Market Intelligence
& Analytics

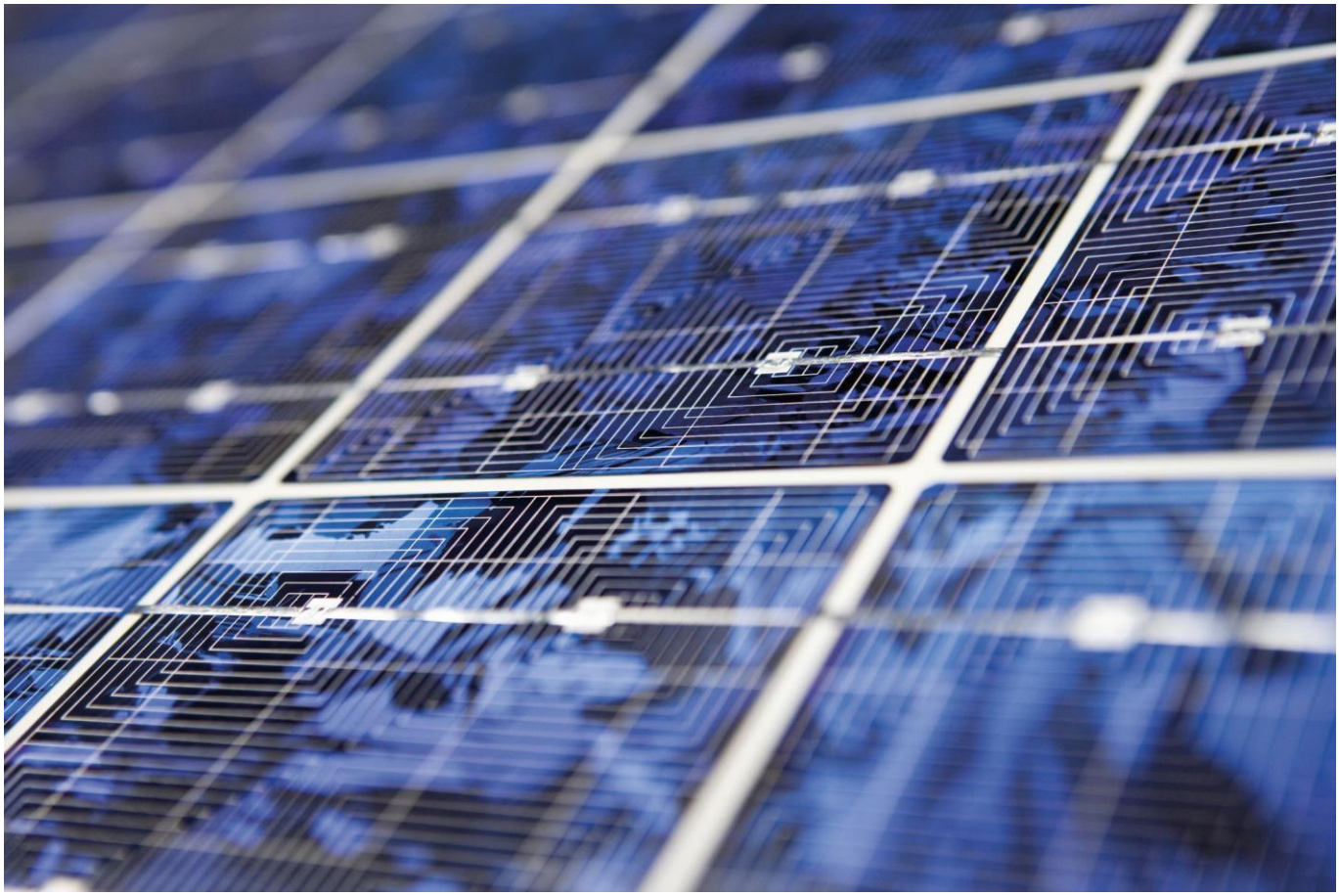
CRISIL
An S&P Global Company

# Solar power market in India

Waaree Energies Ltd.

## Final report

**December 2023**



Consulting

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# 1 Overview of economy

**Executive Summary:**

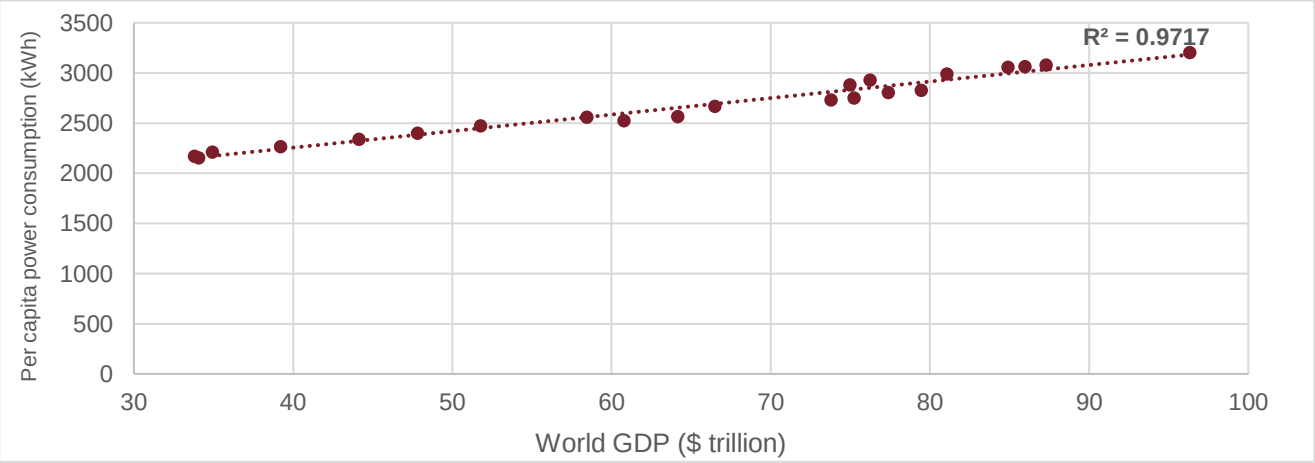
- India is at fifth largest economy in the World as per the estimated GDP for 2023.
- As per IMF, India's GDP growth is estimated to grow at 6.3% in 2023, highest amongst the top 10 economies.
- CRISIL expects India's real GDP to grow 6.4% this fiscal, compared with 7.2% in fiscal 2023.
- India's inflation is expected to be at 5.5% in current fiscal year
- The rupee is likely to average 83 against the dollar by March 2024 compared with 82.3 in March 2023
- The 10-year G-sec yield to settle at ~7.0% by March 2024, compared with 7.4% in March 2023.

## 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**

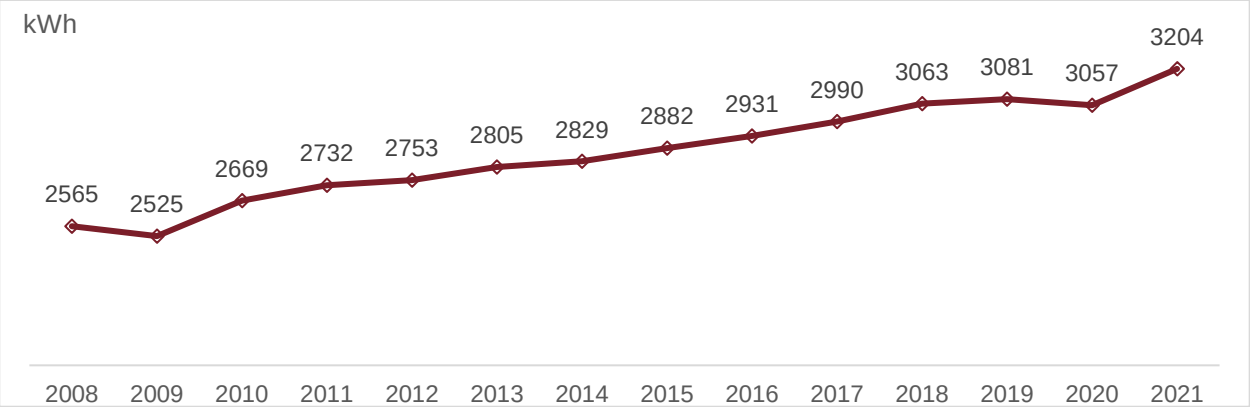



*Source: World Bank, IMF, EIA, UN, CRISIL Consulting*

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 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.

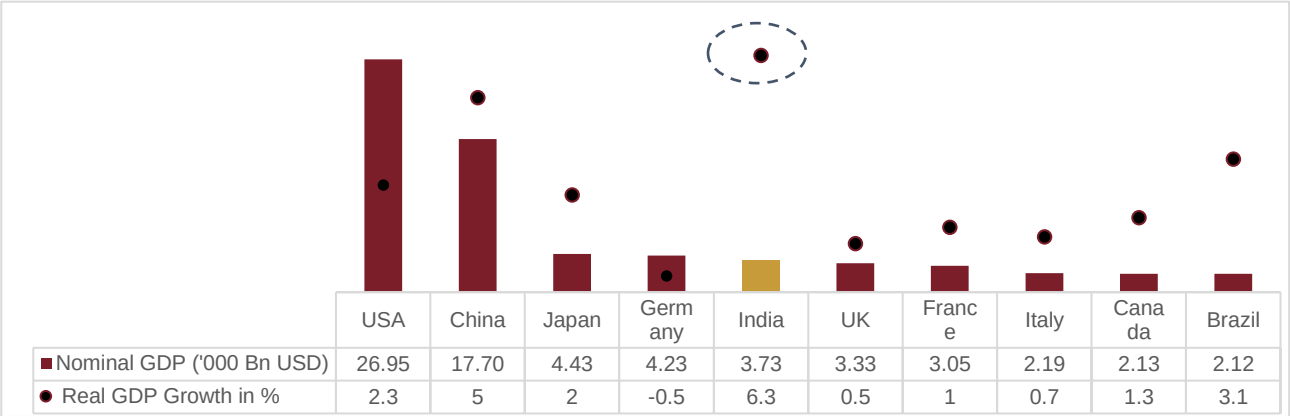
**Carbon markets:** Carbon markets allow countries and companies to trade emissions certificates. This helps to reduce emissions and at the same time raise revenue to fund more clean energy projects.

**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

According to World Economic Outlook (October 2023) by IMF, India is at fifth largest economy in the World as per the estimated GDP for 2023. As per the said Report, India’s GDP growth is estimated to grow at 6.3% in 2023, highest amongst the top 10 economies.

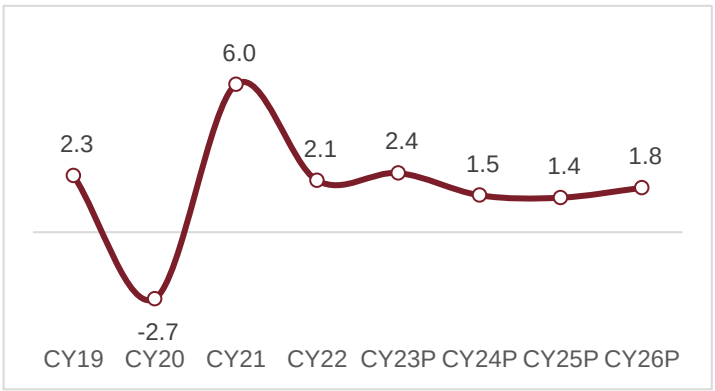
**Figure 3: India's economy ranked 5th in the World**

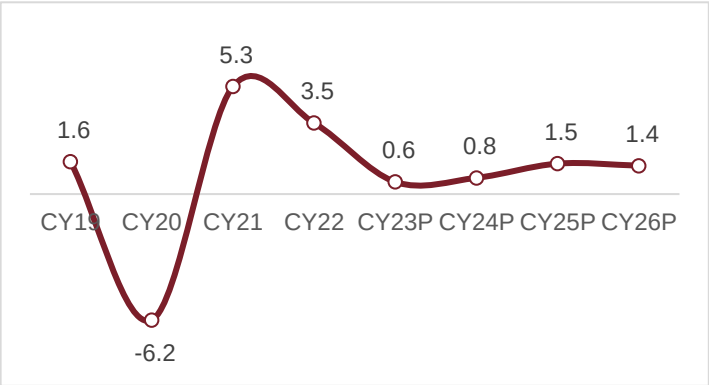
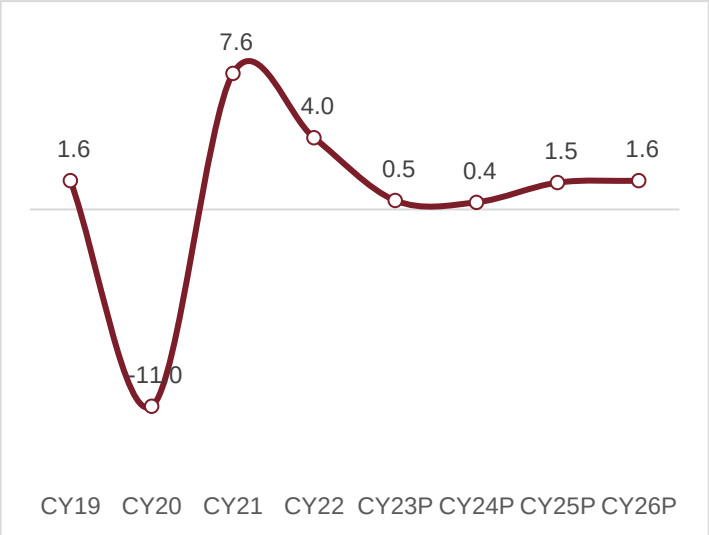


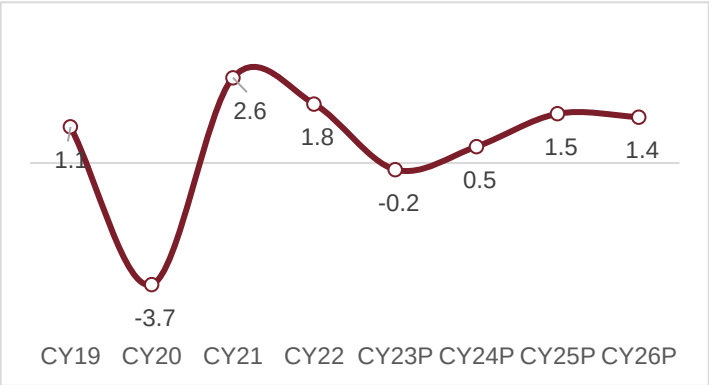
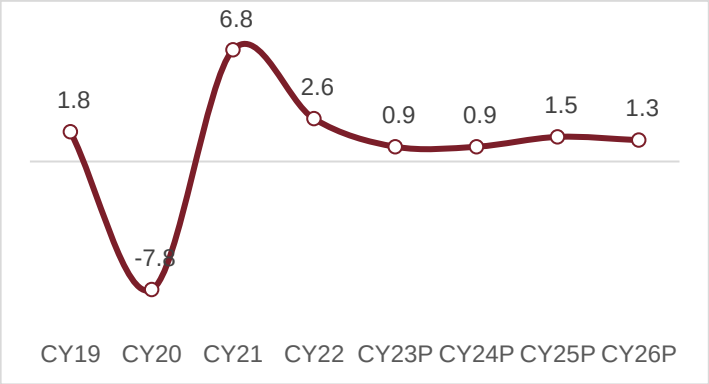

*Source: World Economic Outlook Database (April 2023) by IMF; CRISIL Consulting*

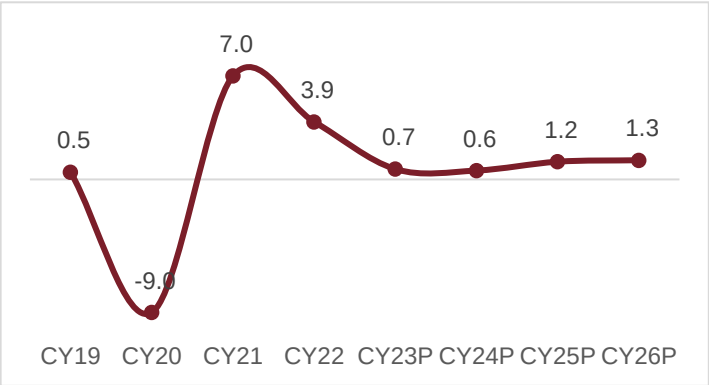
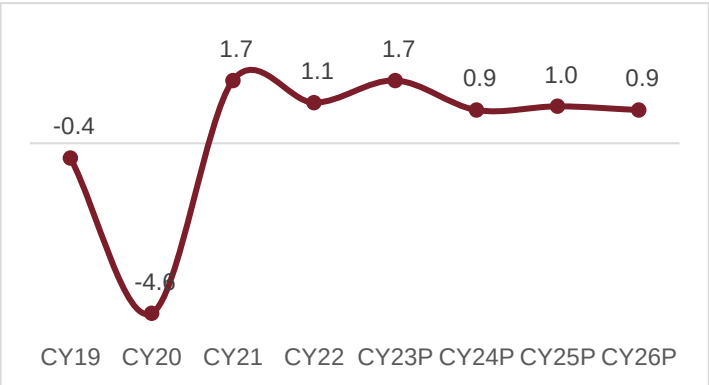
Indian economy has been booming in recent year with GDP increasing at around 6-7% rate. The reasons behind this boom are strong domestic demand, foreign investments, economic reforms, supportive policies, digitalization etc. Indian economy is expected to grow further and is seen as one of the most promising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

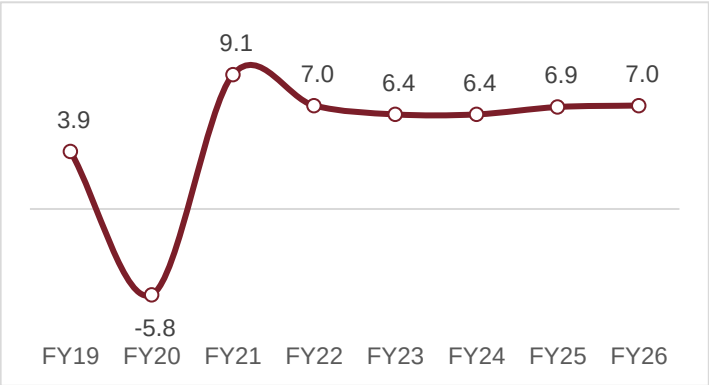
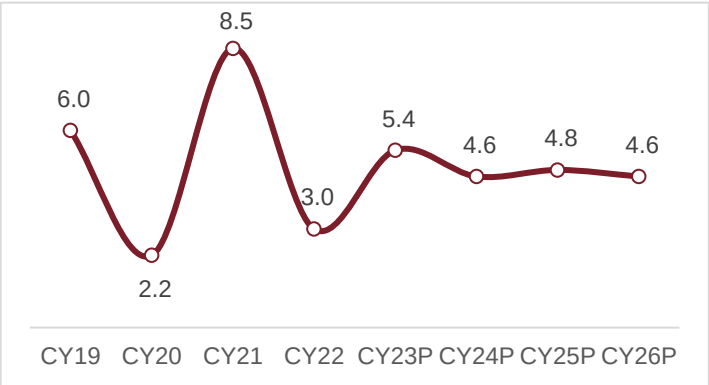
**Table 1: Real GDP growth forecast of major economies**

| | | |
|---|---|---|
| USA | Activity accelerated in the third quarter, with GDP growth at a blockbuster pace of 4.9% annualized.<br><br>S&P Global forecasts GDP growth moderately increasing to 2.4% this year. S&P Global see the Fed on hold into the middle of 2024, with a chance of one more hike in December depending on the near-term data flow. Fiscal policy should remain supportive of growth over forecast horizon. S&P Global see below-trend growth for 2024 and 2025, with unemployment drifting into the mid 4% range in one year's time. |  |

| | | |
|---|---|---|
| Eurozone | In contrast to the U.S., activity in the third quarter was flat in both the eurozone and the U.K. Production has suffered from high energy prices and destocking (manufacturing is in recession); fiscal policy is no longer expansionary (although there are differences from country to country).<br><br>S&P Global expects policy rates to be on hold into mid-2024. It's forecast is for below-trend growth in 2024 before a return to trend in 2025. |  |
| UK | Quarterly GDP growth in the UK was confirmed at 0.2% in the second quarter of 2023 while GDP growth for the first quarter was revised up to 0.3%. The production sector, which expanded 1.2% aided by falling input cost pressures on manufacturers, boosted second-quarter growth. S&P Global expects the UK economy to grow 0.5% in 2023. Looking at the latest available monthly data, the UK's GDP expanded 0.2% on-month in August after a 0.6% contraction in July. The growth was led by output expanding 0.4% in the services sector. However, output in consumer-facing services fell 0.6%, remaining below pre-pandemic levels. Production (-0.7%) and construction (-0.5%) output contracted in August. S&P Global expects annual growth in the UK at 0.5% in 2023. |  |

| | | |
|---|---|---|
| Germany | Germany's real GDP grew 1.8% in 2022 as rising demand, particularly in services, helped partially negate the effects of high inflation. However, in the third quarter of 2022, investment and private consumption could not reach pre-pandemic levels, leading to a decrease of 0.2% in real GDP in the fourth quarter of 2022. Despite some resurgence in the economy, Germany is expected to see a mild contraction in the first quarter of 2023 due to higher energy prices. Additionally, because of a lack of foreign demand, exports are also expected to slow down. |  |
| France | France's real GDP grew 2.6% in 2022 against a backdrop of subsiding of challenges heaped by the pandemic. However, the economy slowed down in the second half of 2022 owing to accelerated energy and commodity prices, along with supply chain disruptions.<br><br>Nevertheless, expected cooling of inflation will assist in a gradual recovery in the second half of 2023, with growing momentum in domestic demand and international trade, supported by rising private consumption. Consequently, Germany's real GDP is projected to grow at a moderate 0.9% in 2023. |  |

| | | |
|---|---|---|
| Italy | Italy's real GDP rose 3.9% in 2022, largely driven by domestic demand. However, higher energy prices put the brakes in the second half, slowing down private consumption and investments.<br><br>In 2023, economic activity is expected to progress at a tepid pace on account of lower household consumption, and expiry of tax rebates on transport fuels and government support measures to boost household income. That said, the economy is expected to revive in the second half with improvement in consumer spending and acceleration in public investment projects, which is part of the government's recovery and resilience plan. Hence, GDP is expected to still grow, albeit at a modest, ~0.7% in real terms in 2023. |  |
| Japan | S&P Global expects Japan to grow at 1.7% in 2023. The au Jibun Bank Manufacturing PMI inched down to 48.5 in September from 48.6 in August, the fourth straight month of contraction. Input prices rose due to rising global crude oil prices. Services PMI, on the other hand, remained in the expansionary zone at 53.8, although it eased compared with the previous month. |  |

| | | |
|---|---|---|
| India | After rapid economic growth in 2022, the Indian economy has continued to show sustained strong growth during the first half of the 2023 calendar year. The near-term economic outlook for the continued rapid expansion during the second half of 2023 and for 2024 is underpinned by strong growth in domestic demand. |  |
| China | Growth in China picked up in the third quarter, rising to 1.3% quarter on quarter (and 4.9% year on year). Fiscal and monetary easing has remained limited, S&P Global see China's GDP growth at 4.6% in 2024 with modest pick-ups elsewhere in the region. |  |

*P: Projected*

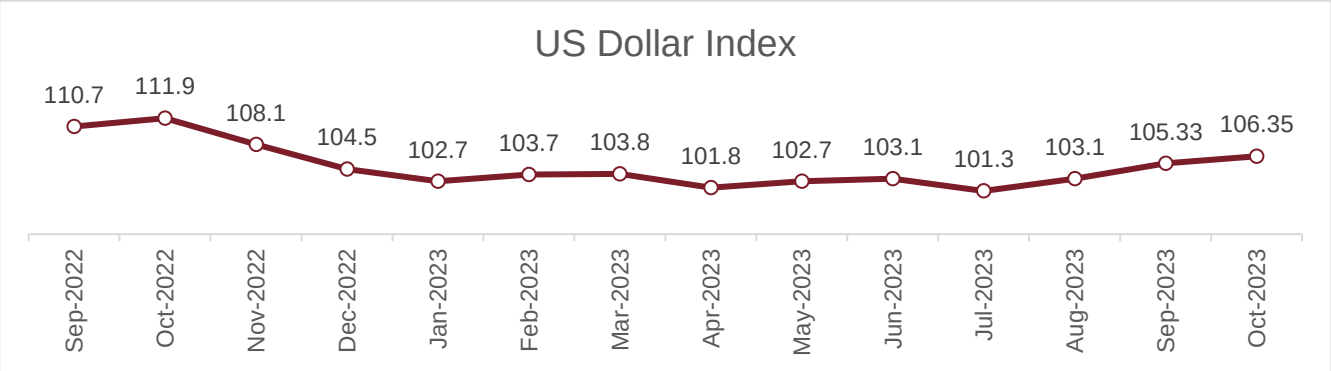
*Source: S&P Global Macro Update: 2024 ; November 29, 2023, European Commission; CRISIL Consulting*

## 1.3 Global currency market and currency movement

The US Dollar Index (DXY), which measures the greenback's strength against a basket of six currencies, rose further in October. The index has moved upwards since July and grew at its fastest pace in nearly two years in the third quarter. It rose 1.0% on-month to 106.35 in October on account of a pickup in new orders and modestly accelerating services amid signs of easing inflationary pressures, as per S&P Global.

Resilient consumption and investment in the US have been boosting growth and strengthening the dollar. Positive economic data from the US has also contributed to the dollar's strength. The data suggests the Federal Reserve may maintain higher interest rates for an extended period, attracting foreign capital and bolstering the greenback's value. The euro area, however, is getting impacted by the tighter monetary policy and a pullback from the energy crisis.

**Figure 4: Dollar rises in October 2023**




*Note: A fall in the index indicates depreciation*

*Source: Bloomberg, CRISIL Consulting*

The rupee is likely to average 83 against the dollar by March 2024 compared with 82.3 in March 2023, a mild depreciation on-year. While a lower current account deficit will support the local currency, volatile external financing conditions could exert some pressure.

## 1.4 Overview of Indian economy

As per data released by the National Statistical Office (NSO) in May 2023, India's GDP at constant (fiscal 2012) prices was estimated at Rs 160.06 lakh crore in fiscal 2023 vis-à-vis the first revised estimate for fiscal 2022 of Rs 149.26 lakh crore, which translated into a growth of 7.2%. This was slower than the 9.1% growth in fiscal 2022. 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 | FY18 | FY19 | FY20 | FY21 | FY22 | FY23E | At market prices | FY18 | FY19 | FY20 | FY21 | FY22 | FY23E |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | GDP | 6.8% | 6.5% | 3.9% | -5.8% | 9.1% | 7.2% |
| **Agriculture** | 6.6% | 2.1% | 5.5% | 3.3% | 3.5% | 4.0% | Private consumption | 6.2% | 7.1% | 5.2% | -6.0% | 11.1% | 7.5% |
| **Industry** | 5.9% | 5.3% | -1.4% | -3.3% | 14.8% | 10.0% | Govt. consumption | 11.9% | 6.7% | 3.4% | 3.6% | 6.6% | 0.1% |
| **Manufacturing** | 7.5% | 5.4% | -2.9% | -0.6% | 11.1% | 1.3% | Fixed investment | 7.8% | 11.2% | 1.6% | -10.4% | 14.6% | 11.4% |
| **Mining and quarrying** | -5.6% | -0.8% | -1.5% | -8.6% | 7.1% | 4.6% | Exports | 4.6% | 11.9% | -3.4% | -9.2% | 29.3% | 13.6% |
| **Services** | 6.3% | 7.2% | 6.3% | -7.8% | 9.7% | 7.2% | Imports | 17.4% | 8.8% | -0.8% | -13.8% | 21.8% | 17.1% |

*E: Estimated*

*Source: NSO, CEIC, CRISIL Consulting*

Among major producing sectors, manufacturing saw the highest growth at 13.9% on-year in the second quarter, a major push from 4.7% in the previous quarter. Resilient domestic demand supported growth, while goods exports were less of a drag relative to the previous quarter. Industrial goods (metals, machinery, infrastructure and construction goods) along with some consumer goods (automobiles and pharmaceuticals) saw highest growth this quarter. Lower input costs on-year (non-food wholesale price index-based inflation averaged -3% in the second quarter) also supported manufacturing GVA.

Construction GVA grew (13.3% vs 7.9%) and was supported by government capital expenditure (capex) in infrastructure.

Services growth slowed (5.8% vs 10.3%) on a high base of the second quarter last year (9.4%)

- Growth in THTC slowed (4.3% in Q2 versus 9.2% in Q1) as the sector caught up with pre-pandemic levels
- Financial, real estate and professional services slowed to 6% from 12.2%. Financial services performed well with strong credit demand. However, services exports growth moderated 4.6%, on average, in the second quarter, compared with 6.0% the previous quarter
- Public administration, defence and other services grew 7.6% vs 7.9%

Agriculture and allied GVA slowed (1.2% vs 3.5%), reflecting monsoon's hit to agricultural output. Kharif output is estimated to be 4.6% lower than last year, based on the government's first advance estimates.

**Table 3: Manufacturing and construction lead growth in Second Quarter**

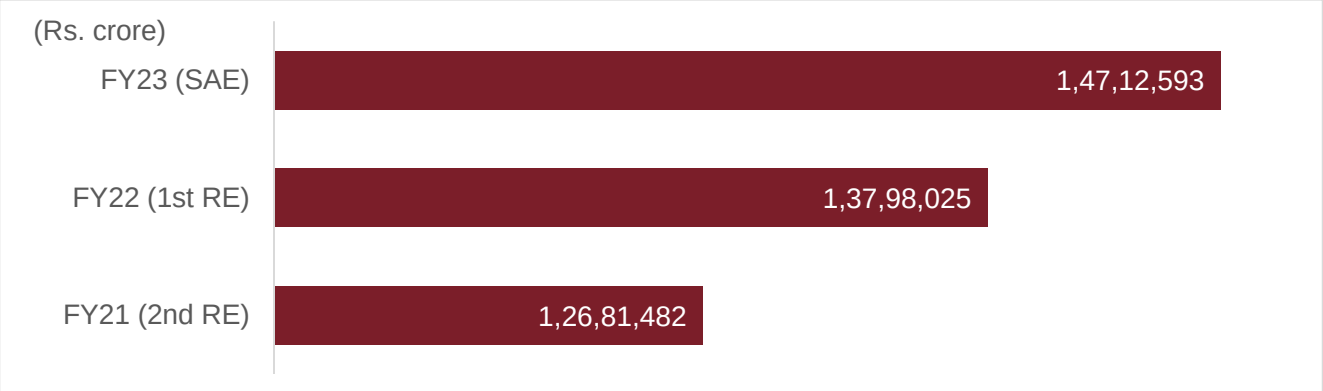
| Particulars | Demand Side | | Particulars | Supply Side | |
|---|---|---|---|---|---|
| | Q1 FY24 | Q2 FY24 | | Q1 FY24 | Q2 FY24 |
| GDP | 7.8% | 7.6% | GVA | 7.8% | 7.4% |
| GFCE | -0.7% | 12.4% | Manufacturing | 4.7% | 13.9% |
| PFCE | 6.0% | 3.1% | Public Ad+ | 7.9% | 7.6% |
| GFCF | 8.0% | 11.0% | Agri | 3.5% | 1.2% |
| Imports | 10.1% | 16.7% | Mining | 5.8% | 10.0% |
| Exports | -7.7% | 4.3% | Financial Services | 12.2% | 6.0% |
| | | | Electricity | 2.9% | 10.1% |
| | | | Construction | 7.9% | 13.3% |
| | | | THTC | 9.2% | 4.3% |

*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 Consulting*

## 1.5 GVA performance

**Figure 5: GVA at basic prices (Rs. crore)**




*RE: Revised estimates; SAE: Second advance estimates*

*Source: Ministry of Statistics and Programme Implementation, CRISIL Consulting*

## 1.6 India's GDP recovered with subsiding of the pandemic

In the past 10 years (during fiscal 2014 to 2023), India's GDP at constant (fiscal 2012) prices grew at a compounded growth of ~5.6% (CAGR).

After the robust growth in fiscal 2023, a slowdown is inevitable this fiscal because of rising borrowing costs. External demand is expected to weaken with interest rates in the major advanced economies hitting the highest level in more than a decade. The rates are expected to peak in the fiscal, hitting both global and domestic demand. S&P Global expects the United States GDP growth to grow at 2.4% in 2023 from 2.1% in 2022 and that of eurozone to slow at 0.6% from 3.5%. These economies account for 33% of the goods exports from India.

Growth surpassed forecasts in the second quarter of fiscal 2023, driven by strong government spending and a sharp rise in manufacturing and construction growth. Globally, too, growth beat expectations in major economies such US and China, contributing to better export earnings for India. However, private consumption was tepid, possibly reflecting the hit to agriculture and rural demand.

However, CRISIL Consulting expects growth to slow in the second half of this fiscal, driven by the impact of (1) tightening financial conditions on global growth and exports, (2) weak rains and reservoir levels on domestic agriculture and (3) transmission of the Reserve Bank of India's (RBI) rate hikes to bank lending rates.

Therefore CRISIL Consulting has revised up GDP growth forecast by 40 basis points to 6.4% for fiscal 2024, compared with 7.2% last year.

**Table 4: CRISIL's key projections**

| | FY18 | FY19 | FY20 | FY21 | FY22 | FY23E | FY24P |
|---|---|---|---|---|---|---|---|
| GDP growth (%) | 6.8% | 6.5% | 3.9% | -5.8% | 9.1% | 7.2% | 6.4% |
| CPI (%, average) | 3.6% | 3.4% | 4.8% | 6.2% | 5.5% | 6.7% | 5.5% |
| CAD/GDP (%) | 1.8% | 2.1% | 0.9% | -0.9% | 1.2% | 2.5% | 2.0% |
| FAD/GDP (%) | 3.5% | 3.4% | 4.6% | 9.2% | 6.7% | 6.4%# | 5.9%* |
| Exchange rate (Rs/$ March-end) | 65.0 | 69.5 | 74.4 | 72.8 | 76.2 | 82.3 | 83.0 |
| 10-year G-sec yield (%, March-end) | 7.6% | 7.5% | 6.2% | 6.2% | 6.8% | 7.5% | 7.0% |

*#Revised estimate, *Budget estimate*

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

*Source: CSO, RBI, CRISIL Consulting*

## 1.7 Overview of other demographic factors

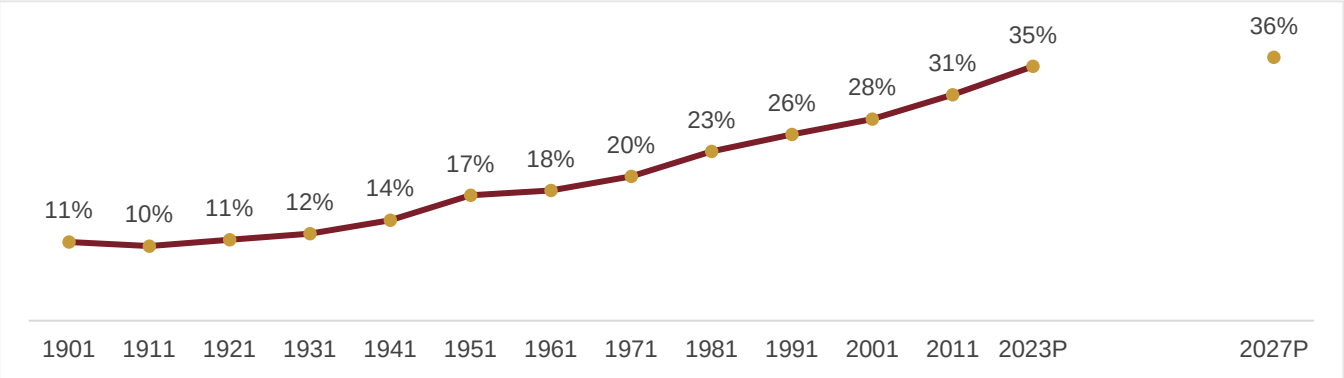
### 1.7.1 Urbanisation

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 6: Urban population as a % of total population of India**



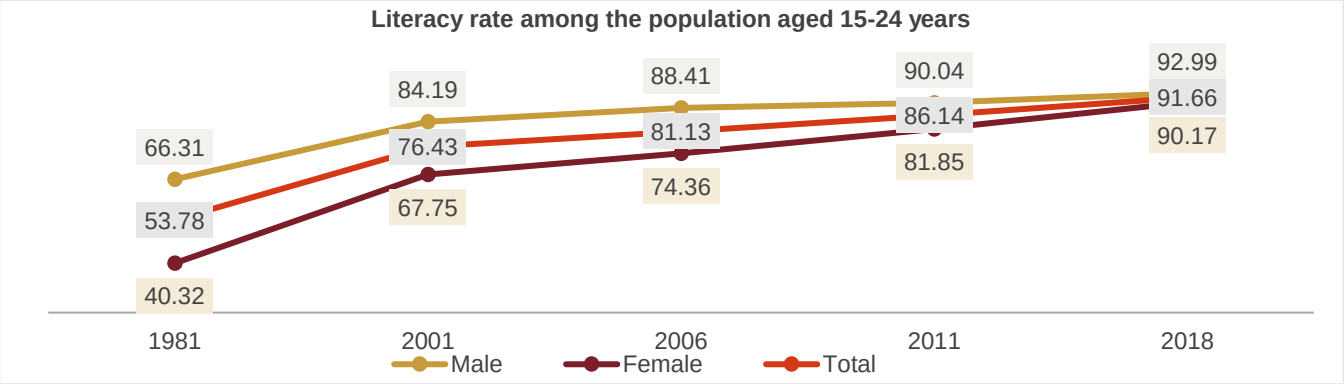

*P: Projected*

*Source: Census 2011, Report of The Technical Group on Population Projections by Ministry of Health & Family Welfare (July 2020), CRISIL 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 7: Youth literacy rate of India**




*Source: UNESCO, WHO, CRISIL Consulting*

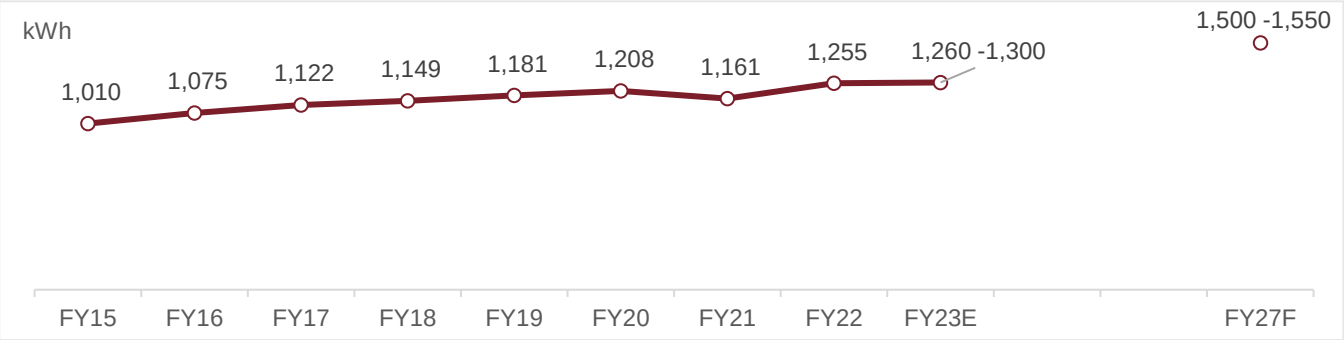
### 1.7.3 Per capita power consumption

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 power demand, with a similar trend estimated in fiscal 2023.

Between fiscals 2022 and 2027, India's per capita electricity consumption is expected to grow at ~4% CAGR over a low base of fiscal 2021. Per capita consumption is expected to gradually improve in the long term on the back of improvement in access to electricity, in terms of quality and reliability, on account of intensive rural electrification and reduction in cost of power supply.

Consequently, CRISIL Consulting expects per capita electricity consumption to reach 1,500-1,550 kWh by fiscal 2027.

**Figure 8: Per capita electricity consumption-India**




*E: Estimated; F: Forecast*
*Source: Central Electricity Authority of India (CEA), CRISIL Consulting*

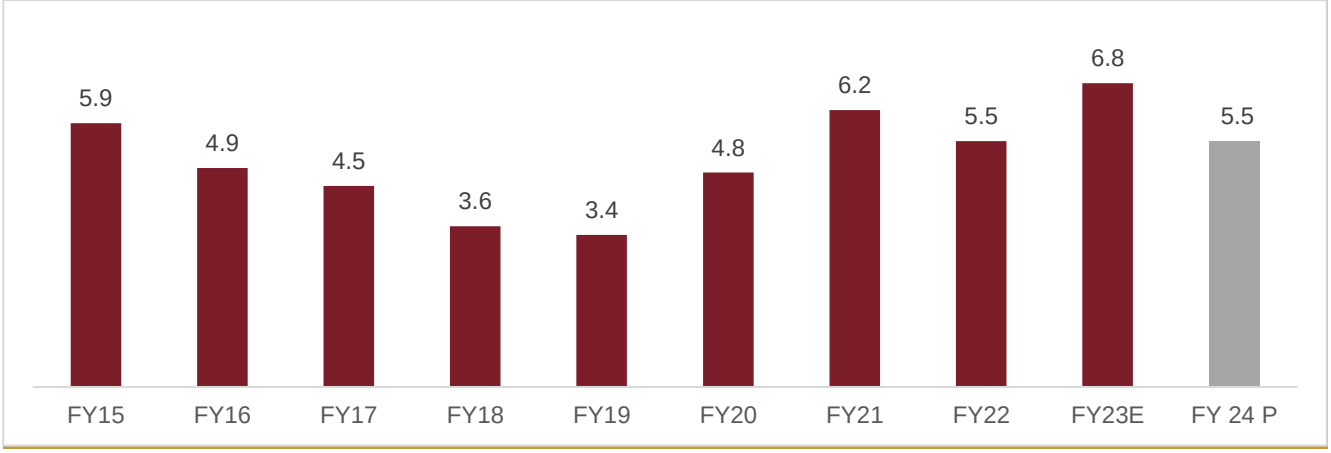
The per capita electricity consumption remains significantly lower than that of other major as well as developing countries, thereby offering strong organic growth potential.

## 1.8 Outlook on inflation, interest rates, etc.

### 1.8.1 Inflation

Inflation based on the consumer price index (CPI) dropped a mild 15 basis points (bps) to 4.87% in October from 5.02% in September 2023, led by a broad-based decline in core and fuel inflation. Food inflation remained steady despite mixed underlying trend. The decline in core inflation (to 4.3% in Oct-23 from 4.5% in Sept-23) was a result of lower input-cost pressure on producers and, hence, on retail prices. Food inflation was steady — as vegetable prices softened, while pulses prices hardened — near 20% and cereal price inflation remained at ~11%. Spices hit 23%. Meanwhile, fuel inflation declined mildly, as it benefitted from a drop in retail LPG prices.

**Figure 9: CPI inflation (%, y-o-y)**




*E: Estimated, P: Projected*
*Source: NSO, CEIC, CRISIL Consulting*

Easing input cost pressures on manufacturers and moderating domestic demand are expected to ease core inflation. That said, several risks to our forecast remain. Tight global food supplies threaten food inflation. So does the flare up in onion prices which continued in October. For the December quarter, CRISIL Consulting expects food inflation to soften, because of the government intervention and as the kharif harvest enters the market. Oil prices remain an unknown and could potentially play a spoilsport if the Middle East conflict

escalates. An adverse index base (inflation had seen a drop in the year-ago period) will somewhat restrict the downside in inflation for two months.

CRISIL Consulting expects the Reserve Bank of India (RBI) to remain vigilant, as the headline inflation remains above the Monetary Policy Committee's (MPC) 4% target and risks to food and fuel inflation persist. Accordingly, CRISIL's base case for this fiscal is an average inflation of 5.5% and the MPC maintaining its policy rate and stance.

### 1.8.2 Interest rates

Liquidity in the Indian banking system was in deficit in October despite the RBI discontinuing its mandate to banks to maintain an incremental cash reserve ratio (I-CRR), releasing 50% of the funds impounded on October 7. Under the I-CRR, banks were required to retain an additional 10% of incremental net demand and time liabilities (NDTL) under the cash credit window. While the central bank released the funds impounded under I-CRR, liquidity remained in deficit because of factors such as open market operations and reduction in government spending. This put pressure on money market rates, which rose further in October. Meanwhile, the RBI maintained the repo rate at 6.5% for the fourth consecutive time at its latest policy meeting. It also maintained its stance of withdrawal of accommodation on account of incomplete transmission of rate hikes and resilient domestic growth.

