil society. Allianz has

been restricting coal since 2015. They are engaging companies in insurance investment as well as Property & Casualty (P&C) insurance portfolios to move away from coal-based business models towards renewable energies and to present effective strategies to reduce the share of coal in mining and combustion to a minimum, in line with the criteria laid out below.

Allianz does not directly invest in any coal-based infrastructure, such as coal power plants, coal mines, coal-related railways or coal ports. Furthermore, Allianz does not offer single-site/stand-alone insurance coverages related to the construction and/or operation of thermal coal power plants and mines where coal is extracted and the construction and/or operation of coal-related infrastructure which predominantly serves the coal value chain (e.g., respective rails, roads, ports, movable equipment, 3rd party equipment & contractors in mines).

Allianz is excluding coal-based companies from business along the following set of criteria and thresholds which have been developed in line with scientific targets to limit global warming to 1.5°C. Coal-based companies are defined by breaching the following thresholds. Companies which, either themselves (directly) or through entities they control (indirectly, minimum of 50% stake), breach any of the following thresholds:

1. deriving more than 25% of their generated electricity from thermal coal (utilities) or revenues (mining companies and coal service providers).

   This threshold will be reduced as per our Coal Phase-Out Plan (section D)

   or

2. planning new coal (e.g., plants and mines (utilities, mining companies, and coal service providers)

   or

3. having more than 5 GW of thermal coal power plant capacity installed or mining more than 10 million tonnes thermal coal annually (utilities and mining companies)

AXA had decided to end investment and insurance support to companies most exposed to coal related activities in the belief that this contributes to reducing some business risks. AXA had defined these companies as mining companies deriving over 50% of their turnover from coal mining and electric utilities deriving over 50% of their turnover from thermal coal energy.

In terms of investments, AXA's new coal policy imposes even more stringent exemption limits, restricting investments in electric utilities that have a coal-based energy mix of over 30% and/or coal power expansion plans of over 300MW (vs 3000MW since 2017). This new threshold will rule out investments in most new coal projects around the world. Furthermore, since 2017, AXA does not invest in mining companies where coal accounts for more than 30% of their revenue and/or that extract over 20MT of coal annually. AXA has extended its existing ban on underwriting new and existing property and construction businesses with any coal-related project, to now include restrictions at client-level, and for any Line of Business, with companies that derive more than 30% of their turnover from coal; have a coal-based energy mix of over 30%; or mines that extract more than 20MT of coal annually. In addition to AXA's new investments and underwriting restrictions, the Group has made a commitment to a long-term coal "exit" strategy, reducing its exposure to the thermal coal industry to zero by 2030 in the European Union and OECD countries, and by 2040 in the rest of the world.

4.3 IRA to boost demand for solar value chain in US

The US Inflation Reduction Act (IRA) has allocated ~$400 Bn for clean energy. It is expected that it will lead to critical implications for climate change, trade, security, and foreign policy. The tax credits provide financial incentives to both domestic solar demand and supply. The "Section 45X Advanced Manufacturing Tax Credit" pertains to manufacturers who produce eligible components within the United States and sell them to unrelated parties. The credit rates for

Section 45X vary and are determined based on the specific component being manufactured. Some credit rates are tied to the cost of production, while others are influenced by certain capacity factors.

For solar modules the credits are expected to include:

- Solar Cells – 4 cents per W_{DC} capacity
- Solar wafers – $12 per square meter
- Solar grade polysilicon – $3 per kilogram
- Polymeric backsheet- 40 cents per square meter
- Solar modules – 7 cents per W_{DC} capacity

The implementation of the UFLP Act in June 2022 has had an impact on the growth of utility-scale installations. Under the said Act, importers are required to furnish evidence that the goods they import were produced without the use of forced labor. This requirement extends to goods that are entirely or partially manufactured in the Xinjiang Autonomous Region (XAUR). Additionally, the Act encompasses goods produced in other countries if they contain inputs that were mined, produced, or manufactured in XAUR. Implementation of the said Act has made the US market exceedingly profitable for non-China solar module manufacturers.

In December 2022, the US Department of Commerce (DOC) determined that some solar cell manufacturers in Southeast Asian countries using input materials from China are evading US anti-dumping and anti-subsidy duties related to solar battery products originating from China. As a result, anti-circumvention duty as high as 254% could be imposed on solar cells imported from the Southeast Asian countries.

4.4 China Plus One strategy

China Plus One strategy encourages companies to diversify their operations by expanding outside of China while still maintaining a presence in the country. This strategy is becoming increasingly popular in the solar industry, as companies look to reduce their dependence on China and diversify their supply chains. There are a number of factors encouraging the China Plus One strategy for solar. Some of them are: The rising cost of labor in China; the increasing complexity of the Chinese regulatory environment; the growing political risk in China; the increasing demand for diversification from investors; number of other countries that are emerging as potential destinations. Countries like India, Vietnam, Malaysia, and Thailand offer a number of advantages, including lower labor costs, favorable government policies, and access to new markets. India is one of the potential destinations for solar manufacturing due to its low labor cost as well as favorable political and regulatory environment for manufacturing.

4.5 Overview of Lithium-Ion Cell chemistries

A lithium-ion cell is a type of rechargeable battery that uses the reversible reduction of lithium ions to store energy. The negative electrode of a conventional lithium-ion cell is typically graphite, a form of carbon. The positive electrode is typically a metal oxide. The electrolyte is a non-aqueous solution that allows the lithium ions to move between the electrodes. Lithium-ion cells are used in a wide variety of devices, including laptops, smartphones, tablets, cameras, and electric vehicles. They offer a number of advantages over other types of batteries, including high energy density, long lifespan, and low self-discharge rate.

There are many different lithium-ion cell chemistries available commercially, each with their own advantages and disadvantages. Some of the most common types include:

Table 11: Different type of Li-ion cell chemistries available commercially

Li-ion chemistries	Li - iron phosphate (LFP)	Li- manganese oxide	Li- titanate	Li- cobalt oxide	Li- nickel cobalt aluminum (NCA)	Li- nickel manganese cobalt (NMC)
Cell voltage (V)	3.2 ~ 3.3	3.8	2.2 ~ 2.3	3.6 ~ 3.85	3.6	3.6 ~ 3.7
Specific energy (Wh/kg)	80 - 130	105 - 120	70	120 - 150	80-220	140 – 180
Energy density (Wh/l)	220 - 250	250 - 265	130	250 - 450	210 – 600	325
Cycle life	1000 - 2000	>500	>4000	>700	>1000	1000 – 4000
Operating temperature range (°C)	-20 to 60	-20 to 60	-40 to 55	-20 to 60	-20 to 60	-20 to 55
Self-discharge (%)	<1%	5%	2% – 10%	1%- 5%	2% - 10%	1%
Applications	Renewable energy storage	Consumer electronics (camera, tablets)	Fast charging applications; Electric vehicles, power tools	High-performance applications such as laptops and smartphones	Space applications, Tesla electric vehicles	Electric vehicles and other applications where high power and long range are required

Source: CRISIL MI&A Consulting

As per government estimates, India would require around 60 GWh of Li-ion capacity by 2025 and 120 GWh by 2030. Currently, the Li-ions are either imported from China or Taiwan to be assembled into batteries or already assembled battery packs are being imported. China has been the fastest mover, and currently is responsible for 78% of global battery manufacturing capacity. The United States and Europe account for 8% and 7% of current manufacturing capacity, respectively. Some of the major existing battery manufacturers are listed in the below table, of which more than 40% battery manufacturing capacity is in China.