Liquidity was in deficit for the second straight month in fact widening. The RBI net injected Rs 0.5 lakh crore (0.2% of NDTL via liquidity management operations) compared with 0.2 lakh crore in September (0.1% of NDTL).

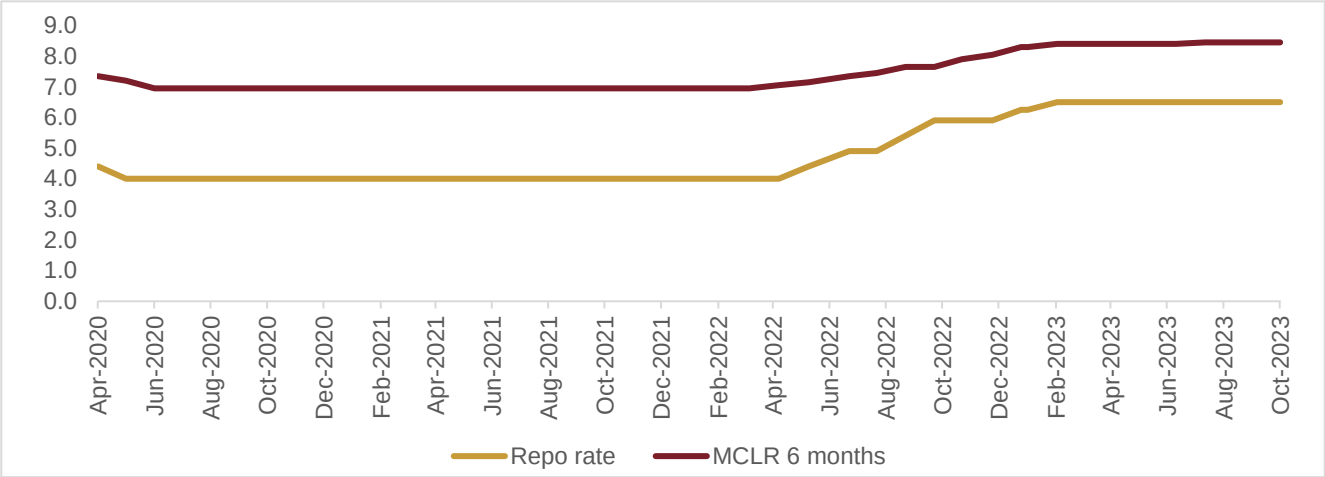
Factors that influenced liquidity conditions during the month were:

- Sale of government securities totaling Rs 9,915 crore through open market operations to drain excess liquidity
- 15.2% on-year increase in bank credit in October vs. 12.6% growth in deposits (both excluding impact of HDFC merger
- Lower government spending, as indicated by rise in the government's cash balance with the RBI

The weighted average call money rate (WACR) hardened 6 bps in October, owing to widening deficit in domestic liquidity. The WACR, which is the operating target for monetary policy, averaged 6.7%, higher than the 6.5% repo rate. Other money market rates also rose in October. The six-month commercial paper and six-month certificates of deposit ended the month a higher 17 bps and 21 bps, respectively, and the 91-day Treasury bill rose a nominal 5 basis points to average 6.9%.

The six-month marginal cost of the fund-based lending rate (MCLR) rose a slight 2 bps, averaging 8.7%. To be sure, lending rates remain above the pre-pandemic average. Full transmission to lending rates is yet to be completed. The auto and housing loan rates have risen 150 bps and 238 bps, respectively, vis-a-vis a 250 bps rise in the repo rate, and the six-month MCLR has risen 160 bps.

**Figure 10: Trend in interest rates**




*Source: RBI, SBI, CRISIL Consulting*

CRISIL Consulting expects the RBI to hold rates steady for the remainder of this fiscal. Assuming normalising inflation and slowing growth, CRISIL Consulting expects the first rate cut in the first quarter of 2024. The rise in inflation in the second quarter was primarily on account of food inflation. While this was outside the Monetary Policy Committee's (MPC) purview, as the rise was because of supply shocks, the MPC will remain vigilant, as elevated food inflation can generalise. Tensions in the Middle East are also a threat to domestic inflation. Though the conflict is currently contained, any escalation can lead to a rise in input costs and supply chain pressures. Meanwhile, CRISIL Consulting expects India's gross domestic product to slow this fiscal, as slowing global growth in the second half of the fiscal will negatively impact exports. The lagged impact of the RBI's rate hikes is projected to also slow domestic demand.

### 1.8.3 Debt

Continuing its upward trend, yield on the 10-year government bond (7.18% GS2033) moved up significantly in October, averaging 7.33% compared with 7.17% in September. On an end-month basis, the yield was 7.35% versus 7.21%. October also saw the yield reaching its highest level yet this fiscal (7.39% on October 29, 2023). Domestic G-sec yields tracked US treasuries in October, high and volatile crude oil prices and rising liquidity deficit. The rise, however, was capped by lower Consumer Price Index (CPI) inflation print and robust FPI debt inflows.

October started with the benchmark trading near 7.2%. Then came the Reserve Bank of India Governor's statement after the Monetary Policy Committee review meeting on October 6, about likely OMOs to manage liquidity, which pushed up yield to 7.34% up from 7.21% the previous day. The yield hovered around the 7.4% mark before CPI data for September showed a substantial softening to 5.0% from 6.8% in August, easing it from there. On October 12, the yield was back at 7.30%. But post that yields firmed up again tracking higher US treasury yields and volatile crude oil prices ($90/bbl in October 2023 vs $94/bbl in September 2023).

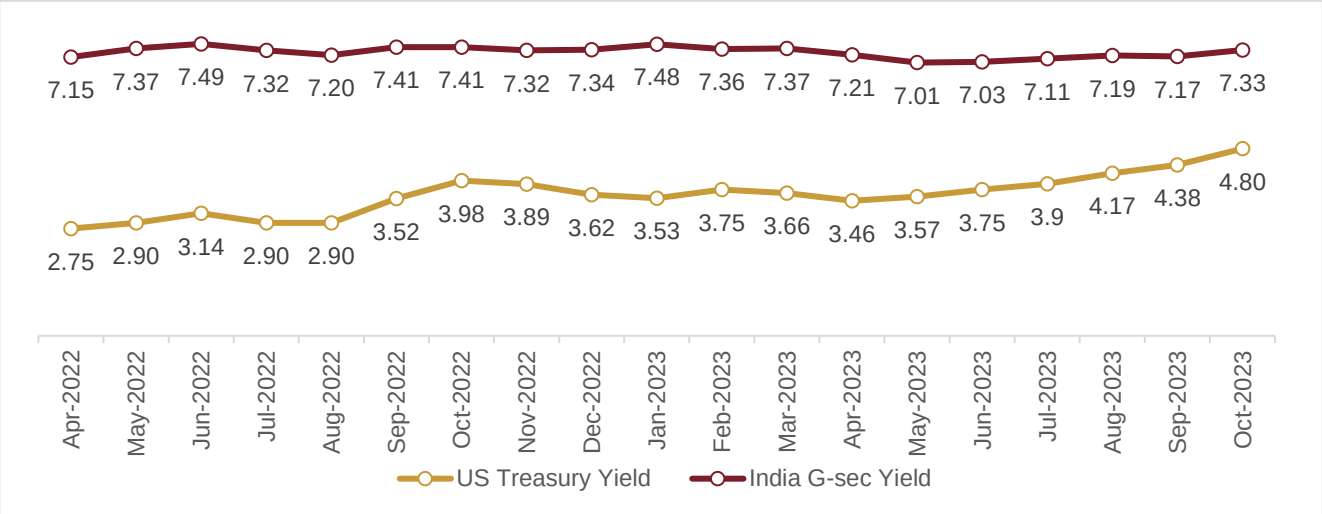
Higher systemic liquidity deficit, as reflected by the RBI's daily average net injection of Rs 0.5 lakh crore in October under the liquidity adjustment facility — up from Rs 0.2 lakh crore in September – also put upward pressure on yields. The surge in FPI debt net inflows in October to $767 million from $114 million in September, however, likely had a sobering effect on yields.

In the US, yields on treasuries continued to rise sharply on account of signals that interest rates could remain higher for longer. The 10-year yield rose for the sixth consecutive month, averaging 4.80% in October (even touching the 5% level in between), up from 4.38% in September.

The gap between the two benchmarks continued to narrow — to 2.53% in October on average, from 2.79% in September and 3.46% in October 2022. The continuous tapering means pressure on foreign capital flows to

move away from India (or for that matter, any emerging market) and towards the US. While FPI equity outflow is already happening, surprisingly, despite such a sharp rise in treasury yields, FPIs remained net buyers of domestic debt, in both September and October.

**Figure 11: with US treasuries continued to narrow**




*Source: RBI, US Department of the Treasury, CRISIL Consulting*

Yields are expected to ease by fiscal-end following the pause in rate hikes, signs of lower inflation and fiscal consolidation moves.

- CRISIL Consulting expects the CPI-based inflation to be lower this fiscal, averaging 5.5% compared with 6.7% in fiscal 2023
- Brent crude is expected to average $80-85 per barrel this fiscal, compared with $95 per barrel last fiscal because of likely slowing global growth. That said, there is an upside to this call since prices have been up sharply in the past few weeks on supply cuts and the Middle-East conflict. It may remain sticky at higher levels
- With the Union Budget 2023-24 giving a thrust to fiscal consolidation and boosting growth via capex, the government's gross borrowing is expected to rise at a slower pace (8.4%) than nominal gross domestic product (GDP) growth (10.5%). In line with this, the budget aims to reduce the fiscal deficit to 5.9% of GDP this fiscal
- The inclusion of government bonds in the JP Morgan Emerging Market Index from June 2024 should also gradually help soften domestic yields

Given all this, CRISIL Consulting expects the 10-year G-sec yield to settle at ~7.0% by March 2024, compared with 7.4% in March 2023.

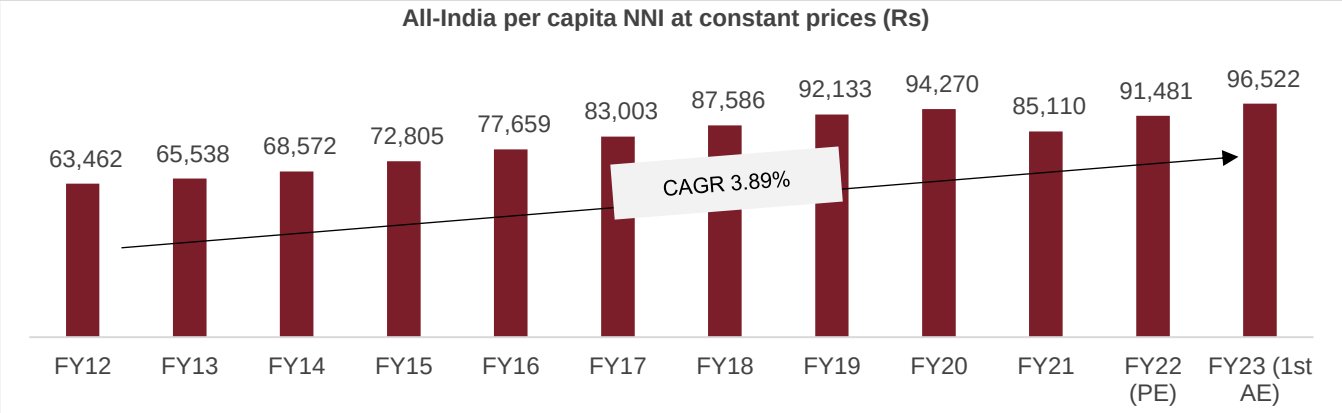
### 1.8.4 Per capita national income

India's per capita income is expected to rise to Rs 96,522 in fiscal 2023 from Rs 63,462 in fiscal 2012 with a compound annual growth rate of 3.89%. In fiscal 2023, per capita income is expected to rise by 5.5% against 7.5% in fiscal 2022 although on a lower base of the pandemic-affected fiscal 2021.

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 12: All-India per capita NNI at constant prices**




*Note: PE - Provisional estimates; AE - Advance estimate*
*Source: RBI, Economic Survey 2022-23; CRISIL Consulting*

### 1.8.5 Currency

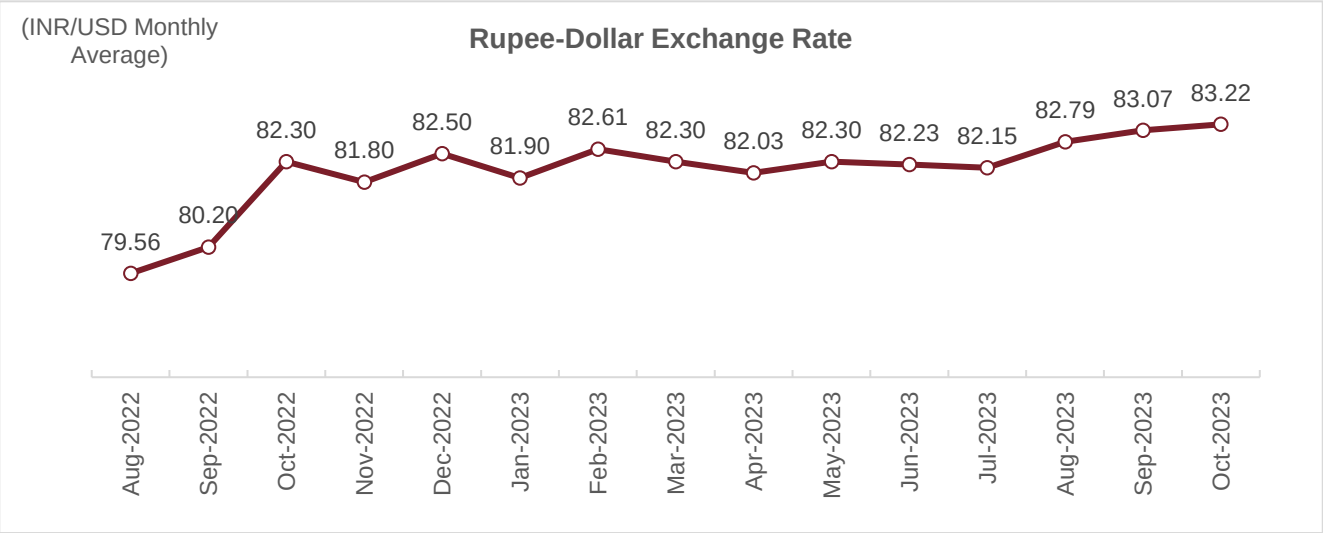
**Under strain**

The rupee averaged 83.22/$ in October compared with 83.07/$ in September. Foreign capital net outflows continued for the second consecutive month, led by a surge in United States Treasury yields and uncertain geopolitical tension from the Israel-Hamas conflict. Despite the weakness, the rupee remains one of the better performing emerging market currencies.

Strengthening US dollar and increasing foreign capital outflows from India's equity market kept up pressure on the rupee in October. The domestic currency depreciated 0.2% sequentially to an average of 83.24/$ compared with 83.05/$ in September. Despite the dip, the rupee remains one of the better performing emerging market currencies this year against the dollar, down just 1.6% on average between January and October.

The rupee is likely to average 83 against the dollar by March 2024 compared with 82.3 in March 2023, a mild depreciation on-year. While a lower current account deficit will support the local currency, volatile external financing conditions could exert some pressure.

**Figure 13: Rupee lost some ground in August 2023**




*Source: Financial Benchmarks India Pvt Ltd, CEIC, CRISIL Consulting*

## 1.9 *Aatmanirbhar Bharat* Abhiyan

Production Linked Incentives (PLIs) in the 14 sectors for the *Aatmanirbhar Bharat* vision received 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 spends | Key schemes |
|---|---|---|
| Renewable energy | ~Rs 24,000 crore | • Rs 4500 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.<br>• Phase – II of Grid Connected Rooftop Solar Programme for achieving 40 GW capacity from rooftop solar by 2022<br>• Public procurement (Preference for 'Make in India') to provide for purchase preference (linked with local content) in respect of renewable energy (RE) sector<br>• Implementation of Pradhan Mantri Kisan Urja Suraksha Utthan Mahabhiyan (PM KUSUM) scheme; 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 |

| Sector | Government spends | Key schemes |
|---|---|---|
| | | • Approved Models & Manufacturers of Solar Photovoltaic Modules (Requirement for Compulsory Registration) Order, 2019<br>• List of manufacturers and models of solar PV modules recommended under ALMM Order<br>• Scheme of grid connected wind-solar hybrid power projects<br>• Basic customs duty (BCD) of 25% on solar cells and 40% on modules, respectively, effective April 1, 2022 |
| Power distribution companies (discoms) | Nil | • Rs 1.35 lakh crore liquidity infusion for discoms via Power Finance Corporation/ Rural Electrification Corporation (PFC/ REC) against receivables<br>• Rebate for payment to be received by generation companies (gencos) to be passed on to industrial customers<br>• Revamped distribution sector scheme (RDSS) to help discoms improve their operational efficiencies and financial sustainability by providing result-linked financial assistance; outlay of 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 finance | Nil | • Rs 1 lakh crore agriculture infrastructure financing fund for the development of farm gate infrastructure for farmers<br>• 25 lakh new Kisan Credit Cards distributed with loan disbursement of Rs 25,000 crore<br>• Rs 1.87 lakh crore disbursed through the PM Kisan scheme<br>• Rs 29,500 crore refinancing assistance provided through NABARD |
| 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<br>• Working capital limit of Rs 6,700 crore sanctioned for procurement of food grains to state government entities<br>• Rs 3,500 crore allocated for the distribution of 5 kg rice/wheat and 1 kg pulses to 8 crore non-card holder migrants<br>• 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)<br>• Rs 20,000 crore for fisherman over the next five years under Pradhan Mantri Matsya Sampada Yojana<br>• Rs 13,343 crore for eradication of foot and mouth disease in Indian livestock population<br>• Rs 15,000 crore for Animal Husbandry Infrastructure Development Fund (AHIDF)<br>• Rs 4,000 crore for enhanced cultivation of herbal and medicinal plants<br>• Rs 500 crore for the Indian apiculture industry<br>• Rs 10,000 crore for formulation of micro food enterprises |

| Sector | Government spends | Key schemes |
|---|---|---|
| Mining | Nil | • Expected to offer 500 mineral blocks, including 50 coal<br>• Promoting commercial coal mining (ordinance to remove captive end-use restriction passed in January 2020); government to expedite policy formulation and auction process<br>• Government to allow composite exploration/auction of coal bed methane reserves for extraction<br>• Rebate offered on revenue sharing quantum to incentivise early operationalisation/ higher produce<br>• Provision of Rs 50,000 crore for evacuation infrastructure |
| New Energy | | • 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<br>• Green Hydrogen Policy launched in February 2022 to facilitate production of green hydrogen/green ammonia<br>• PLI scheme on green hydrogen manufacturing with an initial outlay of 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 Consulting*

# 2 Overview of global solar and Indian power market

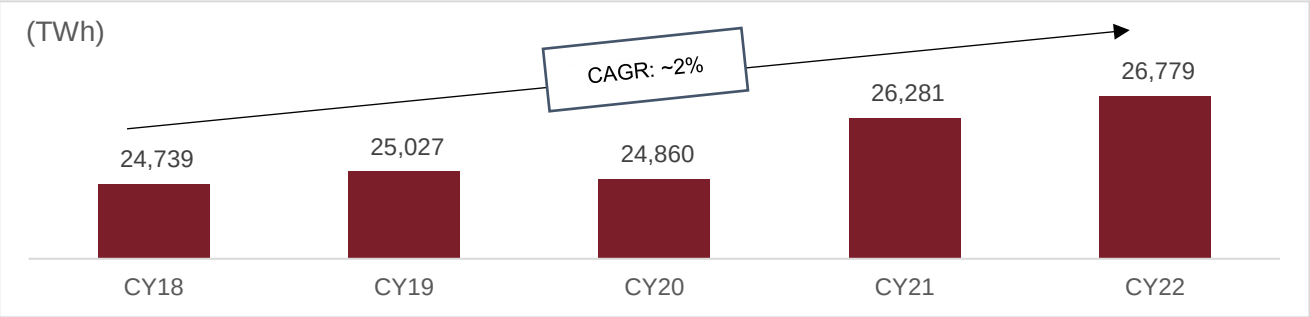
**Executive Summary:**

- Electricity Demand rose by almost 2% in 2022 compared with the 2.4% average growth rate seen over the period 2015-2019
- 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 ~189 GW of solar PV capacity was added in 2022, taking the installed capacity to 1,055 GW, which is a ~22% increase over the previous year.
- China continues to dominate the solar PV market, accounting for about 45% of the global installed capacity, while key European countries control about 23% of the total solar PV installed capacity.
- As per IEA analysis, the cumulative PV capacity is expected to triple to 2,359 GW by 2027, surpassing hydropower in 2024, natural gas in 2026, and coal in 2027 to become the largest installed electricity capacity worldwide. A
- India's power demand to log a healthy growth of 5.0-6.0% CAGR between fiscals 2024 and 2028
- India's power generation is expected to grow at 5.0–5.5% CAGR between fiscals 2024 and 2028
- In India, the share of renewable capacity (including large hydro and BESS) from 41% in fiscal 2023 to ~57% in fiscal 2028. The share of coal would reduce to 37% from 51% currently over the same period.
- CRISIL Consulting expects investments of Rs 23-23.5 trillion in the power sector over the next five years

## 2.1 Overview of the Global Energy demand

Global electricity demand grew by ~1.9% (+498 TWh) in 2022, similar to the average growth of 2.0% in the last five years (CAGR from CY18 to CY22). 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 2% in 2022.

**Figure 14: Overview of global energy consumption**




*Source: IEA, CRISIL 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 U.S. added 24.7 GW of new generating capacity to the grid in 2022, an 11.6% decline from the previous year, according to an S&P Global Market Intelligence analysis. Over the same period, 16.0 GW of capacity was retired, netting an additional 8.8 GW available to the U.S. power grid, a drop of 54.8% compared to 2021's net additions. Data collected (as on January 11,2023) show solar, wind and gas capacity dominated new additions, accounting for 37.6%, 27.1% and 25.9% of the total, respectively. Solar surpassed wind as the leader, adding 9.3 GW in 2022. Wind capacity additions declined the most in 2022, down 4.7 GW from the previous year's additions, while natural gas added 1.2 GW more than in 2021.

**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.

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.

Economic activity in the Middle East and North Africa (MENA) region is expected to sharply decelerate in 2023 after strong growth in 2022.

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 is expected to continue to add significant amounts of solar capacity in the coming years, as it strives to meet its ambitious renewable energy targets. China is expected to add ~100 GW during CY2022-23. 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.

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.

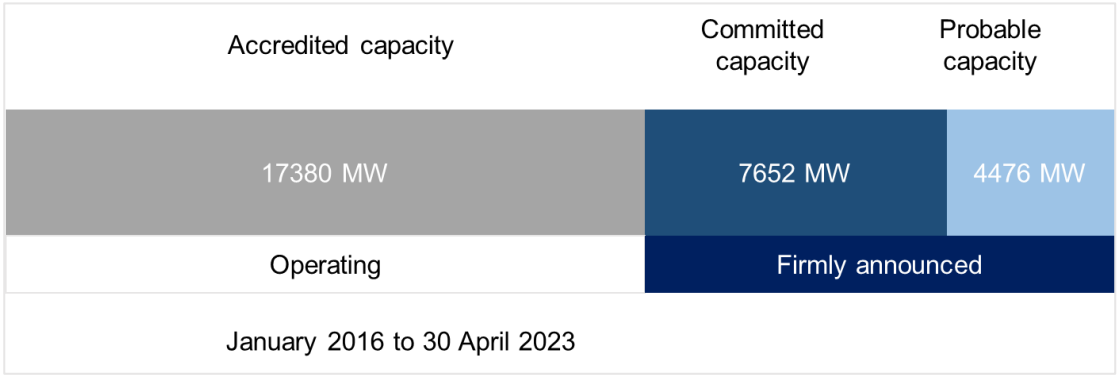
These two-pronged approaches reflect Japan's commitment to advancing the adoption of clean hydrogen and ammonia as part of its overall energy transition and decarbonization efforts.

**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. Following infographic shows the project developments since 1 January 2016, indicating the 6,400 MW required capacity has been met and exceeded. Investment in renewables remains strong and the 2020 target has not acted as a cap on new investment.




*Source: Australian Clean Energy Regulator; CRISIL Consulting*

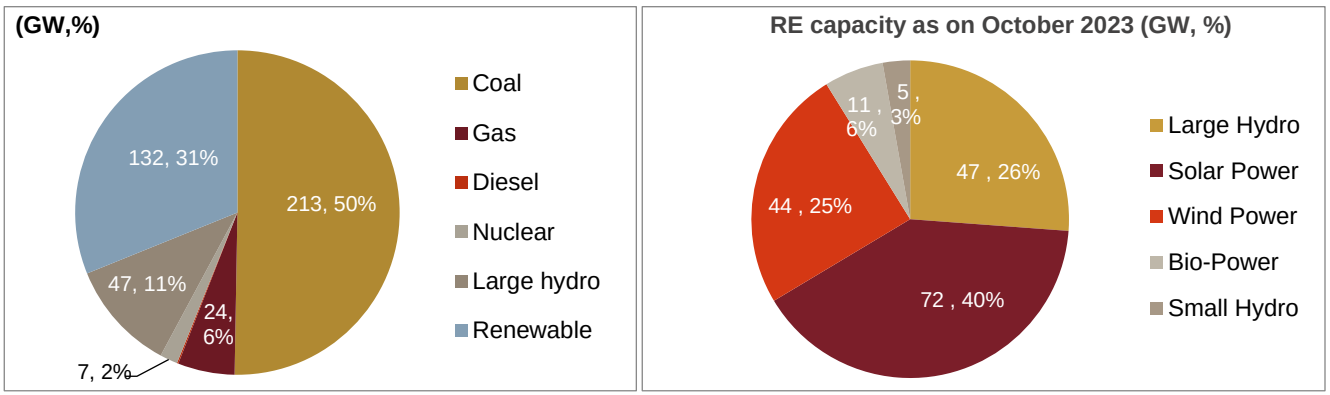
## 2.3 Review of Indian power demand-supply scenario

### 2.3.1 Power supply mix

The total installed generation capacity as of October 2023 was 426 GW, of which ~89 GW of capacity was added over fiscals 2017-23. The overall installed generation capacity has grown at a CAGR of 6.8% over fiscals 2012– 23. Coal and lignite-based installed power generation capacity has maintained its dominant position over

the years and accounts for ~50% as of October 2023. However, RE installations (including large hydroelectric projects), have reached ~179 GW capacity as of October 2023, compared with 63 GW as of fiscal 2012, constituting ~42% of total installed generation capacity as on date. This growth has been led by solar power, which rapidly rose to ~72 GW from 0.9 GW over the same period. In addition, wind power capacity increased to 44 GW from 17 GW, bio-power to 11 GW from 3 GW and small hydro to 5 GW from 3 GW.

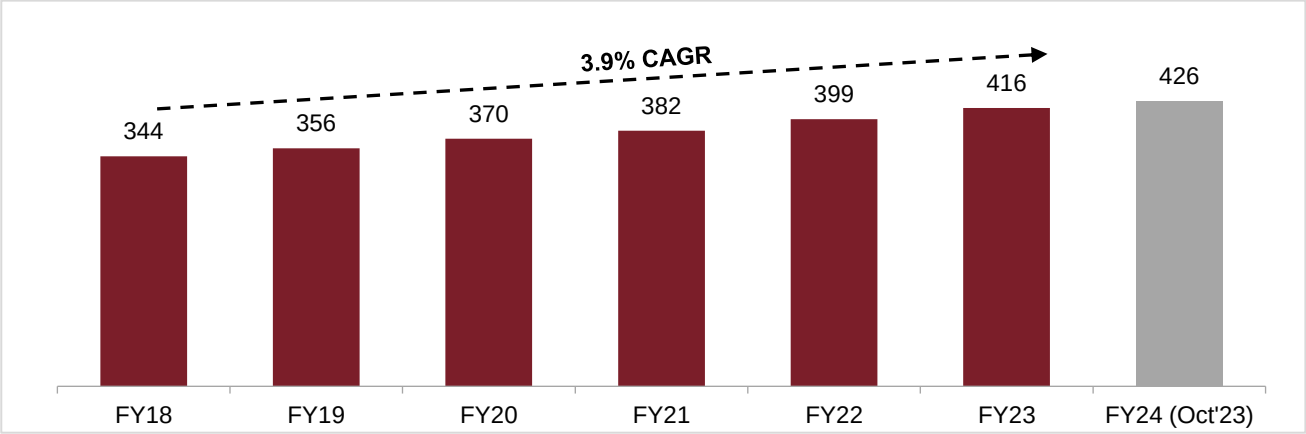
**Figure 15: Details of source wise installed capacity as of October 2023**




**Renewable capacity excluding large hydro; Source: CEA, CRISIL 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 of competitive bidding, capacities of ~22 GW (fiscals 2014-23) were added by the private sector, which accounted for 73.0% 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.

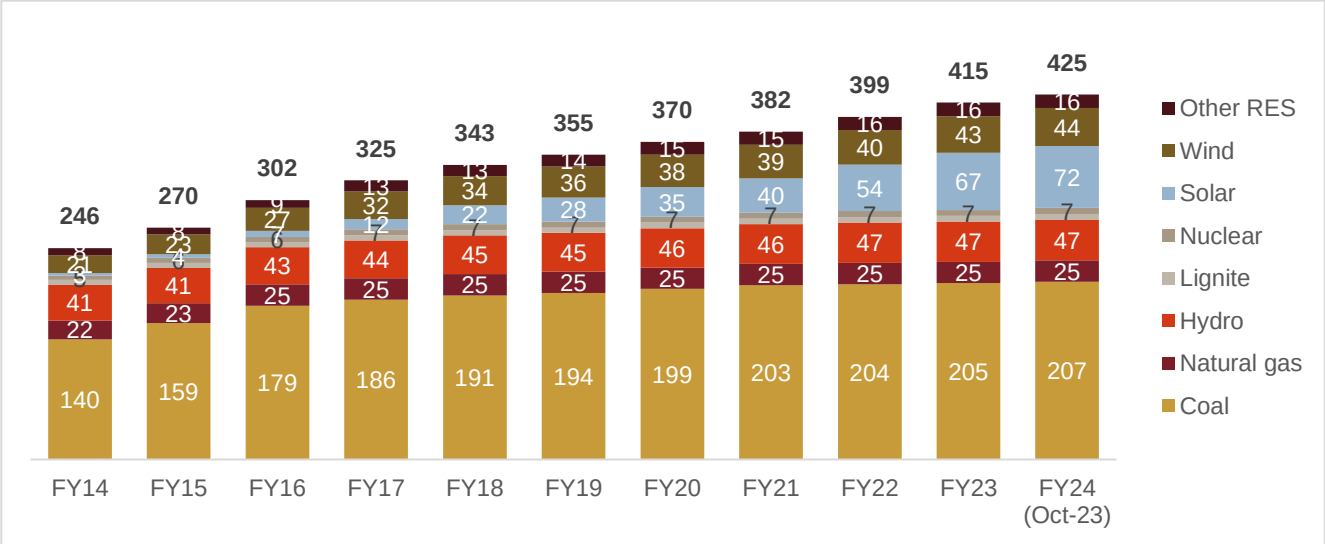
**Figure 16: Evolution of all India installed generation capacity (GW)**




*Note: 3.9% CAGR is for capacity additions growth between FY18 and FY23*
*Source: CEA, CRISIL 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 17: Fuel-wise installed capacity in past 10 years (GW)**



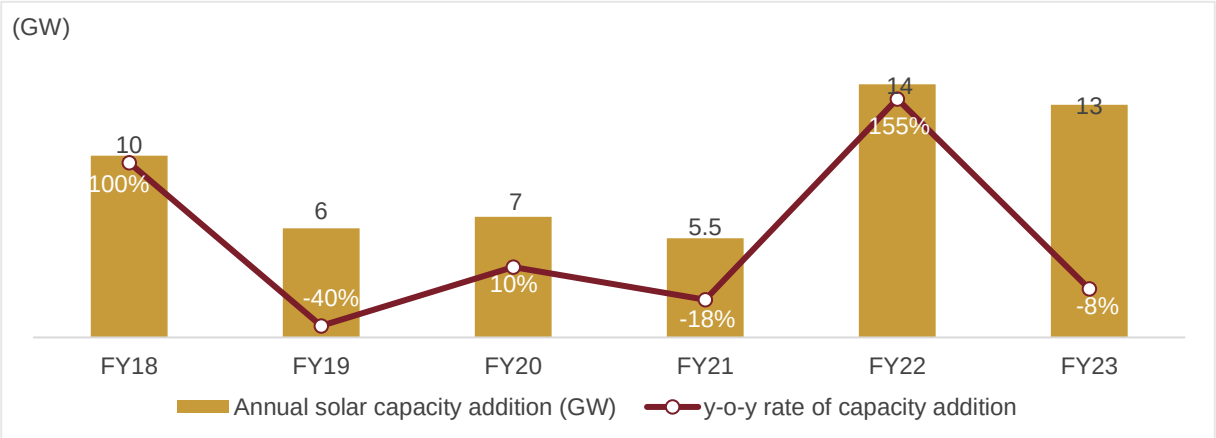

*Hydro: Large Hydro; other RE sources: Incl. small hydro, biomass/bagasse and waste to energy*
*Source: CEA, CRISIL Consulting*

## 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 18: Annual addition in solar capacity installation**




*Source: CEA, CRISIL Consulting*

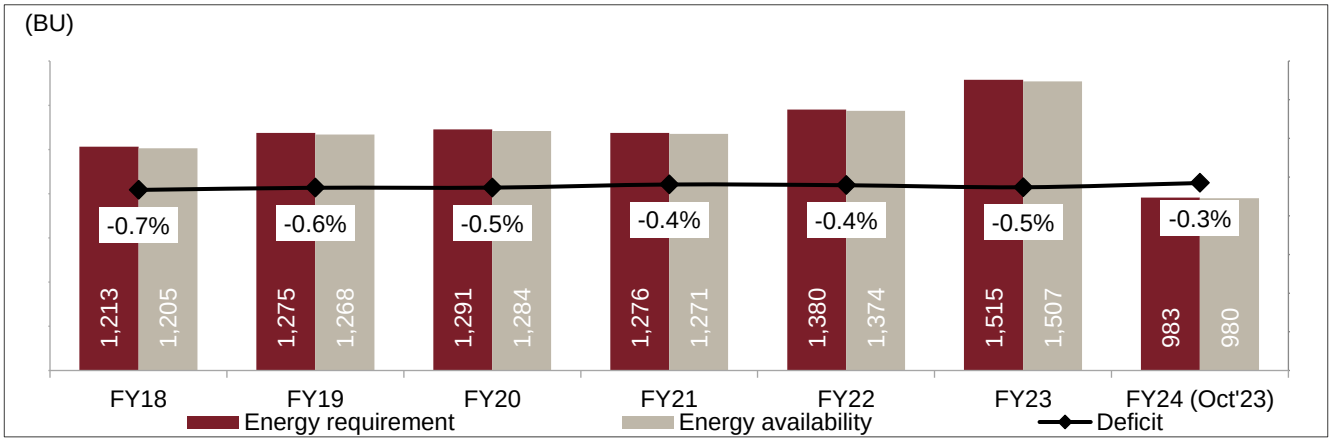
## 2.3.3 Review of power demand-supply gap

India's electricity requirement has risen at a CAGR of ~4.5% between fiscals 2016 and 2023, while power availability rose at ~4.7% CAGR on the back of strong capacity additions, both in the generation and transmission segments.

The energy deficit declined to 0.5% in fiscal 2023 from 2.1% in fiscal 2016 due to increase in capacity addition growth of 4.7% over the same period. Strengthening of inter-regional power transmission capacity over the past five years has supported the rapid fall in deficit levels as it reduced supply constraints on account of congestion and lower transmission corridor availability, thereby lowering the deficit to 0.6% in fiscal 2019. For fiscal 2022, the average energy deficit across states and UTs stood at 0.4%.

Further, in fiscals 2018 and 2019, power demand grew at ~6% and ~5% on-year, respectively, led by a low base and gradual pickup in consumption across categories, with impetus from electrification of un-electrified households, transmission and distribution network expansions, and healthy economic activity. However, in fiscal 2020, power demand grew at a slower 1.3% due to weakening economic activity and extended monsoon. After a minor (1.2%) decline in fiscal 2021, power demand saw a strong rebound in fiscal 2022, registering a ~8.2% on-year growth on the back of healthy revival in economic activity, and as demand picked up with the lifting of COVID-19 restrictions.

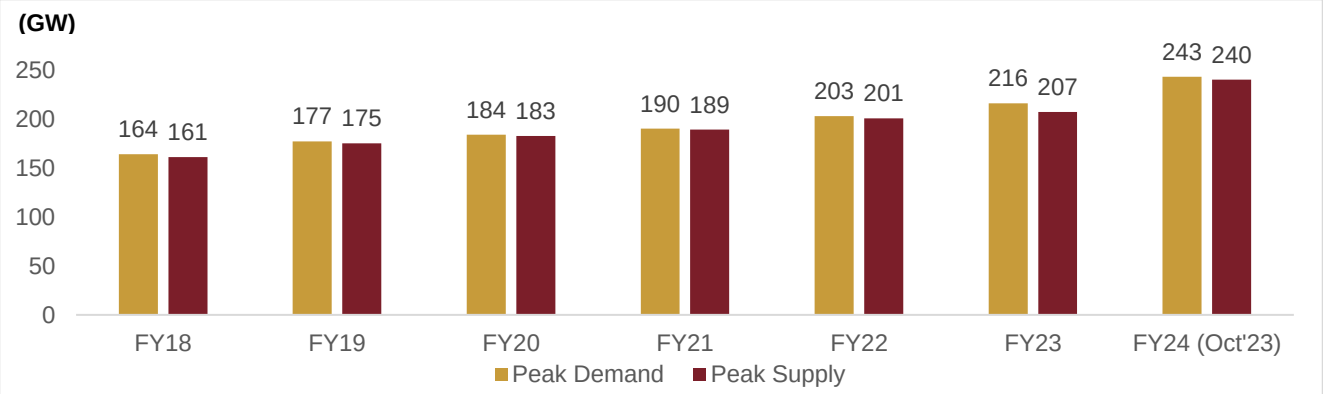
**Figure 19: Aggregate power demand supply**




*Source: CEA, CRISIL Consulting*

Peak electricity demand in India has grown from 164 GW in fiscal 2018 to 216 GW in fiscal 2023 clocking an average growth rate of ~5.7% in the past five years. Peak demand has managed to constantly rise over the past years during fiscal 2021 which witnessed base demand falling into negative territory. Before 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, post pandemic, annual peak demand is occurring in the summer season (April-July), due to extreme heatwave conditions. Peak demand touched record high levels of 216 GW in fiscal 2023 during April 2022, attributed to an increase in cooling demand as intense summers scorched several regions of the country. Generation has struggled to keep up with the booming demand, resulting in an increase in peak deficit to 4.2% in fiscal 2023 as compared with 1.2% for the same period in fiscal 2022. During fiscal 2024 year, the peak demand registered 243 GW (till Oct-2023) which was ~13% higher than the peak demand of fiscal 2023.

**Figure 20: Peak power demand and supply**




*Source: CEA, CRISIL Consulting*

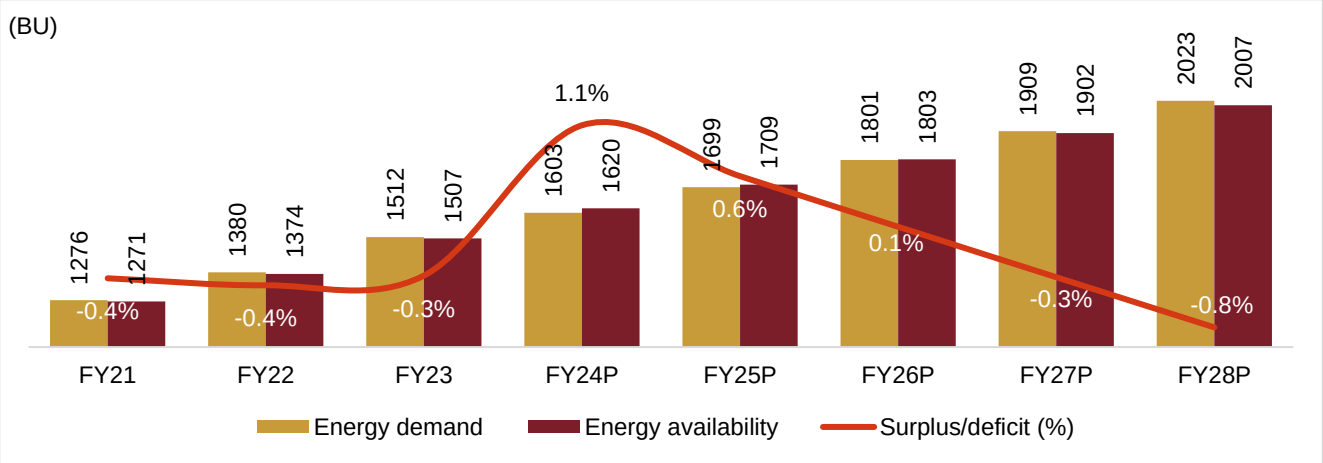
## 2.4 Demand-supply outlook for India

### 2.4.1 Energy demand-supply forecast, fiscals 2024 to 2028

Power demand maintained a strong growth momentum in fiscal 2023 logging a double-digit growth of 10% albeit a moderate base of fiscal 2022. 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 Consulting expects power demand to log a healthy 5.0-6.0% CAGR between fiscals 2024 and 2028, 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 5.0 – 5.5% CAGR between fiscals 2024 and 2028. The energy availability across fuels has grown at 4.6% CAGR between fiscals 2018 and 2023, reaching 1,507 BU in fiscal 2023. However, coal-based generation has seen a slower growth at ~2.5% CAGR, with its share in total generation falling from ~75% in fiscal 2017 to ~71% in fiscal 2023. Coal generation is expected to remain flat over the medium term as it peaks by fiscal 2028, however, coal generation will remain a key part of the nation's energy supply mix in the long term. On the other hand, generation from renewable sources grew at a strong ~24% CAGR over the period, thus taking its share up to ~12% in fiscal 2023. Renewable generation is poised for strong growth at 17-18% CAGR over the next five years, with robust capacity additions and improving capacity utilisation factor (CUF) across solar and wind plants on the back of technological improvements. Other fossil and other non-fossil-based generations are expected to grow at a muted pace over the period, with their share in generation remaining falling to 3-4% and 12-13% respectively.

**Figure 21: Energy demand outlook (fiscals 2021-28)**



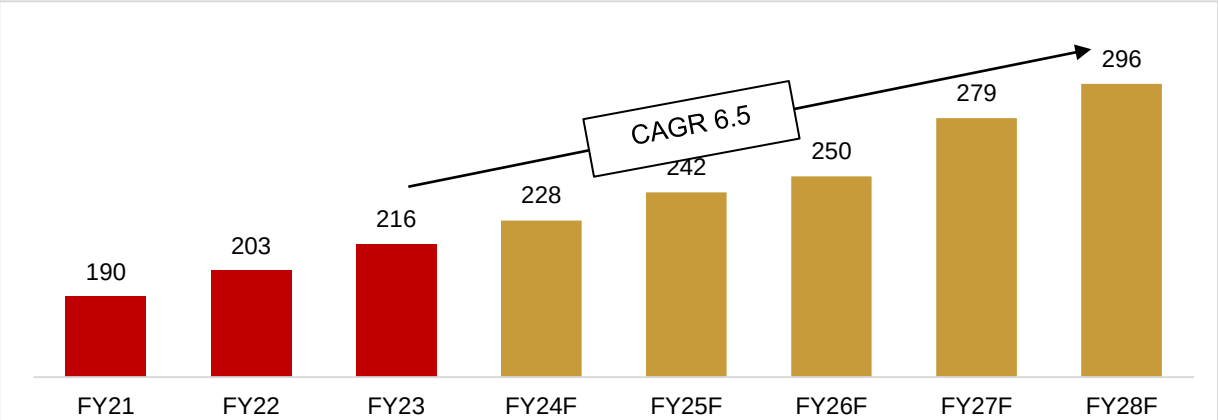

*P: Projected,*
*Source: CEA, CRISIL Consulting*

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.

### 2.4.2 Peak demand outlook

Peak demand has outpaced base demand on several instances. While base demand has grown at a CAGR of nearly 4% over fiscals 2017-22, peak demand has grown at 5%. 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. Peak demand is expected to grow annually at ~6.5% over fiscal 2023-28 to nearly 296 GW by fiscal 2028 with expected persistent high temperatures, rising urbanisation, economic growth and infrastructure push leading to higher power consumption.

**Figure 22: Peak demand outlook (fiscals 2021-28)**




*F: Forecast*
*Source: CEA, CRISIL Consulting*

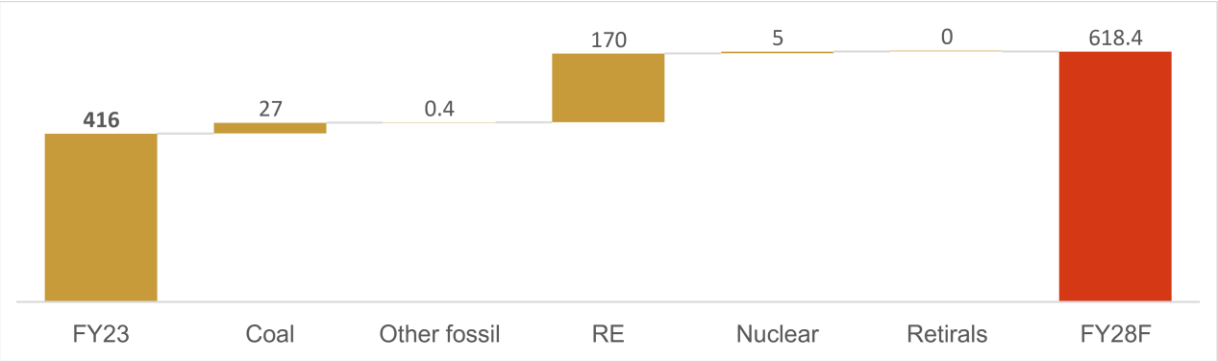
### 2.4.3 Expected capacity installation by fiscal 2028

A thermal power generation capacity of ~27 GW was under construction as of April 2023. However, CRISIL Consulting expects only 27-28 GW of coal-based power to be commissioned over fiscals 2024-28. In addition, 16-18 GW of hydro including pumped storage projects (PSP) and 6-7 GW of nuclear capacities are expected to be added. National Thermal Power Corporation (NTPC) will dominate capacity additions, with 8.4-8.8 GW being added over the next five years. NTPC also announced five brownfield expansion projects with a cumulative capacity of ~6.1 GW in fiscal 2023, for which tendering is expected to be carried out over fiscals 2023-25, whereas commissioning is expected to be beyond the next five years. On the other hand, the contribution of private players to conventional capacity additions over fiscals 2024-28 is expected to be 7.8-8.0 GW as compared with ~6.5 GW over the past five years.

Installed generation capacity across fuels reached 416 GW as of fiscal 2023, on the back of healthy RE capacity additions of ~56 GW over fiscals 2018-23 and is expected to reach 620-630 GW by fiscal 2028 as renewable capacity additions (solar and wind) nearly triple to 166-172 GW over the next five years. Storage-based capacity, consisting of pumped hydro and battery energy storage systems, is likely to reach 24-25 GW by fiscal 2028, driven by PSP and battery energy storage system (BESS) capacity additions of 8.5-8.7 GW and 19-25 GW, respectively, over fiscals 2024-29. Also, India's renewed ambitious target of reaching 500 GW of non-fossil fuel capacity by 2030 is likely to involve enhancement of the hydro capacity pipeline to support core renewables such as solar and wind.

CRISIL Consulting expects 130-140 GW of solar capacity addition between fiscals 2024 and 2028, followed by 24-25 GW through wind. Growth in capacity additions will be driven by government support, with an aggressive tendering roadmap outlined by the government. A few external factors such as an improvement in technology (floating solar and module efficiency), low-cost financing and policy push are enablers. However, a surge in component pricing, additional taxation will increase capital costs consequently affecting the ability of state discoms to offtake power at higher prices.

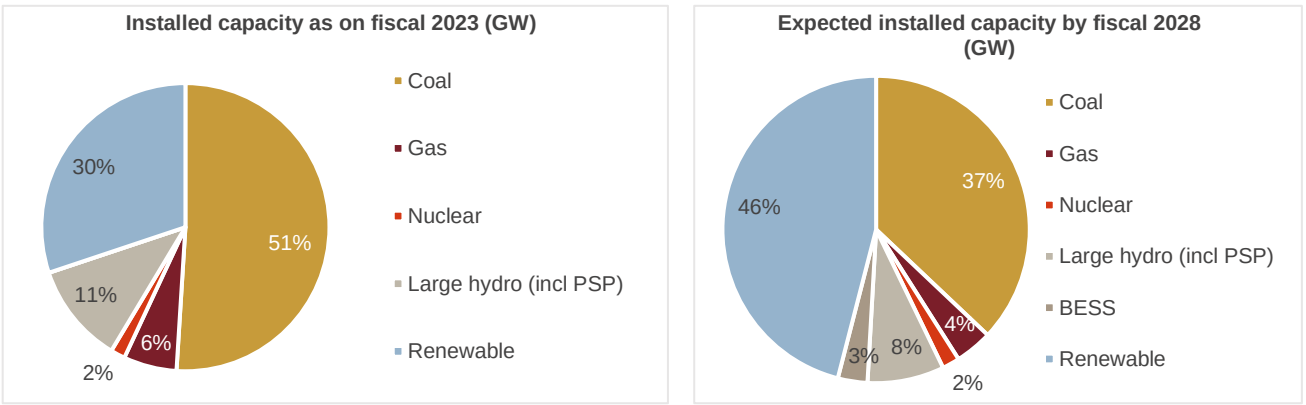
**Figure 23: All India installed capacity addition by fiscal 2028 (in GW)**




*Source: CEA, CRISIL Consulting*

The expected installation pipeline would increase the share of renewable capacity (including large hydro and BESS) from 41% in fiscal 2023 to ~57% in fiscal 2028. The share of coal would reduce to 37% from current 51% over the same period.

**Figure 24: Details of installed capacity**

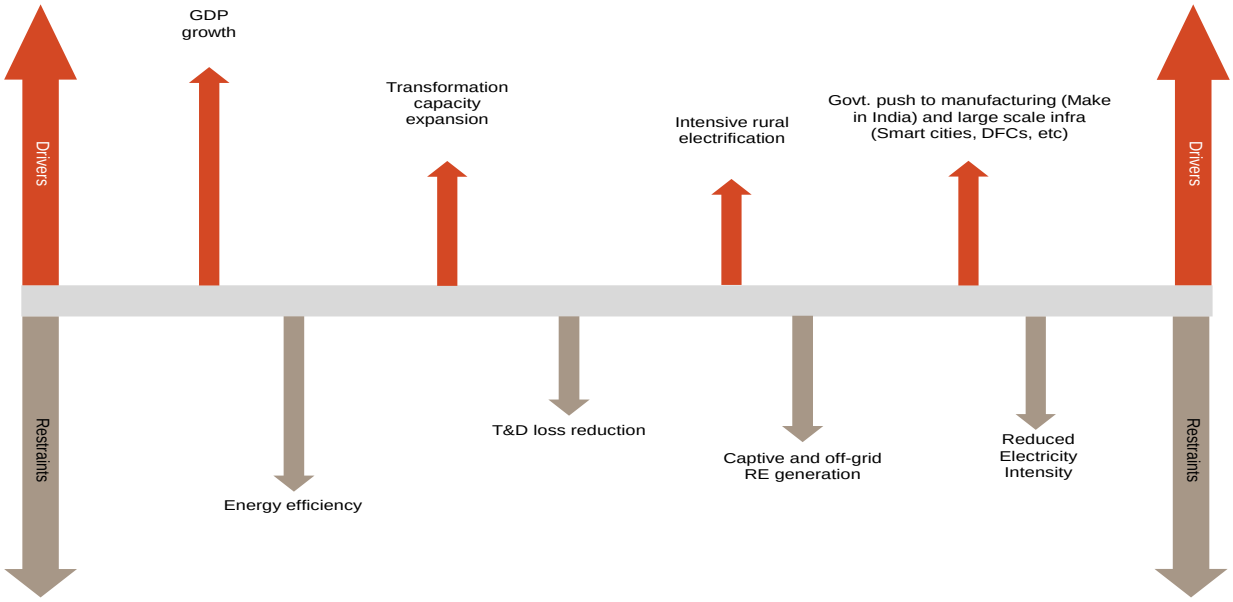



*BESS: Battery Energy Storage System*
*Source: CEA, CRISIL Consulting*

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

Power demand is closely associated with a country's GDP. A booming economy automatically leads to a surge in power demand. India is already the fastest-growing economy in the world, with average GDP growth of 5.5% over the past decade. The trickle-down effect of *Aatmanirbhar Bharat* relief package, government spending on infrastructure through the National Infrastructure Pipeline, commissioning of the dedicated freight corridors, expansion of the services industry, rapid urbanisation, and increased farm income from agriculture-related reforms are key macroeconomic factors fostering power demand. 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 have aided large scale manufacturing in India, further boosting power demand in the country.

**Figure 25: Factors influencing power demand**




*Source: CRISIL Consulting*

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

**Figure 26: Infrastructure development to drive power demand**


*Source: CRISIL Consulting*

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

To become a net zero emitter by 2030, the government aims to achieve 100% electrification of Indian Railways by December 2023. However, given delayed electrification works due to pandemic-induced lockdowns, coupled with the sluggish pace of electrification, 100% electrification is expected to be achieved by fiscal 2027 and lead to incremental power demand of around 27 BUs on average every year. The power sector is poised to witness most of the incremental demand from railway electrification; however, lower energy consumption for electrification per km due to energy efficiency improvements will partially offset the demand.

Metro rail has seen substantial growth in India in recent years, and the rate of growth is set to double or triple in the coming years with multiple cities seeking metro rail services to meet daily mobility requirements. Around 987 km of metro rail is under construction and 245 km is proposed to be added. These developments are expected to add incremental power demand of 4-5 BUs every year on average. Currently, metro rail projects constitute a marginal share of total incremental demand, but the share is expected to increase due to a large quantum of upcoming metro projects.

Further, EV charging requirements are likely to boost power demand over the medium term, with a gradual increase in the share of EVs in the vehicle population. CRISIL Consulting projects that adoption of EVs will boost power demand by 4-5 BUs annually on average over fiscals 2023 to 2028.

**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, namely the Revamped Distribution Sector Scheme (RDSS). RDSS is a reform-based and result-linked scheme for improving the quality and reliability of power supply to consumers through a financially sustainable and operationally efficient distribution sector. Power demand would be reduced by 16-18 BUs on average every year owing to lower T&D losses.

Further, with a boost to rooftop solar and the declining cost of renewable energy generation, off-grid solar generation is expected to increase, reducing power demand from the grid. By fiscal 2028,15-16 GW of rooftop capacities are expected to come onstream, resulting in a reduction of 1-2% in base demand.

Open access or short-term market transactions currently account for nearly 12% of total electricity generation. The share of short-term transactions is expected to increase to 14% by fiscal 2028 primarily driven by demand pressure, better price discovery at exchanges and a slew of exemptions to the prices in the short term. Demand on the short-term market is expected to increase on average by 27 BUs, resulting in a decline in power demand from the grid.

## 2.5 Review of global solar PV capacity additions

### 2.5.1 Outlook 2023-2027: 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.

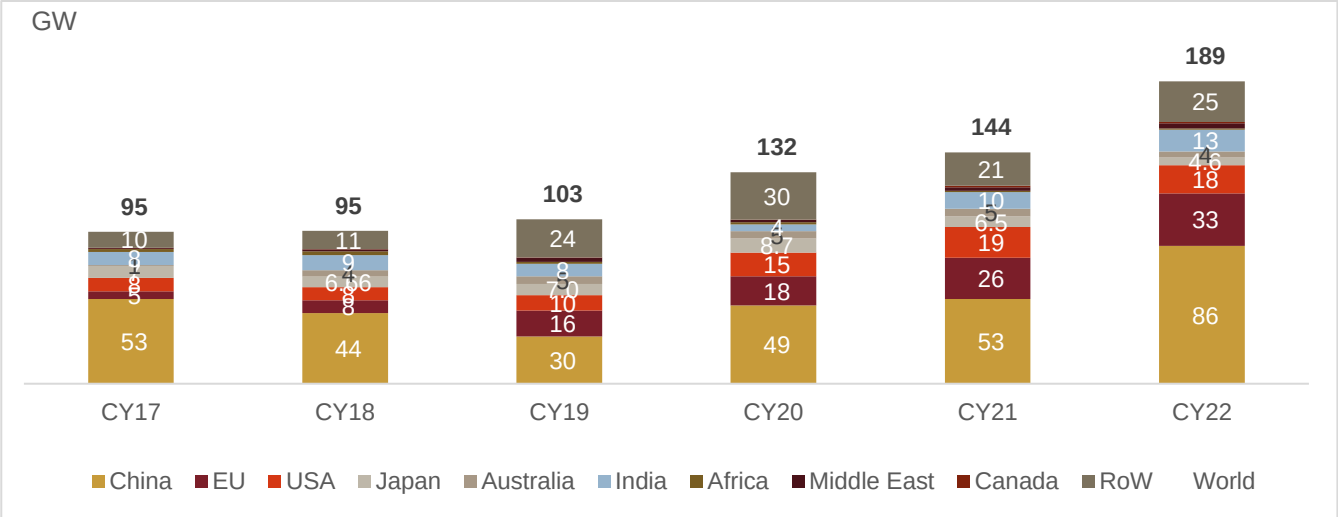
Concerns over climate change are at the heart of the energy shift towards RE and its increasing utilisation will be key for decarbonisation. Various initiatives, such as Kyoto Protocol, Paris agreement, Conference of Paris (COP) 21, COP26, RE 100, ISA, and subsequent favourable policy interventions, 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, ~189 GW of solar PV capacity was added in 2022, taking the installed capacity to 1,055 GW, which is a ~22% increase over the previous year. China continued to lead the market with total cumulative capacity of ~392 GW, whereas the US came in second with ~112 GW, followed by Japan at ~83 GW.

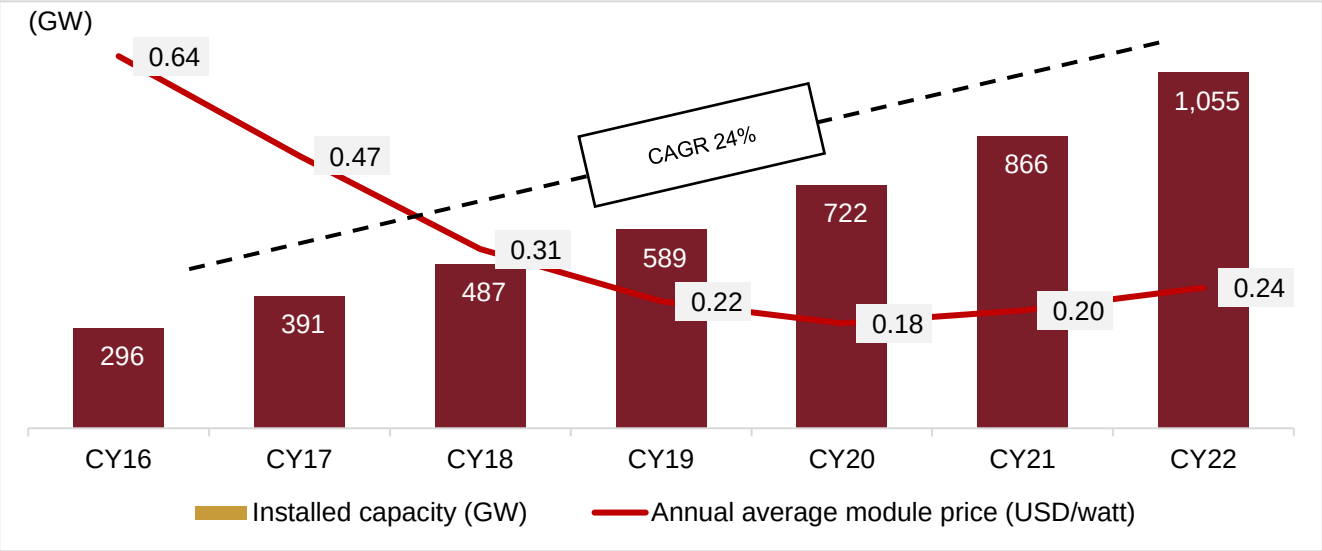
**Figure 27: Annual solar capacity additions in major economies**




*Note: The annual capacity addition numbers pertain to calendar year (January-December)*
*Source: IRENA Statistics 2023; CRISIL 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 ~24% CAGR between 2016 and 2022**




*Source: IRENA, CRISIL Consulting*

**Table 6: Solar PV capacity additions and installed base (2022)**

| Country | Installed capacity (MW) | Capacity additions (MW) |
|---|---|---|
| China | 3,92,436 | 86,033 |
| EU | 1,95,308 | 32,950 |
| USA | 1,11,535 | 17,624 |
| Japan | 83,055 | 4,642 |
| Australia | 29,676 | 3,922 |
| India | 62,850 | 13,462 |
| Africa | 10,543 | 795 |
| Middle East | 12,795 | 3,279 |
| Canada | 5,326 | 772 |
| RoW | 1,51,506 | 25,524 |

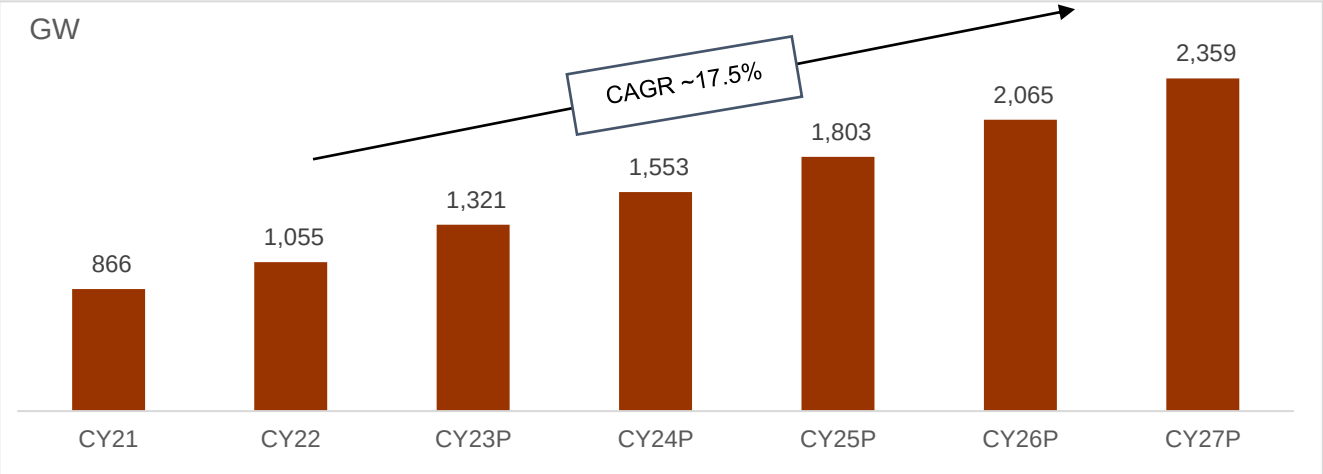
*Source: IRENA, CRISIL Consulting*

China continues to dominate the solar PV market, accounting for about 45% of the global installed capacity, while key European countries control about 23% of the total solar PV installed capacity.

### 2.5.2 Global solar outlook (CY2023-2027)

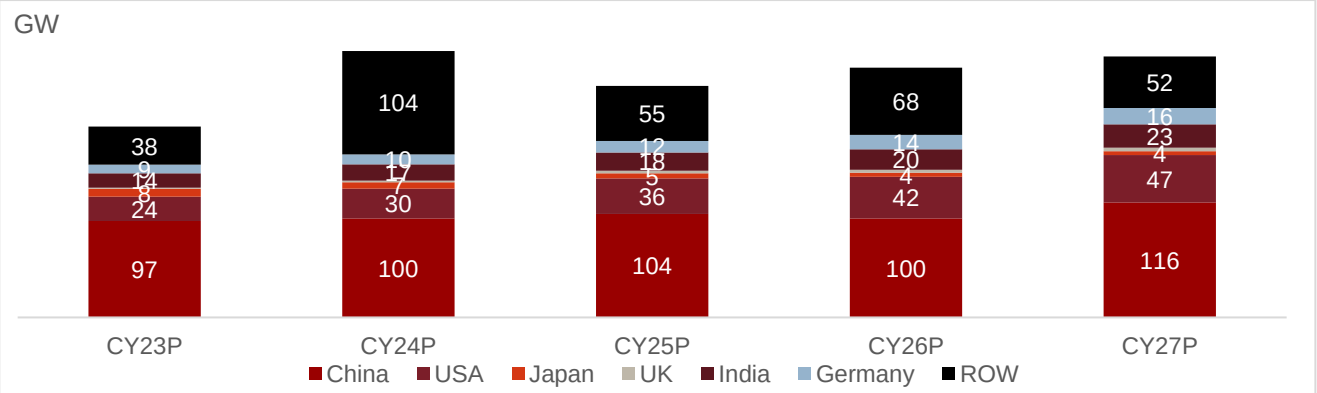
The IEA predicts that the global cumulative solar PV capacity would triple by 2027, surpassing natural gas by 2026 and coal by 2027. Although the current commodity super-cycle may have pushed investment costs up, utility-scale solar PV continues to be the most cost-efficient option for most countries. 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 CY23-27**




*(P): Projected*
*Source: IRENA, IEA Renewables 2022, CRISIL Consulting.*

**Figure 30: Projected annual solar capacity additions in major economies**




*(P): Projected*
*Source: IRENA, IEA Renewables 2022, CRISIL 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 PV capacity is expected to triple to 2,359 GW by 2027, 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 ~100 GW of solar PV in 2023. By the end of 2023, 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 ~25 GW solar PV capacity in 2023. 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. For solar PV, the impact of trade measures on deployment and prices was much larger than for wind. In 2022, the solar PV market contracted 15% due to uncertainty over trade restrictions, which paused imports and slowed project development. However, an interim order published in June 2022 addressed some trade issues and, as a result, the market is expected to expand in the next two years. In fact, solar PV additions could break new records, reaching more than 30 GW in 2024 – a 50% increase from 2022 – thanks to accelerated utility-scale project deployment. Meanwhile, distributed solar PV additions, which benefit from the Investment Tax Credit (ITC) and local net metering provisions, remain stable at around 8 GW.

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 ~8 GW of solar PV capacity in 2023. 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 ~140 GW are expected to be added in 2023, 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 energy.

## 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.

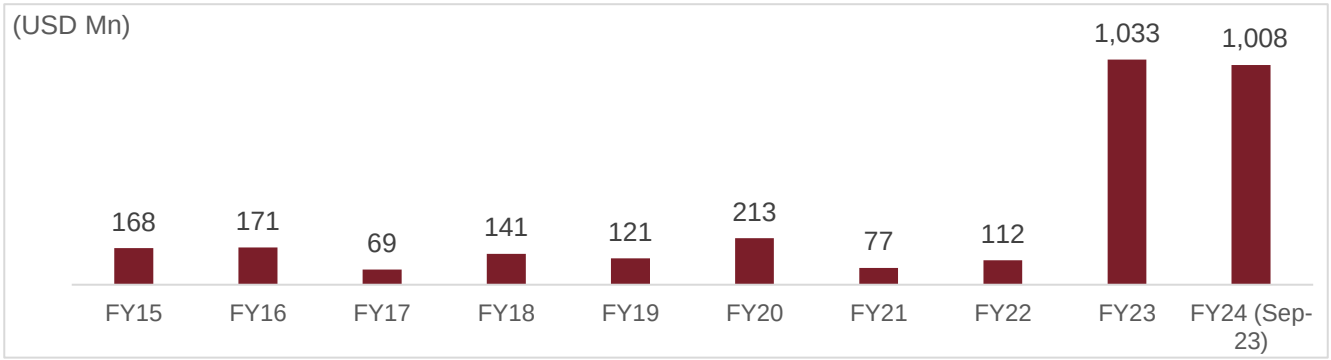
Even as Indian dependence on imported solar modules and cells continues, exports for fiscal 2020 increased to USD 213 million from USD 121 million (increase of 76%) from fiscal 2019. However, due to COVID-19 disruptions, exports declined to USD 77 million in fiscal 2021. Nevertheless, the exports grew 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 modules from India in value terms**




*Source: Ministry of Commerce; Data for HS Code 85414011; FY 21-22 (HS Code 85414011+85414012): FY 22-23: (HS Code 854143+ 85414200); CRISIL 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:*

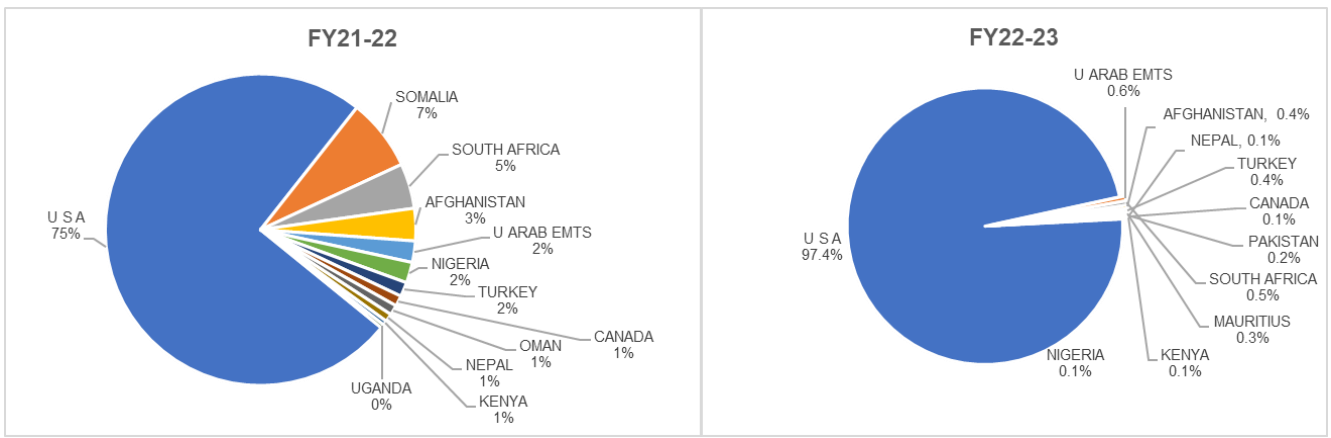
*85414011 - Solar cells (not assembled); 85414012 - Solar cells (assembled in modules or made up into panels)*

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

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

During fiscal 2023, USA accounted for ~98% of the exports of solar modules (in value terms), followed by UAE, South Africa, Afghanistan and Turkey. Also, during fiscal 2024 (till Sept 2023), US accounted for ~98% of the total exports of solar module followed by South Africa and Somalia.

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




*Source: Ministry of Commerce; FY 21-22 (HS Code 85414011+85414012); FY 22-23: (HS Code 854143+ 85414200); CRISIL 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.

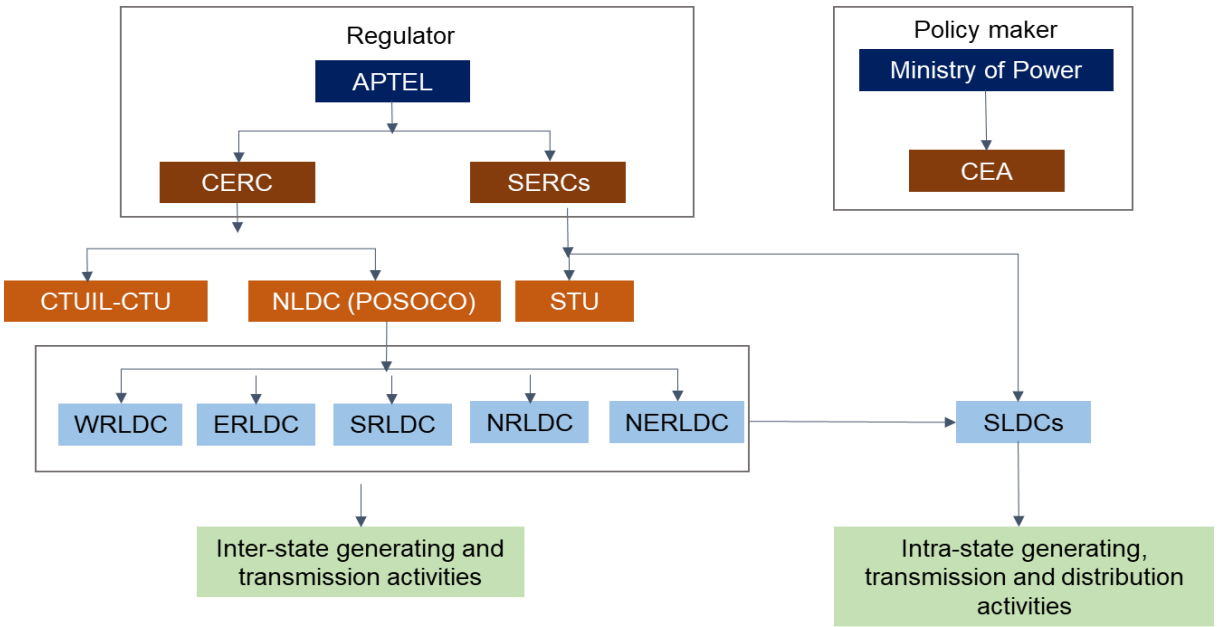
## 2.7 Review of the Indian power sector

### 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 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
- **Renewable generation obligation** (RGO) issued by MoP for the companies installing new coal/lignite based thermal power plants and having the commercial operation date of the project on or after April 1, 2023. These projects would have to establish/procure an RE capacity of a minimum of 40% of the thermal plant capacity. However, in October 2023, the government issued a draft notification to reduce

RGO from existing 40% to 6% for thermal plants commissioned before March 2023 and 10% from April 2023 onwards

- **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 12-15% 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<br>Smart metering to be completed by March 2025 | DT metering in urban and rural areas has reached 95% 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<br>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 4-8 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 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

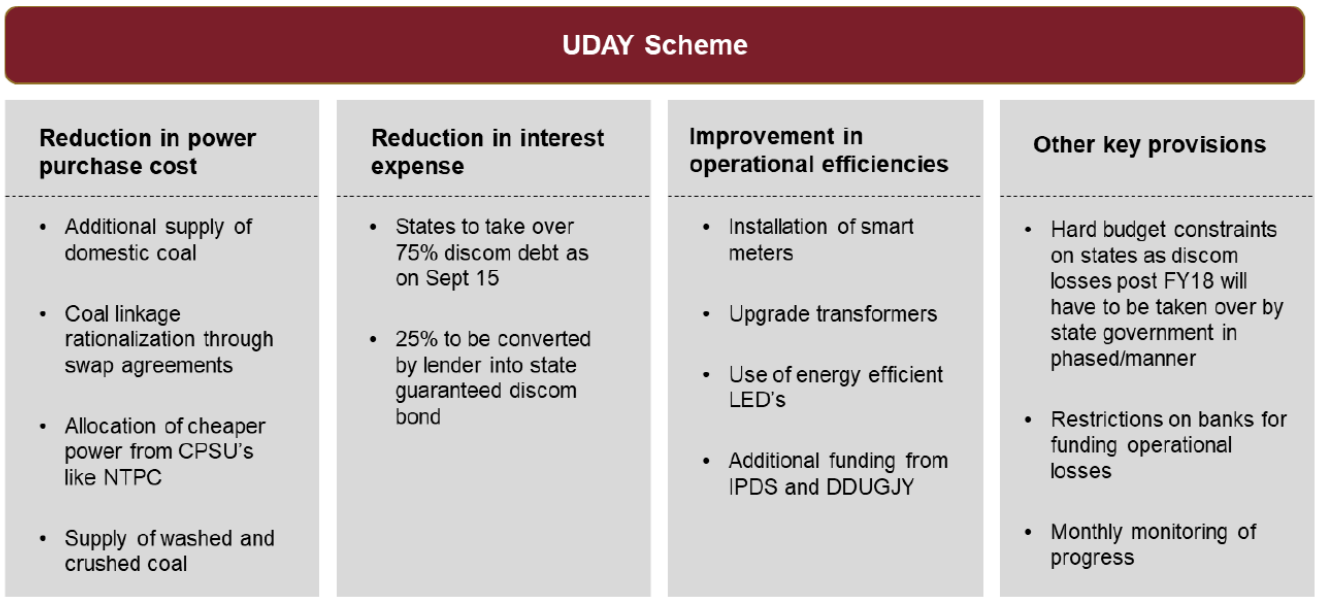
**Review of AT&C loss and ACS-ARR gap of state discoms**

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 Consulting*

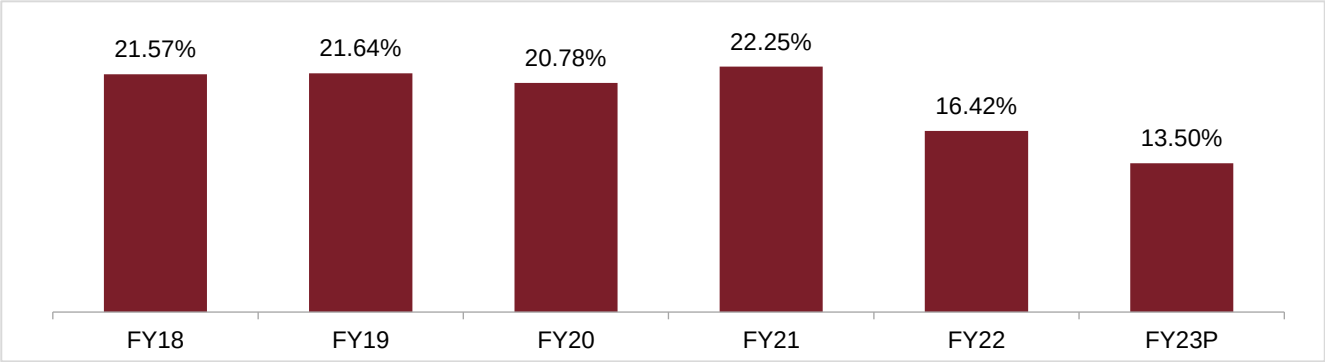
**Improvements in operational efficiency**

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.

AT&C losses reduced to 16.4% in fiscal 2022, significantly lower than 20.8% in fiscal 2020 and 22.3% in fiscal 2021. AT&C losses were considerably high in fiscal 2021, as COVID-19 adversely impacted both billing and collection efficiencies. However, AT&C losses reduced by ~3% even when compared with the pre-pandemic level (fiscal 2020). The AT&C loss further reduced to 13.5% in fiscal 2023 as per the provisional data compiled by MoP.

The AT&C loss trend indicates that the improvement was driven by collection efficiency, which improved from 93.1% in fiscal 2020 to 97.2% in fiscal 2022. On the other hand, billing efficiency remained unchanged at 85.9% during the period.

**Figure 36: AT&C loss trajectory (%)**

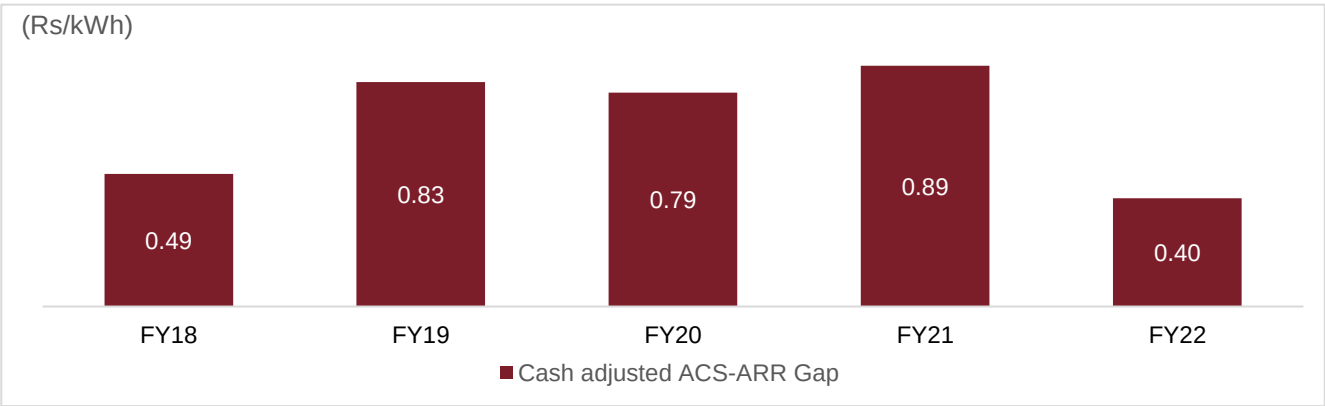



*P: Provisional*

*Source: PFC, CRISIL Consulting*

The average cost of supply (ACS) and average revenue realized (ARR) gap for the states 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, indicating reversal of some of the gains achieved through reduction in power purchase costs, interest burden and AT&C losses over the past three years. The cash-adjusted ACS-ARR gap stood at Rs 0.79 per unit as of March 2020 and widened further to Rs 0.89 per unit as of March 2021, indicating further deterioration in discoms' financial profiles. However, the gap narrowed to Rs 0.40 per unit as of March 2022, reflecting improved financial conditions of reporting discoms.

**Figure 37: ACS-ARR gap**

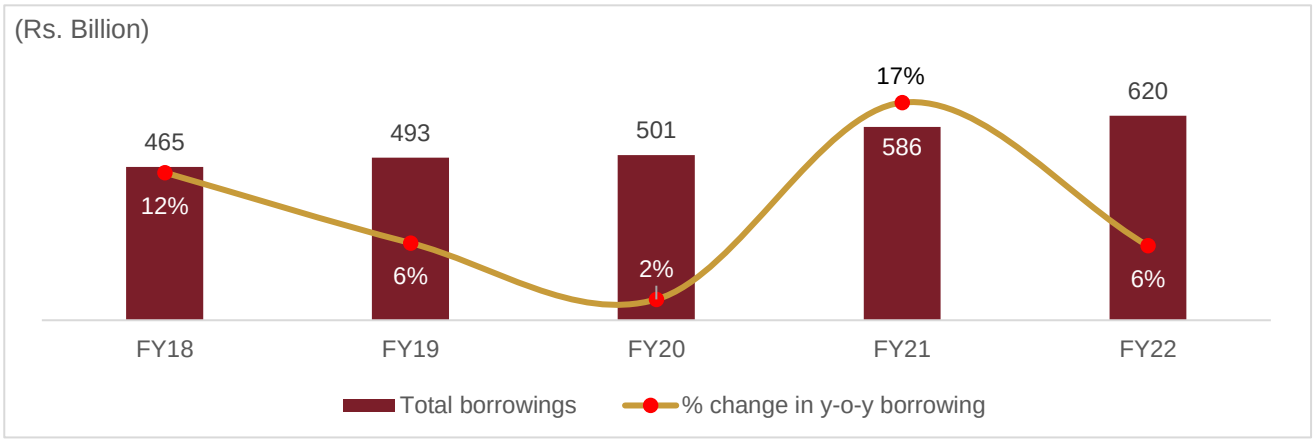



*PFC has not provided figures for FY23*

*Source: PFC, CRISIL 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.

**Figure 38: Total borrowings for discoms**




*Source: MoP, PFC, CRISIL Consulting*

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

***Distribution companies***

As per the 11th Integrated Rating Report on Power Distribution Utilities for fiscal 2022, the financial deficit of power distribution sector was ~Rs 53,000 crore in fiscal 2022, a reduction of ~46% compared to fiscal 2020. This improvement was driven by rising demand for power and a 50% improvement in the ACS-ARR gap from 79 paise per unit in fiscal 2020, which reduced to only 40 paise per unit in fiscal 2022. The improvement in the absolute cash adjusted gap can be attributed to improvement in the profit before tax, subsidy disbursement and collection from trade receivables.

Further, the total debt of discoms increased by 24%, from Rs 5.01 lakh crore in fiscal 2020 to Rs 6.20 lakh crore in fiscal 2022. However, the pace of debt accumulation slowed down significantly. In fiscal 2022, the debt increased by Rs 33,800 crore, which is 60% less than the Rs 85,500 crore increase in fiscal 2021.

Trade payables to generation companies (gencos) and transmission companies (transcos) increased by 10.5% from Rs 2.55 lakh crore in fiscal 2020 to Rs 2.81 lakh crore in fiscal 2022. This was driven by rising power purchase costs, as the days payable remained constant at 163 days. Trade receivables, on the other hand, jumped by 17% from Rs 2.07 lakh crore to Rs 2.42 lakh crore during the same period. This was due to a 10% increase in revenue from operations, which resulted in days receivable increasing from 134 to 142 days. Part of the receivables accumulated during fiscal 2021 were not collected in fiscal 2022, as many C&I customers faced COVID-19 induced business disruption. This resulted in higher trade receivables in fiscal 2022 compared to fiscal 2020.

The trade receivables for SECI improved to 49 days in fiscal 2022 compared to 57 days fiscal 2021 whereas for NVVN, the trade receivables increased to 136 days in fiscal 2022 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**

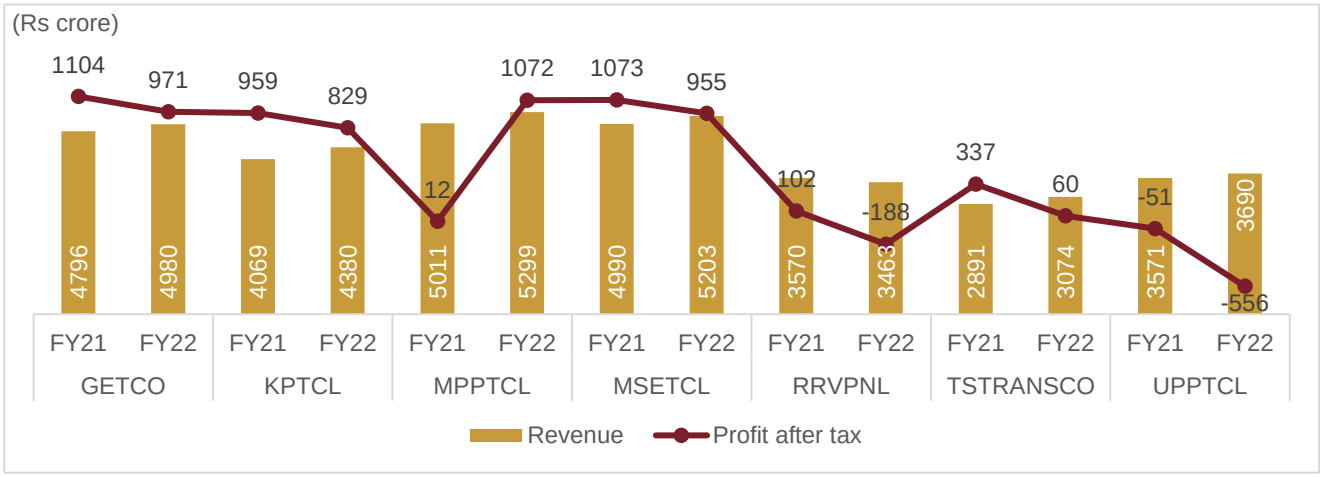
As per the Report on Performance of State Power Utilities for fiscal 2022, transmission utilities together incurred a profit of Rs 4,896 crore, with 15 out of 22 utilities registering profit. GETCO (Rs 971 crore) and MPPTCL (Rs 1,072 crore) were among the top profit earners in transmission utilities. However, RRVPNL (Rs 188 crore), JUSNL (Rs 430 crore), HPPTCL (Rs 170 crore), MePTCL (Rs 82 crore), UPPTCL (Rs 556 crore) and MSPCL (Rs 32 crore) reported losses.

Net worth for transmission utilities stood at Rs 1,01,843 crore and equity at Rs 64,052 crore as on March 31, 2022, as compared with Rs 93,793 crore and Rs 66,925 crore, respectively, as on March 31, 2021.

Total borrowings by transmission utilities reduced by Rs 23,699 crore, from Rs 1,26,611 crore as on March 31, 2021, to Rs 1,02,912 crore as on March 31, 2022.

Trade receivables for transmission utilities increased from Rs 25,095 crore to Rs 32,216 crore, while receivables in days increased from 218 days to 288 days.