Table 12: Existing major battery manufacturers globally

Manufacturer	Country	Cell chemistry	Capacity (GWh)
LG Energy Solutions	European Union	NMC, NMCA	70
LG Energy Solutions	US	NMC, NMCA	50
LG Energy Solutions	China	NMC	32
Tesla	US	NCA	32
Samsung SDI	European Union	NMC	30
SK On	China	-	27

Manufacturer	Country	Cell chemistry	Capacity (GWh)
CATL	China	NMC	39
BYD	China	LFP	20
CATL-SAIC Motor	China	NMC	18

Source: Niti Aayog, CRISIL MI&A Consulting

India's battery manufacturing ecosystem is in a nascent stage compared with global counterparts like China, Europe, and the United States. The government rolled out PLI scheme in 2021, with the objective of promoting domestic manufacturing of various Advanced Cell Chemistries (ACC) batteries. The initiative aims to establish 50 GWh of battery manufacturing in India. To be eligible for the incentive, companies must set up a manufacturing facility in India and achieve a minimum annual production capacity of 5 GWh of ACC. The programme aims to provide budgetary outlay of Rs 18,100 crore as financial incentives to help set up 50 GWh of domestic battery manufacturing over the next five years.

The PLI scheme launched in 2021 secured bids from 10 companies totalling 128 GWh of capacity. Among the bids received, 3 selected bidders signed the programme agreement under the PLI scheme in July 2022.

Table 13: List of winners signed programmer agreement under PLI scheme

Name of firm	Capacity awarded (GWh)	Plans
Reliance New Energy Solar	5	Plan to invest Rs 75,000 crore to build 100 GW of renewable capacity
Ola Electric	20	Electric two-wheeler vehicle manufacturer, planning for cell manufacturing with up to 50 GWh of capacity
Rajesh Exports	5	Planned capacity target of 16 GWh, with an investment of Rs 8,000 crore

Source: Ministry of Heavy Industries, CRISIL MI&A Consulting

In addition to the capacities allocated by the Ministry of Heavy Industries under the PLI Program, private players are expected to create battery manufacturing capacity to the tune of~95 GWh. Many players in automobile and energy space in India have also started to roll out Li-ion battery manufacturing units through identifying international partners or establishing local synergies. Some of the players who have initiated setting up battery manufacturing plants are listed below:

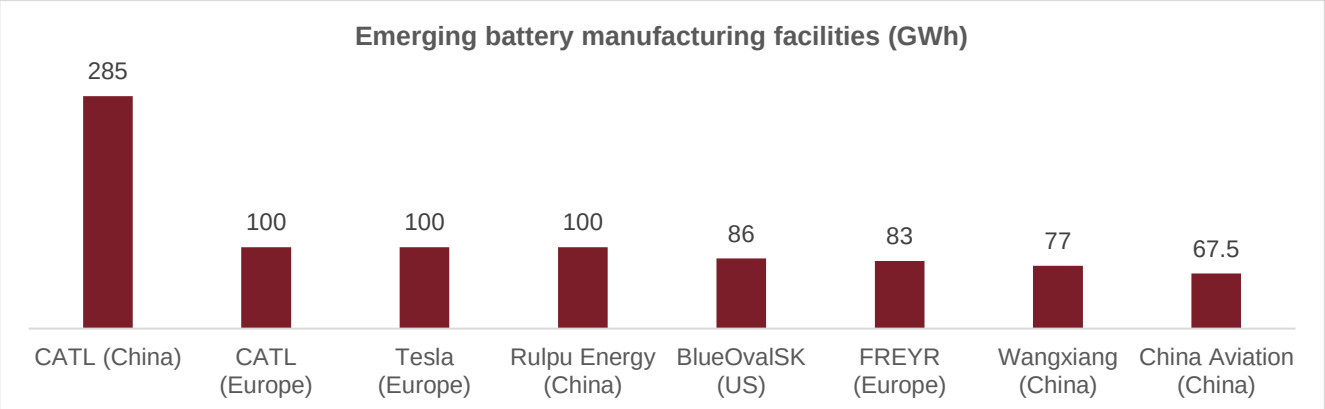
Table 14: Announcements made by key players in India to setup battery manufacturing

Name of firms	Announcements
Exide Industries	It announced the start of construction of multi-gigawatt hour lithium-ion cell manufacturing facility at Haraluru, Bengaluru in September 2022. It also entered into an agreement with SVOLT Energy Technology (China) Exide also formed JV with Switzerland based Leclanche SA called Nexcharge. It would produce Li-ion pouch cell battery modules in India. The plant is located in Gujarat and started with a capacity of 1.5 GWh.
Tata Chemicals	Tata has a commercial pilot cell manufacturing facility which could expand to 3 – 5 GW by 2025. The cells will cater to applications in the automotive sector as well as stationary energy storage. It has also identified land in Dholera, Gujarat where it can house manufacturing of active materials, Li-ion cells and batteries upto 10 GW per annum as well as the recycling operations.
Amara Raja	It is setting up 16 GWh of Lithium cell and 5 GWh of battery packs in the Mehbubnagar district of Telangana
HEG Ltd	It has announced plans to set up a manufacturing facility of graphite anode for Li-ion batteries. The plant is expected to commence operations by 2026 which would also cater for 10-12 GWh of cell manufacturing capacity.
Amperex Technology	A Japanese firm setting up Li-ion polymer battery manufacturing unit in Haryana. The firm already has 2 cell manufacturing units in China.
Manikaran Power	It is setting up a battery raw material project to manufacture lithium hydroxide – producing 20,000 Lithium Carbonate. It is likely to be commissioned by mid-2024
Epsilon Carbon	It has announced setting up production of graphite anode material for Li-ion cells

Source: Industry reports, CRISIL MI&A Consulting

The battery manufacturing capacity is expanding across the world with many new entrants as more countries compete for a share of the market. Most of the facilities are expected to become operational between 2025 and 2028. Below chart shows the proposed capacity addition by major players globally, with China retaining a large market share.

Figure 49: Emerging battery manufacturing facilities across the world



Source: NITI Aayog, CRISIL MI&A Consulting

4.6 Overview of Green Hydrogen Policy and its impact on capacity additions

The National Green Hydrogen Mission was approved by the government on January 4, 2022. The mission aims to make India a leading producer and supplier of green hydrogen in the world. The mission would result in development of green hydrogen production capacity of at least 5 million metric tonne per annum with an associated renewable energy capacity addition of about 125 GW in the country.