**Figure 39: Performance of state power transmission utilities for FY22**




*Source: PFC's Report on Performance of State Power Utilities for FY22; CRISIL Consulting*

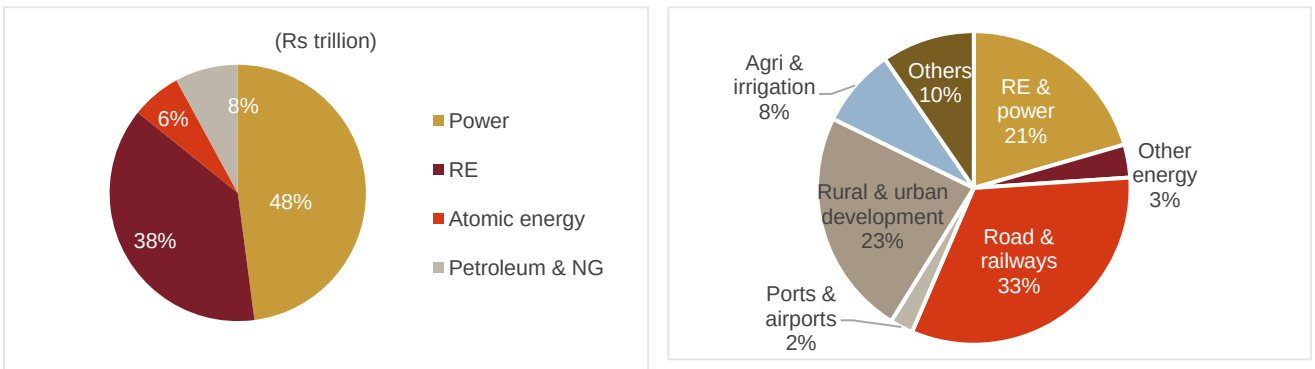
## 2.7.6 Proposed investments in the power sector

**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**

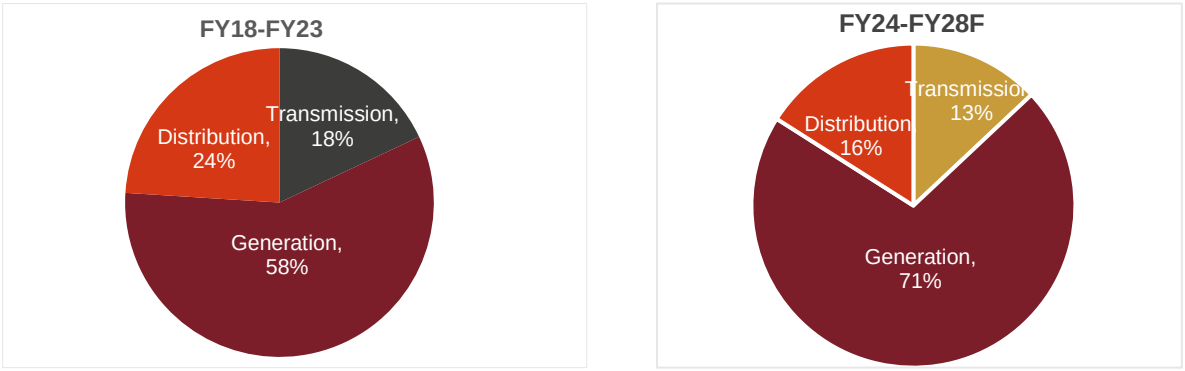



*Source: CEA, CRISIL Consulting*

**Investments in generation, transmission, and distribution infrastructure**

CRISIL Consulting expects investments of Rs 23-23.5 trillion in the power sector over the next five years. The share of investments in generation is expected to increase and that of distribution to decrease over the next five years compared with fiscals 2018-23.

**Figure 41: Segment-wise break-up of total investments-dominance of the generation segment**

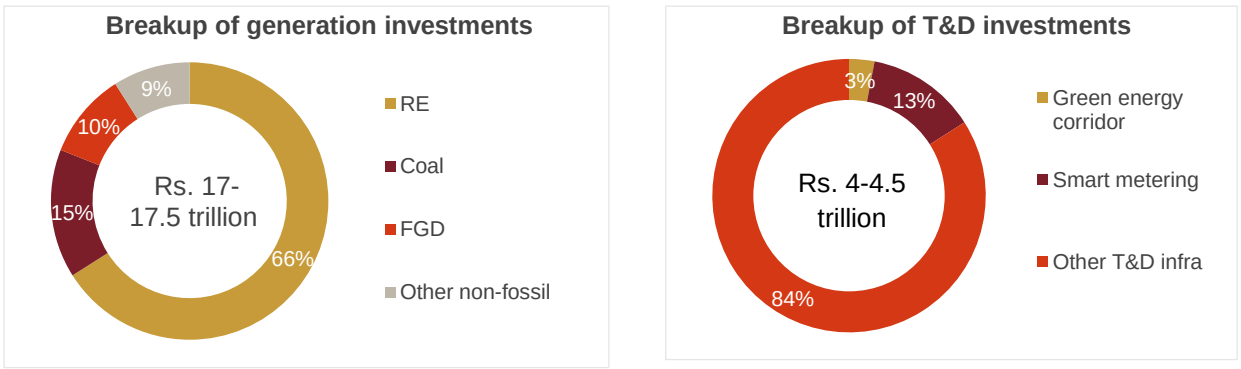



*Source: CRISIL Consulting*

Investments in the generation segment are expected to almost triple from ~Rs 6 trillion to Rs 17.5 trillion over the next five years driven by renewable and conventional capacity additions of 155-160 GW. Investments in distribution to increase the next five years at Rs 3.3 trillion, on the back of RDSS envisaged over fiscals 2022-26. Transmission sector investments will grow to Rs 2.3 trillion, led by upcoming ISTS and green energy corridor (GEC) projects.

Investments in generation will be led by RE capacity additions, followed by investments in conventional generation and flue gas desulfurization (FGD) installations, indicating a shift in fund flows towards enhancing clean energy supply. Investments in RE capacity, which are expected to triple over the next five years in line with capacity additions, will constitute over 77% of overall generation investments. Investments in the segment will be bolstered by increase in conventional generation investments over the next five years as against the last five years, as new coal-based plants will be set up to meet the fast-growing peak load demand and increased installation of emission controlling FGD equipment in thermal stations. Total generation investments are expected to grow 85-90% over fiscals 2024-28 compared with fiscals 2018-23.

**Figure 42: Breakup of investments (FY24F-FY28F)**




*Source: CRISIL Consulting*

To service a large generation installed base, the estimated investment in the transmission sector is expected to cumulatively reach ~Rs 4.5 trillion for fiscal 2024-28 driven by the need for a robust and reliable transmission system to support continued addition in generation capacity and the strong push to the renewable energy sector

as well as rural electrification. Also, strong execution capability, coupled with the healthy financials of PGCIL, will drive investments.

In the Union Budget 2021-22, the government announced RDSS worth Rs 3.04 trillion for state discoms, to be allocated over the next five years, Rs 1.65 trillion worth of detailed project reports (DPRs) have been sanctioned by nodal agencies (PFC and REC) as of June 2022. Investments in the segment are likely to pick up gradually from this fiscal onwards with central/state government(s) expected to provide the required funding support. The distribution segment is expected to attract investments worth Rs 3.3 trillion over fiscals 2024-28 compared with ~Rs 2.8 trillion over the last five years, led by the government's thrust on improving access to electricity and providing 24x7 power to all. The share of the private sector in overall power sector investments during fiscals 2024-28 is expected to increase to 48% from ~30% over the past five years largely driven by renewable capacity additions, bulk of which are funded by private investments. The share of the central sector would decrease to ~16% over fiscals 2024-28 compared with ~24% over the previous five years. The state sector is expected to account for over 36% of power investments led by both RDSS and generation investments.

### 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.

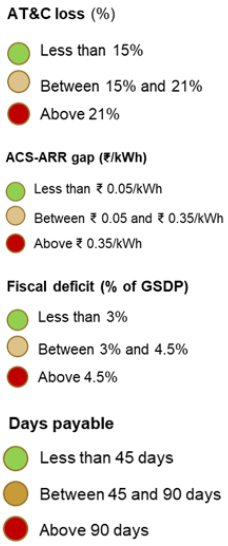
### 2.7.8 Assessment of key off-taker entities

**Distribution utilities**

CRISIL 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 2022.

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

| | State | AT&C loss (%) | ACS-ARR gap (₹/kWh) | Fiscal deficit (% of GSDP) | Days payable | PFC Rating FY22 |
|---|---|---|---|---|---|---|
| Strong | Gujarat | 9.20% | -0.22 | 1.51% | 0 | A+ |
| | Karnataka | 11.10% | -0.73 | 2.84% | 179 | A/B |
| | Haryana | 13.80% | 0.03 | 3.36% | 42 | A+ |
| Moderate | Andhra Pradesh | 10.50% | 0.50 | 3.18% | 167 | B/C |
| | Punjab | 11.70% | 0.08 | 5.65% | 65 | A |
| | Madhya Pradesh | 23.13% | 0.29 | 3.80% | 316 | B-/C |
| | Chhattisgarh | 18.10% | 0.46 | 3.81% | 214 | C |
| | Maharashtra | 15.50% | 0.08 | 2.79% | 177 | B- |
| | Tamil Nadu | 13.50% | 1.79 | 4.18% | 200 | C- |
| | Telangana | 11.60% | 1.46 | 3.88% | 366 | C- |
| | Rajasthan | 17.13% | -0.25 | 3.03% | 139 | B/C |
| Weak | Uttar Pradesh | 28.33% | 1.34 | 4.27% | 246 | C/C- |
| | Jharkhand | 33.80% | 1.81 | 5.10% | 537 | C- |
| | Bihar | 30.25% | 1.26 | 11.31% | 160 | C- |




*Source: PFC, CRISIL Consulting*

**Strong states have performed better in operational parameters**

Gujarat, Karnataka, and Haryana have been classified as strong states, as they have AT&C losses lower than 15% and their per-unit ARR is more than ACS, which is the target under RDSS. Also, the state profile is preferable with lower fiscal deficit. Gujarat and Haryana have payable days less than 45 days, as specified in LPS Rules, 2022.

**Moderate states have promising operational parameters, but lower than strong states**

Andhra Pradesh, Punjab, Tamil Nadu, and Telangana have AT&C losses under 15% despite a relatively large ACS-ARR gap, except Punjab. Madhya Pradesh, with high AT&C losses, is considered a moderate state as its ACS-ARR gap is considerably lower than the aforementioned states. Punjab, Maharashtra, and Rajasthan significantly minimised their ACS-ARR gap in fiscal 2022. Chhattisgarh and Rajasthan have registered AT&C losses above 15% but less than 20%.

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

AT&C losses and ACS-ARR gap in states such as Bihar, Jharkhand and Uttar Pradesh are higher than the national average on account of weak distribution infrastructure, higher power purchase costs, and lower billing and collection efficiency. These three states have failed to perform on any of the parameters mentioned in Figure 43.

**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 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 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) |

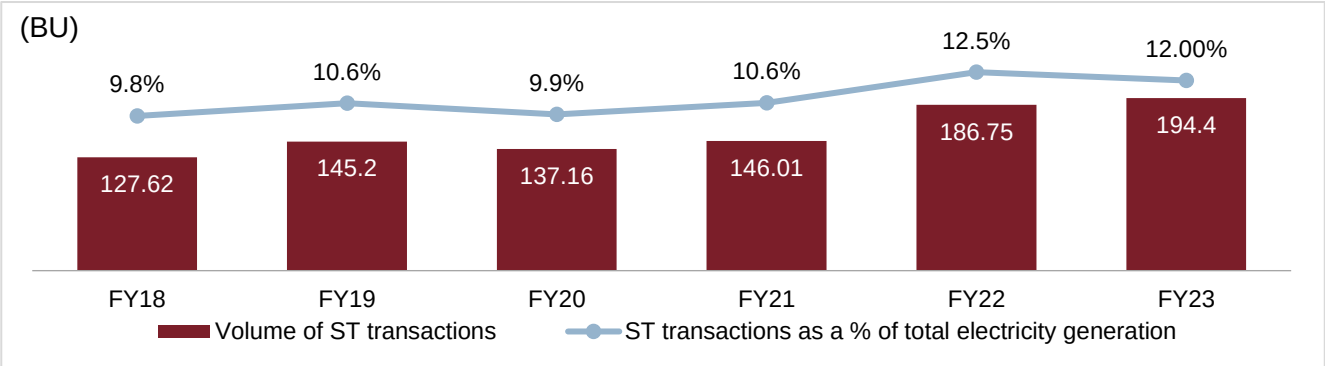
*Credit rating of the Company was withdrawn in January 2022 due to receipt of no-objection certificate from bankers*

## 2.8 Trend in short-term power transactions

### 2.8.1 Short-term power market in India

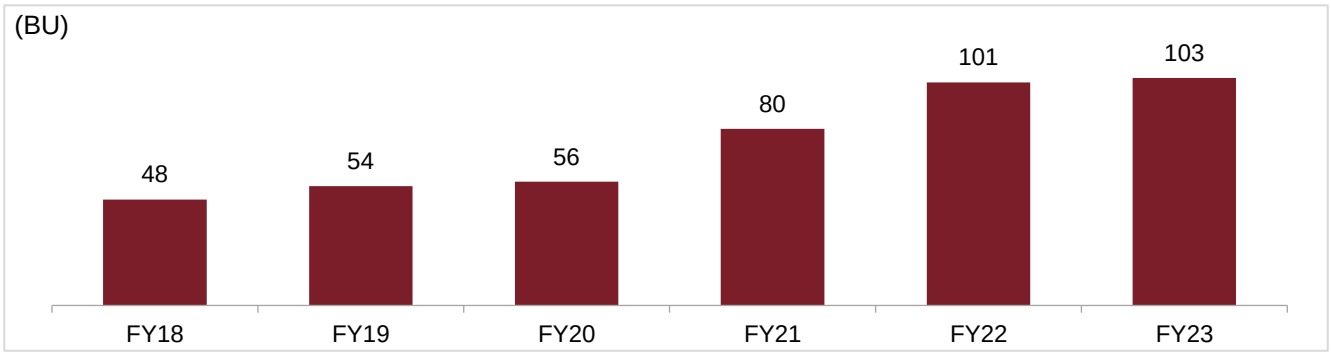
Total volume of short-term transactions of electricity increased from 65.90 BUs in fiscal 2010 to its all-time high of 194.4 BUs in fiscal 2023. Over the period, volume of short-term transactions of electricity increased at a higher rate (CAGR of 8.8%) than total electricity generation (CAGR of 5.9%). 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 2023.

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




*Source: CERC, Annual Report on Short-term Power Market FY22-23, CRISIL Consulting*

**Figure 45: Transactions through power exchanges**

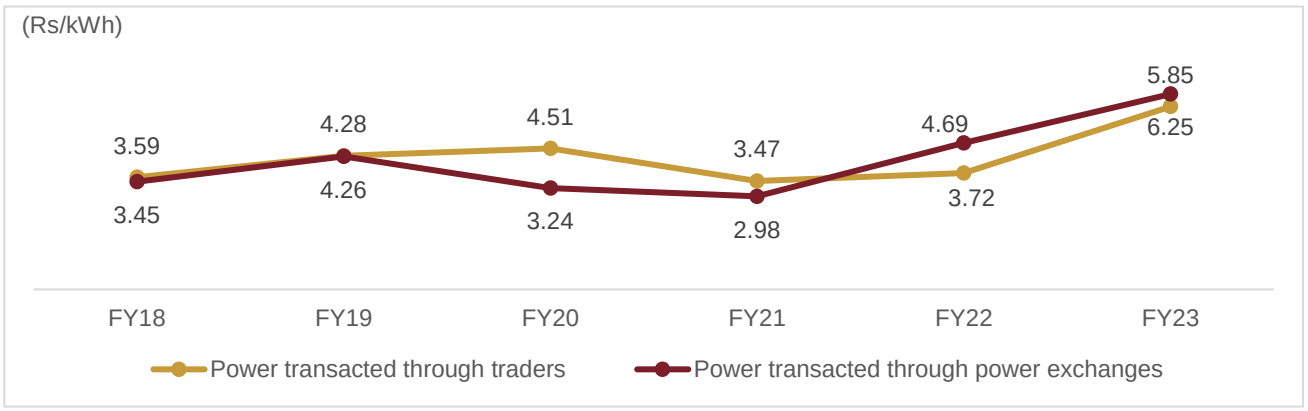



*Source: CERC, Annual Report on Short-term Power Market FY22-23, CRISIL Consulting*

## 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**




*Source: CERC, CRISIL 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.

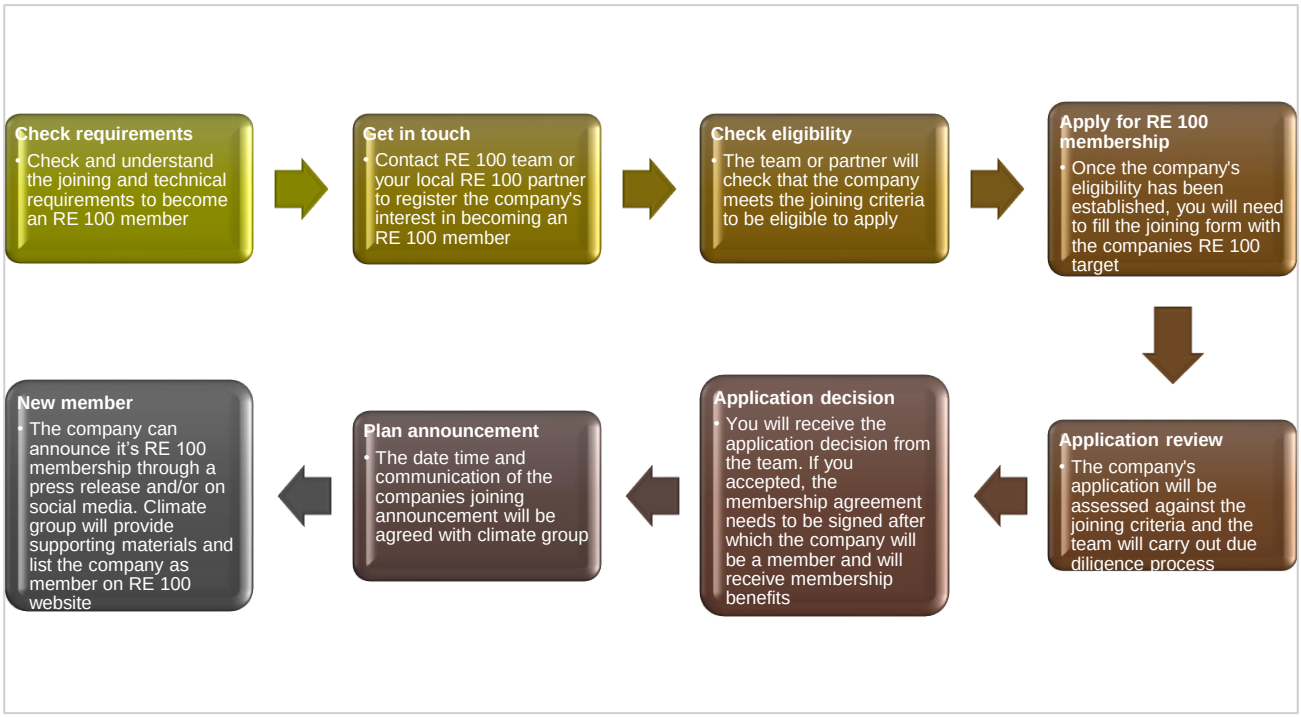
## 3.1 Key global initiatives for promoting renewable energy

### 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 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.<br>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:<br>1.1.1. Key player in a RE100 priority region<br>1.1.2. Key player in their industry/RE100 target sector<br>1.1.3. Willing to be involved in policy advocacy in RE100 priority regions<br>1.1.4. Globally or nationally recognised and trusted brand and/or major multi-national company (Fortune 1000 or equivalent)<br>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%:<br>• 60% by 2030<br>• 90% by 2040<br>• 100% by 2050<br>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<br>3.1. All Scope 2 emissions associated with purchased electricity: and<br>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)<br>3.3. All companies operating within the brand or company group, including operations that are >=50%owned by the brand or company group<br>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:<br>4.1. Has clear separate branding from the parent company, AND<br>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 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.

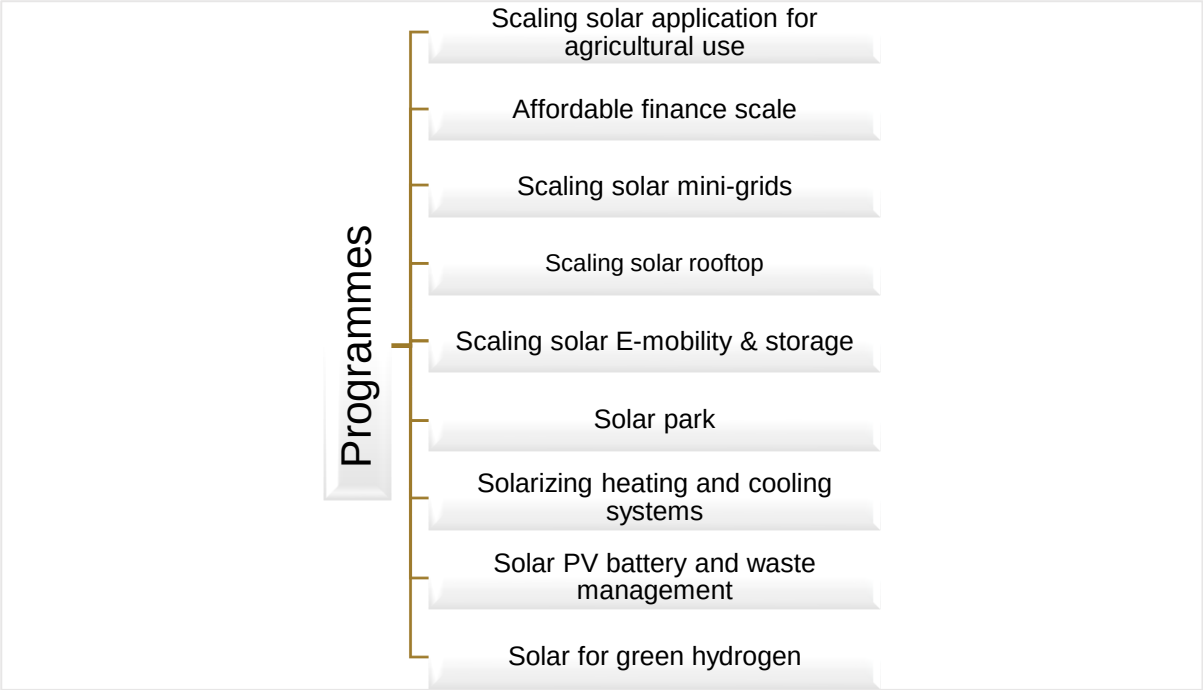
**The interests and objectives of the ISA**

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 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 of 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 101$^{st}$ 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.

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.<br>• To achieve about 40% cumulative electric power installed capacity from non-fossil fuel-based energy resources by 2030<br>• 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].<br>• To reduce Emissions Intensity of its GDP by **45%** by 2030, from 2005 level [UPDATED].<br>• 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].<br>• 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<br>• Reduce carbon dioxide emissions per unit of GDP by 60-65% from the 2005 level<br>• Increase the share of non-fossil fuels in primary energy consumption to around 20% | • Aims to have CO2 emissions peak before 2030 and achieve carbon neutrality before 2060.<br>• To lower CO2 emissions per unit of GDP by over 65% from the 2005 level.<br>• To increase the share of non-fossil fuels in primary energy consumption to around 25%. | 28/10/2021 |

| Country | NDCs (COP21) | NDCs (COP26) | Revised NDCs Submission date |
|---|---|---|---|
| | • Increase the forest stock volume by around 4.5 billion cubic meters on the 2005 level | • To increase the forest stock volume by 6 billion cubic meters from the 2005 level.<br>• To bring its total installed capacity of wind and solar power to over 1.2 billion kilowatts by 2030. | |
| **USA** | • Reducing its net GHG emissions by 50-52% below 2005 levels in 2030<br>• 100% carbon pollution-free electricity by 2035 | Revised NDCs not submitted | 22/04/2021 |
| **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<br>• Long-term goal of achieving net-zero by 2050.<br>• 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<br>• 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 | Revised NDCs not submitted | 18/12/2020 |
| **Canada** | • To reduce emissions by 40-45% below 2005 levels by 2030<br>• To reduce emissions to net-zero by 2050 | Revised NDCs not submitted | 12/07/2021 |

*Source: NDC Registry (Interim) UNFCCC; CRISIL Consulting*

## 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 Consulting expects solar PV manufacturing capacity to reach ~57 GW by fiscal 2028 as against announced capacity of 89 GW with full integration from polysilicon to module. The cell manufacturing capacity is expected to reach ~50 GW as against announced capacity of 63 GW by fiscal 2028. 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 do 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 (ºC)** | -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 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 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 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:

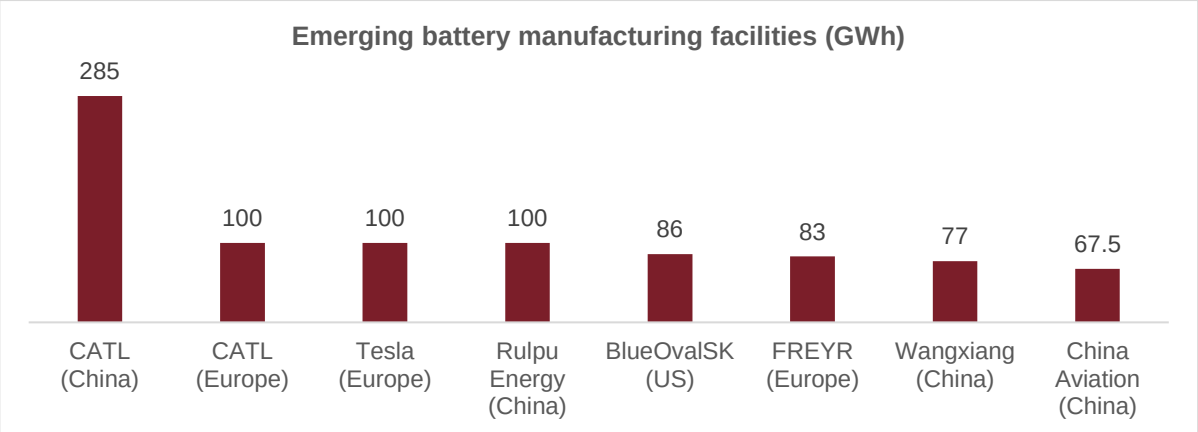
**Table 14: Announcements made by key players in India to setup battery manufacturing**

| 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)<br>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.<br>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 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 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 (°C)** | 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 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 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.

# 5 Indian solar power market

**Executive Summary:**

- With strong government thrust, India added ~13 GW solar capacity in fiscal 2023 and over 5 GW as of October 2023 during fiscal 2024
- A tariff of Rs 2.8-3.0 p.u. would be required to generate a 10-12% IRR with the imposition of BCD and supply-side issues
- Solar capacity additions of 130-140 GW expected over fiscals 2024-2028
- As the government pushes towards the Green Hydrogen targets, more solar capacities are expected to commission totaling 30-34 GW by fiscal 2028
- 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.
- ~11-12 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 OA-related provisions.
- ~19.0-21.5 GW rooftop solar additions expected over 2024-28; 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

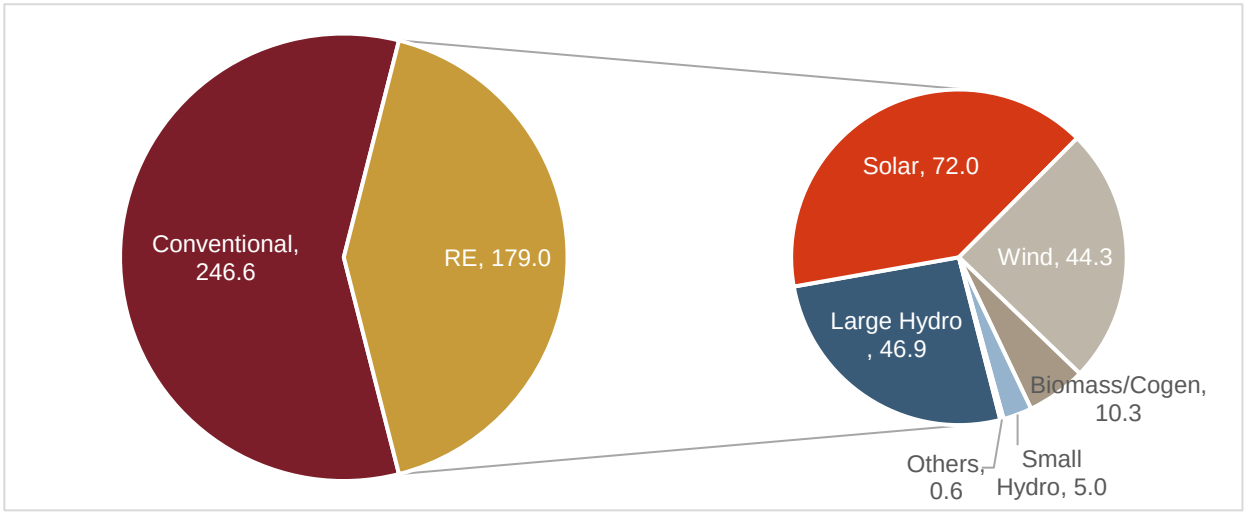
The impact of two oil shocks pushed the government to establish a Commission for Additional Sources of Energy under the Department of Science and Technology in March 1981. This division was responsible for formulating and implementing policies regarding the development of new and renewable energy sources 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 ~179 GW as of October 2023, as compared with ~63 GW as of March 2012 (source: MNRE), led by various central and state-level incentives. As of Oct-2023, installed grid connected renewable energy generation capacity (incl. large hydro) in India constituted

~42% of the total installed generation base in India. In particular, this growth has been led by solar power, which has grown to ~72 GW from ~0.09 GW over the discussed time period.

**Figure 50: India's RE (incl. Large Hydro) capacity was ~42% as of October-2023 (GW)**

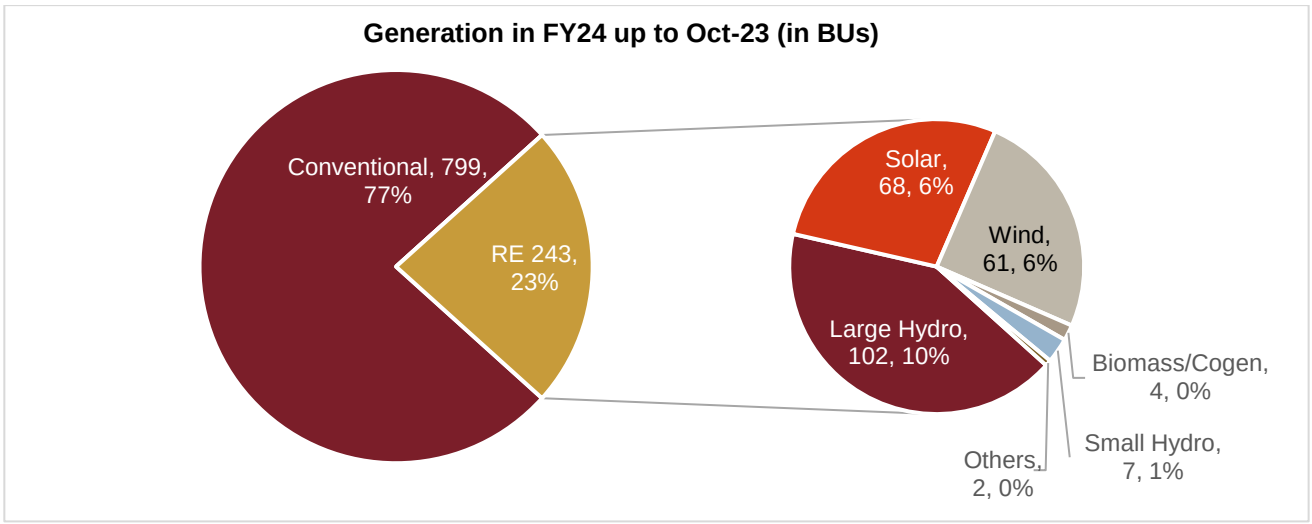



*Note: Excl. imports from Bhutan*

*Source: MNRE; CEA, CRISIL Consulting*

However, owing to lower capacity utilisation factors, the RE penetration (incl. large hydro) in terms of energy generation was at ~23% as of Oct-2023.

**Figure 51: India's RE (incl. Large Hydro) energy penetration was ~23% at end of Oct- 2023**




*Note: Excl. imports from Bhutan*

*Source: MNRE; CEA, CRISIL Consulting*

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

**Table 17: Potential and cumulative capacity of RE (technology-wise)**

| Technology | Potential | Cumulative capacity (as of Oct 23) | Untapped potential |
|---|---|---|---|
| Wind | ~696 GW (120 m hub height) | 44.3 GW | 93.6% |
| Solar | 750 GW | 72.0 GW | 90.4% |
| Bioenergy | 25 GW | 10.26 GW | 59.0% |
| Hydro | 165 GW | 51.8 GW | 68.6% |
| Waste to energy | NA | 0.6 GW | NA |

*Hydro: Large + Small hydro*

*Source: MNRE; NITI Aayog; CRISIL 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 18: State-wise estimated potential v/s percentage achievement of potential for solar energy across major states of India (as of Oct-2023)**

| States | Potential (GW) | Installed capacity (GW) | Potential achieved (%) |
|---|---|---|---|
| **Andhra Pradesh** | 38 | 4.56 | 12.0% |
| **Gujarat** | 36 | 10.42 | 28.9% |
| **Karnataka** | 25 | 9.35 | 37.4% |
| **Madhya Pradesh** | 62 | 3.17 | 5.1% |
| **Maharashtra** | 64 | 5.06 | 7.9% |
| **Punjab** | 3 | 1.27 | 42.2% |
| **Rajasthan** | 142 | 18.09 | 12.7% |
| **Tamil Nadu** | 18 | 7.16 | 39.8% |
| **Telangana** | 20 | 4.71 | 23.6% |
| **Uttar Pradesh** | 23 | 2.63 | 11.4% |

*Source: MNRE; NISE; CRISIL Consulting*

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

**Table 19: State-wise estimated potential v/s percentage achievement of potential for wind energy projects across major states of India (as of Oct-2023)**

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

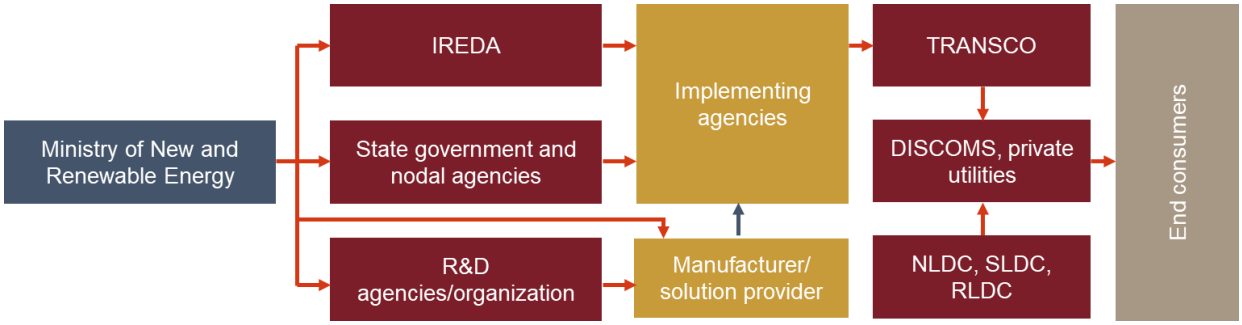
| States | Potential (GW) | Installed capacity (GW) | Potential achieved (%) |
|---|---|---|---|
| **Gujarat** | 84 | 11.17 | 13.3% |
| **Karnataka** | 56 | 5.31 | 9.5% |
| **Madhya Pradesh** | 10 | 2.84 | 28.4% |
| **Maharashtra** | 45 | 5.15 | 11.5% |
| **Rajasthan** | 19 | 5.19 | 27.3% |
| **Tamil Nadu** | 34 | 10.33 | 30.4% |
| **Others** | 9 | 0.19 | 2.2% |

*Note: Wind Power Potential at 120 mtr agl in GW*

*Source: MNRE; NIWE; CRISIL 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:

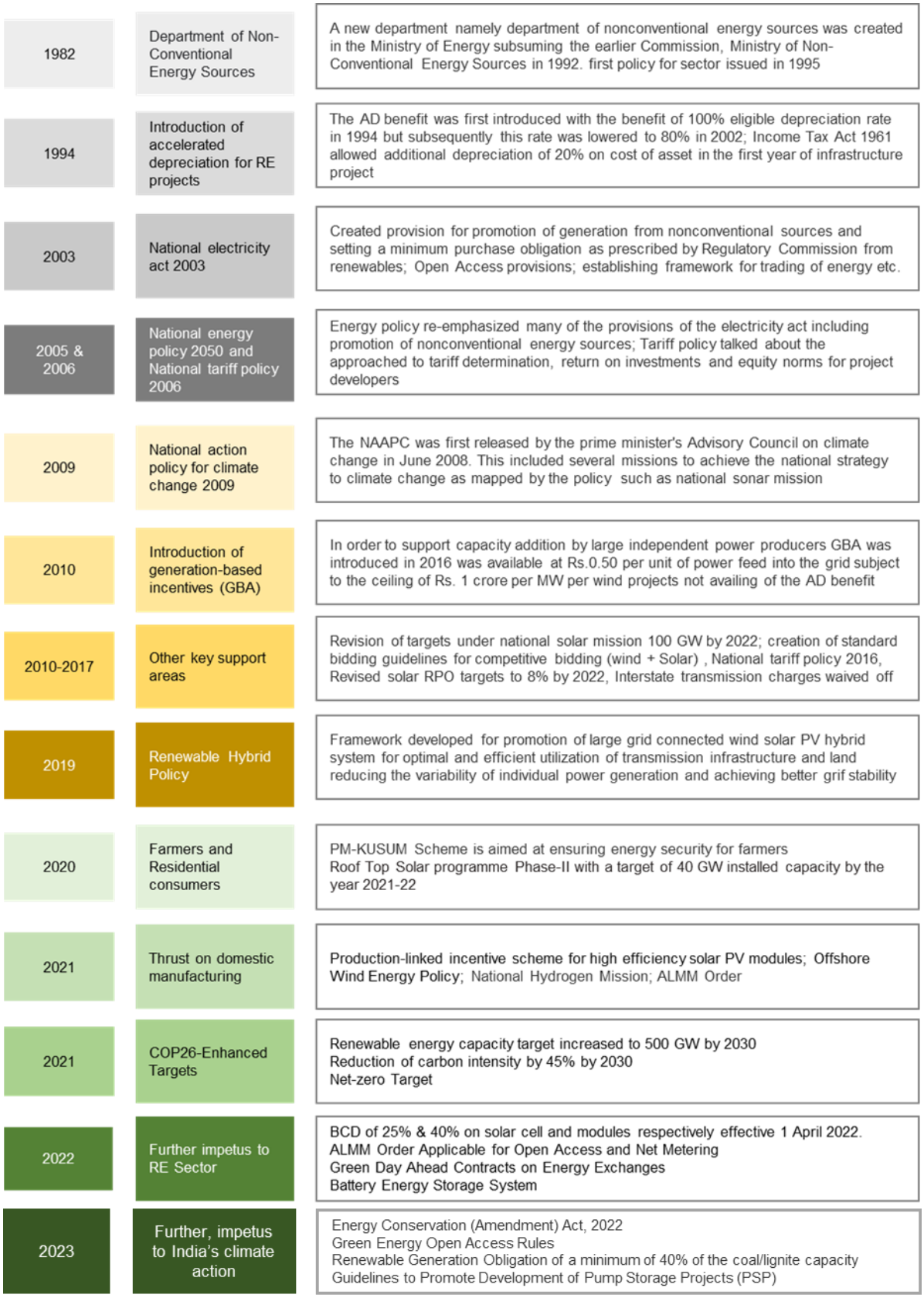
**Figure 52: Key stakeholders in the renewable sector in India**




*Source: CRISIL Consulting*

In the section below, CRISIL 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 Consulting*

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

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

The 2021 United Nations 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

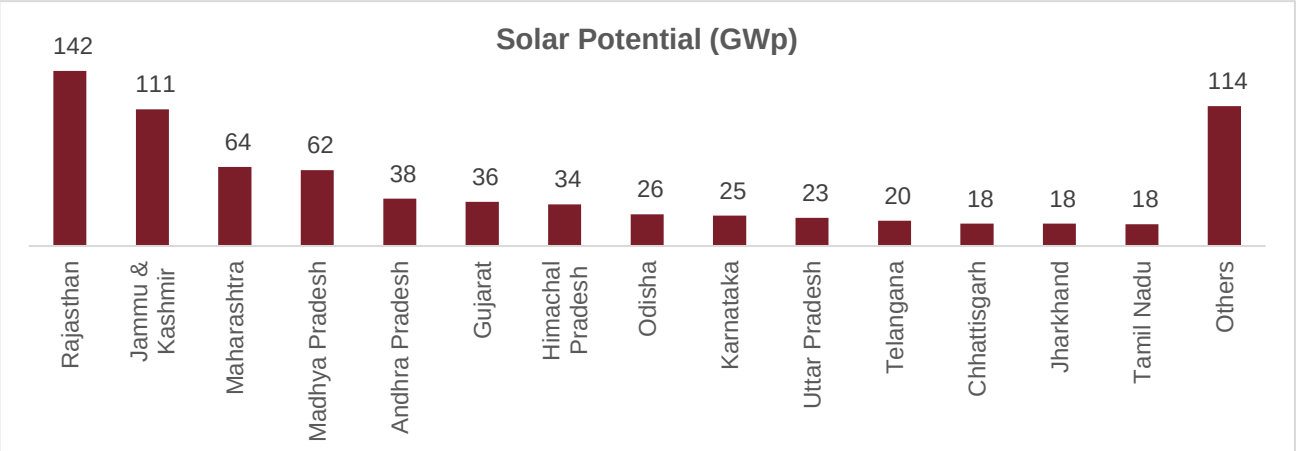
These are more ambitious and are way beyond the current NDCs agreed under the Paris Agreement. These will provide a new thrust to the RE Sector in India and will boost the already accelerating RE Sector. These will also provide guidelines to the Regulators as well as Government Authorities while setting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

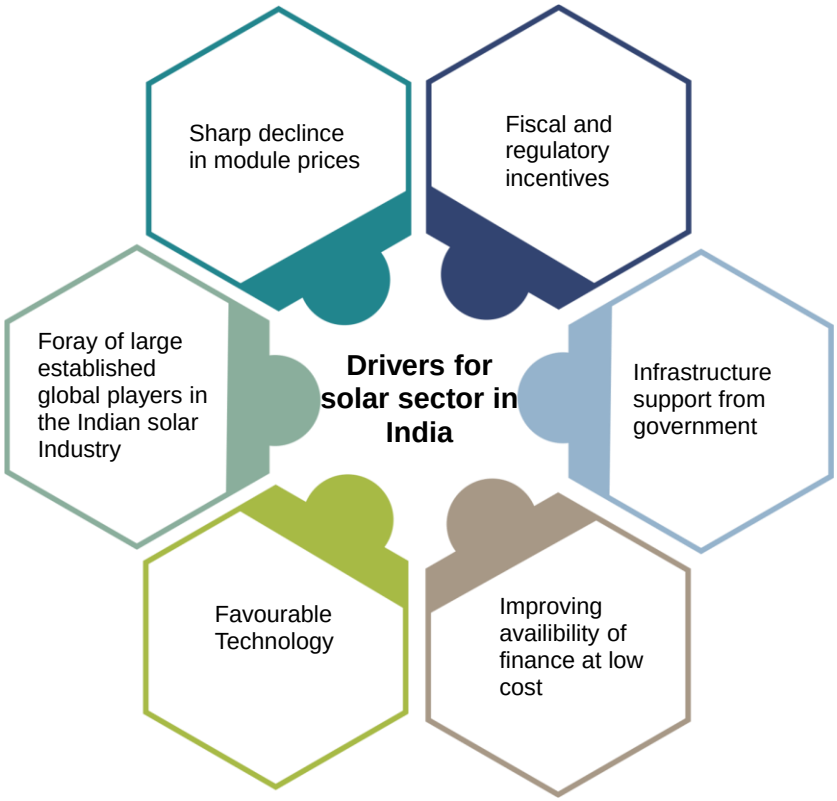
By March 2012, India had reached close to 1 GW of installed capacity, with projects providing satisfactory generation performance along with timely receipt of payments from both NVVN and discoms of Gujarat. The bidding guidelines became stringent to avoid commissioning defaults by successfully bid projects 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 2023, solar energy accounted for a share of 38.8%. Growth in the solar power sector over the last five years has been robust. As much as 54.8 GW capacity was added in the segment over fiscals 2018-23, registering a CAGR of ~25.27%, although on a moderately low base. However, in fiscal 2023, the solar capacity added was slightly lower at 12.78 GW (13.91 GW in fiscal 2022). The sector missed its capacity addition targets for the fifth year in a row. Despite the second wave of COVID-19 infections, fiscal 2022 witnessed solar capacity additions of ~14 GW. In a relief to developers, the MNRE has 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 ~12.78 GW, with ~2.2 GW coming from rooftop solar projects, led by state-level incentives and the remaining from utility scale.

### 5.2.3 Growth drivers for the solar sector in India

**Figure 55: Growth drivers for the solar sector in India**



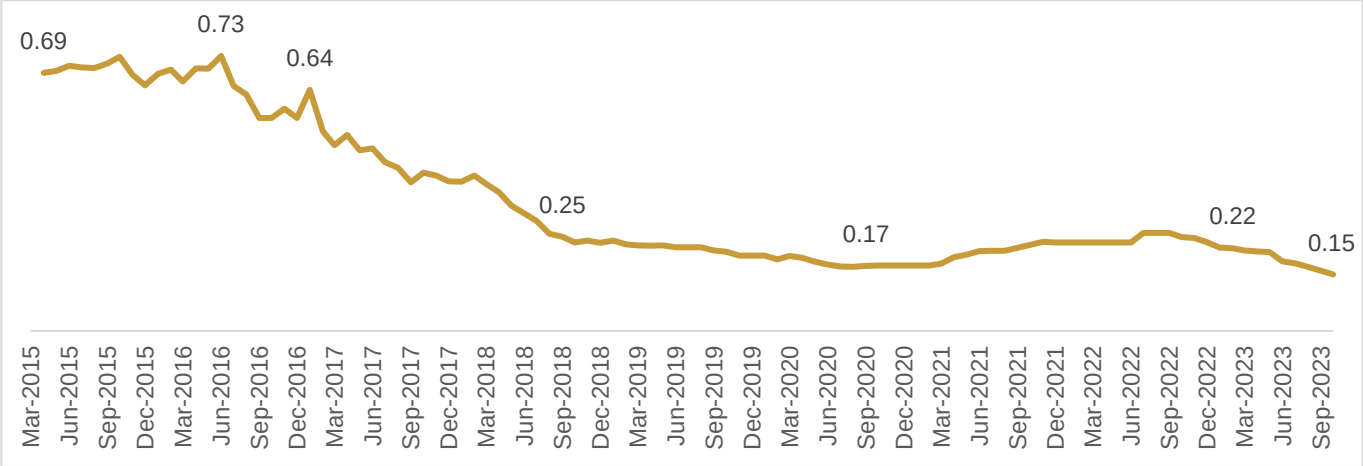

*Source: CRISIL Consulting*

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. The increase in tariffs is compounded by already elevated module pricing due to external factors such as the energy crisis in China and the Russia-Ukraine war. As a result, there is a risk of reduced viability for projects already bid out at lower tariffs. Oversupply of upstream components in fiscal 2024 to force module prices at $0.19-0.21 per Wp until end-March 2024.

**Figure 56: Module prices declined over 80% from fiscal 2010 to 2023**




*Source: CRISIL Consulting*

**Table 20: 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% | 14.9 | 14.5 | 15% | Module – 40%<br>Cell – 25% |

*Source: CRISIL Consulting*

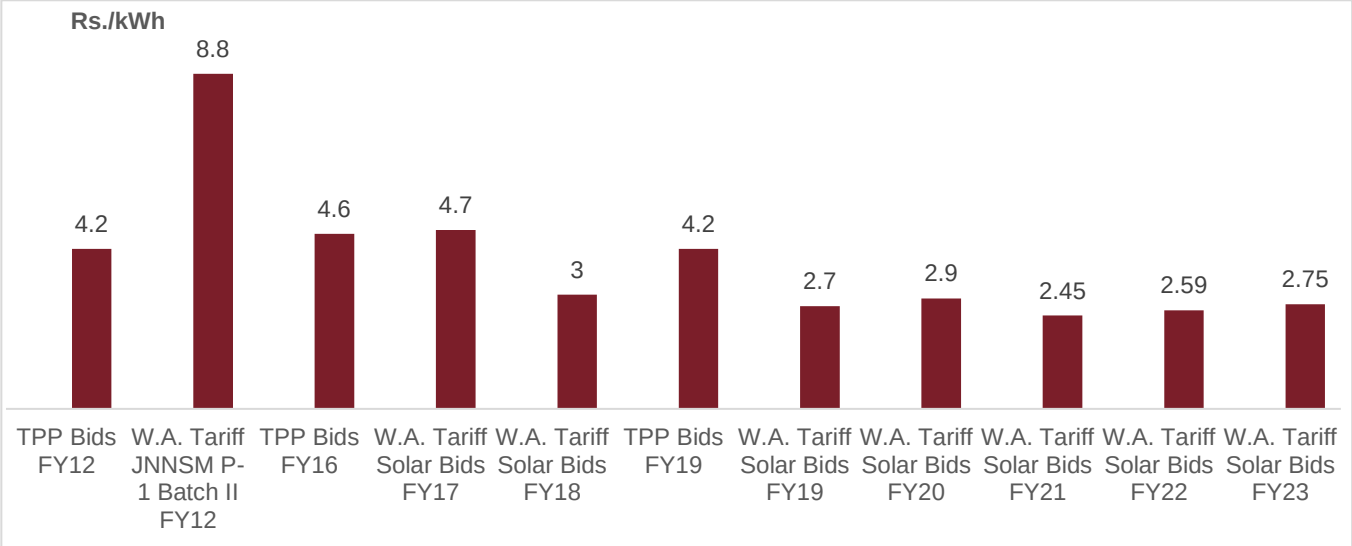
Various players from the Indian solar component manufacturing industry filed additional duty petitions against imports. The key in this regard was a safeguard duty investigation filed by the Indian Solar Manufacturer's Association (ISMA) in front of the Directorate General of Trade Remedies (DGTR).

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.

**Figure 57: Competitively bid solar power tariffs are much lower than coal-based power tariffs**




*Note: TPP – Thermal power plant; JNNSM – Jawaharlal Nehru National Solar Mission; W.A. – Weighted average levelised tariffs*
*Source: Details of Case I bids, Bidding of power from stressed assets, CEA; CRISIL Consulting*

However, while looking at solar tariffs, one will have to increasingly factor in grid integration costs as the penetration level of renewable energy increases. This is expected to increase the procurement cost from solar power plants.

### 5.2.3.2 Strong government thrust

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

**National Solar Mission**

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

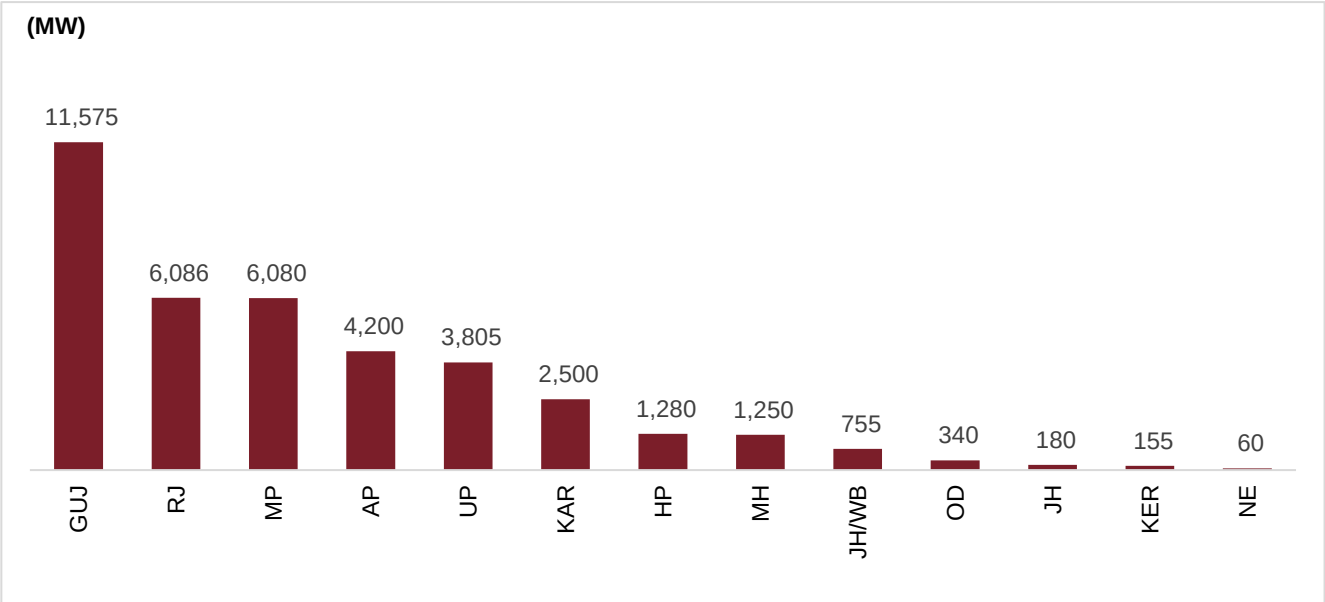
**Operational support to execute solar projects**

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

**Solar parks**: One of the most important initiatives by the GoI has been setting up solar parks in the country. This is critical given the land-intensive nature (~5 acres required per MW of solar PV) of solar projects, coupled with low average holding (1.16 hectare) per person in India. Under the Solar Park Policy released in September 2014, the government planned to prepare land banks for 20,000 MW of solar projects across 25 states. The capacity of the scheme was doubled from 20,000 MW to 40,000 MW on March 2017, to set up at least 50 solar parks by fiscal 2022. Such parks significantly reduce construction/ execution risk as they include a contiguous parcel of land, evacuation infrastructure (HV/EHV substation evacuating to state grid substation), and other ancillary infrastructure and utilities such as road, water, and drainage.

Currently, 25 states, including Andhra Pradesh, Madhya Pradesh, Gujarat, Rajasthan, Uttar Pradesh, Karnataka, Telangana, West Bengal, Chhattisgarh, Tamil Nadu, Jammu and Kashmir, and a few north-eastern states, have started preparing land banks for solar parks, either through their own implementing agencies or through joint ventures with SECI. The GoI had approved 57 solar parks with aggregate capacity of 39.28 GW as of February 2023. Out of these solar parks, nine parks are fully complete, and eight parks are partially complete, with a cumulative capacity of 10,117 MW commissioned in these parks.

**Figure 58: State wise solar park approved capacity (MW)**




*Source: MNRE, CRISIL Consulting*

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

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

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

**Availability of low-cost capital** — With the emergence of several large players in the sector, scale and experience have aided fundraising to an extent, especially with the backing of several foreign investors. However, a weak rupee, conservative risk appetite of lenders and other added cost pressures make it imperative for developers to maintain prudent capital management to sustain over the long term. To mitigate this, developers have been tapping alternative/ new routes to raise money from time to time.

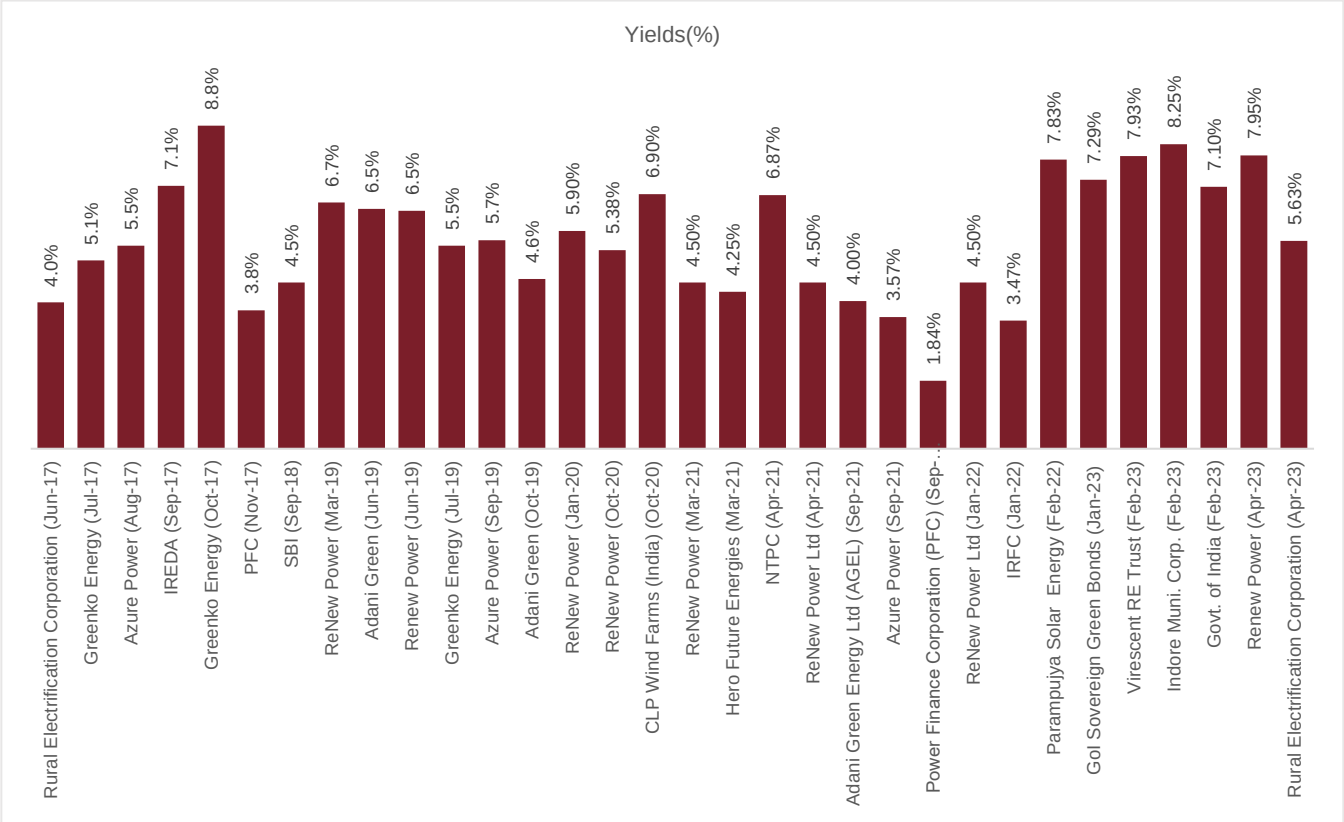
**Availability of debt and equity finance to the solar sector**

To facilitate growth of renewable energy and, in particular, the solar power sector, the GoI has provided several fiscal and regulatory incentives to developers. These incentives have been elaborated below.

Some steps taken by the government to ensure availability of low-cost finance are as follows:

- *Funding from lending institutions such as IREDA and PFS:* Government financial institutions such as PTC India Financial Services Limited (PFS), Rural Electrification Corporation (REC) and Indian Renewable Development Agency (IREDA) are also financing many solar projects. As of March 2019, the cumulative debt sanctioned by PFS to renewable energy projects stood at Rs 216.4 billion. Further, IREDA, under its IREDA-NCEF refinance scheme, refinances 30% of total loan disbursed by scheduled commercial banks/ financial institutions to the project developer at a concessional rate of interest. However, projects that are aggressively bid are finding it difficult to achieve financial closure.
- *Green bond / masala bonds market:* A green bond is like any other bond; however, it invests the proceeds to support green energy or renewable energy projects. The tenure of the bonds typically ranges from 18 months to 30 years and currently they are being issued for a tenure 5 year and 10-year tenure. India is the second country after China to have national-level guidelines for green bonds; in India's case, they were published by SEBI. The green bonds may be issued by the national government; multilateral organisations such as Asian Development Bank, the World Bank or the Export-import (EXIM) bank of the country; financial institutions; and corporations. Some recent instances of green bond issuances in India are given below:

**Figure 59: Yields of recent green bond issuances**




*Note: Excludes certain issuances whose proceeds were not directed towards funding of renewable energy projects in India.*
*Source: Industry; CRISIL Consulting*

- *Pension funds / endowment funds*: Pension / endowment funds are expected to play a key role in financing solar projects. Canadian funds such as Brookfield Asset Management and Caisse de Dépôt et Placement du Québec (CDPQ) have already announced a ~$2 billion investment in India.
- *Private equity investments and debt investments:* In a quest to reduce the cost of capital for projects and further improve project economics, many players have increasingly resorted to private equity and debt investments to free up capital. The proceeds are used to invest in new projects. Developers have been

exploring several diverse instruments / sources to raise finance such as green bond issuances, external borrowings, private placements (qualified institutional buyers), etc. This not only lowers the cost but also frees credit from domestic banks to be used again as initial capital for new projects.

Further, there have been debt investment deals in the renewable energy sector with APG and Piramal Enterprise investing ~$132 million in Essel Green Energy and IFC investing ~$62 million in Ostro Energy.

**Table 21: Private equity investments**

| Name of the company | Type of deal | Investor | Deal value | Date of investment |
|---|---|---|---|---|
| Juniper Green | Equity | AT Capital Group and Vitol | $350 million | Sep-23 |
| Adani Green Energy | Equity | INQ Holding LLC | $473 million | July -23 |
| Waaree Energies | Equity | ValueQuest | $122 million | July -23 |
| Fourth Partner Energy | Equity | Nofund | $42 million | July -23 |
| Avaada Energy | Equity | Global Power Synergy Public Company Limited | $233 million | June-23 |
| Virescent Renewable Energy Trust | Acquisition | IndiGrid | $486 million | May-23 |
| Solar Ladder | Equity | Multiple Investors | $1.3 million | May-23 |
| CleanMax Enviro | Acquisition | Brookfield | $360 Mn | Apr-23 |
| Avaada Energy | Equity | Nxtra Data (Bharti Airtel) | $0.29 million | Apr-23 |
| Suncloud Solar (Cleantech Solar) | Equity | DLF Cyber City | $1.03 million | Apr-23 |
| Prozeal Infra | Equity | Alchemie Ventures | $4 million | Apr-23 |
| Tata Power Delhi Distribution Limited | Equity | Asian Development Bank | $18.2 million | Apr-23 |
| Serentica Renewables | Equity | KKR | $250 million | Apr-23 |
| Avaada Energy | Equity | Equity Solar Brookfield | $1000 million | Apr-23 |
| Mytrah Energy | Acquisition | JSW Energy | $1,200 million | Mar-23 |
| Greenko Group | Equity | GIC, ORIX Corporation, Abu Dhabi Investment Authority | $700 million - | Mar-23 |
| Tata Power | Equity | GreenForest New Energies Bidco (GreenForest) | $486 million | Mar-23 |
| Scorpius Trackers | Acquisition | Gensol Engineering Ltd | $16.42 million | Mar-23 |
| Aerem | Equity | Avaana Climate Fund | $5 million | Mar-23 |
| Insolation Energy | Equity | Energy Access Relief Fund (EARF) | $2.5 million | Mar-23 |
| Samta Energy | Acquisition | Virescent Renewable Energy Trust | ND | Mar-23 |
| Hero Future Energies | Equity | KKR | $450 million | Feb-23 |
| SolarArise | Acquisition | ThomasLloyd Energy Impact Trust (TLEI) | $38.5 million | Jan-23 |
| CleanMax Thanos (CTPL) | Equity | Welspun India | $0.46 million | Jan-23 |

| Name of the company | Type of deal | Investor | Deal value | Date of investment |
|---|---|---|---|---|
| Loom Solar | Equity | Social Investment Managers and Advisors (SIMA) | $2 million | Jan-23 |
| Essel Saurya Urja company of Rajasthan Limited | Equity | Adani Green Energy | $1.85 million | Jan-23 |
| Vayudoot Solarfarms | Acquisition | Aries Renewables | $1.73 million | Dec-22 |
| StrongsunSolar | Equity | Mahindra CIE Automotive | $0.29 million | Dec-22 |
| Name not disclosed | Acquisition | Inox Wind | ND | Dec-22 |
| Vector Green | Acquisition | Sembcorp | $474 million | Nov-22 |
| Serentica Renewables | Equity | KKR | $400 million | Nov-22 |
| Atha Group | Acquisition | BluPine Energy | $245 million | Nov-22 |
| SolarSquare | Equity | Elevation Capital and LowerCarbon | $12.11 million | Nov-22 |
| Clean Electric | Equity | Climate Angles and Kalaari Capital | $2.2 million | Nov-22 |
| Ethan Energy (Vibrant Energy) | Equity | Laurus Labs | $0.48 million | Nov-22 |
| Waaree Energies | Equity | various private investors | $122.4 million | Oct-22 |
| Hygenco | Equity | Neev Fund | $25 million | Oct-22 |
| Refex Energy | Equity | Sunedison | $1.75 million | Oct-22 |
| Sembcorp Energy India Limited | Acquisition | Tanweer Consortium | $1.43 billion | Sep-22 |
| Hero Future Energies | Equity | KKR and Hero Group | $450 million | Sep-22 |
| Mahindra Susten | Equity | Ontario Teachers' Pension Plan Board | $300 million | Sep-22 |
| Apraava Energy | Equity | CDPQ Infrastructures | $82.6 million | Sep-22 |
| Serentica Renewables (SPV of Sterlite Power) | Equity | Hindustan Zinc | $42.88 million | Sep-22 |
| SenseHawk | Acquisition | Reliance Industries | $32 million | Sep-22 |
| Clean Max Kratos | Equity | UPL Ltd | $4.96 million | Sep-22 |
| Navitas Alpha Renewables Private Limited | Equity | Niveshaay, with the participation of Action Tesa Group, Madhusudan Sarda, IVY Growth Associates, and others | $0.86 million | Sep-22 |
| Sprng Energy | Acquisition | Shell | $1,550 million | Aug-22 |
| Mytrah Energy | Acquisition | JSW Neo Energy Limited | $1,320 million | Aug-22 |
| Atha Group | Acquisition | Actis | $264 million | Aug-22 |
| Tata Power | Equity | BlackRock-backed GreenForest New Energies Bidco | $251 million | Aug-22 |
| O2 Power | Equity | Syngene International | $0.38 million | Aug-22 |

| Name of the company | Type of deal | Investor | Deal value | Date of investment |
|---|---|---|---|---|
| Emmvee | Acquisition | O2 Power | ND | Aug-22 |
| Wind Two Renergy Private Limited | Acquisition | Torrent Power | $4.1 million | Jul-22 |
| Aerem | Equity | Blume Ventures | $2.5 million | Jul-22 |
| Fourth Partner Energy | Equity | Filatex India | $1.29 million | Jul-22 |

*Note: ND: Not disclosed*

*Source: Industry, CRISIL Consulting*

- *Funding from multilateral banks and International Solar Alliance (ISA):* Further, the government channelises the funds available from multilateral banks and financing institutes such as World Bank and KfW. Funds are also provided to the Indian government under the Climate Investment Fund of the World Bank. For instance, SBI has received ~$625 million of soft loans with a long tenure of 20 years. On the same lines, KfW Germany provided a 1-billion-euro loan through IREDA for funding solar projects. Further, European Investment Bank has signed a long-term loan of 150 million euros with IREDA to finance clean energy projects in India.

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

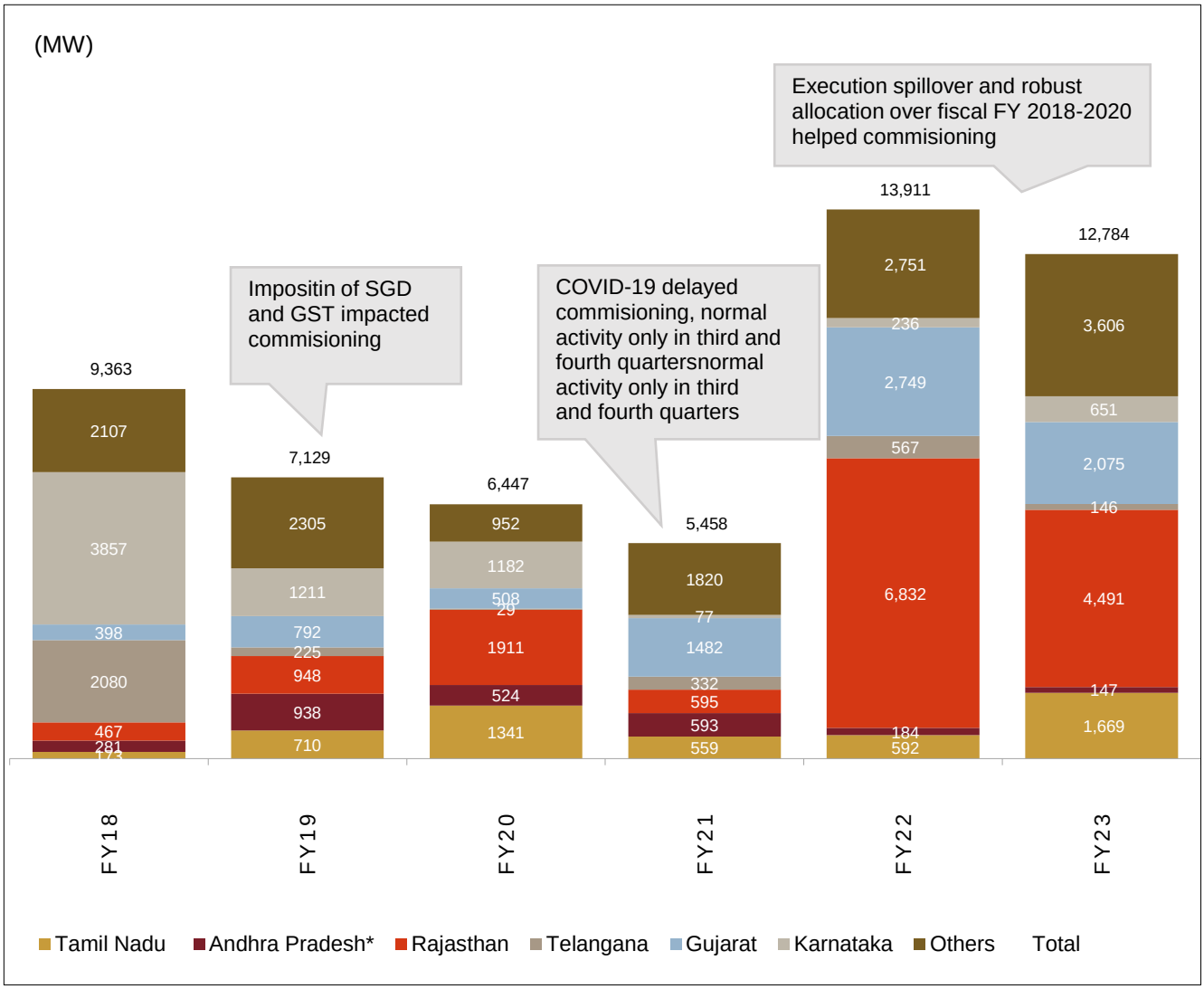
## 5.3 Solar capacity additions in India from fiscals 2018-2023

#### 5.3.1.1 Robust pick-up in solar additions in fiscal 2023; momentum expected to continue

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

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

**Figure 60: States that helped drive solar capacity addition in India**



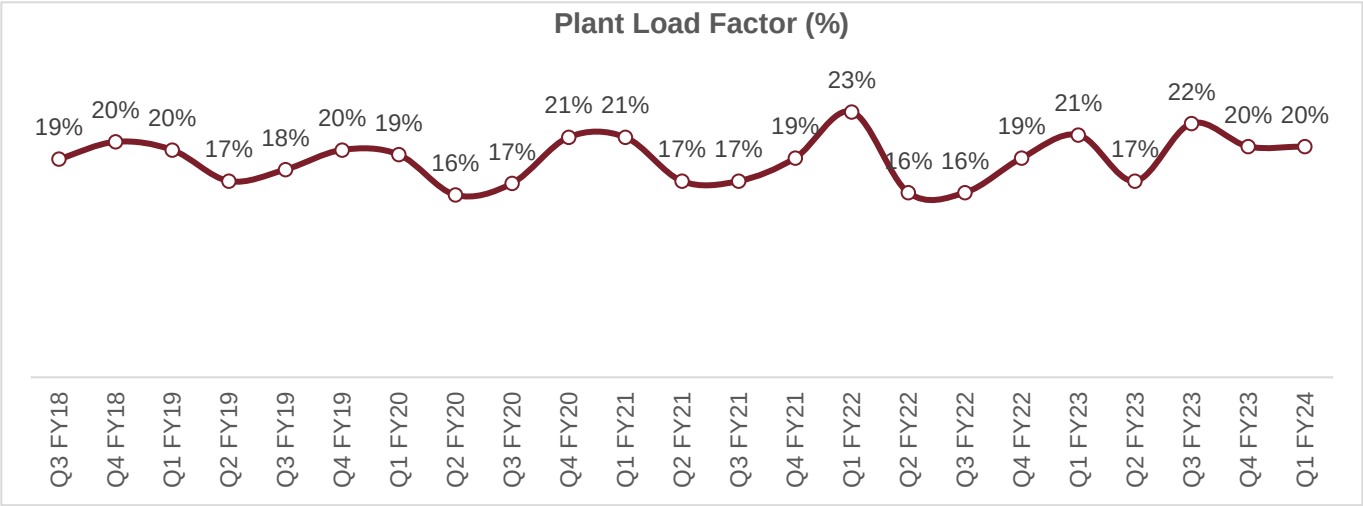

*Source: MNRE; CRISIL Consulting*

Commissioning activity has been concentrated in the key states of Rajasthan, Gujarat, and Tamil Nadu, where of ~8 GW capacity was added in fiscal 2023; ~65% share was concentrated in these three states combined. In the previous fiscal as well, the installation trend was driven by the same states.

Scheme-wise commissioning was driven by several large projects under SECI ISTS hybrid 1200 MW tranche-I, SECI ISTS hybrid 1200 MW tranche-II, SECI ISTS 2000 MW Tranche IX, SECI 2000 MW CPSU Tranche-I and CPSU scheme Phase-II Tranche I, which got commissioned in the third quarter of the previous fiscal.

The performance of operational projects remains stable with healthy PLFs of 18-20% over the past 12 quarters. However, there is a dip in the second quarter of each fiscal due to monsoons. Players have been designing projects with DC (direct current) overloading, which entails connecting more modules on the DC side of the plant to generate incrementally more in the non-peak generation hours. This has helped improve PLFs for larger developers / newer projects to 22-25%. Players have been known to utilise DC overloading up to 40-50% of the AC (alternating current) side capacity.

**Figure 61: Average PLF of the operational projects**




*Source: Company Filings; CRISIL Consulting*

### 5.3.1.2 Policy changes, pandemic-related relief and renegotiation have impacted execution momentum

Robust capacity addition is expected from fiscals 2022 to 2024 due to a strong pipeline nearing the end of timeline extensions. Capacity additions slowed since fiscal 2019-2021 in the segment due to several policy and execution-related challenges as mentioned below.

- **Abeyance of ALMM (**Approved List of Models and Manufacturers**):** The ALMM mandate has been kept in abeyance for a year and will not be applicable if a project is commissioned before March 31, 2024. The draft was introduced to give momentum to solar additions which declined in fiscal 2023 due to the unavailability of domestically manufactured modules. The mandate was introduced in 2021 to boost domestic manufacturing by approving the list of manufacturers who could participate in the solar development projects bid out by the government. The mandate was later extended to the government's open-access projects as well.
- **COVID-19 restrictions:** The pandemic led to mobility and labour-related challenges in the first quarter of fiscal 2022 and the first half of fiscal 2021, which hampered execution. Further, the MNRE provided 7.5 months of extension for the segment, which was a positive move for developers but delayed commissioning schedules.
- **Power sale agreement (PSA) delay**: Nearly 8 GW of auctioned solar projects floated by the SECI were delayed due to challenges in finding off-takers, with PSAs remaining unsigned. This is largely due to the state discoms, who are the major off-takers, increasingly deferring the signing of the PSAs amid lower tariffs of Rs 2.3-2.5 per unit. However, with the government's plan of stricter RPOs, a higher penalty in case of non-compliance, and a revision of tariff in the manufacturing-linked tender from Rs 2.92 per unit to Rs 2.54 per unit, PSA-signing activity increased in fiscal 2022 with ~14 GW of PSAs signed. Further, SECI had also already signed ~1,200 MW till September 2022.
- **Infrastructure issues**: Land availability and grid connectivity challenges delayed 5-6 GW of projects. Land acquisition challenges arise since many stakeholders must be involved to acquire large tracts of land in a single location as well as reported delays in solar park infrastructure, leading to a slowdown in the pace of project execution.
- **Payment delays:** After the record-breaking tariffs of Rs 2.44 per unit in the Bhadla solar park auctions in May 2017, several state discoms became hesitant to go through with fresh bids, which were at higher tariffs. This

created a fear of discoms reneging on commitments, especially for the duration in which PPAs remained unsigned after the auctions.

Post this, while tariffs have fallen further bolstering the desire of distributions entities to sign contracts at low tariffs, the Andhra Pradesh incident, and a positive result for the developer helped stem such activities. The Andhra Pradesh High Court settled a crucial three-year-old matter concerning the State's attempt to renegotiate the PPA. The court had directed the discoms to make interim payments to power generators and make payments of all the dues at the rate mentioned in the PPA within six weeks. The decision was made conclusively in favour of generators and the court affirmed that the primacy of the contract will boost confidence in the renewable energy sector. This confidence will also support execution momentum for the industry. The high court judgment provided positive reinforcement to the Andhra Pradesh renegotiation incident. However, the prolonged litigation did lead to a build-up of receivables over three years and offtake issues.

Since most of the cancellations/renegotiations have happened due to the higher tariffs, CRISIL Consulting's analysis suggests capacities contracted at tariffs above Rs 3-3.5 per unit, which are the tariff rates of competitive sources such as coal and wind. Therefore, an amount above this threshold runs a higher risk of payment delays in the current scenarios. As a result, out of CRISIL Consulting's assessed 106 GW, nearly 35% of the projects with tariffs above Rs 3.5 per unit and majorly state-auctioned projects are prone to the risk of payment delays.

Further, in state-auctioned projects, Karnataka, Andhra Pradesh, and Gujarat lead in terms of share of higher tariff projects. Even though capacities will be retendered and PPAs were unsigned for the majority of the above, the cancellation of already auctioned capacities creates an environment of distrust or risk for developers.

**Additional duty investigations on solar sector inputs:** Various players from the Indian domestic solar component manufacturing industry (mainly modules) 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 DGTR.

However, despite the duty levy, imports continued to dominate module supplies. With the safeguard duty ending on July 29, 2020, five Indian producers, including Mundra Solar and Jupiter Solar, filed applications through ISMA to review and extend the safeguard duty for another four years. After initiating a probe to decide on the continuation of the safeguard duty on solar imports and further to applications invited from domestic companies for the same, DGTR extended the imposition of 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. The safeguard duty cannot be levied for more than four years with decreasing rates every year (this is in accordance with international regulations); hence, it was removed post-July 2021.

The MoP alternatively levied a BCD effective April 1, 2022. The imposition of BCD of ~40% on modules and 25% on cells led to a 20-25% increase in capital costs for projects based on imported modules and Rs 0.2-0.5 per unit rise in tariffs, with tariffs ranging from Rs 2.6-2.8 per unit.

**GST issues:** Initially, a GST rate of 5% was imposed on solar modules; other electrical equipment (such as power cables, transformers, and inverters) was classified under 18%. The GST rate on solar components was later revised to 12%. Further, due to the disparity in rates for solar components and other electrical equipment, there was a lack of clarity on the rate for solar projects in general. The GST Council later clarified that all such contracts would be taxed by splitting the overall value into a 70:30 ratio, with 70% taxed at a 12% rate and 30% at the applicable GST rate for services, i.e., 18%. This raises the applicable GST rate for such contracts to 13-14%, a further cost pressure on developers. Additionally, developers have been facing delays in obtaining the input tax refund from corresponding counterparties (SECI/NTPC/discoms).

## 5.4 Review of competitive bidding

**Positive changes to bidding guidelines undertaken to support bidder interest**

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

Following section discusses the solar competitive bidding guidelines after the amendment of certain key provisions in September 2020 by MNRE:

- Expanded the definitions of force majeure and outlined the definitions of adjusted equity, debt due and other key terms of the agreement
- Outlined that in case a state discom is not party to the tripartite agreement (an agreement between state governments, SECI, NTPC and the RBI to ensure payment security), the state will either provide some alternate state government guarantee or pay an additional risk premium of Rs 0.10 per unit towards the payment security fund maintained for paying developers in case of payment delays / defaults. However, the implementation has been lax
- It also states that to maintain the payment security fund (fund maintained by SECI /NTPC to support payment of at least three months' billing), the intermediary may collect Rs 5.0 lakh/MW from the solar power generator. This will be mentioned in the PPA
- The new guidelines also outline a grant in extension of the scheduled COD (SCOD) deadline as defined in the PPA terms if:
    1. The applicable state electricity regulatory commission delays adoption of tariffs post competitive bidding, and
    2. There is any delay in land allotment from the side of the state government
- Reduction in lock-in periods for solar project developers was enabled. Project developers now need to maintain a controlling shareholding of 51% in the special purpose vehicle (SPV) or project company executing the PPA for one year from the COD of the project, reduced from three years earlier
- Bidders can now furbish earnest money deposit in the form of a bank guarantee or a letter of undertaking, unlike earlier when only bank guarantees were considered

Further, the Ministry of Finance, in November 2020, reduced performance security deposits from 5-10% to 3% of the value of the contract for all existing contracts. However, the benefit of the reduced performance security will not be given to contracts under dispute wherein arbitration/court proceedings have already been started or are completed. All tenders/contracts issued/concluded till March 31, 2023, will also have the provision of this reduced performance security.

Also, on July 23, 2021, MNRE announced amendments in guidelines for the tariff competitive bidding process for the procurement of power from wind-solar hybrid (WSH) projects. Following are the key changes:

a. SECI will be treated as a procurer, and not a nodal agency
b. Hybrid power generator will be allowed to commission the project even partly or fully before the scheduled commissioning date (SCD), provided transmission connectivity is available
c. An appropriate regulatory commission will approve deviation from guidelines, which was done by the ministry earlier

d. Discoms can directly procure power from hybrid power generators, which would help them to procure power at a lower tariff by eliminating the trading margin they had to pay to SECI

e. Interstate and intra-state transmission systems at delivery point and transmission infrastructure for which the generator applies for connectivity must be completed before the project's SCD

The MoP has also made amendments to the bidding guidelines for procurement of round-the-clock (RTC) power. The original order dated July 22, 2020, stated that during the bidding process, if the allocated quantum of power to the bidder quoting the least weighted average levelised tariff (L1), is less than the total quantum of power to be contracted, then the remaining qualified bidders would be asked to match their tariff with the L1 tariff. Hence, the bidder willing to match the L1 tariff will be allocated the remaining quantum of power, or the quantum offered by it. If some quantum is still left, it will be allocated to the next lowest bidder, and so on. However, the amendment in the order dated February 3, 2022, states that during the bidding process if the allocated quantum of power to the bidder quoting the least weighted average levelised tariff (L1) is less than the total quantum of power to be contracted, then the remaining qualified bidders will be on the basis of bucket filling, which means that capacity will be first allocated to the L1 bidder at the L1 rate, then the capacity will be allocated to the next lowest bidder at the rates quoted by him till the tender capacity is completely exhausted.

On June 6, 2022, the government also made amendments to the open access regulations through the Green Energy Open Access Rules, 2022, via energy banking regulations, changes in minimum contract demand, standardising calculation of charges, etc. These regulations are a positive step towards promotion of the open access market as it ensures:

a. Centralised procedure for registration and applications of open access to remove variability across states

b. Standardisation of some key policy aspects such as procedures and banking provisions

c. Concessions for green energy by removing certain ancillary charges where applicable, again eliminating state-wise variability

d. Creating a mechanism for the discoms to supply green energy and certify the same to promote competitiveness

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

**Table** 22: **Bid tariffs quoted over fiscal 2018 to Apr 2023**

| Sr no | Bidding scheme/Tender | Month of bidding | Lowest tariffs discovered (Rs/unit) |
|---|---|---|---|
| 1 | 1 GW ISTS SECI auctions (SECI – I) | Feb 2017 | 3.46 |
| 2 | 0.5 GW Tamil Nadu | Aug 2017 | 3.42 |
| 3 | 1 GW ISTS SECI auctions (SECI – II) | Oct 2017 | 2.64 |
| 4 | 0.5 GW Gujarat | Dec 2017 | 2.43 |
| 5 | 2 GW ISTS SECI bidding (SECI – III) | Feb 2018 | 2.44 |
| 6 | 2 GW ISTS SECI bidding (SECI – IV) | Mar 2018 | 2.51 |
| 7 | 1.2 GW ISTS NTPC | Aug 2018 | 2.77 |

| Sr no | Bidding scheme/Tender | Month of bidding | Lowest tariffs discovered (Rs/unit) |
|---|---|---|---|
| 8 | 1.2 GW ISTS SECI | Sep 2018 | 2.76 |
| 9 | 1.05 MW ISTS SECI | Dec 2018 | 2.64 |
| 10 | 1.2 GW ISTS SECI | Feb 2019 | 2.55 |
| 11 | 0.8 GW ISTS SECI | May 2019 | 2.7 |
| 12 | 0.25 GW BERC | Jun 2019 | 3.15 |
| 13 | 1.2 GW NTPC | Oct 2019 | 2.93 |
| 14 | 0.5 GW MSEDCL | Nov 2019 | 2.9 |
| 15 | 1.2 GW* SECI | Nov 2019 | 2.88 |
| 16 | 7 GW SECI | Jan 2020 | 2.92 |
| 17 | 1.2 GW SECI | Jan 2020 | 6.3 |
| 18 | 1.2 GW SECI | Feb 2020 | 2.5 |
| 19 | 0.5 GW UPNEDA | Feb 2020 | 3.18 |
| 20 | 0.3 GW GUVNL | Mar 2020 | 2.63 |
| 21 | 2 GW NHPC | Apr 2020 | 2.55 |
| 22 | 2 GW SECI | Jul 2020 | 2.37 |
| 23 | 0.2 GW KSEB | Nov 2020 | 2.97 |
| 24 | 1.07 GW SECI | Nov 2020 | 2.00 |
| 25 | 0.75 GW SECI | Feb 2021 | 2.70 |
| 26 | 0.3 GW Torrent Power | Feb 2021 | 2.22 |
| 27 | 0.19 GW NTPC | Feb 2021 | 2.25 |
| 28 | 0.5 GW GUVNL | Mar 2021 | 2.20 |
| 29 | 0.5 GW MSPGCL | May 2021 | 2.51 |
| 20 | 0.1 GW GUVNL | May 2021 | 2.64 |
| 31 | 0.5 GW MSEDCL | May 2021 | 2.43 |
| 32 | 0.5* GW MSEDCL | May 2021 | 2.62 |
| 33 | 0.5 GW RUMSL | July 2021 | 2.44 |
| 34 | 0.45 GW RUMSL | Jul 2021 | 2.35 |
| 35 | 0.5 GW RUMSL | Aug 2021 | 2.14 |
| 36 | 0.25 GW BREDA | Aug 2021 | 3.11 |
| 37 | 5 GW IREDA | Sep 2021 | 2.45 |
| 38 | 2.5** GW SECI | Oct 2021 | 3.01 |
| 39 | 500 MW MSEDCL (KUSUM) | Oct 2021 | 3.05 |
| 40 | 500 MW PSPCL | Nov 2021 | 2.33 |
| 41 | 1300 MW MSEDCL | Dec 2021 | 3.00 |

| Sr no | Bidding scheme/Tender | Month of bidding | Lowest tariffs discovered (Rs/unit) |
|---|---|---|---|
| 42 | 1.785 GW SECI | Dec 2021 | 2.17 |
| 43 | 487 MW MSEDCL (KUSUM) | Dec 2021 | 3.10 |
| 44 | 200 MW UPNEDA | Jan 2022 | 2.98 |
| 45 | 444 MW MSEDCL (KUSUM) | Jan 2022 | 3.10 |
| 46 | 1200 MW SECI | Feb 2022 | 2.35 |
| 47 | 500 MW GUVNL | Mar 2022 | 2.29 |
| 48 | 1200* MW SECI | May 2022 | 2.53 |
| 49 | 600# MW RUMS | May 2022 | 3.21 |
| 50 | 500 MW GUVNL | Jun 2022 | 2.30 |
| 51 | 431 MW MSEDCL (KUSUM) | Jul 2022 | 3.10 |
| 52 | 500 MW MSEDCL | Aug 2022 | 2.90 |
| 53 | 500 MW MSEDCL | Sep 2022 | 2.82 |
| 54 | 750 MW GUVNL | Sep 2022 | 2.49 |
| 55 | 750* MW RUMS | Sep 2022 | 3.03 |
| 56 | 105# MW MSPGCL | Oct 2022 | 3.93 |
| 57 | 300# MW RUMS | Nov 2022 | 3.89 |
| 58 | 255* MW TPDDL | Dec 2022 | 3.00 |
| 59 | 500 MW MSEDCL | Dec 2022 | 2.90 |
| 60 | 250** MW MSEDCL | Dec 2022 | 9.00 |
| 61 | 500 MW GUVNL | Jan 2023 | 2.51 |
| 62 | 1250 MW RECPDCL | Apr 2023 | 2.55 |
| 63 | 500 MW RECPDCL | Apr 2023 | 2.69 |
| 64 | 1000 MW* RUMSL | Apr 2023 | 3.99 |
| 65 | 200 MW* SECI | Apr 2023 | 4.64 |
| 66 | 500 MW MSEDCL | Apr 2023 | 2.87 |
| 67 | 500 MW GUVNL | Apr 2023 | 2.71 |
| 68 | 600 MW GUVNL | May 2023 | 2.73 |
| 69 | 1000 MW RUVNL | May 2023 | 2.61 |
| 70 | 150 MW CESC* | May 2023 | 3.07 |
| 71 | 40 MW AVVNL Rajasthan (KUSUM-C) | May 2023 | 3.33 |
| 72 | 31 MW JVVNL Rajasthan (KUSUM-C) | May 2023 | 3.43 |
| 73 | 27 MW JdVVNL Rajasthan (KUSUM-C) | May 2023 | 3.55 |
| 74 | 800 MW GUVNL Tranche XX | July 2023 | 2.70 |
| 75 | 200 MW SECI Tranche XI | July 2023 | 2.60 |

| Sr no | Bidding scheme/Tender | Month of bidding | Lowest tariffs discovered (Rs/unit) |
|---|---|---|---|
| 76 | 200 MW PSPCL | Jull 2023 | 2.53 |
| 77 | 300 MW RUMSL# | Aug 2023 | 3.79 |
| 78 | 1,200 MW RUVNL (Storage hybrid peak power) | Aug 2023 | 6.68 |
| 79 | 50 MW APDCL | Aug 2023 | 3.90 |
| 80 | 70 MW APDCL | Aug 2023 | 3.92 |
| 81 | 225 MW TPC-D Hybrid | Sep 2023 | 3.27 |
| 82 | 18 MW PEDA | Sep 2023 | 2.63 |
| 83 | 810 MW RUVNL | Oct 2023 | 2.64 |
| 84 | 3,000 MW NHPC | Nov 2023 | 2.52 |
| 85 | 1,500 MW Hybrid peak power | Nov 2023 | 4.38 |

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

## 5.5 Review of project economics and levelised tariffs for solar PV power plants in India

**Tariff of Rs 2.8-3.0 per unit would be required to generate 10-12% IRR with the imposition of BCD and supply-side issues**

CRISIL's base-case analysis is for an IPP undertaking EPC in-house and using imported modules, given that this is the most prevalent model. Additionally, due to variations in land prices, the model has been based on a solar park scenario, with charges modelled for the Bhadla solar park, Rajasthan. CRISIL has not assumed any other source of income like income from carbon credit.