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

The initial outlay for the Mission will be Rs.19,744 crore, including an outlay of Rs.17,490 crore for the Strategic Interventions for Green Hydrogen Transition Programme (SIGHT) programme, Rs.1,466 crore for pilot projects, Rs.400 crore for R&D, and Rs. 388 crore towards other Mission components. Under the SIGHT, two distinct financial incentive mechanisms have been proposed, one is targeting domestic manufacturing of electrolysers and the other for production of Green Hydrogen. The Mission will also support pilot projects in emerging end-use sectors and production pathways.

Some of the key highlights of Green Hydrogen Policy are as follows:

- The waiver of inter-state transmission charges shall be granted for a period of 25 years for Green Hydrogen and Green Ammonia projects commissioned before 30 June 2025.
- Developers can manufacture Green Hydrogen/Green Ammonia using Renewable Energy from co-located or remotely located plants, or from the Power Exchange. They will be granted Open Access within 15 days of a complete application. Open Access charges will be in accordance with the Rules.
- Banking permitted for a period of 30 days for renewable energy used for making Green Hydrogen /Green Ammonia.
- Under the Electricity (Transmission system planning, development and recovery of Inter State Transmission charges) Rules 2021, renewable energy projects set up to manufacture green hydrogen/green ammonia will be granted priority for ISTS connectivity.
- Land in Renewable Energy Parks can be allotted for the manufacture of Green Hydrogen / Green Ammonia.
- Manufacturers of green hydrogen/ammonia can set up bunkers near ports to store green ammonia for export or use by shipping. Port authorities will provide land for storage at applicable charges.
- Renewable energy used to produce green hydrogen /ammonia counts towards RPO compliance for consumer and the discom in whose area the project is located
- Distribution licensees may also procure and supply Renewable Energy to the manufacturers of Green Hydrogen / Green Ammonia in their States. In such cases, the Distribution licensee shall only charge the cost of procurement as well as the wheeling charges and a small margin as determined by the State Commission.
- MNRE to create a single portal for all Green Hydrogen/Ammonia clearances. All clearances will be provided within a period of 30 days from date of application

Central government has been encouraging production and use of green hydrogen and ammonia in the country. Various initiatives by Government include:

- Production-linked incentive (PLI) scheme: The PLI scheme will provide financial assistance for production of green hydrogen and manufacturing of electrolysers in India.

- Draft roadmap for research and development (R&D): The objective is to decrease the cost of carbon-free fuel and develop efficient and safe technologies for its production, storage, and transportation.

The policy is expected to have a significant impact on the future renewable capacity addition in India. Green hydrogen is a key enabler of the clean energy transition, and the policy will help to accelerate the development of the green hydrogen sector in India.

The policy is expected to lead to increased investment in the green hydrogen sector, development of new green hydrogen technologies and increased demand for renewable energy.

Overall, the Green Hydrogen Policy is a major step forward for the clean energy transition in India. The policy is expected to have a significant impact on the future renewable capacity addition in India and will help to make India a prominent player in the green hydrogen sector.

4.7 Overview of electrolyser manufacturing

Electrolyser technologies vary with respect to cell design, variation within components, and degree of technology maturity. Alkaline and PEM electrolysers are the most advanced technologies with higher adoption rates compared to other technologies. On the other hand, Solid oxide and AEM (anion exchange membrane) electrolysers have high potential but are much less mature technologies.

Table 15: Comparison of electrolyser techniques

Parameters	Alkaline Electrolysers (AE)	Proton Exchange Membrane (PEM)	Solid Oxide Electrolyser Cell (SOEC)
Operating temperature (ºC)	70-90	50-80	700-850
Operating pressure (bar)	1-30	< 70	1
Electrolyte	Potassium hydroxide (5-7 /mol/l)	PFSA membranes	Yttria-stabilized Zirconia (YSZ)
Separator	ZrO_2 stabilized with PPS mesh	Solid electrolyte	Solid electrolyte
Electrode/catalyst (Oxygen side)	Nickel coated perforated stainless steel	Iridium oxide	Perovskite-type (LSCF, LSM)
Electrode/catalyst (Hydrogen side)	Nickel coated perforated stainless steel	Platinum nanoparticules on Carbon black	Ni/YSZ
Frames and sealing	PSU, PTFE, EPDM	PTFE, PSU, ETFE	Ceramic glass
Capital Expenditure (Rs lakh/kW_e)	0.5 - 1.2	1.0 - 2.0	2.0 - 5.0
Advantages	Simple design and stack components that rely on nickel which is abundantly available make it cheap.	Quick reaction to fluctuating RE power generation, higher output pressure, small size.	Highest efficiency due to favorable kinetics and thermodynamics at higher temperatures.

Parameters	Alkaline Electrolysers (AE)	Proton Exchange Membrane (PEM)	Solid Oxide Electrolyser Cell (SOEC)
Drawbacks	Liquid electrolyte is corrosive at elevated temp., resulting in shorter lifespan of electrodes	Rare and emission-intensive metals like Pt and Ir required, resulting in high cost.	Not as mature; limited long-term cell stability of low suitability in fluctuating systems

Note: PFSA: Perfluorosulfonic acid, PPS- Polyphenylene sulphide, LSCF- Lanthanum strontium cobalt ferrite, LSM- Lanthanum strontium manganite

Source: IRENA, CRISIL MI&A Consulting

As per NITI Aayog, India may witness a 20 GW electrolyser demand by 2030 There have been a number of announcements by key industry players towards boosting the electrolyser production capacity in India. Adani New Industries Limited (ANIL) is currently setting up a 5 GW integrated electrolyser plant and has signed an agreement with Cavendish Renewable Technology (CRT) to manufacture electrolysers based on AE, PEM and SOEC technologies. Ohmium, which has a PEM electrolyser capacity of 500 MW/year set up in Karnataka has plans to take its capacity to 2 GW in the near future. Greenko and John Cockerill partnered in March 2022 to set up a 2 GW electrolyser manufacturing plant in Andhra Pradesh. H2E Power Systems is building a 1 GW electrolyser plant in a phased manner while exploring all four electrolyser technologies. Lastly, Reliance has partnered with Stiesdal and L&T with HydrogenPro to set up AE-based electrolyser plants in Gujarat and Maharashtra, respectively.

In the global scenario, China presently dominates electrolyser manufacture with players like LONGi, PERIC and Sungrow Power. However, American and European players have announced significant capacity plans that will make them competitive over the next few years.