For analysis of project economics, following key assumptions were made based on interactions with project developers and bankers:

- **Capital cost:** CRISIL has assumed an equipment cost of Rs 55-60 million per MW (including DC side overloading at 40%) for a project based on imported modules. CRISIL has also assumed some inverter overhaul charges in the 13$^{th}$ year of the project. These assumptions are based on landed monocrystalline module costs of ~$0.27, in addition to the BCD of 40% and GST rate of 12%.
- **Capacity utilisation factor (CUF):** CRISIL has assumed a CUF of 26.5% based on an all-India average CUF and the favourable impact of DC side overloading, which has been assumed at 40%. DC side overloading implies that PV arrays (DC side) of the higher-than-rated capacity of inverters could be connected to generate more output (number of units) from inverters, essentially adjusting for losses in the system design. However, given that there is no restriction on the power that can be fed to the grid and also no cap on the prices of such additional power, players are optimising system design to generate more CUF at an incremental cost. However, CUF could vary significantly from location to location, depending on the level of irradiance.
- **Debt to equity:** CRISIL has assumed a debt-equity ratio of 75:25, based on the typical capital structure of projects under operations.
- **Foreign borrowing costs:** CRISIL has assumed the cost of debt at 8%, with developers availing of various routes to lower the cost of debt, including the option of refinancing debt once assets become operational and the entry of several global participants, who would be privy to lower cost of funding.

Based on the above assumptions (factoring in DC overloading), CRISIL Consulting believes that a levelised tariff of Rs 2.8-3.0 per unit is necessary for an equity IRRs of 10-12% at current module prices. This is applicable for IPPs, which generally do not avail of AD (the accelerated depreciation benefit allows depreciation of 40% of the capital cost in the first year of commissioning).

**Table 23: Sensitivity analysis of capital costs and bid tariffs**

| Equity IRR | Tariffs (Rs per unit) | | | | | | |
|---|---|---|---|---|---|---|---|
| Capital cost (Rs million/MW) | | **2.2** | **2.5** | **2.8** | **2.9** | **3.0** | **3.2** |
| | 47 | 1% | 5% | 9% | 11% | 12% | 15% |
| | 51 | 1% | 5% | 9% | 10% | 12% | 14% |
| | 53 | 1% | 5% | 9% | 10% | 11% | 14% |
| | 56 | 1% | 4% | 8% | 10% | 10.8% | 13% |
| | 59 | 1% | 4% | 7.9% | 9% | 10% | 13% |
| | 43 | 2% | 6% | 10% | 11% | 13% | 16% |
| | 54 | 1% | 5% | 9% | 10% | 11% | 14% |

*Source: CRISIL Consulting*

Further, PLFs are another important aspect of tariffs; a 1% change in PLFs can increase equity IRRs by 125-175 bps. Consequently, projects located in high irradiance states such as Rajasthan, where projects have reported PLFs of 21% (without overloading based on irradiance), would enjoy higher IRRs.

**Table 24: Sensitivity analysis of equity IRR to CUFs and bid tariffs**

| **Equity IRR** | | | **Tariffs (Rs per unit)** | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **CUFs** | | **2.2** | **2.4** | **2.6** | **2.8** | **2.9** | **3.0** | **3.1** | **3.2** |
| | **21%** | -4% | -2% | -1% | 1% | 3% | 3% | 4% | 5% |
| | **22%** | -3% | -1% | 1% | 3% | 4% | 5% | 6% | 7% |
| | **23%** | -2% | 0% | 2% | 4% | 6% | 6% | 8% | 9% |
| | **24%** | -1% | 1% | 3% | 5% | 7% | 8% | 9% | 10% |
| | **25%** | 0% | 2% | 4% | 7% | 9% | 9% | 11% | 12% |
| | **26%** | 1% | 3% | 6% | 8% | 10% | 11% | 12% | 13% |
| | **27%** | 2% | 4% | 7% | 10% | 11% | 12% | 14% | 15% |
| | **28%** | 3% | 5% | 8% | 11% | 12.9% | 14% | 15% | 17% |

*Source: CRISIL Consulting*

Finally, cost of debt also plays an important role in determining returns to the industry.

**Table 25: Sensitivity analysis of equity IRR to interest rates and bid tariffs**

| **Equity IRR** | **Tariffs (Rs per unit)** | | | | | |
|---|---|---|---|---|---|---|
| **PLFs** | | **2.6** | **2.8** | **3.0** | **3.2** | **3.4** |
| | **6.5%** | 8% | 10% | 13% | 15% | 18% |
| | **7.0%** | 7% | 10% | 12% | 15% | 18% |
| | **7.5%** | 7% | 10% | 12% | 15% | 17% |
| | **8.0%** | 7% | 9% | 12% | 14% | 17% |
| | **8.5%** | 7% | 9% | 11% | 14% | 16% |
| | **9.0%** | 6% | 8% | 11% | 13% | 16% |
| | **9.5%** | 6% | 8% | 10% | 13% | 15% |

| Equity IRR | Tariffs (Rs per unit) | | | | | |
|---|---|---|---|---|---|---|
| | **10.0%** | 6% | 8% | 10% | 12% | 15% |

*Source: CRISIL Consulting*

Also, capital costs and bid tariffs would vary based on the following scenarios:

| Scenarios | Module Price ($/Wp) | BCD | Capital cost (Rs million/MW) | Tariff (Rs/kWh) |
|---|---|---|---|---|
| Module is imported | 0.21 | 40% | 50-55 | 2.8-3.0 |
| Cell is imported and assembled in India | 0.23 | 25% | 51-56 | 3.1-3.2 |

*Source: CRISIL Consulting*

Hence, CRISIL Consulting believes that to generate 10-12% IRR, tariffs should be in the range of Rs 3.1-3.4 per unit depending on whether the modules are directly imported, or cells are imported, and modules are assembled in India. The above bid tariffs are considering only changes to module prices and capital costs and keeping other factors such as interest rates, PLF and debt: equity structure, constant.

**New business models, however, warrant higher tariffs to maintain returns**

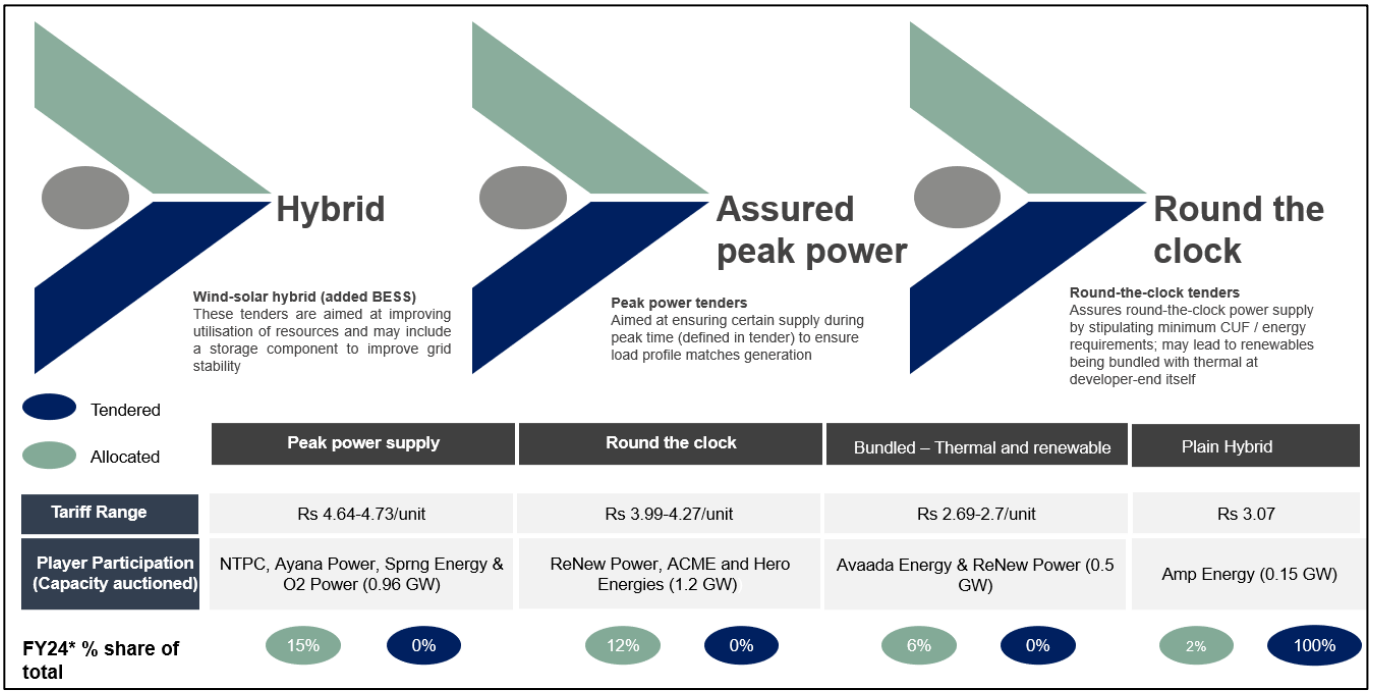
With a large quantum of the pipeline already in place for solar/ wind only projects, nodal authorities are now resorting to issue tenders, which improve the quality of power supplied to off-takers. Some key changes were made to tender structures with respect to the quantum of generation available from RE and the ability to match peak demand.

Three new tender structures have been issued so far to solve the above aspects – assured peak power supply (PPS), RTC, and the relatively newer thermal bundled with RE. A key feature across these tenders is the increase in the quantum of generation, which was required to be supplied and the PPS tender for stipulating the power to be provided during peak hours. The PPS tender also mandated the use of storage, as that would be essential to supply power during peak hours.

Modelling the above three tender structures with basic assumptions (as mentioned in the note below), coupled with industry interactions, has led to the understanding that the higher generation quantum mandated by these newer tenders could either be met using storage components or scaling up the plant capacity, i.e., setting up the plant of capacity larger than its rated capacity.

This has resulted in the expected tariff ranges required to maintain the equity IRRs of 10-12%, which are currently seen in regular tenders, to be higher than the norm of Rs 2.5-2.75 per unit, approaching the range of ~Rs 3-5 per unit. This increase will mainly be driven by higher capital and operating costs resulting from either the inclusion of a storage element or the need for higher capacity. Some moderation was observed only in the RTC tender, where the stipulated escalation in tariff will lead to higher tariffs.

**Table 26: Higher tariff range at around ~Rs 3-5 per unit mark required to maintain returns similar to regular tend**



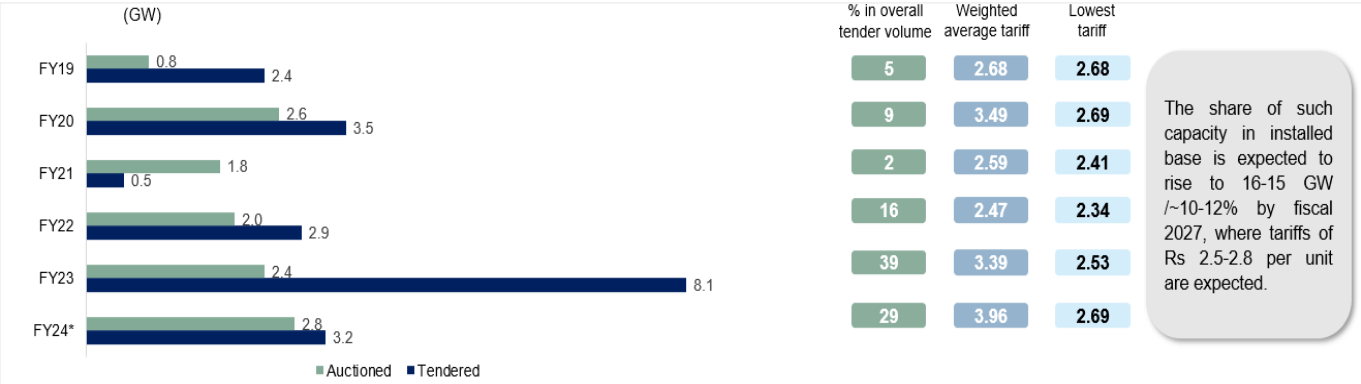

FY24: as of June 2023

*Source: CRISIL Consulting*

So far, all three tender models have already seen the first successful allocations, with RTC at 400 MW and PPS tender at 1,200 MW, and thermal-bundled tender at 2,500 MW. In the third type of tender, thermal energy can either be sourced from existing plants or a new setup, each with its own set of challenges. While in the existing plants, power may either be already tied up, funding would be a key hurdle if power is sourced from a stranded asset or a new setup. Consequently, while the newer implementation models improve the dispatchability of power for off-takers, in the current scenario, they would still warrant a higher tariff to be executed. This would be a monitorable as key off-takers, i.e., state discoms, may be hesitant to offtake RE at much higher costs, despite the improving quality. Since these projects are still very new and recently allocated, execution dynamics are yet to be concretely seen. However, due to the lower proportion of such tenders in the overall mix, only ~2.5 GW is expected from these till fiscal 2027 based on the current pipeline.

Additionally, CRISIL Consulting expects 6-7 GW of solar capacity to be added from the plain hybrid tender pipeline till fiscal 2027. Hence, the future execution of these models provides some comfort to the outlook here. In addition, technological improvements, especially on the storage side may further lower cost requirements over the longer term to make implementation more feasible.

**Figure 62: New business models for tendering & allocation**




*Source: CRISIL Consulting*

The share of the new model tenders in the overall tender volume has grown approximately 8 times between fiscal 2019 and 2023, indicating a push from central and state agencies to address the intermittency problem. The first quarter of fiscal 2024 has witnessed a robust start for new model tenders, with the Hybrid model dominating the tender share. The government has also released four Firm and Dispatchable RE tenders of over 2.5 GW across Haryana, Madhya Pradesh, and Punjab since then. The share of new business models in the total tendered volume is expected to exceed last year's share this fiscal. Tariffs have also increased over the past five fiscal years due to pressure on commodity pricing, leading players to exercise caution.

**Capital cost to moderate as basic custom-duty imposition is offset by falling module prices**

The MNRE and Ministry of Finance have approved a BCD of 40% on PV modules. The duty had a direct impact on capital costs, raising them by 10-15%, despite module prices falling from $0.30 per Wp in March 2018 to $0.25 per Wp by September 2018. This declining duty trajectory provided relief and made procurement possible after June 2019 for all new bids at a duty rate of 15%. DGTR further extended safeguard duty at 14.9% from July 30, 2020, to January 29, 2021, and 14.5% from January 30, 2021, for another six months. Declining duty led to easing of cost pressures, and tariffs also started to reduce. However, with the imposition of BCD from April 1, 2022, capital costs increased to Rs 55-60 million/MW for imported mono-crystalline modules, and corresponding tariffs would rise accordingly depending on the module procurement scenarios outlined above.

A key factor determining capital costs is component pricing, which is mainly imported from China. Solar modules form 55-60% of the total capex for a solar project. Elevated polysilicon prices and surge in commodity prices, such as of copper and aluminium (used in mounting structures and other components), have led to current capital costs mounting up to Rs 55-60 million/ MW, including BCD of 40%. This coupled with the demand recovery in key solar markets such as China, where demand has gained momentum after the COVID-19 led lockdown in the country in 2022, coupled with recovery in key markets of the US and India, which is supporting elevated prices.

However, module prices started to fall in 2023 owing to the ramp-up in the production of upstream components. Prices of modules fell to $0.20 in April-August 2023 from $0.23 in January 2023. This is expected to ease some pressure on capital costs in fiscal 2024, resulting in capital costs coming to Rs 50-55 million/MW. CRISIL MI&A Research projects module prices to be in the range of USD 0.19–0.21 per Wp for mono-crystalline, declining 18-22% year-on-year due to a high inventory of upstream components like wafers, cells, etc., coupled with upcoming capacities in China, which will keep module prices low. Also, solar glass pricing, another key input to modules, is expected to come down in the next quarters due to increased inventory levels in Europe and other demand centers such as China and Japan, which is likely to moderate. However, end-market demand remains strong, with the recovery driven by clean energy policies and support for decarbonization post-COP26.

**Module prices to fall till the end of fiscal 2024**

Previously, capital costs declined sharply to about Rs. 30-35 million per MW (without factoring overloading) by March 2018 from Rs. 100 million per MW at the end of 2011 due to a sharp fall in module prices, led by significant overcapacity, particularly in China. Chinese players remain key exporters of readymade modules and cells to the Indian domestic market. Historically, module prices have seen a sharp fall due to overcapacities, which persist in the entire value chain from polysilicon to modules in the Chinese market - a major exporter of modules to India - also impacting capital costs. The capital cost remained in the range of Rs. 30-35 million per MW due to a relatively slower fall in module prices over fiscal 2019. However, by the end of fiscal 2019, module prices faced a sharp drop of approximately 17% year-on-year to USD 0.19 per Wp levels from USD 0.23 per Wp levels in March 2019. This has led to a fall in capital costs of approximately 10% to Rs. 27-30 million per MW in fiscal 2021.

This, however, has had significant consequences for the leading module makers. Chinese module manufacturers have not fared well, with several large players witnessing low margins as they aggressively compete for a shrinking domestic market and a slower-growing international one. Also, the recent surge in the prices of polysilicon has led to higher production costs for Chinese module manufacturers, impacting profitability and leaving limited room for a further decline in average selling prices.

**Increase in GST rate to 12% also adds to cost woes**

The GST roll-out has increased the taxation rates across all components of solar power plants, as indicated in the chart below. For instance, pre-GST, solar modules were exempt from any additional customs duties and from value-added tax (VAT) in several key states; however, GST imposition now implies an additional IGST component (apart from existing BCD) on imports and 12 % CGST + SGST for modules procured domestically (replacing VAT/CST).

The government brought solar power generating systems (entire system, all equipment) under the 12% GST slab and electrical equipment such as transformers, inverters, and cables under the 18% category, applicable from October 1, 2021. All services involved in the development of solar projects also attract GST of 18%.

This has caused much consternation in the sector as most projects are set up in the EPC mode (i.e., procurement and services together). Even a simple supply order usually involves a service component, which would again attract GST rates applicable to EPC contracts. The final tax rate would be in the 13-14% range, compared with the earlier 5%.

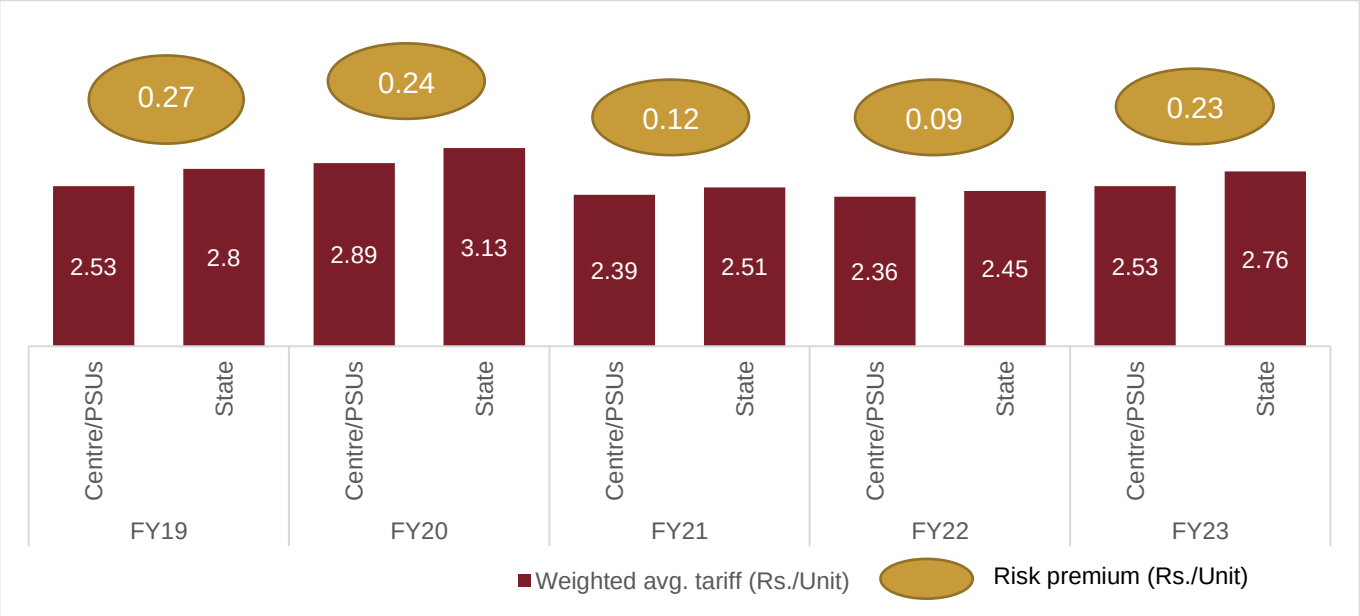
**Counterparty risk felt, as sector faces delayed payments**

The financial health and payment track record of state counterparties have become a cause for concern over the past 1–1.5 years, as power generators face prolonged delays in payments. The average payment cycle over the past 15 months for state counterparties has been 4-5 months, while certain states, such as Andhra Pradesh and Tamil Nadu, have been paying beyond six months. This leads to increased cost for developers in terms of working capital needs.

In comparison, central counterparties and Gujarat are known to pay within the two months' time frame stipulated in agreements.

The following chart shows the counterparty risk premium that the industry has attached to state bids over the past four fiscals.

**Figure 63: Industry attached ~Rs 0.23 per unit as counterparty risk premium in FY23**




*Source: CRISIL Consulting*

The counterparty risk premium was higher in fiscals 2019 and 2020, as the renegotiation incident initiated by the AP state government led to investor appetite dipping, which forced state agencies to be more lenient in their approach in terms of tariff ceiling. The risk premium was lowered to 12 paise per unit in fiscal 2021 and 9 paise per unit in fiscal 2022, mainly due to a better mix in terms of state counterparties. However, this went up to 0.23 paise per unit in fiscal 2023 over to supply chain disruption.

The LC payment mechanism order implemented by the government from August 1, 2019, is a positive step towards resolving the payment issue; however, on-ground implementation remains plagued by challenges. Structural reforms are required to be made to discoms' financial position and the government has expressed intent to work towards resolution of key pain points of the sector.

Developers have also been factoring in delays in payments from utilities when bidding; hence, the premium charged, plus projects of large / established developers, also have the comfort of group support.

Lastly, going forward, CRISIL Consulting believes majority tendering and allocation is going to happen under the umbrella of central agencies like SECI and NTPC, which have better bargaining power compared with individual IPPs. However, as more and more projects come online under these agencies, wherewithal of these firms also remains to be tested.

**Aggressive bidding a monitorable for projects yet to be executed, tariffs have already increased**

Project allocations in fiscal 2022 witnessed average bid prices at Rs 2.4 per unit. However, allocations under the National Solar Mission for open category projects have witnessed bid prices falling as low as Rs 2.00 per unit. Tariffs remained at average Rs 2.4 per unit for solar only projects awarded in fiscal 2022, which was a decline from the weighted average of Rs 2.45 per unit in fiscal 2021, mainly due to global participation and a lower interest rate regime.

CRISIL Consulting believes that returns of aggressively bid projects are likely to be low, as assuming current capital cost (Rs 55-60 million/MW), 9% finance cost and 23.5% PLF, tariffs of Rs 3.1-3.4/ unit will be required for IRRs of 10-12%.

As per CRISIL Consulting, following could be the reasons for continued competitiveness of solar tariffs:

- Given the relatively large scale of projects, players are banking on bargaining on module prices as well as balance of plant
- Foreign players, in particular, are relying on reducing finance costs, given the availability of low-cost funding in global markets. As per our analysis, a 100 bps fall in financing cost improves equity IRRs by 50-60 bps. Moreover, for such players, expectation of returns may also be lower for a particular project compared with the player's overall portfolio
- Some of these bids are for projects to be set up in solar parks, which reduces the construction life cycle of projects by 6-8 months (time taken for land acquisition and evacuation infrastructure) and provides pre-developed infrastructure
- PPAs for these projects will be signed between the developer and SECI/NTPC/NVVN, which mitigates the risk associated with off-taker credibility considerably, making it more bankable. SECI, NTPC and NVVN have much better credibility and payment track records compared with discoms and are also a part of the tripartite payment security agreement (between certain PSUs, the government and RBI) that ensures payment from state budget allocations in case these entities default on payments. Also, some central scheme PPAs ensure the setting up of a payment security fund, covering 2-3 months of payments to generators
- Players' portfolios also impact the extent to which they can bid aggressively. For example, a higher weighted average tariff for a player's overall portfolio would enable it to bid aggressively in a few auctions just to enlarge one's portfolio or if that specific auction is lucrative.

However, following factors are also key to determining tariffs:

- *Counterparty of bid:* As mentioned before, counterparty for the bid is vital, as a weak payment track record increases the risk to the developer.
- *Increase in project size*: With the availability of land under solar parks and availability of grid infrastructure, the average size for allotment of projects has increased from ~15 MW under NSM Phase II Batch I, to 600 MW in solar ISTS tranches. With increase in project size, the capability of developers to bargain with suppliers and EPC players increases, leading to decrease in per MW cost of projects.
- *Availability of foreign funds*: Solar market is established in India, with solar capacities providing satisfactory PLFs, which has given comfort to funding agencies for sanctioning loans to new capacities. Further, many large conglomerates with strong promoter backing have entered this segment, which has led to a fall in the cost of capital for new capacities. Despite that, sustained investor confidence and continued availability of low-cost funding remain keys to keeping bid tariffs low.
- *Type of tender*: Increasingly, tenders with unique structures are being issued by nodal agencies such as SECI. Since these are first time constructions, bid tariffs for such tenders may be higher than the Rs 2.5-2.7 per unit range.

Under the present circumstances, tariffs have been set at Rs 2.66 per unit owing to price volatility and supply scenarios. CRISIL Consulting expects tariffs to reach Rs 2.6-2.8 per unit by fiscal 2024 as developers will factor in falling prices amidst easing cost pressures.

## 5.6 State-wise status of solar RPOs in India

To fulfil their RPO targets, as per respective trajectories, states have increased tendering. Key state schemes allocated over fiscals 2018-2022, under which capacities remain to be commissioned, include:

- MSEDCL: 5,401 MW allocated, ~3,389 MW yet to be commissioned
- Gujarat, Phase I – XIII (Phase II scrapped): ~5,900 MW allocated, 3,850 MW yet to be commissioned

- KREDL: 715 MW allocated, 122 MW yet to be commissioned
- UPNEDA: 1,750 MW allocated across states, 457 MW yet to be commissioned
- RUMSL Agar, Shajapur & Neemuch Solar Park: 1,500 MW allocated, entire capacity yet to be commissioned
- BREDA: 250 MW, 200 MW allocated, entire capacity yet to be commissioned. PSERC: 250 MW allocated, 100 MW yet to be commissioned
- RUMSL: 600 MW floating solar yet to be commissioned

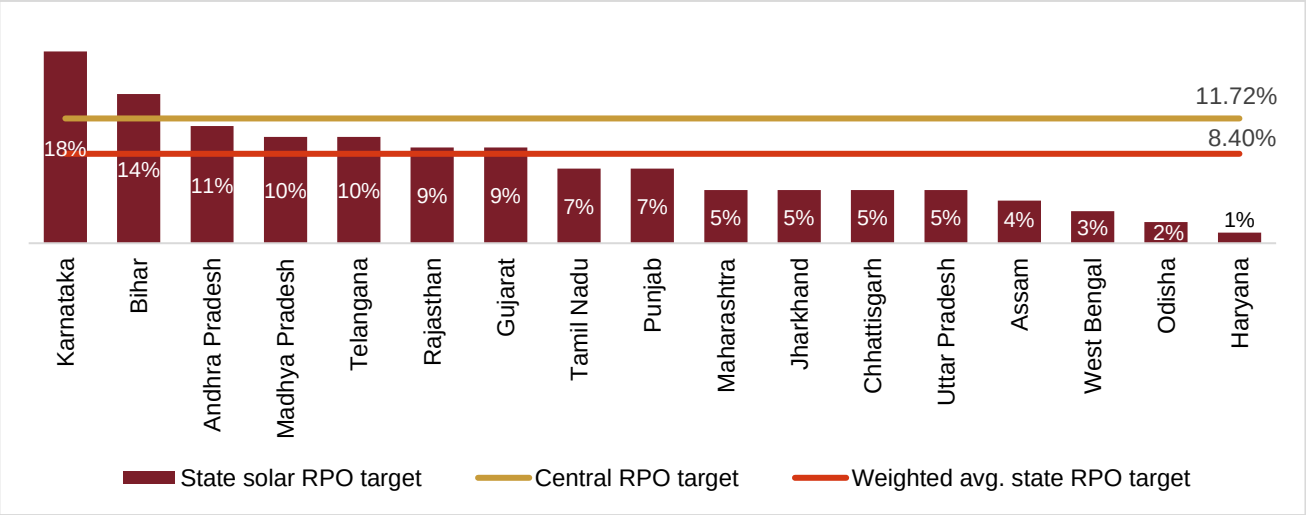
**Table 27: State-wise capacity tendered**

| State | Tendered capacity (MW) |
|---|---|
| Maharashtra | 9,526 |
| Gujarat | 2,024 |
| Kerala | 271 |
| Uttar Pradesh | 1,125 |
| Rajasthan | 3,679 |
| Jharkhand | 130 |
| Karnataka | 1,081 |
| Madhya Pradesh | 3,060 |
| Manipur | 50 |
| Odisha | 500 |
| Punjab | 2,283 |
| Tamil Nadu | 420 |

*Source: CRISIL Consulting*

**Compliance estimated at 91% as focus on solar helps meet state RPO targets**

**Figure 64: Weighted average state solar RPO target lower by 300-350 bps compared to even half of MoP target set for other sources for FY23**




*Source: MNRE; distribution utility tariff orders, CRISIL Consulting*

To promote the installation of solar power systems across various Indian states, the government amended the National Tariff Policy in fiscal 2016, proposing an increase in the solar RPO target to 10.5% by fiscal 2022. Consequently, several states set RPO targets based on their respective RE potential. However, the MoP issued a revised trajectory in June 2018 as follows:

**Table 28: RPO trajectory**

| Category | FY17 | FY18 | FY19 | FY20 | FY21 | FY22 |
|---|---|---|---|---|---|---|
| Non-solar | 8.75% | 9.50% | 10.25% | 10.25% | 10.25% | 10.50% |
| Solar | 2.75% | 4.75% | 6.75% | 7.25% | 8.75% | 10.50% |
| Total | 11.50% | 14.25% | 17.00% | 17.50% | 19.00% | 21.00% |

*Source: Ministry of Power, CRISIL Consulting*

The revision has allowed for inter-replacement of non-solar and solar RPO. Backlog, if any, would be carried forward.

In October 2023, the Central Government modified the trajectory for RPO. The new segment called 'distributed renewable energy (DRE)' has been introduced, allowing RE projects with a capacity of less than 10 MW to qualify for RPO for distribution companies and open-access consumers.

**Table 29: RPO targets**

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

*Source: Ministry of Power, CRISIL Consulting*

The revised trajectory shall come into force from 1st April, 2024 and till then, the previous RPO trajectory specified in September 2022 shall be applicable. As per the new RPO guideline, any excess energy consumption under “Other” RE component in a particular year, may be utilised to meet the shortfall in achievement of stipulated Wind or Hydro renewable energy consumption.

The overall solar RPO compliance was estimated at 75-80% in fiscal 2022, thanks to the over-achievement of the existing RPO targets by Karnataka, Andhra Pradesh, and Telangana, which have seen rapid solar capacity additions. These three states exceeded their solar RPO targets, and collectively accounted for ~29% of the total installed base in May 2022.

Another contributor is the low RPO targets set by state commissions compared with the MoP’s trajectory set in June 2018. However, states such as Odisha, Punjab, Chhattisgarh, and Uttar Pradesh are yet to realign their RPO targets with the MoP’s new trajectory.

Higher compliance is also on account of lower targets set by most states and factoring in the non-solar-rich states that are much behind in terms of capacity additions. Going forward, unless states can purchase the required number of RECs or intra-state RE power, compliance is unlikely to go up in the face of steeply rising RPOs as per the trajectory. Hence, while Telangana, Karnataka, Andhra Pradesh, Rajasthan, and Gujarat may be able to comply due to the rapid addition of solar capacities, Delhi, Uttar Pradesh and Punjab may still lag. Despite continuing non-compliance by most states, there has been limited enforcement on obligated entities – discoms and open access and captive power users – to meet RPO targets. CRISIL Consulting believes this is primarily because

of the weak financial health of state discoms. However, instances of penalty imposition have increased over the past year. For instance, in June 2021, the Uttar Pradesh regulator asked Uttar Pradesh Power Corporation Ltd (UPPCL) to deposit Rs 7,244.7 crore by January 2022, to meet RPO obligations for fiscal 2022 and clear past dues. Nevertheless, uniform imposition of penalties is still lacking, with imposition cases currently being few. While a few states, as mentioned above, have taken some action, success has been limited.

That said, lower solar REC prices on the exchange are expected to support an increase in compliance levels. Lower REC prices will help discoms buy more RECs from the exchange to meet their RPO targets.

CRISIL Consulting believes that strict enforcement is critical for significant improvement and fair distribution of RPO compliance across states. The MoP has proposed an amendment to the Electricity Act, 2003, stipulating a penalty on RPO non-compliance to the tune of Rs 1-5 per unit for the extent of shortfall as determined by the Central Electricity Regulatory Commission. However, this has not been passed so far. MNRE also set up an RPO Compliance Cell in May 2018, but strict enforcement of RPO targets is lacking.

## 5.7 Review of solar rooftop segment in India

### 5.7.1 Grid connected rooftop capacity totals ~11.1 GW as of August 2023

Rooftop projects are small-scale PV installations on roofs of buildings (detailed view of the operating models at the end of this section). Rooftop projects may or may not be connected to the grid.

The government had proposed to achieve 100 GW of solar energy by fiscal 2022, of which 40 GW was proposed to be added under rooftop-based solar systems. This was extended to fiscal 2026. However, it is estimated that ~ 11.1 GW of rooftop capacity was installed till August 2023, with ~2201 MW added in five months of fiscal 2024 so far as against ~1568 MW of ground-mounted solar projects. Additions are seen across Gujarat and Karnataka accounting for 61% of total additions. These additions are also 2.5 times the additions in first six months of fiscal 2022. The expansion of the market can be attributed to several factors, including increased consumer awareness, advancements in technology, and proactive subsidy initiatives implemented by both central and state governments. Additionally, Chinese solar module prices have reached a historic low, standing at just US$ 0.20 per Wp, which is expected to stimulate growth in solar power capacity.

The capacity addition in fiscal 2023 was largely driven by robust additions under the residential rooftop segment, especially in Gujarat driven by Surya Gujarat solar rooftop scheme, closely followed by Maharashtra at 516 MW driven by rooftop subsidy scheme. These two states accounted for 58% of the total 2.2 GW additions in fiscal 2023. Capacity additions in fiscal 2023 were ~19% lower than in fiscal 2022 owing to policy changes and surging cost of modules as the imposition of the BCD and the ALMM mandate for rooftop solar projects added to the volatility in solar module prices and supply in the market. Further, the 40% subsidy for 3KW projects announced by the Haryana government, also supported overall capacity additions. Most of the additions were under the capex model with states empaneling vendors & commissioning the allocated capacities under MNRE Phase II of the rooftop solar program.

The rooftop solar segment in India is dominated by Commercial & Industrial (C&I) consumers, accounting for over 75-80% of the total market. Some of the reasons for their dominance are availability of large rooftop space, higher electricity consumption, increasing electricity costs, favorable economics, strong thrust on sustainability and increasing awareness.

Nevertheless, rooftop solar projects have attracted interest from players in the entire solar value chain, ranging from module manufacturers (Tata Power Solar, Waaree Energies, Vikram Solar, etc.) to system integrators (Rays Power, Jackson Engineers) and independent power producers (Fourth Partner, Amplus, Cleanmax, Azure Power, SunEdison, Mahindra Solar, Radiance etc.) owing to falling costs and favorable regulatory policies in key states (net metering, exemption on electricity duty, wheeling and cross-subsidy charges).

## 5.7.2 Regulatory support required to drive the sector

The GoI's target of 40% of 100 GW generation capacity target under the NSM from this segment by 2022, fell short of ~31 GW. Thus, government support is critical to boost growth to achieve the target till fiscal 2026; for instance, the GoI's 30% capital subsidy for rooftop projects. The MNRE had increased its financial assistance target (in the form of capital subsidy) eightfold to Rs 50 billion over fiscals 2016-20. This subsidy was sufficient to support ~4.2 GW of rooftop projects in the residential category of consumers and for public institutions (government hospitals, schools, etc.) across various sectors.

Central-level benefits provided for rooftop projects are detailed below.

**Figure 65: Policy provisions at a glance**

| | |
|---|---|
| **Capital subsidy** | 1. Central Government provides 30% capital subsidy to residential consumers, government buildings, social and institutional sector such as hospitals, educational institutions etc.<br>2. **Subsidy reduces the generation cost by ~Rs 1.4/unit to Rs 3.0-3.2/unit** and payback (which without subsidy is ~**75-80 months**) by ~20 months |
| **Tax incentives** | 1. **Accelerated depreciation (AD) of 40% and** an additional depreciation of 20% are allowed on solar assets in the first year of operations. This reduces the taxable income and reduces generation cost by **Rs 1.0-1.1/unit**<br>2. The sunset clause for solar power developers for availing 10 year tax holiday under section 80 IA is now withdrawn, effective 1st April 2017. |
| **Generation-based incentives by various states** | 1. States such as **Delhi** provided generation-based incentives over and above the feed-in tariff. The incentive provided was Rs. **2/unit which** improved the internal rate of return by **100-300 bps**. |
| **Lower cost of financing** | 1. The Indian Renewable Energy Development Agency (IREDA) provides loans at cheaper rate of interest **(8.45% to 9.40% p a)** to system aggregators and developers. This is critical as every 50 bps reduction in interest cost leads to 10-15 paise per unit (or up to 5%) reduction in the generation cost. |
| **Availability of capex and RESCO modes of operation** | 1. Under the **capex mode of operation**, the developer of the project owns the rooftop, while under the **RESCO (opex) mode of operation** the developer leases the rooftop with the rooftop owner, with the liberty of captively consuming the entire power or trading electricity under net-metering mechanism.<br>2. Allocating projects under both these models allow the project developer to enjoy the benefits of offsetting expensive grid power by cheaper solar rooftop generation. |
| **Other central level initiatives** | 1. Central level agencies such as SECI allocate city-wise capacities under both capex and RESCO modes. Further SECI provides 30% capital subsidy to along with other available tax incentives to project developers.<br>2. As per the new Reserve Bank of India norms, renewable generators can get loan of up to Rs 15 crore, while home owners can get ~Rs 10 lakh (~20 kw project could be installed) of loan for setting up rooftop projects on which the interest paid is tax deductible<br>3. Government has launched National Rooftop Portal to promote growth in the segment. |

*Source: CRISIL Consulting*

The MNRE had also implemented phase II of the Residential Solar Rooftop scheme with a target to achieve 40 GW from rooftop solar. Under the scheme, as on February 28, 2022, the ministry allocated ~3,162 MW out of 4,000 MW. While the target was not achieved, it does support capacity additions in the segment, where against the total allocated capacity of ~3,162 MW, ~1,252 MW has been installed.

The important features of the scheme are as follows:

Component A: Central financial assistance to the residential sector – 4 GW

| Size of the installation | Incentive |
|---|---|
| 1-3 kW | 40% of system cost |
| 3-10 kW | 20% of system cost |
| 10-500 kW (housing societies/residential welfare) | 20% of system cost |

*Source: MNRE*

Component B: Incentives to discoms for initial 18 GW capacity

| Installed capacity within one financial year | Incentive |
|---|---|
| Up to 10% of installed base | No incentive |
| >10% to <15% of installed base | 5% of project cost for capacity achieved above 10% of base |
| >15% of installed base | 5% of project cost for capacity achieved above 10% of base and up to 15% of base + 10% of project cost for capacity over 15% of base |

*Source: MNRE*

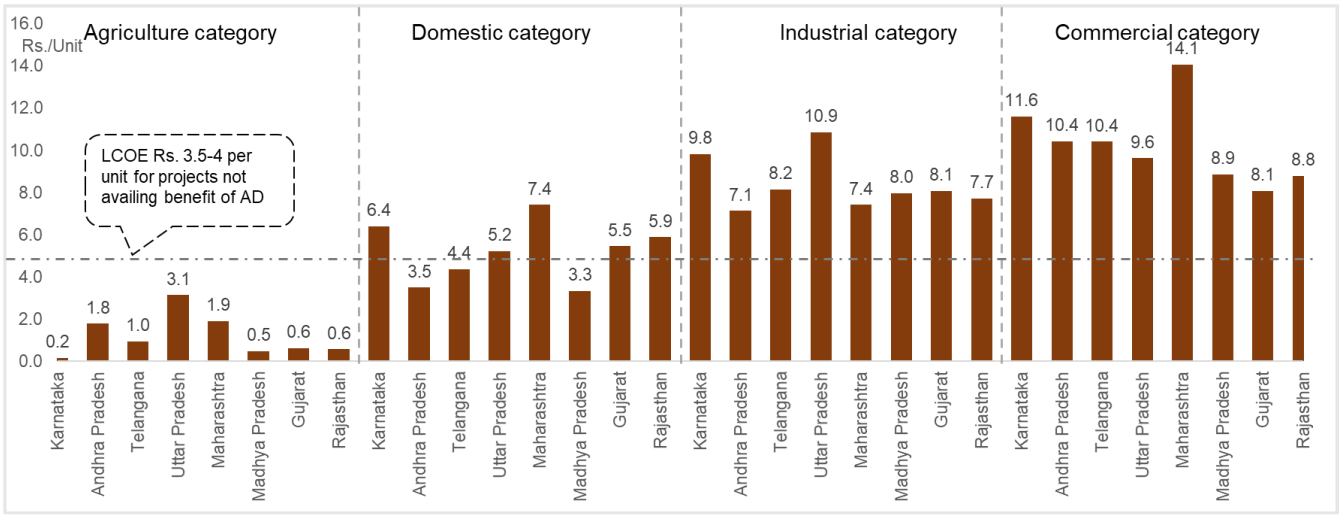
In most state policies, net metering is allowed for residential and C&I consumers.