Table 16: Existing major electrolyser manufacturers globally

Manufacturer	Country	Technology	Existing Capacity	Expansion Plans
LONGi	China	Alkaline	1.5 GW	5 GW by 2025
PERIC	China	Alkaline/PEM	1.5 GW	-
Sungrow	China	Alkaline/PEM	1.1 GW	1.1 GW by 2024
John Cockerill	Belgium	Alkaline	1.0 GW	8 GW by 2025
Thyssenkrupp	Germany	Alkaline	1.0 GW	5 GW by 2025
Plug Power	US	PEM	1.0 GW	10-12 GW by 2025
ITM Power	UK	PEM	1.0 GW	5 GW by 2024
Nel	US	Alkaline/PEM	0.5 GW	4 GW by 2025
Bloom Energy	US	SOEC	2.0 GW	-

Source: Company websites, CRISIL MI&A Consulting

Incentive scheme for Electrolyser manufacturing under SIGHT program

The MNRE has issued guidelines for the implementation of the SIGHT programme in June 2023. This programme consists of two components: the incentive scheme for electrolyser manufacturing (component-I) and the incentive scheme for hydrogen production (component-II). The national green hydrogen mission has allocated a total of Rs. 17,490 crore for the SIGHT programme, with Rs 4,440 crore allocated for electrolyser manufacturing and Rs. 13,050 crore for green hydrogen production.

Component-I focuses on the electrolyser scheme with an allocation of Rs. 4,440 crore, aiming to maximize domestic electrolyser manufacturing capacity. The first phase of the SIGHT programme would assist in developing 1500 MW of manufacturing capacity. The incentives for electrolyser manufacturing would be provided based on manufacturing capacity, calculated in rupees per kilowatt, for a period of 5 years from the start of electrolyser manufacturing.

The introduction of these schemes is expected to have a transformative effect on the Green Hydrogen ecosystem in India, propelling it forward and laying the groundwork for a cleaner and more sustainable energy future for the country.

SECI issued its first electrolyser manufacturing tender awarded under SIGHT program for total manufacturing capacity of 1.5 GW. The details of the winners are as follows:

Table 17: List of winners for SECI electrolyser manufacturing tender

Bidder	Allocated Capacity (MW/annum)	Maximum Incentive (INR million/year)
Bucket I: Any stack technology		
Reliance Electrolyser Manufacturing	300	4,440
Ohmium Operations	137	2,027.6
John Cockerill Greenko Hydrogen Solutions	300	4,440
Advait Infratech	100	148
Jindal India	300	4,440
L&T Electrolysers	63	932.4
Total	**1,200**	
Bucket II: Indigenous technology		
Homihydrogen	101.5	1,502.2
Adani New Industries	198.5	2,937.8
Total	**300**	

Subsequently, in August 2024, SECI announced the snapshot of opening of enevlope-2 under SIGHT (Tranche II) for a total capacity of 1.5 GW as under.

Table 18: List of winners for SECI electrolyser manufacturing tender SIGHT (Tranche II)

Bidder	Allocated Capacity (MW/annum)
Bucket 1: Any stack technology	
Newage Green Electro Private Limited 3	71.5
Waaree Energies Ltd	300
Matrix Gas and Renewables Limited	237
Advait Infratech Limited	200
Ohmium Operations Private Limited	137
GH2 Solar Private Limited	105
Avaada Electrolyser Private Limited 3	49.5
Total (MW)	**1100**
Bucket 2A: Indigenously developed stack technology	
Adani Enterprises Limited	71.5

Bidder	Allocated Capacity (MW/annum)
Newage Green Electro Private Limited	228.5
Total (MW)	300
Bucket 2B: Indigenously developed stack technology-smaller units	
Adani Enterprises Limited	30
Eastern Electrolyser Limited	30
Newtrace Private Limited	30
Suryaashish KA1 Solar Park Private Limited	10
Total (MW)	**100**

Source: SECI, CRISIL MI&A Consulting

5 Indian solar power market

Executive Summary:

- With strong government thrust, India added ~13 GW solar capacity in fiscal 2023; over 15 GW during fiscal 2024 and ~7.6 GW during first five months of fiscal 2025
- A tariff of Rs 2.5-2.6 p.u. would be required to generate a 12-14% IRR owing to a sharp decline in module prices on year in fiscal 2025, despite rising BoS cost
- Solar capacity additions of 137-142 GW expected over fiscals 2025-2029
- As the government pushes towards the Green Hydrogen targets, more solar capacities are expected to commission totaling 32-37 GW by fiscal 2029
- Central and state tendering has grown multi-fold with a healthy pipeline giving comfort; resolution of execution-related hurdles critical
- ALMM order poses a risk to ~8-9 GW of solar projects if the planned capacity expansion gets delayed.
- ~13-15 GW of projects to be commissioned under the open access utility segment over the next five years
- Green Energy Open Access Rules, 2022 to provide greater clarity in various open access related provisions.
- ~20-22 GW rooftop solar additions expected over 2025-29; 3x over FY19 to FY23
- Deterioration in the financial profile of distribution utilities resulting in offtake issues and payment defaults, declining power deficit, and aggressive bidding are some of the key monitorable for Indian Solar Industry.
- Wind Solar Hybrid (WSH) is fast becoming the preferred RE option in India given the various advantages of RTC power, reliability and grid stability
- Lack of good sites, optimal sizing, higher tariffs, and grid balancing requirement poses implementation risks for WSH Projects

5.1 Overview of RE Sector in India

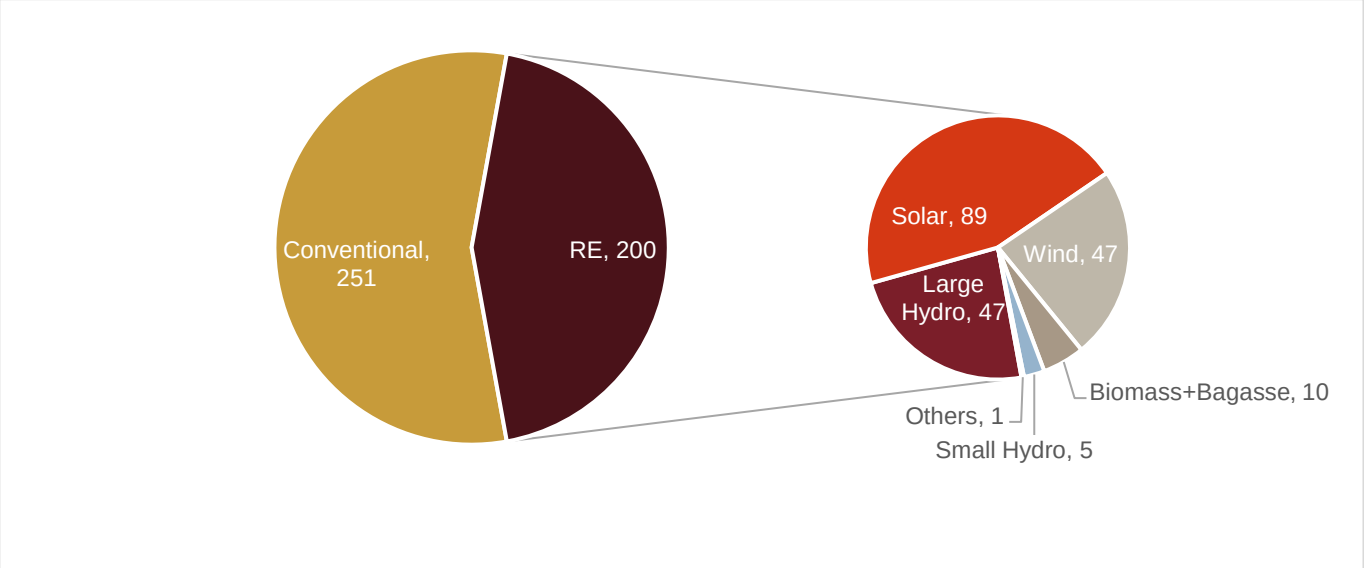
The impact of two oil shocks pushed the government to establish a Commission for Additional Sources of Energy under the Department of Science and Technology in March 1981. This division was responsible for formulating and implementing policies regarding the development of new and renewable energy sources and to propel research and development in the sector. In 1982, a new department, the Department of Non-Conventional Energy Sources was created in the Ministry of Energy, subsuming the earlier commission, paving the way for new renewable energy in India.