- All discoms are to utilise units generated from solar rooftop power plants to comply with their solar RPO targets if the consumer is not an obligated entity. Further, any excess unit generated by the obligated entity, i.e., over and above its obligations, would be utilised by discoms to meet their solar RPO targets
- Discoms alone will meet their RPO targets from the units injected into the grid, if FiT are paid by discoms

Given lower capital cost, rooftop projects have become attractive for C&I consumers. In particular, the net-metering scheme – under which power generated can be consumed captively and the balance/excess sold to the grid – is attractive for consumers paying tariffs upwards of Rs 4.5 per unit to discoms. The cost of generating solar power from rooftop projects is estimated at Rs 3.5-4.0 per unit (without availing AD).

C&I consumers are best placed to claim the AD benefits and increase their project returns/reduce generation costs. This group includes all high-tension consumers and commercial consumers such as malls, hospitals, government establishments, and high-consumption group residential complexes.

**Figure 66: Average tariff for different categories of customers**




*Note: Tariffs as of fiscal 2021*

*Source: PFC, CRISIL*

Conversely, residential and agricultural consumers have no economic incentive to set up rooftop projects on a net metering basis since their tariffs are low because of high cross-subsidy. For such consumers, the economics would be favourable only if they were allowed to install projects sized more than ~2.5 times their connected load (currently the restriction is 0.5-1 times their load, on average). This would enable them to meet their electricity needs and earn revenue for additional electricity sold to discoms at average power purchase cost (APPC) tariffs. Further, discoms have set limits for the maximum capacity of plants that could be installed under the net metering mechanism as 0.5 kW to 1,000 kW, which dampens interest in such projects.

## 5.8 Outlook of solar energy capacity additions in India

Fiscal 2023 saw slower additions, totaling ~12.78 GW against ~13.91 GW in fiscal 2022. Capacity additions slowed down last fiscal because of shortages of domestically manufactured solar modules, the pandemic-led low imports, and the imposition of duty on imported solar modules leading to an increase in prices of imported modules.

A robust ~13.9 GW was added in fiscal with open access utility-scale installations estimated at 1.2-1.4 GW, led by Karnataka, Uttar Pradesh, Tamil Nadu, and Maharashtra. This was on the back of a slowdown in capacity addition in fiscal 2021, mainly due to continued localised restrictions and extension in timelines post pandemic.

Commissioning activity is concentrated in Rajasthan, Gujarat, and Tamil Nadu, collectively accounting for ~65% of the ~8.2 GW added last fiscal. In fiscal 2022 as well, the installation trend was driven by these three states.

Scheme-wise commissioning was driven by several large projects under SECI ISTS hybrid 1200 MW Tranche I, SECI ISTS hybrid 1200 MW Tranche II, SECI ISTS 2000 MW Tranche IX, SECI 2000 MW CPSU Tranche I, and CPSU scheme Phase II Tranche I, which got commissioned in the third quarter of fiscal 2023.

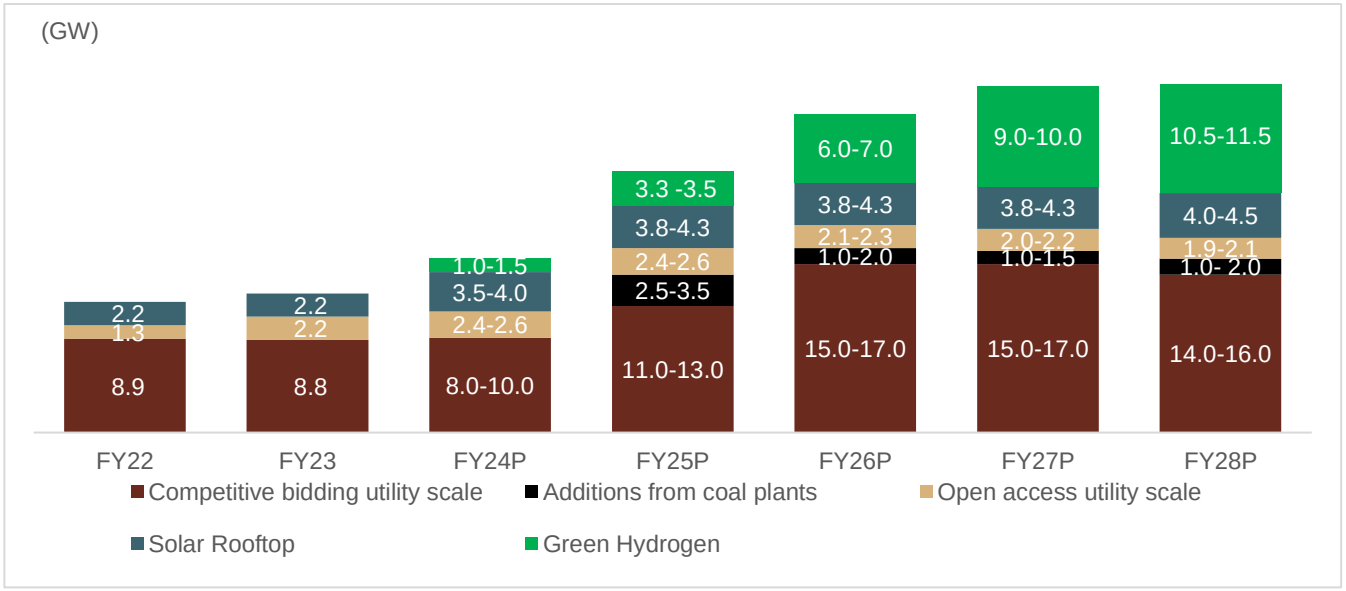
**Table 30: Rajasthan alone garners 2.8 GW of main capacities commissioned in FY23 and 2 months of FY24**

| Developer | Project location | Scheme | Capacity |
|---|---|---|---|
| AGEL | Rajasthan | SECI 1200 MW Hybrid Tranche II | 600 |
| NTPC | Rajasthan | SECI PSU Tranche I | 500 |
| Axis Energy | Rajasthan | NHPC 2 GW Pan India Solar | 400 |
| TBEA | Anywhere in India | NTPC 1.2 GW ISTS | 300 |
| ACME Solar | Rajasthan | MSEDCL 1 GW Phase II | 300 |
| NTPC | Rajasthan | IREDA 5 GW CPSU | 296 |
| O2 Power | Rajasthan | SECI Rajasthan Tranche II | 250 |
| Mahindra Susten | Rajasthan | SECI ISTS Tranche IV | 175 |
| UPC Solar | Madhya Pradesh | SECI 1200 MW Solar Tranche VI | 150 |
| TP Saurya | Rajasthan | KSEB 200 MW Solar | 110 |
| UPC Solar | Madhya Pradesh | Seci 1200 Solar Tranche VI | 87.5 |
| NTPC | Rajasthan | SECI 1500 MW CPSU Tranche II | 50 |
| NTPC | Rajasthan | SECI 2000 MW CPSU Tranche I | 50 |
| NTPC | Rajasthan | IREDA 5 GW CPSU | 49 |
| Enel | Rajasthan | SECI 2 GW Solar Tranche IX | 36 |
| Adani Green Energy | Rajasthan | SECI 1200 MW Solar Tranche III | 25 |
| NTPC* | Gujarat | SECI 2000 MW CPSU Tranche I | 10 |

*Source: Industry; CRISIL*

The solar additions momentum in fiscal 2023 witnessed flat movement at ~13 GW owing to cost pressures arising from supply chain disruptions. However, with increase in capacity additions and ease of supply chain pressures, fiscal 2024 is expected to add 16-17 GW supported by 1-1.5 GW of solar additions on account of green hydrogen led demand. This will be supported by moderating raw material prices. The first five months of fiscal 2024 have witnessed an addition of 4 GW. This is expected to pick up in H2 of fiscal 2024.

**Figure 67: Solar capacity additions of 130-140 GW expected over fiscals 2024-2028**




*Source: CRISIL Consulting*

Potential long term growth drivers

- **NSM**: The entire NSM Phase II Batch II Tranche I of 3,000 MW has been commissioned. Under NSM Phase II, Batch III and Batch IV, SECI through its state-specific viability gap scheme (VGF) has tendered out ~7 GW of capacities, most of which has been completed.

- **Other central schemes:** The Solar Energy Corporation of India (SECI) has also started tendering projects outside the JNNSM Batch programme. It has initiated the Inter-State Transmission System (ISTS) scheme, wherein projects are planned for connection with the ISTS grid directly. Under this, the SECI has already allocated ~23 GW (including hybrid) while 6 GW is tendered.

- **State solar policies**: ~15 GW of projects are under construction and are expected to be commissioned over the fiscal 2024-2028. Based on tendered capacities by states at the end of August 2023, a further ~13 GW worth of solar projects is expected to be up for bidding over the coming months.

- **PSUs:** The Central Public Sector Undertaking (CPSU) programme under JNNSM has been extended to 12 GW in February 2019. The government is also encouraging cash-rich PSUs to set up renewable energy projects. In particular, NTPC has already commissioned a total of over ~2,120 MW of capacities, allocated ~4 GW, and tendered a further ~1 GW, under various schemes. It has a target of installing ~35 GW of renewable energy capacities by fiscal 2028. Similarly, NHPC had allocated 2 GW of projects in 2020, while the Indian Railways has committed to 20 GW of solar power by 2030. Other PSUs such as NLC, defence organizations, and governmental establishments are also expected to contribute to this addition.

- **Rooftop solar projects:** CRISIL Consulting expects 18-22 GW of rooftop solar projects (under the capex and opex mode) to be commissioned by fiscal 2028, led by high industrial and commercial tariffs and declining levelized cost of energy for these projects. However, growth in rooftop solar capacity additions needs to be supported by improvement in the discoms infrastructure, continuation of net metering regulations/benefits, and other regulatory incentives.

- **Open-access solar projects:** CRISIL Consulting expects 11-13 GW of open-access solar projects (under the capex and opex mode) to be commissioned by fiscal 2028, led by green energy open access rules 2022, sustainability initiatives/RE 100 targets of the corporate consumers, better tariff structures and policies of states such as Uttar Pradesh and Karnataka, which are more long term in nature.

- **Push for Green hydrogen:** Production for green hydrogen is expected to start from fiscal 2026 with expected production of 0.5-1 million tonnes of production which will see solar capacities coming from fiscal 2024. As the government pushes towards the target production of 5 million tonnes of green hydrogen by 2030 more solar capacities are expected to commission totaling 30-34 GW by fiscal 2028 to cater to the demand of producing 2-2.5 million tonnes of green hydrogen.

- **Renewable generation obligation (RGO):** Upcoming coal power plants will additionally add capacities of 7-8 GW by fiscal 2028. As per the guidelines upcoming coal plants are obligated to establish renewable generating capacity on a minimum of 40% of their generating capacity. This will be applicable for plant commissioning from April 2023 onwards. Plant commissioning prior to March 2025 will be required to achieve 40% RGO by April 1st, 2025. All plants commissioning after April 1st, 2025, will be required to comply with RGO from the day of commissioning.

## 5.9 Key factors driving capacity additions

**a. Central and state tendering grows multi-fold with a healthy pipeline giving comfort; resolution of execution-related hurdles critical**

In June 2015, the Union Cabinet approved the revision of cumulative targets under NSM, from 20 GW by 2021-22 to 100 GW over the same period. Hence, phase II of the NSM comprised a variety of schemes to attract investments in solar.

In April 2021, ~14 GW under various schemes had been tendered under NSM phases I and II, comprising:

460 MW in phase I, Batch I and II – fully commissioned

680 MW in phase II, Batch I – fully commissioned

**3,000 MW under NVVN Batch II, Tranche I**

This scheme was created to lower the cost of solar power by bundling it with thermal power from NTPC's power stations in the ratio of 2:1 (MW terms) and then selling it to discoms. In Tranche I of Batch II, 3,000 MW of projects (of which some capacity was allocated in the domestic content requirement or DCR category) has been fully awarded. The scheme was initially planned in three tranches and for a cumulative capacity of ~12 GW. However, with solar tariffs falling below thermal power tariffs, the scheme has been restricted till Tranche I.

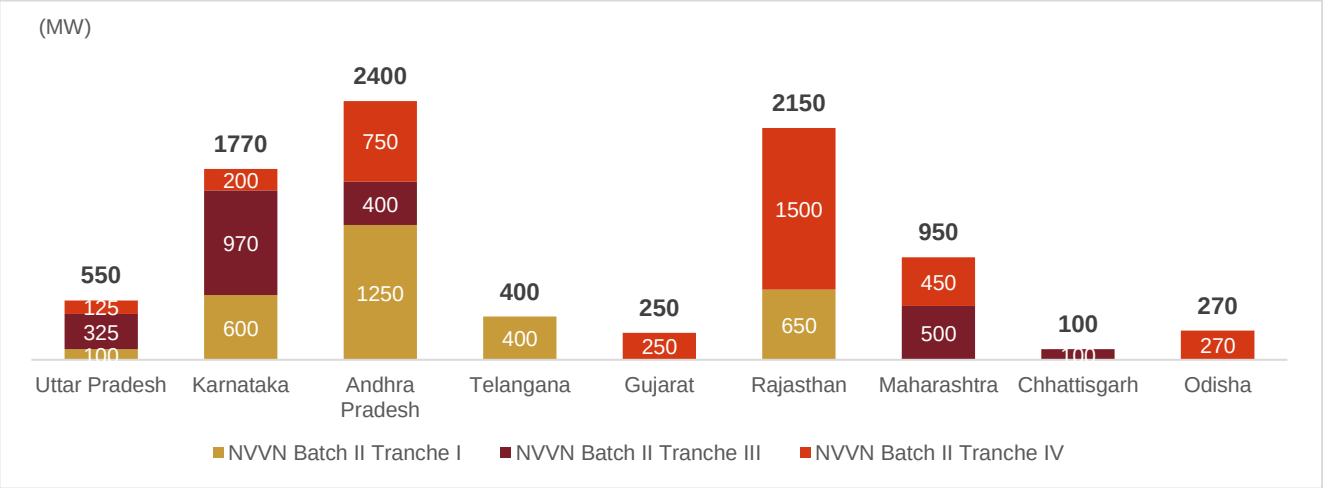
**5,840 MW under Batch III and IV of NSM in various locations**

Under NSM phase II, Batch III, 2,000 MW of solar PV capacity was envisaged to be installed through a state specific VGF scheme by SECI, but 2,300 MW has already been tendered in this batch, which is estimated to be fully commissioned.

Subsequently, the next batch under the same scheme, i.e., phase II, Batch IV VGF scheme, was envisaged for ~5,000 MW, with ~3,545 MW already tendered and most of the capacity commissioned in this scheme.

The state specific VGF scheme received approval from Cabinet Committee on Economic Affairs (CCEA) and budgetary sanction of ~Rs 7,000 crore (~Rs 1 crore/MW) for VGF disbursement.

**Figure 68: Phase II, Batch III and IV (SECI) – state-wise break-up of allocated capacities**




*Source: CRISIL Consulting*

**b. 12,000 MW (2,027 MW allocated by SECI) under NSM's CPSU programme, 357 MW to be set up on defence establishments.**

Through the CPSU programme under JNNSM, the government is encouraging cash-rich central PSUs to set up renewable energy projects. The government expanded the CPSU programme from 1 GW to 12 GW in February 2019, to provide impetus to the domestic solar module manufacturing industry, as procurement by CPSUs for self-consumption is exempt from the WTO ban on DCR. Apart from the CPSU programme, CPSUs such as NLC and NTPC have been tendering capacities to set up solar assets outside of this programme, in a bid to diversify portfolios.

With a significant chunk of phase 1 executed, under phase II (programme expanded in February 2019), SECI has issued two tenders of 2,000 MW and 1,500 MW. Both SECI's and NTPC's tenders failed to attract sufficient interest from CPSUs, due to which they undersubscribed (SECI 2 GW, subscribed for only 932 MW and 922 MW allocated,

SECI 1,500 MW only ~1,104 MW allocated). However, after that, for a 5 GW tender, the entire capacity has been allocated under CPSU Tranche III and is under construction.

NTPC, for instance, has already commissioned ~2,120 MW of projects under its capacity addition at the end of September 2022. It has commissioned large-scale solar projects of 250 MW each in Andhra Pradesh, Madhya Pradesh, and Rajasthan to achieve the ~60 GW solar target by fiscal 2030.

NTPC is expected to continue robust capacity additions of solar, with the following key tenders allocated/ pending allocation by it as of September 2022:

* 450 MW allocated at SECI 1.2 GW wind-solar hybrid in August 2021.

* 1990 MW allocated at IREDA's 5 GW CPSU Tranche III in September 2021.

* 500 MW allocated at SECI's 1785 MW Rajasthan Tranche IV in December 2021.

* 450 MW allocated at Wind-Solar Hybrid Tranche V in May 2022.

NTPC releases tenders periodically, which are pending allocation and will be a part of the pipeline over the medium to long term.

Similarly, NLC aims to achieve a 2.1 GW renewable portfolio in the medium term and a 6 GW+ renewable portfolio in the long term. It had awarded EPC tenders to BHEL and Jakson Engineers Ltd for a 130 MW (~650-acre) project in Neyveli, Tamil Nadu, which was commissioned in January 2018. It also completed the commissioning of another 500 MW in Tamil Nadu in March 2019. Further, it has won 510 MW under wind-solar hybrid Tranche IV and is yet to be commissioned. It also has 4 GW+ under the planning stage, comprising more than 2.5 GW of solar. It has announced plans to set up 500 MW projects in Odisha (300 MW), Andaman Islands (50 MW), etc. based on the availability of land and other necessary infrastructure. However, these are still in the planning phase.

NLC also won 709 MW under the Tamil Nadu – TANGEDCO 1,500 MW auctions in June 2017, which is now fully commissioned. Other CPSUs such as NHPC, ONGC and GAIL also plan to generate solar power. The Indian Railways has also committed to generating 25% of its power consumption needs through renewables by 2025, and targets 5 GW of solar capacity for the same. It has floated three solar tenders of 1GW, 1.55 GW, 740 MW, and 1 GW RTC tender to date, which are yet to be allocated.

The government plans to set up 357 MW of solar projects in defence establishments, such as cantonments, military stations, ordinance factory boards, and other defence factory establishments. MNRE provided the administrative approval for this scheme on January 7, 2015. It intends to disburse VGF of up to Rs 2.5 crore/MW for projects selling power to the grid at the tariff of Rs 5.5 per unit. CRISIL estimates fulfilment of the entire capacity last fiscal.

**a. Other schemes – SECI/MNRE**

As of June 2023, SECI is driving certain other schemes:

- ISTS Scheme – ~8.6 GW allocated across various tranches
- Wind-solar hybrid scheme – ~6.5 GW allocated (part of the capacity will be wind) as of May 2023
- Other schemes – ~6.7 GW allocated across various states as of June 2023

**ISTS scheme**

Under this, SECI has already allocated 8.6 GW. Projects under this scheme shall be directly connected to PGCIL 's ISTS network and can be located in any part of the country. Land and transmission connectivity costs would be borne by the developer.

**Wind-solar hybrid schemes**

Under this, SECI has already allocated ~6.5 GW, and would entail setting up of projects with both solar and wind resources to better utilise resources, enhance the energy generation pattern (solar and wind can be complementary in terms of energy generation hours), and ensure better grid stability.

**Other schemes –** SECI has also been actively issuing tenders other than the ISTS and hybrid schemes. It has issued the following so far:

**Table 31: Schemes allocated by SECI as of June 2023**

| Scheme | Capacity allocated (MW) |
|---|---|
| SECI Rajasthan Tranche II | 680 |
| SECI Dhule Solar Park, Maharashtra | 250 |
| SECI Floating Solar Rihand Dam | 150 |
| SECI assured peak power supply | 1,200 |
| SECI RTC-I | 400 |
| SECI Rajasthan Tranche III | 1,070 |
| SECI RTC-II (bundled with thermal) | 250 |
| SECI Rajasthan Tranche IV | 1,785 |
| SECI ISTS Hybrid Tranche VI (Storage + Peak supply) | 1,200 |
| SECI Karnataka Tranche X | 1,200 |
| **Total** | **8,185** |

*Source: SECI, CRISIL Consulting*

### c. Manufacturing capacity-linked projects

SECI had floated an expression of interest (EoI) with the proposition of linking solar project tendering to the setting up of module manufacturing capacities. The initially floated proposal was for 5 GW of manufacturing capacities linked to 10 GW of solar projects. This was subsequently reduced to 3 GW of manufacturing capacities but linked to 10 GW of projects. Under the initiative, developers would have had to comply with a 1:3 ratio between manufacturing capacities and projects and adhere to timelines; failure to do so would attract strict penalties. Additionally, developers could only import polysilicon. The remaining manufacturing chain, from silicon wafers to modules, was to be set up. However, they were not necessarily required to use modules manufactured in these capacities for the projects to be set up concurrently; modules from other sources could be used for the purpose.

However, the above tenders failed to attract bidder response, except for a bid from Azure Power for 600 MW of manufacturing capacity and 2,000 MW of solar projects. However, the bid was cancelled due to a disagreement over the final bid price (no auction was conducted, given there was only one bidder).

SECI reissued the tender in January 2019, having reduced the manufacturing component to 1.5 GW and solar project capacity to 3 GW. The tender saw several bid extensions again due to low developer interest. The tariff cap was also set low, at Rs 2.7 per unit. Despite the extensions, the tender could not be allocated, and in June 2019, SECI issued a similar tender again. This time, it was for 2 GW of manufacturing capacity and 6 GW of solar projects, but with a tariff cap of Rs 2.7 per unit. This tender was also extended several times. In October 2019, the tender was scaled up to 7 GW of power generation capacity linked to 2 GW of PV manufacturing capacity. This also included a green-shoe option that developers could avail of if they wished. The tender got allocated in January 2020, with a 1 GW oversubscription (several clauses were amended, and the tariff ceiling was raised). Adani Green Energy (6W of power generation) and Azure Power (2 GW) won the bid. The companies also availed 2 GW each

under the green-shoe option. Both these companies recently signed PPAs with SECI for ~4.67 GW and 2.3 GW, respectively.

The capacities for manufacturing-linked tenders are expected to be commissioned in phases from fiscal 2025. Additionally, in September 2021, SECI revised the tariff to Rs 2.54 from Rs 2.92 per unit. This led to a pickup in PSA signing activity for manufacturing-linked tenders, with 1 GW of PSAs signed by TANGEDCO, 0.5 GW by GRIDCO, and the remaining capacity signed by AP discoms. In August 2023, Adani Green Energy commissioned a 2 GW solar cell and module factory under a manufacturing linked tender by SECI in Mundra, Gujarat.

**d. Capacity additions of ~11 GW under construction from different state policies, ~18 GW in tendering, with the majority under the PM-KUSUM scheme**

To fulfil their RPO targets, as per respective trajectories, states have increased tendering activity. Key state schemes over fiscals 2018 to 2023, under which, capacities remain to be commissioned, include:

- MSEDCL: 5,401 MW allocated, and ~3,389 MW yet to commission
- Gujarat, Phase I-XIII (Phase II scrapped): ~5,900 MW allocated, and 3,850 MW yet to commission
- KREDL: 715 MW allocated, and 122 MW yet to commission
- UPNEDA: 1,750 MW across states allocated, and 457 MW yet to commission
- RUMSL Agar, Shajapur and Neemuch Solar Park: 1,500 MW allocated, and the entire capacity yet to commission
- BREDA: 250 MW, out of which 200 MW allocated, and the entire capacity yet to commission
- PSERC: 250 MW allocated, and 100 MW yet to commission
- RUMSL: 600 MW floating solar yet to commission

**e. Considerable under-construction capacity expected to be commissioned**

Solar tariffs have been trending downward in the recent past, led by lower capital costs amid falling module prices, the availability of cheaper debt, and a short window of duty pass-throughs, among other factors. This resulted in a record low tariff of Rs 2.36 per unit in the SECI ISTS-IX auctions in June 2020 and an even lower ~Rs 2.0 per unit tariff bid in the SECI Rajasthan-III auctions in November 2020. However, developers have kept bids in the range of Rs 2.3-2.5 per unit in most auctions, be it central or state, as the supply-side pricing surge has led to a rise in tariffs.

Solar tariffs were on an upward trend in fiscal 2023, led by various factors such as higher capital cost amid increasing module prices and higher interest rates on debt. This led the solar tariff to increase to Rs 2.79 per unit in fiscal 2023. However, module prices have started falling and with the abeyance of ALMM tariffs are expected to decline to Rs 2.6 – 2.8 per unit.

Having said that, state bids unlike central ones have higher variability in terms of payment security, provisions of infrastructures, penalty clauses, and commissioning schedules. Additionally, state income credibility and back-down incidents in the state also influence state bids. As a result, bid tariffs are influenced by these factors and vary between auctions.

CRISIL Consulting expects a large proportion of the SECI under-construction capacity, ~17 GW, to be commissioned by 2024-2028.

**f. 19-21.5 GW of rooftop solar capacity addition expected over fiscals 2024 to 2028**

Rooftop projects are small-scale solar PV installations on roofs of buildings. In the government's 100 GW target, 40 GW is attributed to rooftop solar projects. Total solar rooftop installed capacity as of August 2023 is estimated at ~11.1 GW (refer to chapter on 'Solar rooftop' for detailed analysis), which is quite far from the required target.

However, in five months of fiscal 2024, rooftop capacity additions are estimated to be ~ 3x on-year owing to increasing residential additions.

Although the MNRE has entrusted SECI with the implementation of large-scale, grid-connected rooftop PV projects with subsidy support from the NCEF, inherent technical and operational issues associated with discoms, coupled with delayed clearances, have slowed growth in capacity additions. This issue is proposed to be resolved via the Solar Rooftop Implementation for Solar Transfiguration of India (SRISTI) scheme. It has been proposed by the MNRE with an approval of Rs 11,000 crore and is aimed at making state distribution utilities the nodal agency for the central rooftop subsidy programme, while providing incentives to promote rooftop installations in their areas of jurisdiction.

Considering the sector's slow growth rate in the residential segment, while also factoring in the spurt in installations by commercial, industrial, and government organisations, CRISIL Consulting expects 19-21.5 GW of rooftop solar capacity additions over fiscals 2024 to 2028 and Karnataka, Andhra Pradesh, Telangana, Rajasthan, Tamil Nadu, Maharashtra, and Gujarat to account for over 50% of total additions, led by favourable economics and incentives.

**g. 500 GW non-fossil target by 2030 under COP26 to drive solar capacity additions**

India set an ambitious goal at the COP26 summit. Addressing the UN's Climate Change Conference in Glasgow in November 2021, Indian Prime Minister announced that India would achieve a net-zero emissions target by 2070, revised the non-fossil-based target from 450 GW to 500 GW by 2030, and pledged to reduce the carbon intensity of the country's economy by 45% within the decade. Further, the MOEFCC has stated that 50% of the installed power generation capacity will likely be from renewable energy, indicating increased thrust towards renewable capacity additions. This is expected to ensure continued positive regulatory support, which is a critical enabler of capacity additions in the segment.

**h. PLI scheme for domestic module manufacturing**

On November 11, 2020, the government introduced the PLI scheme for 10 key sectors to enhance India's manufacturing capabilities and exports under its *Aatmanirbhar Bharat* initiative.

One of the 10 sectors for which PLI was approved is high-efficiency solar PV modules, for which, the MNRE has been designated as the implementing ministry. The financial outlay for the PLI scheme is Rs 4,500 crore over a five-year period. This was later increased to Rs 24000 crore.

The scheme is aimed at promoting the manufacture of high-efficiency solar PV modules in India and thus, reducing import dependence in the area of renewable energy. The MNRE will implement the scheme through IREDA as the implementing agency. For Tranche II, SECI was given the responsibility of conducting bidding process.

Beneficiaries of the scheme were to be selected via a bidding process. To qualify, a manufacturer was required to set up a plant of minimum 1,000 MW capacity. Manufacturers were also required to fulfil the following minimum performance parameters:

- Minimum module efficiency of 19.50% with the temperature coefficient of Pmax better than -0.30% per degree Celsius, or
- Minimum module efficiency of 20% with the temperature coefficient of Pmax equal to or better than -0.40% per degree Celsius

In September 2021, IREDA, the implementing agency, released the list of PLI scheme participants, and the scheme received a response of 54.8 GW worth of bids for a 10 GW scheme. Bids of ~19 GW were submitted for the manufacture of polysilicon, 32 GW for wafers, and 54.8 GW for cells and modules.

Reliance New Energy Solar's PLI award amount was Rs 1,917 crore for a capacity of 4 GW. Shirdi Sai Electricals was Rs 1,875 crore for 4 GW and Adani Infrastructure's was Rs 663 crore, out of the total quoted amount of Rs 3,600 crore for a capacity of 737 MW under the bucket-filling method.

In March 2023, the government, through SECI, allocated 39.6 GW of domestic solar PV module manufacturing capacity under the PLI scheme (Tranche-II) to 11 companies, with a total outlay of ~Rs 14,000 crore. Total manufacturing capacity of 7,400 MW is expected to become operational by October 2024, 16,800 MW by April 2025, and the remaining 15,400 MW by April 2026.

**Table 32: Capacity awarded (in MW) under the PLI scheme (Tranche-I and II)**

| Player | Polysilicon | Wafer | Cells | Modules |
|---|---|---|---|---|
| **Shirdi Sai Electricals Ltd.** | 4,000 | 4,000 | 4,000 | 4,000 |
| **Reliance New Energy Solar Ltd.** | 4,000 | 4,000 | 4,000 | 4,000 |
| **Adani Infrastructure Pvt. Ltd.** | 737 | 737 | 737 | 737 |
| **Total PLI Tranche I** | **8,737** | **8,737** | **8,737** | **8,737** |
| **Indosol** | 6,000 | 6,000 | 6,000 | 6,000 |
| **Reliance** | 6,000 | 6,000 | 6,000 | 6,000 |
| **First Solar** | 3,400 | 3,400 | 3,400 | 3,400 |
| **Waaree** | | 6,000 | 6,000 | 6,000 |
| **Avaada** | | 3,000 | 3,000 | 3,000 |
| **ReNew** | | 4,800 | 4,800 | 4,800 |
| **JSW** | | 1,000 | 1,000 | 1,000 |
| **Grew** | | 2,000 | 2,000 | 2,000 |
| **Vikram** | | | 2,400 | 2,400 |
| **AMPIN** | | | 1,000 | 1,000 |
| **Tata Power Solar** | | | 4,000 | 4,000 |
| Total PLI Tranche II | **15,400** | **32,200** | **39,600** | **39,600** |
| Total PLI Tranche I+II | **24,137** | **40,937** | **48,337** | **48,337** |

*Source: MNRE, SECI, IREDA, CRISIL Consulting*

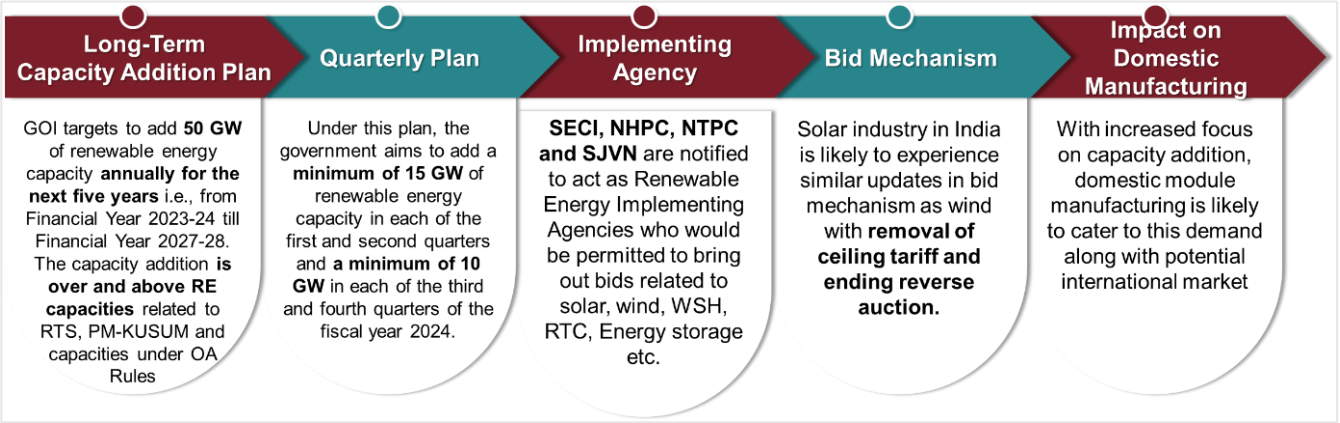
### i. Bidding of 50 GW annual capacity

The Government has decided to invite bids for 50 GW of renewable energy capacity annually for the next five years i.e., from fiscal 2024 till fiscal 2028. These annual bids of ISTS (Inter-State Transmission) connected renewable energy capacity will also include setting up of wind power capacity of at least 10 GW per annum.

Bidding trajectory will enable the power procurers, including the distribution companies, to manage their RE procurement plans effectively. The bid trajectory will also provide a fillip to the RE manufacturing industry in the country by indicating the demand that would be created for their equipment.

In addition to this, the Ministry has declared a quarterly plan of the bids for fiscal 2024, which comprises of bids for at least 15 GW of renewable energy capacity in each of the first and second quarters of the financial year (April-June 2023 and July-September 2023 respectively), and at least 10 GW in each of the third and fourth quarters of the financial year (Oct-December 2023 and January-March 2024 respectively).

**Figure 69: Long term RE capacity additions through bidding**

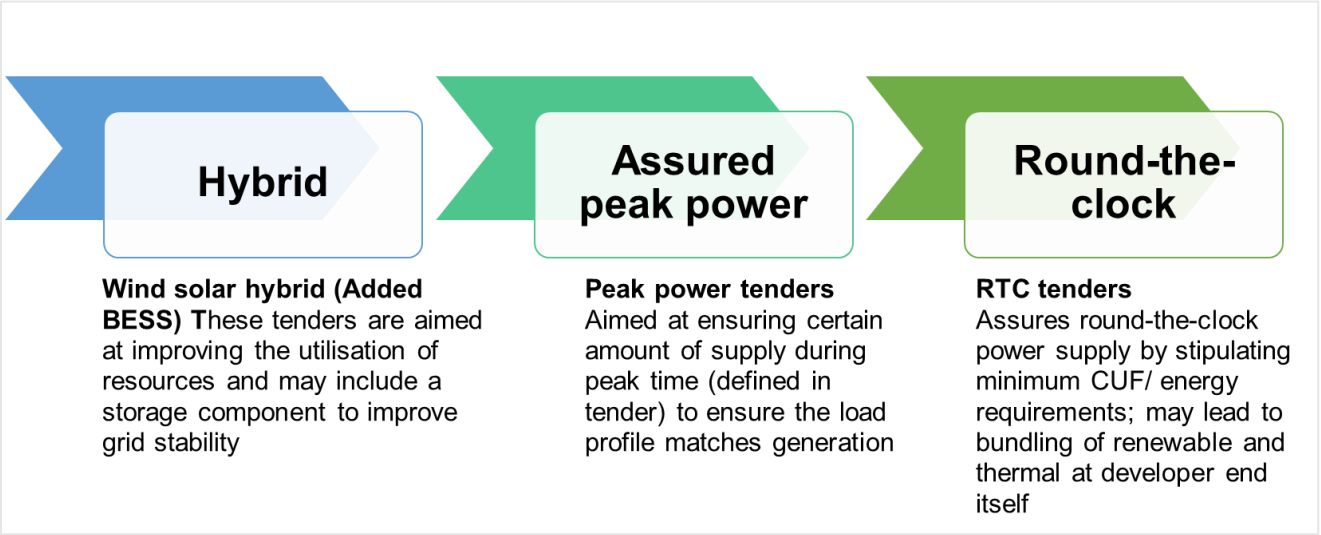



*Source: MNRE; Industry, CRISIL Consulting*

## 5.10 Key risk factors

Supply-side disruptions, additional taxes, and intermittent hurdles such as the Great Indian Bustard (GIB) litigation have often led to a pile-up of tenders in the market or an increase in bid tariffs, prolonging the time taken to sign PSAs with distribution utilities. Robust allocations over fiscals 2018 to 2020 propped up a healthy pipeline for commissioning over fiscals 2023 to 2024; fiscal 2021 was a weak year, given the pandemic-led halt in activities. However, allocations and consequent additions to the pipeline turned weaker post fiscals 2018 and 2019, comparatively, with allocation getting delayed. That said, nodal agencies, especially central, are keen on allocating large tenders hereon, such as the manufacturing-linked 7 GW tender, or those in the range of 1.2-2.5 GW in the current scenario. SECI has also outlined the agenda of experimenting with tender structuring to solve other incidental issues related to renewable energy, especially regarding grid balancing via its tender provisions. A few structures are outlined below:

**Table 33: Unique tender structures issued by SECI**




*Source: SECI, CRISIL Consulting*

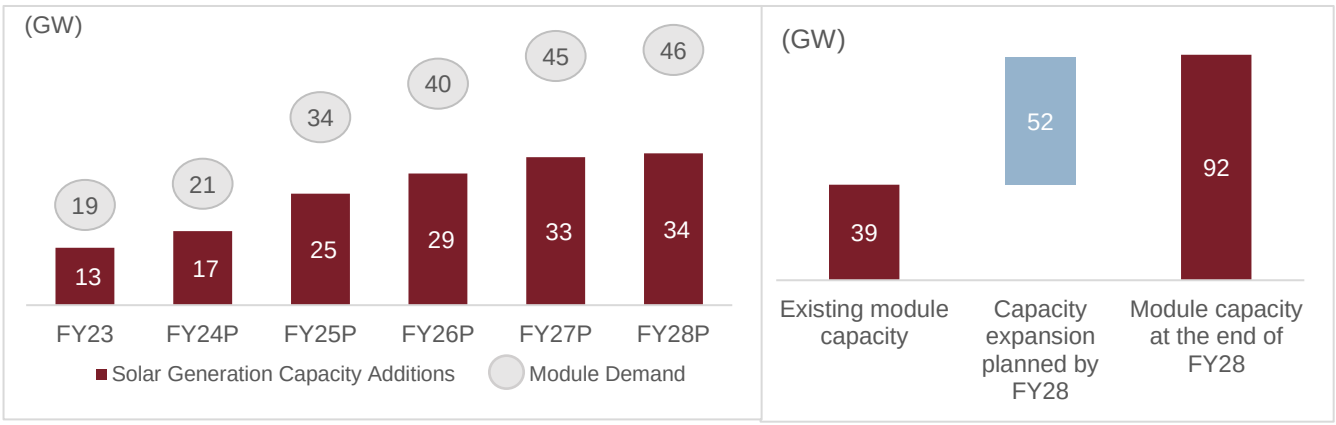
This may lead to allocations being larger in size, but more concentrated in terms of developers and/or locations/types.

a. Revision in the GST rate from 5% to 12% in October 2021 for solar project components has added to the cost pressure, where module prices have already surged last fiscal, coupled with the imposition of a 40% BCD on imported modules.

b. The ALMM order, which applies to bids made after April 10, 2021, mandates the use of domestic modules for government and government-assisted projects under government schemes and programs. "Government" includes both central and state government entities, CPSUs, PSUs, and central/state organizations. These projects, which are put out for bids after April 10th, are likely to be commissioned post-June 2023. As of fiscal 2023, the current operational capacity of new domestic module technology is approximately 20 GW. However, it is expected to increase to approximately 27-31 GW by the end of fiscal 2024 if the planned expansions are successful. Nevertheless, even with these additions, there will still be reliance on imports. A silver lining in the form of ALMM abeyance for projects commissioned before March 2024 will prove to be the most effective way to commission delayed projects in this fiscal year. According to CRISIL Consulting estimates, between fiscal years 2024-2028, approximately 130-140 GW is expected to be added, implying an annual module requirement of approximately 40-44 GW when considering 40% DC overloading.

c. However, should the planned expansion for this fiscal year be further delayed, CRISIL Consulting believes that approximately 8-10 GW of projects will face high risk, as none of the key global supplier players are part of the ALMM list. Furthermore, the absence of an ALMM abeyance extension in fiscal 2025, coupled with the absence of foreign manufacturers, can hinder the pace of these additions.

**Figure 70: Demand-supply dynamics for solar modules**




*P: Projected, Source: Company reports, CRISIL Analysis*

d. PLI scheme encouraging the domestic manufacturing industry will witness fresh allocations

PLI could increase nameplate module manufacturing capacity by 2x of domestic demand by FY24, creating a possible excess supply scenario in modules and ~12 GW of upstream supply chain capacities. This would aid price competitiveness for project developers sourcing modules, however, it would create profitability concerns for module makers. In an ideal scenario, CRISIL consulting expects enhancement of PLI outlay to result in ~20-30 GW of additional manufacturing base by fiscal 2026.

e. Litigation over transmission equipment harming GIBs: The Supreme Court (SC) has ordered that transmission lines be laid underground in the areas where GIBs are found, which is a challenge for developers, given that they will need to incur an additional ~ Rs 4 billion in expenses, and this could impact under-construction RE projects in Rajasthan and Gujarat to the tune of ~20 GW. Finally, as per the SC order dated April 20, 2022, projects in Rajasthan and Gujarat were required to have bird diverters installed before July 20, 2022; however, final decision on which areas and which projects is still to be finalized. Other issues also exist, wherein overall policy coherence from the government is imperative. While policies under other government agencies, in addition to renegotiation cases in states such as Andhra Pradesh and long payment delays seen by the sector

so far have created much confusion, the government has also provided significant support in terms of allocations and incentives.

For instance, clarification on GST procedures and their implementation for solar projects, and the quick guidance on the extension of commissioning timelines for pandemic relief as allowed by the MNRE for another five months in August 2020 were quick support measures by government entities.

Overall, the outlook for the sector is positive as the government remains focused on clean energy goals. Further, the June 2018 and July 2021 amendments by the MoP have provided a fillip for the renewable energy market in India:

- The July 2021 amendment waived off the interstate transmission charges and losses on solar power for projects that are granted extension of the SCOD on behalf of the government, provided these are commissioned no later than the extension date beyond June 30, 2025. However, as per the order dated November 23, the waiver on ISTS charges for renewable energy would be phased out gradually beginning June 30, 2025. ISTS charges levied would increase 25% annually till June 30, 2028, by when, 100% of the charges would be applicable. This would have some negative impact post the aligned period on the open access and utility interstate transactions as it would raise costs. Waiving of interstate charges also allows for large industrial consumers to offset their RPO requirements by executing long-term power purchase contracts from solar capacities located far away from the consumption centre. This will also help consumers reduce their power bills considerably, given that presently, the price of competitively bid solar projects is lower than the tariffs charged by discoms for industrial consumers.

f. Land acquisition, transmission infrastructure, and fund availability critical to successful implementation of solar projects

Following are the key constraints to solar capacity growth:

**Land availability**

Land acquisition is difficult, considering that average land holding in India is small, at 1.16 hectares (NABARD 2014); to acquire large tracts of land in a single location, many stakeholders need to be involved, which slows down the project execution pace. The central and state governments have taken the following measures to accelerate the land acquisition process.

The government has planned to prepare land banks for 40,000 MW (enhanced from 20,000 MW earlier in March 2017) of solar projects spread across 25 states in India, under its Solar Park Policy released in September 2014.

Under this policy, a state-designated nodal agency (SNA) will construct solar parks of 500-1,000 MW size each, in association with either SECI or a PSU or in a joint venture with a private developer under the PPP model. The GoI will provide budgetary support of Rs 20 lakh/MW to the entity undertaking the solar park projects with necessary infrastructure such as land, transmission, roads, drainage, water, and warehousing.

Currently, 25 states, including Andhra Pradesh, Madhya Pradesh, Gujarat, Rajasthan, Uttar Pradesh, Karnataka, Telangana, West Bengal, Chhattisgarh, Tamil Nadu, Jammu and Kashmir, and a few north-eastern states have started preparing land banks for solar parks, through either their own implementing agencies or joint ventures with SECI. As of February 2022, 56 solar parks with an aggregate capacity of 38.2 GW have been approved in 15 states.

The GoI and World Bank have signed a $98 million loan agreement and $2 million grant agreement in November 2017. The said funds will be used to fund solar park infrastructure in various states via IREDA under the MNRE’s solar park implementation scheme. The first two solar parks to be supported were in the Rewa (750 MW) and Mandsaur (250 MW) districts of Madhya Pradesh. The agency is also looking at other solar parks in the country in Odisha, Haryana, and Chhattisgarh, among other states. Previously, the World Bank

had also provided $25 million to develop the transmission infrastructure for the Rewa solar park on concessional loan terms.