Renewable sources are a cleaner source of energy than conventional ones as they do not burn like fossil fuels, preventing the release of pollutants into the air. Increasing use of renewable energy would help reduce carbon emissions, and thereby, 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, solar and wind remain key sources.

Renewable energy installations (incl. large hydro) have increased fivefold to ~200 GW as of August 2024, as compared with ~63 GW as of March 2012 (source: MNRE), led by various central and state-level incentives. As of August, 2024, installed grid connected renewable energy generation capacity (incl. large hydro) in India constituted

~44% of the total installed generation base in India. In particular, this growth has been led by solar power, which has grown to ~89 GW from ~0.09 GW over the discussed time period.

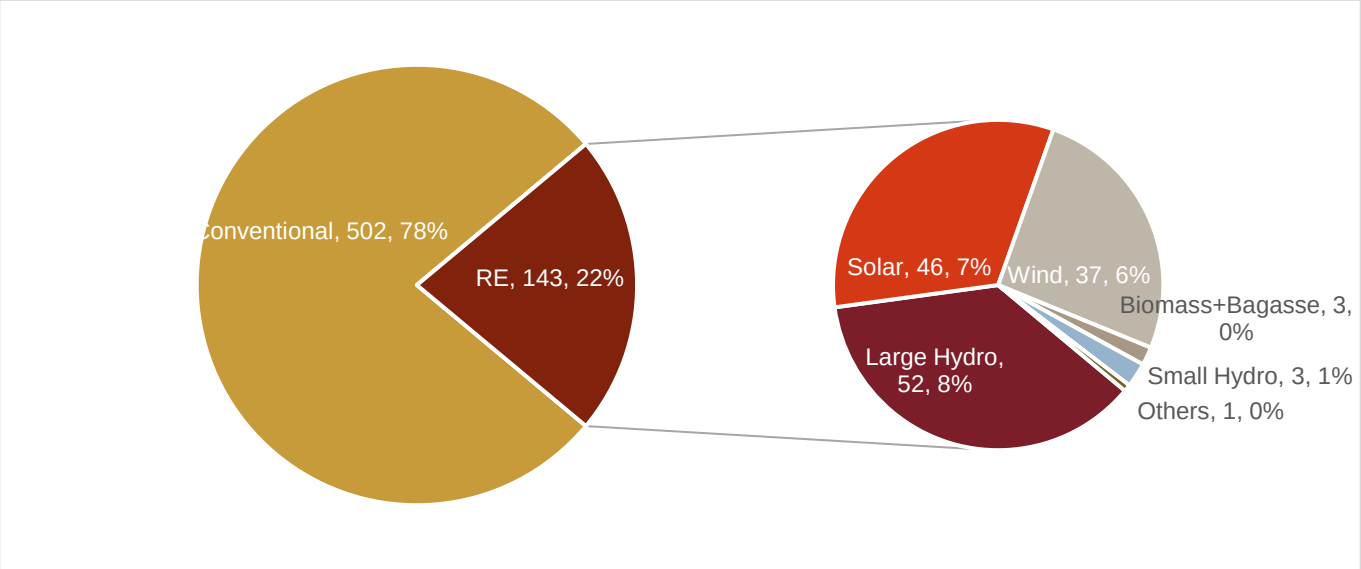
Figure 50: India's RE (incl. Large Hydro) capacity was ~43% as of August 2024 (GW)



Note: Excl. imports from Bhutan
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 ~22% as of July -2024.

Figure 51: India's RE (incl. Large Hydro) energy penetration was ~22% at end of July - 2024



Note: Excl. imports from Bhutan; At CEA RE Generation data lags compared to installed capacity data.
Source: MNRE; CEA, CRISIL MI&A Consulting

Despite such strong capacity addition, there is huge untapped potential for RE installations in India, as is evident from the table below.

Table 19: Potential and cumulative capacity of RE (technology-wise)

Technology	Potential	Cumulative capacity (as of August -24)	Untapped potential
Wind	~696 GW (120 m hub height)	47.19 GW	93%
Solar	750 GW	89.43 GW	88%
Bioenergy	25 GW	10.35 GW	59%
Hydro*	165 GW	52.00 GW	68%
Waste to energy	NA	0.6 GW	NA

**Hydro: Large + Small hydro*

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

However, solar energy potential is the greatest in India amongst all the commercially available renewable energy sources. As per an assessment by the National Institute of Solar Energy (NISE) and a report by MNRE, the top five states with the highest solar PV potential are Rajasthan, Jammu & Kashmir, Maharashtra, Madhya Pradesh and Andhra Pradesh. While the MNRE has considered 3% of wasteland that can be utilised in a state for the installation of ground-mounted solar PV projects, it has also considered 2%-25% of the rooftop space being utilised (1 kWp – 100 kWp) across various buildings, such as offices, shops, hospital, and government buildings, for the setting up of rooftop solar PV projects.

Further, there is huge untapped potential across the states for solar energy, as can be seen from the table below:

Table 20: State-wise estimated potential v/s percentage achievement of potential for solar energy across major states of India (as of Aug 2024)

States	Potential (GW)	Installed capacity (GW)	Potential achieved (%)
Andhra Pradesh	38	4.63	12.2%
Gujarat	36	14.75	41.0%
Karnataka	25	8.83	35.3%
Madhya Pradesh	62	4.13	6.7%
Maharashtra	64	7.38	11.5%
Punjab	3	1.38	46.0%
Rajasthan	142	24.10	17.0%
Tamil Nadu	18	8.99	49.9%
Telangana	20	4.82	24.1%
Uttar Pradesh	23	3.28	14.3%

Source: MNRE; NISE; CRISIL MI&A Consulting

Further, there is huge untapped potential across the states for wind energy also, as can be seen from the table below:

Table 21: State-wise estimated potential v/s percentage achievement of potential for wind energy projects across major states of India (as of March 2024)

States	Potential (GW)	Installed capacity (GW)	Potential achieved (%)
Andhra Pradesh	44	4.10	9.3%

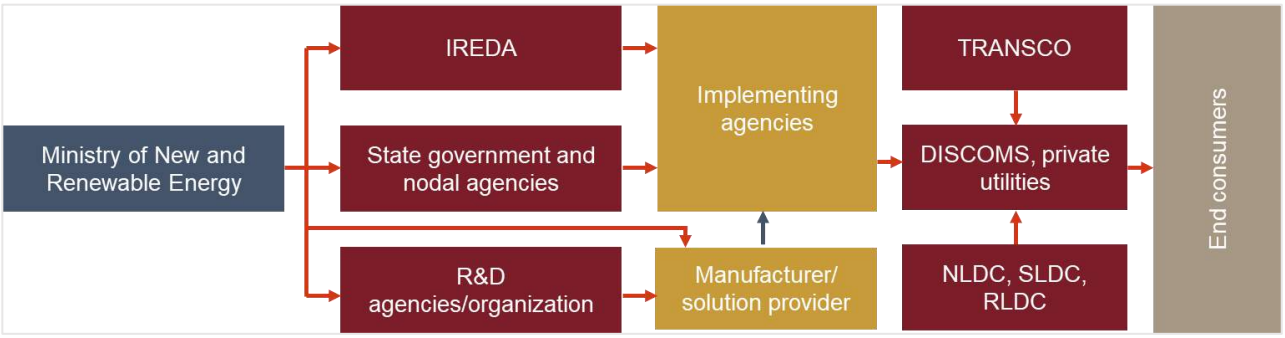
States	Potential (GW)	Installed capacity (GW)	Potential achieved (%)
Gujarat	84	12.16	14.5%
Karnataka	56	6.55	11.7%
Madhya Pradesh	10	2.84	28.4%
Maharashtra	45	5.21	11.6%
Rajasthan	19	5.20	27.3%
Tamil Nadu	34	10.93	32.1%
Others	9	0.20	2.2%

Note: Wind Power Potential at 120 mtr agl in GW

Source: MNRE; NIWE; CRISIL MI&A Consulting

The capacity additions in the RE segment are mainly driven by various fiscal and regulatory incentives, such as accelerated depreciation, 80 IA, additional depreciation, generation-based incentives, and renewable purchase obligations by the central government. The key stake holders in the RE segment are represented in the figure below:

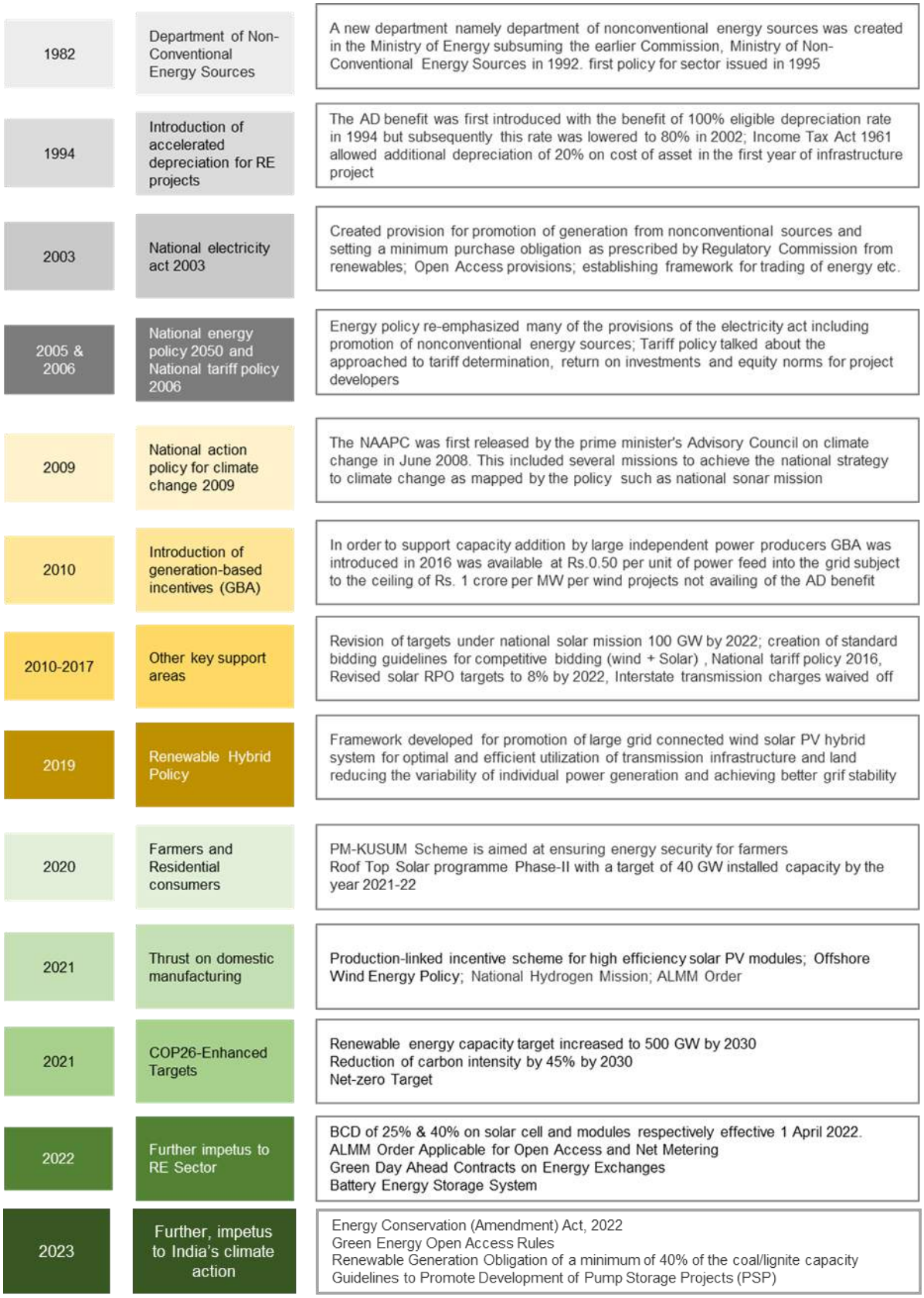
Figure 52: Key stakeholders in the renewable sector in India



Source: CRISIL MI&A Consulting

In the section below, CRISIL MI&A Consulting has elaborated on the evolution of the regulatory framework and key provisions in the major reforms undertaken.

Figure 53: Timeline of regulatory changes



Source: Policy documents; CRISIL MI&A Consulting

In 2014, the government set a target to achieve 175 GW of renewable energy in India- 100 GW of solar energy by December 2022, 60 GW of wind energy by December 2022 and 15 GW via other sources, including small hydro projects, biomass projects and other renewable technologies, by December 2022.

Further, under the Paris Agreement, the Indian government has committed to generating 40% of electricity from non-fossil fuels sources by 2030. The country also has a target of setting up 450 GW of RE by 2030 (500 GW from non-fossil fuels) and providing 17 lakh solar pumps to farmers under the Pradhan Mantri-Kusum Yojana.

The 2021 United Nations Climate Change Conference (COP26) was the 26th United Nations Climate Change conference, held at Glasgow, Scotland during Oct-Nov 2021 and a draft agreement was circulated with respect to climate change action. The proposal aims at updating the time frame for revised targets NDCs to next year — much sooner than the requirement of every five years as laid out in the 2015 Paris Climate Accord. India updated its NDCs as follows:

i. To reduce Emissions Intensity of its GDP by 45% by 2030, from 2005 level

ii. To achieve about 50% cumulative electric power installed capacity from non-fossil fuel-based energy resources by 2030,

iii. By the year 2070, India will achieve the target of Net Zero

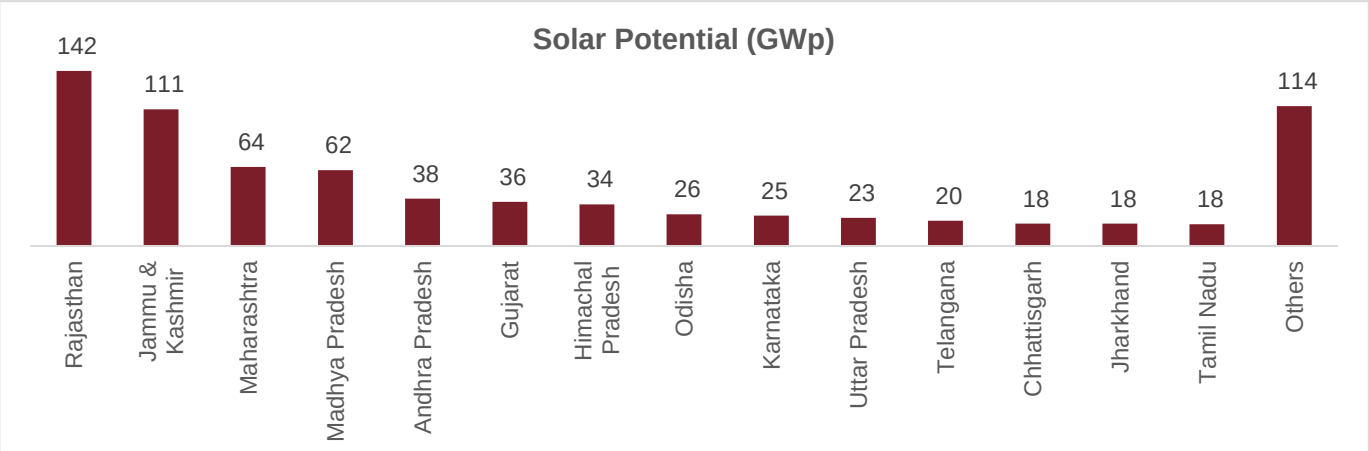
These are more ambitious and are way beyond the current NDCs agreed under the Paris Agreement. These will provide a new thrust to the RE Sector in India and will boost the already accelerating RE Sector. These will also provide guidelines to the Regulators as well as Government Authorities while setting the rules, regulations, and targets.

5.2 Review of solar energy capacity additions in India

5.2.1 State-wise potential of solar energy

India is endowed with vast solar energy potential. About 5,000 trillion kWh per year of energy is incident over the land area, with most parts receiving 4-7 kWh per sq m per day. Solar PV power can effectively be harnessed, with a huge scalability potential in India. The National Institute of Energy estimated the country's solar potential at 748 GW, assuming solar PV modules cover 3% of the geographical surface. India is a perfect location for solar energy because of its location. It has 300 days of sunshine each year, with daily peak electricity use being in the evenings and a seasonal peak in the summer.

Figure 54: State-wise solar potential



Source: MNRE, NISE, CRISIL MI&A Consulting

5.2.2 Evolution of solar power in India

The growth story of the solar sector in India commenced with the commissioning and operation of 15 MW of solar photovoltaic (PV) pilot projects between 2008 and 2009. Later, with the introduction of the NTPC Vidyut Vyapar Nigam Limited (NVVN) scheme under JNNSM (which allowed bundling of solar power with cheaper thermal power), solar capacity allocations picked up pace.

Under JNNSM Phase I, 450 MW of solar PV capacities were tendered out in two batches — 150 MW (Batch I) and 300 MW (Batch II) — in fiscal 2011. In addition, 470 MW was offered under solar thermal technology. These capacities were commissioned over fiscals 2011-13. The state-level schemes also saw rapid growth in the disbursement of solar power during the same period. Until fiscal 2012, only Gujarat and Rajasthan had a state solar policy. After the success of Gujarat's state solar policy, Andhra Pradesh, Tamil Nadu, Karnataka, Madhya Pradesh, and Telangana introduced their respective solar policies.

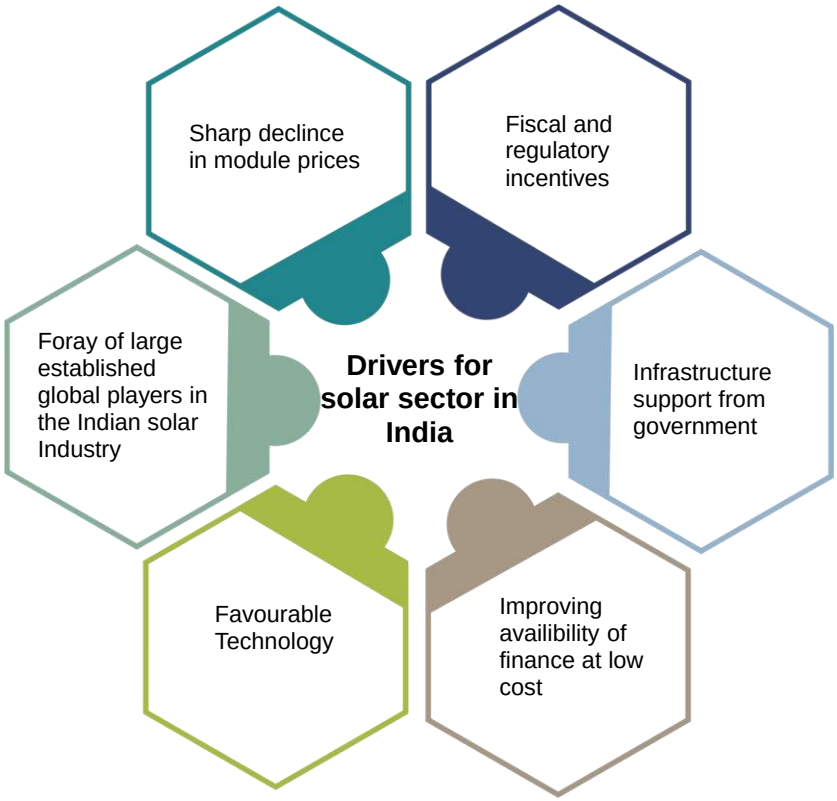
By March 2012, India had reached close to 1 GW of installed capacity, with projects providing satisfactory generation performance along with timely receipt of payments from both NVVN and discoms of Gujarat. The bidding guidelines became stringent to avoid commissioning defaults by successfully bid projects and to ensure the entry of only serious players. Further, the Ministry of New and Renewable Energy (MNRE) created a new agency, SECI, to handle solar bidding and channelise the subsidy and incentives to developers. Consequently, between March 2012 and March 2016, the GoI released several schemes, such as NSM Phase II Batch II Tranche I (3 GW), Batch III (3 GW), Batch IV (5 GW), Batch V (1 GW), Batch VI (50 MW), over and above other schemes for defence organisations, canal-top plants and 1.5 GW under-rooftop solar plants. Further, many states such as Madhya Pradesh, Andhra Pradesh, Telangana, Karnataka, Maharashtra, and Tamil Nadu introduced their solar policy and respective targets, and also allocated 7 GW of solar capacity during this period.

After a continuous decline in solar tariffs over the years and a revision of solar targets under the NSM (from 20 GW till fiscal 2022 to 100 GW in fiscal 2022), the government is focusing on improving the supporting infrastructure for solar projects, including the construction of solar parks and green energy corridors. Further, allocations under GoI schemes have risen to meet the solar power demand from state discoms willing to meet their revised RPO targets; the National Tariff Policy revised the solar RPO target to 10.5% by fiscal 2022. Such large allocations have resulted in growth of solar IPPs in India. Further, lower counterparty risk, lower offtake risk (because of solar park transmission infrastructure), and a multi-layer payment security mechanism attracted more IPPs with access to cheaper funds.

In the renewable energy basket (including 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. The first five months of fiscal 2025 saw a capacity addition of ~7.6 GW.

5.2.3 Growth drivers for the solar sector in India

Figure 55: Growth drivers for the solar sector in India



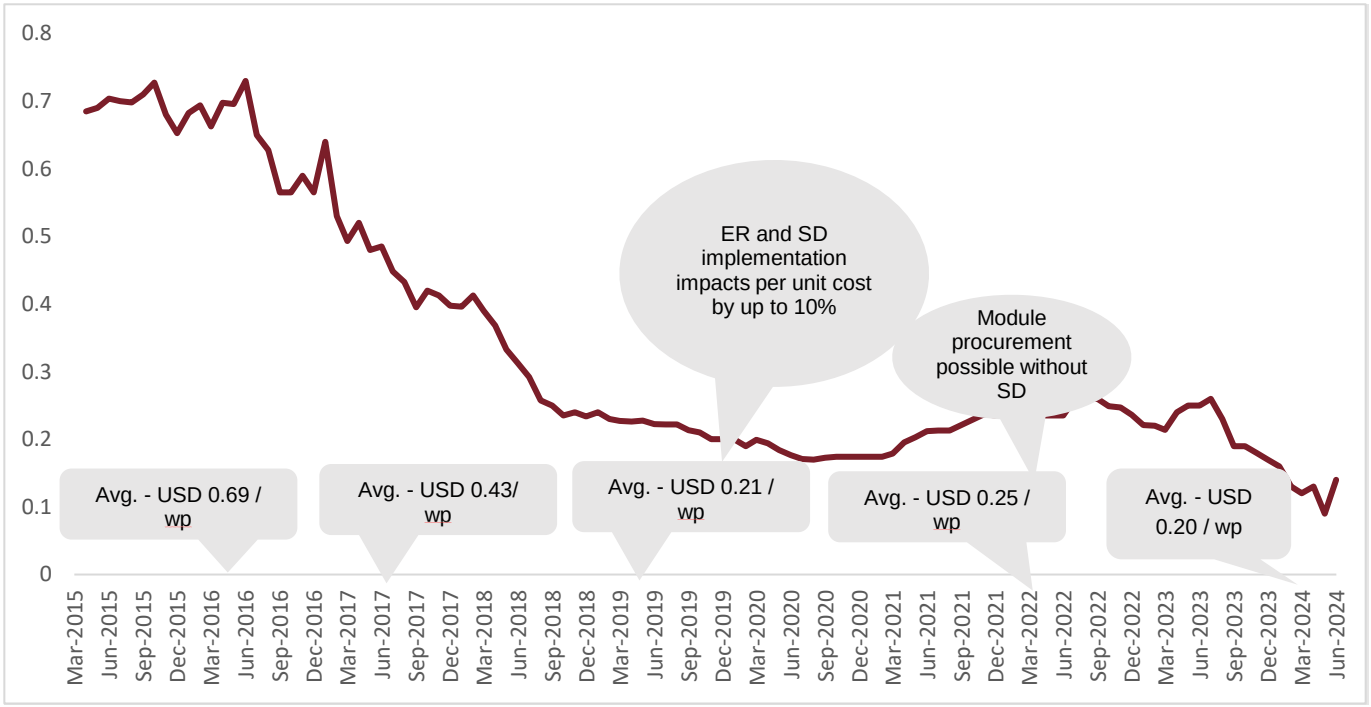
Source: CRISIL MI&A Consulting

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

5.2.3.1 Declining module prices and tariffs

The global average solar module price, which constitutes 55-60% of the total system cost, crashed 73% to $0.47 per Wp in 2016 (average for January-December) from $1.78 per Wp in 2010. In fact, prices continued to decline to $0.22 per Wp by end-August 2019, owing to the wide demand-supply gap in the global solar module manufacturing industry. Historically, global solar demand has been half of the total module manufacturing capacity. Moreover, innovation in the manufacturing processes has reduced costs, putting downward pressure on module prices. Further, declining inverter prices (6-7% of the capital cost), which fell to $21 per Wp by March 2020, reduced system costs. Module prices reached $0.22 per Wp level in fiscal 2021. Module prices started to fall in 2023 owing to the ramp-up in the production of upstream components. Prices of modules fell to $0.15-0.20 per watt-peak in April-November 2023 from $0.23 per watt-peak in January 2023. This has eased some pressure on capital costs in fiscal 2024. Global solar module prices have reached a historic low, standing at just $0.09 per watt-peak in June 2024, which is expected to stimulate growth in solar power capacity. Prices are expected to remain stable over the medium term due to supply glut and relatively weak demand internationally. In line with this trend domestic prices too fell to $ 0.14 per watt peak maintaining a steady premium over landed cost of imported modules. Additionally, MNRE has reinstated the applicability of Approved List of Module Manufacturers (ALMM). As a result, only ALMM enlisted manufacturers can supply cells and modules to government and government-assisted projects. Projects under open access and rooftop solar by private parties are also brought into the ambit of ALMM. Therefore, the fall in prices across the value chain is expected to be arrested in fiscal 2025.

Figure 56: Module prices declined over 200% from fiscal 2015 to 2024



Source: CRISIL MI&A Consulting

Table 22: Safeguard 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	25.0%	20.0%	15%	14.9%	14.5%	Module – 40% Cell – 25%

Source: CRISIL MI&A Consulting

Various players from the Indian solar component manufacturing industry filed additional duty petitions against imports. The key in this regard was a safeguard duty investigation filed by the Indian Solar Manufacturer's Association (ISMA) in front of 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 per unit (with the tariffs ranging from Rs 2.6-2.8 per unit).

- ***Solar power tariffs have been lower than coal-based power tariffs***

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