**Availability of transmission infrastructure**

Large-scale, grid-connected solar plants are usually located in far-flung areas devoid of transmission infrastructure. Thus, robust transmission planning to optimise costs, utilisation levels, and losses associated with transmission systems, and transmit the power generated from the solar plants to load centres (cities and industrial areas) is critical.

The industry had been raising concerns regarding connectivity for renewable projects. Considering this, nodal agencies (PGCIL, SECI) have planned schemes to alleviate grid congestion and improve connectivity to RE projects.

The grid capacity additions will come under two main schemes, namely the Green Energy Corridor Scheme and Renewable Energy Zones (REZs), both of which, were to be implemented by fiscal 2022, but the timelines are now delayed. This would add ~80 GW of transmission grid capacity to an existing ~24 GW, taking the grid capacity planned for RE integration to ~100 GW.

The GEC scheme is aimed at developing specific evacuation corridors for renewable energy in key renewable-rich states. The government has planned to integrate renewable energy into the national grid by setting up interstate and intra-state schemes for the evacuation of power from wind and solar projects, termed as green energy corridors. The interstate component of the scheme was completed in March 2020, while the intra-state component is seeing delays in execution. A total of 8,651 ckm length of transmission lines have been constructed under the intra-state scheme as of October 2022, with Madhya Pradesh, Tamil Nadu, and Rajasthan leading the execution as per the last available information for the scheme. Additionally, the cabinet approved intra-state transmission system GEC-II to facilitate grid integration and power evacuation of ~20 GW of renewable energy power projects in Gujarat, Himachal Pradesh, Karnataka, Kerala, Rajasthan, Tamil Nadu, and Uttar Pradesh. The transmission systems will be created over fiscals 2022 to 2026.

PGCIL has also come up with a scheme for setting up grid infrastructure in identified REZs. Under this scheme, key areas with a concentration of existing/planned renewable energy projects have been identified in the country's western and southern regions. Of this, 20 GW of grid capacity will be added for solar projects in the western region and 10 GW in the southern region. These would be known as solar energy zones, and 10 GW of this 30 GW will come up in Phase I (December 2020), and the remaining 20 GW in Phase II (December 2021). However, clarity on the scheme's implementation and its progress are limited as on date.

In conclusion, these schemes provide comfort against the estimate of 80-90 GW to be added by fiscal 2027. However, the timely execution of planned capacities is key as renewable energy projects take only 1-1.5 years to come online, while transmission capacities would take 2-3 years.

However, grid stability and maintenance charges are going to be a key risk, going forward, for renewable energy projects. As of September 2022, total installed renewable energy capacity was ~118 GW out of the total ~408 GW power generation capacity in India. However, based on the units supplied, renewable energy's share amounts to only 11-12% of the total power supplied. Its share is expected to rise to 23-24% in generation by fiscal 2027, with solar generation estimated to comprise 12-13%. This may result in grid instability due to the variable nature of generation of power from renewable energy sources. Hence, renewable generation may have to be backed down to maintain grid stability.

To address the issue of grid variability, the government has started taking measures such as planning and deploying electricity generation reserves, augmenting transmission infrastructure, creating technical standards and regulations for renewable energy generators, introducing features such as low-voltage ride through (LVRT) and high-voltage ride through (HVRT), setting frequency thresholds for disconnection from the grid, and finalising regulations for active and reactive power generation. Further, the government is

planning ancillary services to support electricity grids. These services, regulations, and charges will be partly shared between generators as their direct costs and by consumers as pass-through costs.

Moreover, under/over-injection of power beyond the limits of the forecast schedule will attract penalties, which will hike grid maintenance charges. Several states have also started releasing forecasting and scheduling regulations to start the implementation of the same. This may add to costs for developers, going forward.

**Availability of funds for projects**

Given the capital-intensive nature of solar power projects, the cost of capital plays an important role in project implementation. In the past, high domestic interest rates, lower repayment tenures, and inadequate and delayed capital subsidy increased the minimum tariffs required to achieve a healthy internal rate of returns (IRR).

However, recently, a reduction in the MCLR, coupled with opening up of other financing avenues, helped players reduce their cost of capital. Further, interest rates across the globe have been declining since the pandemic hit; however, the trend reversed recently, with rates going up to fight inflation.

Over fiscal 2019 and 2020, interest rates were higher due to several macro factors at play. However, with no changes in interest rates by the RBI from the second quarter of fiscal 2021, the MCLR has remained stable after having declined sharply. The low-interest rate regime has been reversed in fiscal 2023 due to a gradual increase in repo rates by the RBI in response to increasing inflation.

Traditionally, domestic lenders have been risk-averse towards lending to the sector due to much stress witnessed in the conventional power segment and assuming the same may happen for renewable energy. Past incidents of renegotiations and delayed payments by counterparties have also caused some concern among lenders. They are also hesitant to lend due to the aggressive bidding seen previously and regulatory uncertainty prevalent in the market. However, over the past two fiscals, with a push from the government to achieve nationwide clean energy targets and ESG-related targets for lenders, funding to the segment from domestic lenders, including PSUs, has gained traction.

In addition, even foreign fund raising has seen some impact:

- A weaker rupee has also led to higher hedging costs, adding cost pressure to ECB or green bond issuances.
- Frequent policy changes and a lack of clarity on the same would make global investors wary of entering/funding the sector. This is highly detrimental to growth in the sector, which requires significant equity over the coming years to continue supporting additions.

Going forward, solar developers will have access to a broader spectrum of cheaper financing options, in addition to prudent capital management, to sustain over the long term. However, at present, fund availability may be a concern for a few projects where viability is sub-par or for those facing project implementation issues, given that the solar sector in India is still maturing.

The GoI and other financial institutions have announced the following measures to improve fund availability to support solar capacity additions.

- SBI has taken several measures to support renewables in the country. It has committed Rs 750 billion in debt funding over the next five years to 15 GW of renewable energy projects, in addition to securing $625 million of credit from the World Bank at a concessional rate to support viable grid-connected rooftop solar PV projects. The European Investment Bank has also committed to provide € 200 million at a concessional rate (LIBOR plus 0.99 percentage point) to fund solar projects under the National Solar Mission across India. Other banks and NBFCs are also actively supporting the sector, with Yes Bank, Axis Bank, and IDFC

First Bank going for bond issuances (green bonds) to procure funds for financing renewable energy in the country.

- Multilateral funding agencies such as ADB and IFC, and several other private equity funds are funding many solar projects, even at concessional credit terms.
- Government financial institutions such as PTC India Ltd, REC, and IREDA are financing many solar projects.

Many entities active in the sector are utilising diverse areas of fundraising such as green/masala bond issuances, plans to use infrastructure InvITs, and listing on global exchanges such as the Alternate Investment Market (London) or the Nasdaq to lower the cost of capital in their quest to become more competitive. An estimated $16.9 billion worth of green bonds have been raised by Indian entities till date (September 2022), raised by both corporate and financial institutions. However, the purpose of these funds is not only to fund growth capital, but also to refinance existing debt. Nevertheless, this does provide developers an option to raise lower-cost debt later in the lifecycle of assets once they are operational.

Consequently, while there are ways to lower the cost of debt for developers, players would have to actively manage the same as a rising interest rate regime and other factors, as detailed above, impact borrowing costs. This remains a key monitorable for the sector.

Other key risks to which the sector is sensitive are as follows:

- A rise in the capital cost on account of a weakening in the rupee or supply side issues, resulting in expensive imported modules (which account for 55-60% of the total capital cost)
- Further worsening of the financial health of state distribution utilities, which could lead to power offtake issues, as well as potential payment delays/defaults
- Aggressive bidding despite execution challenges

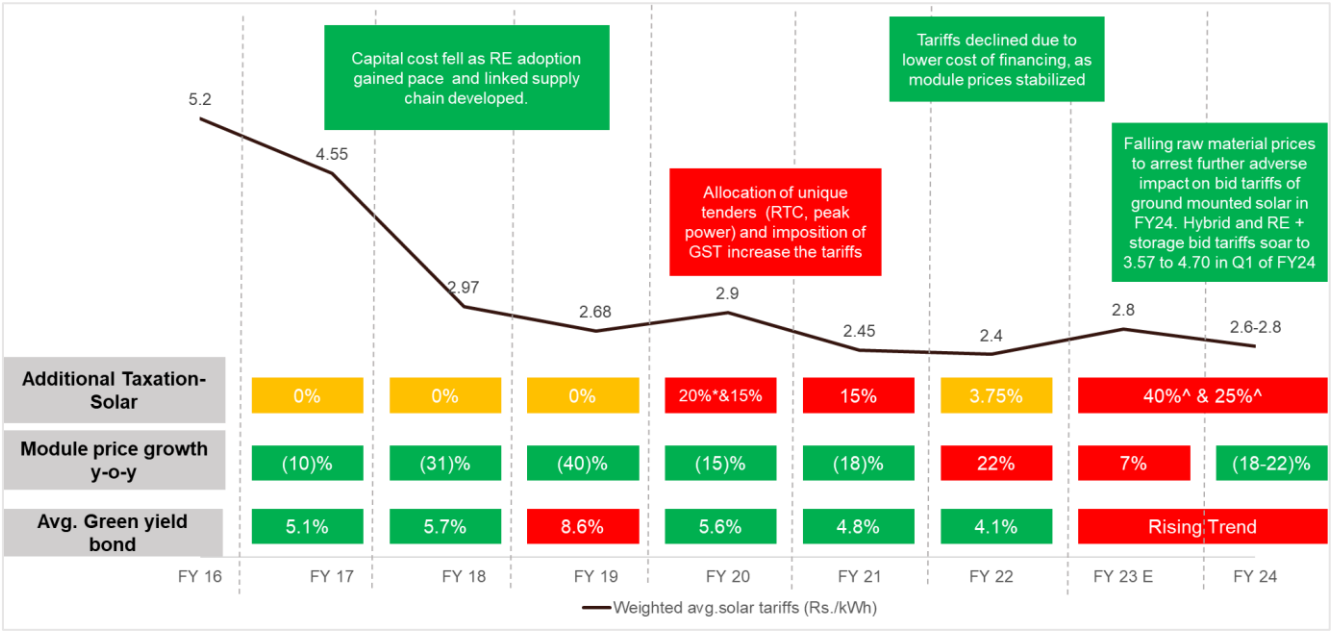
## 5.11 Outlook on levelised tariffs for solar PV power plants in India

On the pricing front, solar tariffs declined rapidly from fiscals 2016 to 2020, with a rapid fall in component pricing, technological improvements in efficiency, and the government's policy push. While declining module prices contributed to a reduction in tariffs over fiscals 2017 to 2019, access to low-cost financing was the primary driver for the decline in tariffs over fiscals 2020 to 2022, where global investments in the Indian renewable energy segment picked up via green bond issuances and external commercial borrowings, helping lower the cost of debt for the space.

The participation of global players and entities with strong credit profiles (CPSUs) has helped tariffs remain in the Rs 2.4-2.6 per unit range even until fiscal 2022, when supply-side disruptions started to emerge.

The global energy crisis, geopolitical tensions, and supply-side disruptions at key locations in China have led to a reversal in module pricing, with prices climbing to USD 0.25 per Wp in fiscal 2023 for mono-crystalline technology. The increase in module prices, coupled with policy changes impacting the sourcing of modules for new projects and the rising cost of debt in an uncertain global climate, has led to an increase in weighted average tariffs to Rs 2.79 per unit in fiscal 2023. In the first five months of fiscal 2024, tariffs for vanilla solar have fallen due to decreasing upstream and commodity prices. Prices of polysilicon, wafers, cells, as well as steel, copper, and aluminum prices, are expected to moderate in fiscal 2024, easing the pressure on capital costs. CRISIL Consulting expects bid tariffs to be in the range of Rs 2.60-2.8 per unit in fiscal 2024. A key point to note is that historically, tariffs have not risen or fallen at the same pace as the rise or fall in module prices. Therefore, despite a steep 18-22% year-on-year fall in module prices, tariffs are not expected to fall at the same pace, as EPC players and developers exercise caution.

**Figure 71: Weighted average solar tariff trend**




*Note: * Represents the duty rate for six months each in the fiscal. ^ Represents imposition of 40% and 25% BCD on solar cells and modules, respectively.*

*Source: CRISIL Consulting*

## 5.12 Outlook on open access utility scale segment

The C&I users consume ~51% of the electricity generated in India, but only a small percentage of their energy procurement comes from renewable energy sources. C&I users have emerged as an important standalone business segment in recent years in the renewable energy market, indicating their huge untapped potential. Although the present market size is small, specialised developers catering to C&I consumers have emerged with innovative business models and competitive prices. The C&I segment already accounts for 70-80% of the country's rooftop solar installations and is making headway in the utility-scale solar space as well through open access and group captive routes.

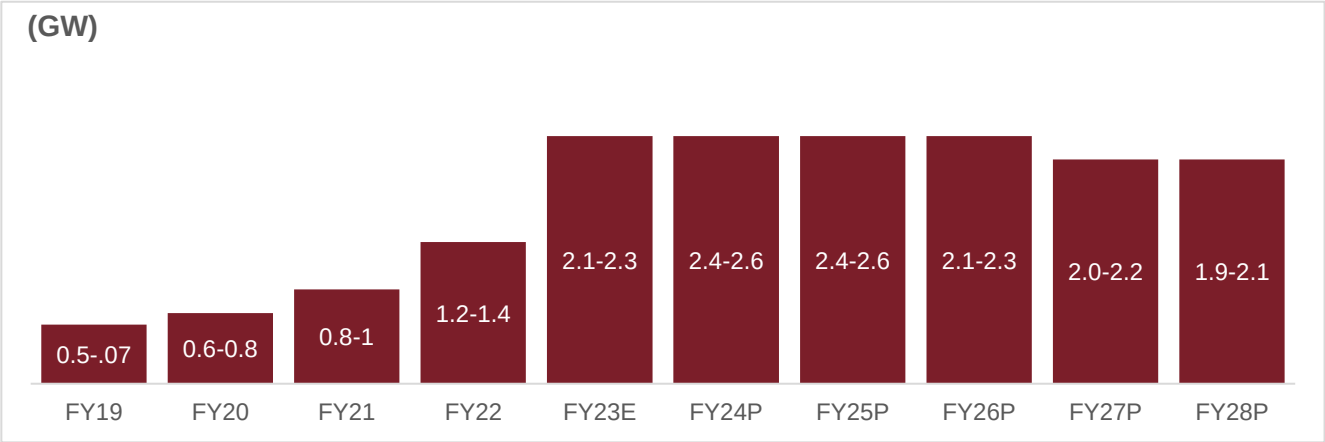
The Indian C&I solar sector added ~10+ GW over fiscals 2019 to 2023, with the total installed capacity as of March 2023 at ~17 GW. Capacity additions picked up in the last two years in response to the easing of pandemic restrictions and increasing power demand. Further, the market has gained momentum over the last few years, with consumers keen on reducing their power bills, as well as carbon emissions. Increasingly, there is also very strong interest among investors with leading independent power producers, private equity funds, and other institutional investors committing huge sums to this market.

Solar power is preferred over other renewable energy sources by C&I consumers due to its ease of implementation, versatility, and negligible operating costs. Moreover, solar power prices have declined significantly over the past few years, making it more affordable for C&I consumers. In contrast, state discoms continue to charge C&I consumers very high tariffs compared with residential and public sector consumers to provide subsidies to agricultural and below poverty line consumers. Thus, large industries across segments and commercial consumers, including metro corporations, railways, airports, hotels, and multinational corporations, can generate substantial savings by meeting their electricity requirements through solar power-based captive, group captive, and open access projects.

CRISIL Consulting expects 11-12 GW of projects to be commissioned under the open access utility segment over the next five years through 2028, led by the go-green initiatives/sustainability targets of C&I consumers, effective long-term policies in key states such as Uttar Pradesh and Maharashtra, and lower offtake risk.

Additionally, in the proposed Draft Electricity Amendment Act 2022, several progressive measures have been proposed for the solar sector, including the introduction of a pan-India RPO with a strict penalty mechanism. Discoms and other large electricity customers are obligated to purchase a specific percentage of their power from solar energy sources under these RPOs. These measures will provide a significant boost to the uptake of rooftop solar in the C&I segment.

**Figure 72: Open access utility scale capacity additions (FY24-FY28)**




*Note: Historical installed capacity is based on internal estimates. P: Projected*
*Source: Industry; CRISIL Consulting*

## 5.13 Policy support in terms of incentives for C&I capacity addition

C&I capacity addition is largely influenced by the policy and regulatory framework governing open access. Some of the policies have helped in the C&I segment's growth, whereas certain provisions have acted as obstacles to capacity addition. State-wise variations, coupled with different interpretations of provisions, has constituted a major challenge. To avoid ambiguities, the MoP has issued a few rules to provide greater clarity in various OA-related provisions.

### a. Electricity (Promoting Renewable Energy Through Green Energy Open Access) Rules, 2022

**Highlights of Green OA Rules 2022:**

- Multiple avenues (own generation, captive, open access, and from distribution licensee) provided to generate, purchase, and consume renewable energy
- Consumers having contracted demand or sanctioned load of 100 kW and above eligible to take power through green energy open access
- No limit on supply of power for captive consumers taking power under green energy open access
- A central nodal agency to set up and operate a single-window green energy open access system for renewable energy
- After registration at a centralised registry, all applications routed to the concerned nodal agency for the grant of green energy open access

- Concerned nodal agency: Short-term OA: load dispatch centre (LDC); medium-term OA: state transmission utility (STU); long-term OA: central transmission utility (CTU)
- Monthly banking allowed at least 30% of the total monthly consumption of electricity from the distribution licensee by consumers
- Charges to be levied on green energy open access consumers clearly defined
- CSS on a C&I consumer shall not be increased, during 12 years from the date of operating of the generating plant using RE sources, by more than 50% of the surcharge fixed for the year in which open access is granted
- Obligated entities can meet their RPO targets by purchasing green hydrogen or green ammonia
- Cross-subsidy surcharge and additional surcharge shall not be applicable if green energy is utilised for the production of green hydrogen and green ammonia

**b. Waiver in ISTS transmission charges**

The MoP, in August 2020, waived the inter-state transmission system (ISTS) charges and losses on all solar and wind projects commissioned before June 30, 2023. In June 2021, the waiver was extended up to June 30, 2025. However, this time, only the ISTS charges were waived off, and losses remained applicable. Subsequently, in November 2022, the waivers were amended as follows:

| RE Source | ISTS Charge Waiver | Remarks |
|---|---|---|
| Solar | Yes | Waiver available for useful life of 25 years |
| Wind | Yes | Waiver available for useful life of 25 years |
| Pumped storage hydro plant | Yes | Waiver available for 25 years, provided minimum 51% of pumping energy from wind/solar sources |
| BESS | Yes | Waiver available for 12 years, provided minimum 51% of charging energy from wind/solar sources |
| GTAM/GDAM | Yes | Only for trading energy from solar/wind/PSP/BESS in GTAM/GDAM |
| Green hydrogen | Yes | Waiver available for 8 years for green hydrogen production using solar/wind/PSP/BESS sources |

Waivers are available for projects commissioned by June 30, 2025. Hoverer, post June 2025, an annual increase of 25% in the ISTS charges will be applicable for solar, wind, hydro PSP, and BESS sources, resulting in the applicability of 100% of ISTS charges from July 2028.

Subsequently, in February 2023, it was clarified that green hydrogen and green ammonia projects would get a waiver of ISTS charges for 25 years if the projects are commissioned before June 30, 2025.

**New hydro power projects:**

The MoP has decided to extend the waiver of ISTS charges on the transmission of power from new hydro power projects, for which, construction work is awarded and PPAs are signed on or before June 30, 2025.

ISTS charges will be levied for the transmission of power from hydro power projects where construction work is awarded and PPAs are signed after June 30, 2025, as follows:

| S. No. | Award of construction work + signing of PPA | ISTS charges |
|---|---|---|
| 1. | 01-07-25 to 30-06-26 | 25% of applicable ISTS charges |
| 2. | 01-07-26 to 30-06-27 | 50% of applicable ISTS charges |
| 3. | 01-07-27 to 30-06-28 | 75% of applicable ISTS charges |

| S. No. | Award of construction work + signing of PPA | ISTS charges |
|---|---|---|
| 4. | from 01-07-28 | 100% of applicable ISTS charges |

The waiver/or concessional charges, as shown in the table above, shall be applicable for 18 years from the date of commissioning of the hydro power plants. The waiver shall be allowed for inter-state transmission charges only and not losses. The waiver would be made applicable from the prospective date.

**c. Cross-subsidy and additional surcharge**

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

## 5.14 Outlook on rooftop solar PV capacity additions in India

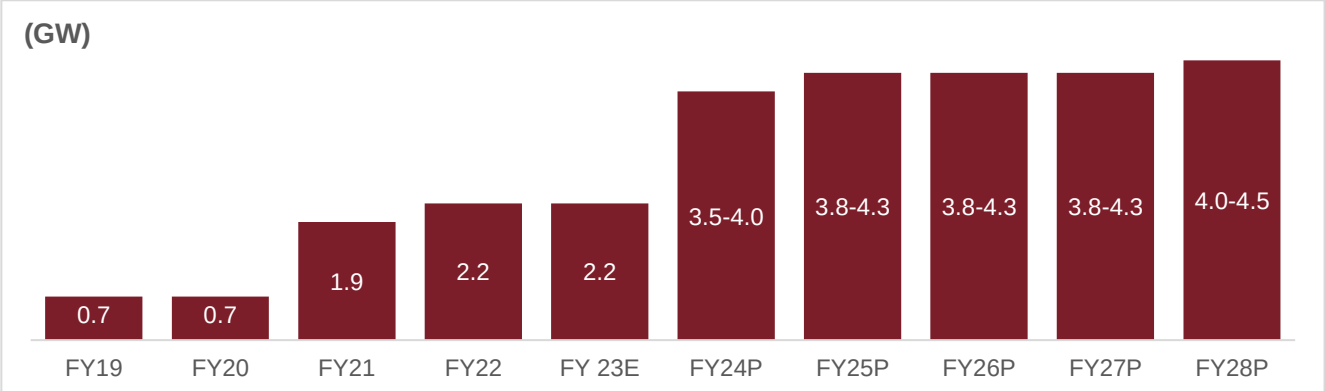
**a. Rooftop solar additions of 19-21.5 GW expected over fiscals 2024-2028**

CRISIL Consulting expects 19-21.5 GW of projects to be commissioned under the solar rooftop segment over the next five fiscals (2024-2028), mainly led by the commissioning of capacities by SECI (up to 2,000 MW); capacities allocated by state governments (1,500-2,000 MW); commissioning of 1,000-1,500 MW of capacities by government institutions such as metro, railways, and airports; 7,000-7,500 MW of capacities to be added by industrial and commercial consumers under net/gross metering schemes of various states; and 1,500-2,000 GW added by residential rooftop consumers. Furthermore, the ministry's approval for net metering up to 500 kW would provide a much-needed fillip to the sector, leading to an increase in the demand for rooftop installations. Also, the MNRE provides central financial assistance for all rooftop projects constructed by residential consumers: 70% for special category states and 30% for other states. Furthermore, to promote quicker adoption of residential rooftops, the MNRE has issued a simplified procedure for such consumers; the key highlights are as follows:

- A national single portal will be developed to register applications from such beneficiaries
- Rooftop solar plants can be installed by the consumers themselves or through any vendor of their choice
- Household beneficiaries who wish to install rooftop solar (RTS) under the new mechanism will apply on the national portal; the subsidy amount can be availed to install the RTS plant
- The beneficiaries need to install the plant within a specified period; otherwise, the application would be cancelled, and they would have to re-apply

Solar power can act as an alternative for states with high load shedding, such as Tamil Nadu, Uttar Pradesh, and Punjab, which are also serviced by diesel generator sets, and for rural areas with poor grid connectivity

**Figure 73: Projected rooftop capacity additions over fiscals 2024-2028**




*Source: MNRE; CRISIL Consulting*

**b. Concentration risk within select states and supply risk to shape additions over the next five fiscals**

Over 50% of the new capacity additions would be undertaken by Gujarat, Rajasthan, Maharashtra, Andhra Pradesh, Telangana, Karnataka, and Tamil Nadu. However, limited availability of modules with higher capacity wattage (>500 Wp) coupled with the domestic content requirement for the rooftop segment can have ramifications and impact 1-1.5 GW of rooftop additions over the next five fiscals.

On concentration of capacity, the states were analysed on the following parameters. Each parameter was assigned a weight and scored on a scale of 1 to 5. The weighted average score was computed, and a potential achievement rate was assigned to state-wise MNRE targets to arrive at the outlook.

1. **Industrial and commercial load**: Since rooftop solar is profitable for C&I consumers, states with more loads under this category are expected to witness higher additions. Thus, Gujarat, Maharashtra, and Tamil Nadu, which had over 50% annual sales in this category, will drive additions.
2. **Average tariffs for C&I consumers**: The higher the discom tariffs, the more favourable the economics of rooftop projects. Consequently, consumers in states such as Maharashtra and Tamil Nadu, where average tariffs are Rs 8-9 per unit, will drive additions.
3. **Net/gross metering regulations**: States with clearly defined regulations are more likely to attract investments in rooftop projects, as clarity in regulations (technical parameters, clearances, interconnectivity, and invoicing approvals) would result in discom officials acting swiftly on applications. Some states, such as Tamil Nadu, Maharashtra, Andhra Pradesh, Telangana, and Delhi, have covered most of the necessary parameters in their policy/regulations, while others, such as Chhattisgarh and Kerala, have not formulated detailed guidelines.
4. **Availability of feed-in-tariffs (FiTs):** FiTs are typically attractive as they are computed on a cost-plus model, which ensures healthy project returns. Delhi offered FiTs of Rs 2 per unit. In case FiTs are not available, there is a provision for supplying compensating units to a grid at the APPC. Hence, states with high APPC will be preferred, as they would help reduce the payback period.
5. **CUF**: States with higher solar irradiance and sunny days would generate more units and, hence, reduce the payback period, attracting more investments. States such as Maharashtra, Rajasthan, Gujarat, Andhra Pradesh, and Telangana have high solar radiation [Global Horizontal Irradiance (GHI) of 5.6-6.1 kWh/square meter per day) compared with states such as Kerala, Bihar, and Odisha (GHI of 5.03-5.4 kWh/square meter per day).

6. **Other regulatory charges**: Karnataka, Andhra Pradesh, and Tamil Nadu provide concessions to their C&I consumers on cross-subsidy surcharges, wheeling and banking charges, and electricity duties levied on normal open-access consumers. Hence, such states would be preferred.
7. **AT&C loss**: Discoms in states with higher AT&C losses would prefer to bring down their share of electricity supplied to agricultural and residential consumers, supporting the rooftop initiatives for such consumers.

## 5.15 Impact of large RE capacity additions on grid security

Domestic RE energy penetration varies greatly across the various states. There is vast difference in the share in RE-rich states and others. In fact, some RE-rich states have higher RE shares than those of some countries internationally. That said, the high RE penetration is causing system integration issues for certain states.

India aims to increase its non-fossil-fuel-based installed electricity generation capacity to 500 GW by 2030. RE will be at the core of achieving this target, with around 450 GW RE expected to be added by 2030. Some of the key challenges due to higher RE penetration include fluctuations in hourly demand, increasing ramping requirements, frequency, and voltage-related grid issues.

Variability affects system management as well as scheduling challenges due to the intermittency associated with RE output. As a result, RE-rich states would have to export some power to other states, back down or avoid coal-based power, and curtail RE for the sake of grid security.

Potential sources of power system flexibility, including demand-side flexibility, power plant flexibility, and storage (pumped storage hydro and batteries) and grid flexibility, should be prioritised to maximise the value of solar and wind.

India has already adopted measures to manage variability using different products, such as wind-solar hybrid tenders and energy storage solutions, including pumped hydro storage.

To enable higher RE capacity, areas with high solar and wind energy potential need to be connected to Inter-State Transmission System (ISTS) so that the power generated could be evacuated to the load centres. The gestation period of wind and solar generation projects is much lower than that for associated transmission systems, so the transmission system has to be planned well in advance.

In a significant step towards achieving the planned RE capacity by 2030, CEA has planned a transmission system for about 537 GW of RE capacity. The transmission system has been planned for major RE potential zones, such as the RE park in Leh, Ladakh; Fatehgarh, Bhadla, and Bikaner in Rajasthan; the Khavda RE park in Gujarat; Anantapur and Kurnool RE zones in Andhra Pradesh; and offshore wind farms in Tamil Nadu and Gujarat. The transmission schemes have been factored in energy storage in order to meet the requirement of RTC power. Several high-voltage direct current transmission corridors have also been planned for the evacuation of power from large potential RE zones.

## 5.16 Battery Storage and its impact on solar capacity additions

Solar energy may not always align with peak energy demand periods. The highest demand for electricity typically occurs during summer afternoons and evenings when power usage peaks. However, during these times, solar energy generation starts dipping. The generation of solar energy can be influenced by various factors such as seasonal variations, time of day, cloud cover, dust, haze, and obstacles like shadows, rainfall, snow, and dirt.

The utilization of storage technology enables solar energy to contribute to the electricity supply even during periods when sunlight is unavailable. Additionally, storage systems can assist in mitigating fluctuations in the flow of solar energy on the grid, thereby ensuring a more consistent and stable power output.

Incorporating a solar battery into a solar power system is a crucial enhancement. A solar battery plays a vital role in storing surplus electricity, which can be utilized by owners/developers during periods when solar panels are unable to generate sufficient energy.

**Technology disruptions can boost capacity addition, especially with the advent of battery storage solutions**

With India setting an ambitious target of 175 GW of renewable energy capacity by 2022, several measures have been taken to effectively integrate the high penetration of renewables into the grid. The measures include making conventional generation flexible, maintaining generation reserves, and introducing ancillary services. Though energy storage has been around for a while, its role in energy systems is starting to become important only now. On account of the rise in intermittent renewables, energy storage is needed to maintain a balance between demand and supply.

Rapid innovation and a rise in the global scale of production have helped gradually lower the prices of battery storage systems from 2011 onwards. Prospects of using battery-based storage for grid-scale projects are gaining wider acceptance amid rapid progress in battery technologies, such as lithium-ion. The technologies, which were earlier developed to support the electric vehicle industry, have elicited equal interest from rooftop solution providers on account of rising grid electricity prices and falling costs of modules and batteries.

RE projects, along with battery storage, can provide firm power supply for a longer duration in on-grid as well as off-grid applications, helping utilities and consumers meet energy requirements efficiently and, in an environment-friendly manner. Globally, deployment has already started picking up.

The introduction of battery storage in the power system network will support higher integration of RE sources, such as wind and solar, into the grid. Amid rising adoption of battery storage and maturing technology, newer business models based on storage will evolve, which will change the present market structure of electricity production and consumption.

Further, as per CEA's report on optimal generation mix 2030, the likely requirement of BESS would be 42 GW/208 GWh by fiscal 2030 and 47 GW/236 GWh by fiscal 2032 under base case scenario. To support BESS installations, the government also approved VGF scheme for 4 GWh BESS projects which would be developed by fiscal 2031. An initial outlay of Rs 9,400 crore including budgetary support of Rs 3,760 crore has been provided under the scheme. The VGF would be provided from fiscal 2024-26 and will be capped at 40% of the capital cost. As per MNRE, the cost of BESS is anticipated to be in the range of Rs 2.40 to Rs 2.20 Crore/MWh during the period 2023-26 for development of BESS capacity of 4GWh, which translates into Capital Cost of Rs 9,400 Crores.

**Table 34: Tariffs discovered in recent Energy Storage Tenders**

| Sr. no. | Tender name | Capacity (MW/MWh) | Result date | Bid allocation basis | Lowest bid |
|---|---|---|---|---|---|
| **1.** | KSEB Storage | 10 MW / 20 MWh | Jul 2022 | Capital cost bid | Rs 1.13 Mn/MW/month |
| **2.** | NTPC Storage | 500MW/3000 MWh | Dec 2022 | Capital cost bid | Rs 2.79 Mn/MWh/year |
| **3.** | SECI Rajasthan | 500MW/1000 MWh | Aug 2022 | Capital cost bid | Rs 1.08 Mn/MWh/month |

*Source: Industry, CRISIL Consulting*

Usage of battery storage is expected to be strong across the generation, transmission, and distribution segments as well as at the consumer end. The National Renewable Energy Laboratory has also forecasted a fall in the price of storage solutions, especially lithium-ion technology. The increased adoption of lithium-ion battery storage,

improvement in battery efficiency, and large-scale manufacturing are expected to decrease the four-hour utility-scale lithium-ion battery installation costs to $100-120 per kWh in 2030 from $140-160 per kWh in 2022.

**Figure 74: Projected levelised cost of four-hour lithium-ion battery technologies**


*Source: NREL; CRISIL Consulting*

Falling costs of energy storage and increase in distributed energy sources are expected to bring a paradigm shift in the way electricity is generated and consumed. Traditional business models in the electricity space are expected to evolve into a more dynamic marketplace, where consumers will become “prosumers” (producers + consumers).

Wider deployment of energy storage can benefit power utilities by improving grid performance and reliability, avoiding investments in the peaking generation capacity. More conventional sources of electricity (coal, crude oil, and gas) will be replaced with solar/wind-plus-storage systems, where storage can address variability in wind speed/solar radiation, which was the biggest impediment in making renewables the primary source of energy in the electricity value chain.

## 5.17 Impact of Energy storage solutions in countering intermittent supply of RE power

To enhance the integration of RE generation with the grid and mitigate the challenges posed by weather conditions, governments have implemented various measures. Some of these measures include:

a. Construction of Intra-State and Inter-State transmission systems for evacuation of Renewable power.

b. Setting up of Renewable Energy Management Centers (REMCs) for accurate forecasting of renewable power and for assisting grid operators to manage variability and intermittency of renewable power.

c. Innovative products like solar-wind hybrid projects, Round the Clock RE projects, RE projects with energy storage systems and supply of RE power balanced with power from non-RE sources started to reduce intermittency.

d. Implementation of Green Term Ahead Market (GTAM) and Green Day Ahead Market (GDAM) for sale of renewable power.

e. Flexibility in Generation and Scheduling of Thermal/Hydro Power Stations through bundling with Renewable power and Storage Power.

f. Notification of Energy Storage Obligation trajectory till 2029-30.

As of now, PSP and BESS are the major feasible options to store RE. The PSPs have long gestation period, and their capacity is dependent on location, however, they have longer life. On the other hand, BESS have short gestation periods, are non- dependent on location but limited by availability of minerals and technology.

The present installed capacity of PSPs in the country is 4745.6 MW and another 1500 MW capacity is under active construction.

Energy storage plays a crucial role in smoothing out the delivery of variable or intermittent resources like wind and solar power. By storing excess energy during periods of high generation, such as when the wind is blowing or the sun is shining, energy storage systems can then release this stored energy when generation is low, such as during calm or cloudy periods. This balancing effect helps ensure a more consistent and reliable energy supply, reducing dependence on immediate availability and improving overall grid stability.

Energy storage systems are not limited to supporting variable renewable resources alone. They can also play a vital role in efficiently delivering electricity for inflexible, baseload resources. When rapid changes in demand occur, requiring flexibility in electricity supply, energy storage can provide the necessary support by injecting or extracting electricity as needed. This capability allows energy storage to precisely match the load requirements, ensuring electricity is delivered efficiently and on-demand, regardless of location or time. Thus, energy storage offers versatility and adaptability, serving as a valuable asset in meeting fluctuating energy demands and optimizing grid operations.

## 5.18 Overview of Indian wind solar hybrid market

WSH is fast becoming the preferred RE option in India. Although the MNRE has not yet set a generation target, the nascent sector has received strong support from SECI and several state governments. There are two types of WSH projects — pure-play ones and those with storage. There are also projects that may come up under the government's RTC power scheme, which has a mandatory 51:49 blend of RE and thermal.

India has introduced RTC generation tenders, including hybrid tenders to strengthen clean generation combining solar, wind and storage technologies. The MNRE introduced the National Wind-Solar Hybrid Policy on May 14, 2018. The main objective of the policy is to provide a framework for the promotion of large grid-connected wind-solar PV hybrid systems and efficient utilisation of transmission infrastructure and land. It also aims to reduce the variability in renewable power generation and achieve better grid stability. As on 31$^{st}$ March 2023, Hybrid projects of aggregate capacity 6475.37 MW are under construction in the country. It is expected that India will witness ~13-15 GW of WSH capacity in the next five years ((fiscal 2024 to fiscal 2028) out of which around 6-6.6 GW will be from wind.

## 5.19 Key growth drivers

Wind Solar Hybrid segment in India is experiencing rapid growth, driven by several key factors:

- **Potential:** India has around 696 GW (120 m hub height) wind potential and around 750 GW of solar potential. Currently only around 10% of the potential is developed and balance 90% potential yet to be exploited. This provides huge opportunities for wind and solar development.
- **Geographical advantages:** India's coastline provides high wind speed as well as excellent solar potential. State such as Gujarat, Maharashtra, Karnataka, Tamil Nadu, Andhra Pradesh have excellent wind as well solar potential. Such advantage provides great opportunity for hybridisation. Depending on the project requirements, the hybrid projects can be co-located or located in different locations also making it more flexible even if natural resources are located in different places.
- **Complementary resources:** Wind and solar source complements each other. Due to their inherent characteristics, they generate power during different times of the day as well as seasons. Wind power is at its maximum during nighttime whereas solar power is available only during the day. Therefore, for 24X7 supply, they complement each other and hence WSH projects provide more reliable power and can be used for round-the-clock (RTC) supply.
- **Resource optimisation:** Co-located WSH plants can help in resource optimisation. With optimum land utilisation, infrastructure sharing, the wind and solar resources can be optimally utilised leading to better CUF

as well as cost optimisation. With energy storage facilities, the WSH plants help in better grid management and higher penetration of renewable energy into existing power systems.

- **Policy push:** Government of India's policy push has also helped the WSH segment. With increased ROP targets, VGF funding, PLI schemes, solar park schemes, simplified land allocation has helped both the resources to thrive.

## 5.20 Support policies for WSH plants

**National Wind-Solar Hybrid Policy 2018**

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

**Capacity:** A wind-solar plant will be recognised as hybrid if the rated power capacity of one resource is at least 25% of the rated power capacity of other resource.

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

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

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

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

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

**State level policies**

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

**Figure 75: State-wise WSH policies**

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

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

*Sources: MNRE, respective state policy documents, CRISIL Consulting*

## 5.21 Constraints in setting up hybrid power plants

**Lack of good sites**

WSH projects require wind and solar plants to be co-located to inject power into the same pooling station. This means the ideal location should have good irradiation and experience high wind speeds. But such locations are hard to find, especially as all major windy areas with strong grid evacuation facilities have been saturated. Hence, the industry has demanded that wind and solar plants of a WSH project be allowed to operate from different locations. This will also help bring down tariffs owing to better plant optimization levels. The only advantage of co-location is better optimization of transmission infrastructure. However, CRISIL Consulting believes the advantage from reduced tariff (when wind and solar units are located separately) is much higher than the benefit of improved transmission capacity optimization (with co-location).

**Grid balancing requirement poses implementation risks**

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

**Optimal sizing**

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

**Higher tariff**

The average tariff for WSH projects is Rs 2.6-2.9 per kWh today — higher than solar tariff, which has dropped to Rs 2.5 per kWh in recent bids, and comparable to wind tariff, which has remained sticky at Rs 2.80-2.85 per kWh. And although cross-subsidising costly wind power with low-cost solar will provide some price cushion at the lower end, the pricing needs to be attractive to make WSH competitive.

# 6 Assessment of EPC solar market in India

**Executive Summary:**

- EPC contracts help in the bankability of the project by allocation of different risks.
- Construct of an EPC contract includes scope, obligations of parties involved, representation and warranties, Force Majeure and Termination Clauses
- Features of an EPC contract includes Performance security/guarantee, Defect liability period (DLP), Retention money, liquidated damages and change of scope.
- To reduce costs, more developers are opting to carry out their own EPC rather than outsourcing to a contractor.
- Standalone, large EPC firms are diversifying their portfolio towards building their own generation capacities to stay competitive.

## 6.1 Introduction

A typical EPC solar project covers design, civil works, equipment purchase and installation, and commissioning. However, with constrained returns, the scope of an EPC solar project has been evolved and now includes O&M services also. Most of the EPC players provide integrated and customised solutions as per the client requirements through a consultative approach. Favourable government initiatives, increased demand for clean and green energy, rooftop installations by C&I Consumers have provided impetus to solar installations. The EPC services can be classified into various subcategories based on the scale and type of installations, i.e., utility scale and rooftop solar installations.

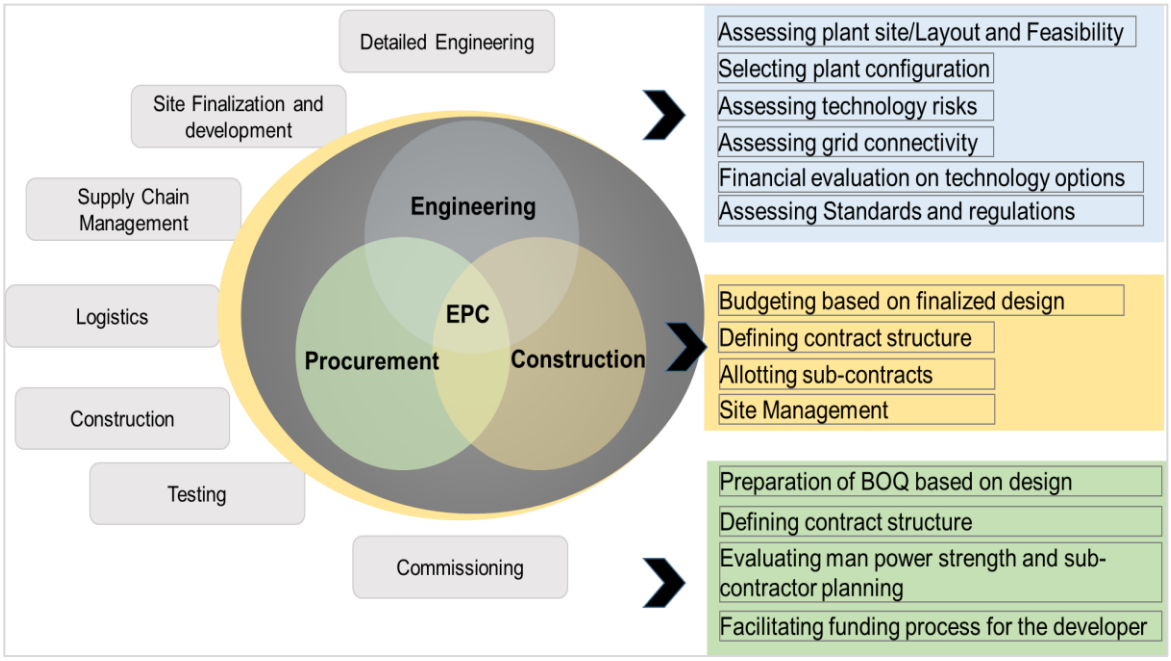
Some of the key players in EPC are Waaree Energies, Tata Power, Sterling & Wilson, Vikram Solar, BHEL, Prozeal Infra, L&T and Jakson etc. Most of these players are also present in rooftop solar installation's EPC.

The overall project works is classified as supply (material) contracts and services contracts and are awarded to different entities instead of one single EPC contractor. The capital-intensive items, such as modules, transformers, inverters and cables, covering around 75-80% of the project cost are being procured by developers. The developers enter into third-party contracts for services part, covering civil works, commissioning, erection and mounting of equipment, which forms around 20-25% of the project cost. However, some solar module manufacturers insist on buying the entire package and not just solar modules, since they also provide EPC services.

## 6.2 EPC project: Turnkey versus balance of plant

Nations, majorly developing ones, have been investing heavily on large infrastructure projects through public as well as private investments. To ensure efficient and timely construction, it is imperative to have an effective model which ensures timely project execution, minimise construction delays and improve transparency. The EPC model is primarily used in construction and O&M of solar plants.

**Figure 76: Checklist of an EPC model**




*Source: CRISIL Consulting*

Under turnkey project structure, the contractor holds full responsibility of design and execution of the works, including EPC. Therefore, the contractor makes the facility ready to be used at the turn of a key. The project must be delivered at a pre-determined time and pre-determined cost and the contractor must adhere to project specifications. In case of deviations, the contractor is liable to pay monetary compensation.

In case of balance of plant (BoP) structure, the entire project is broken into multiple packages with a major chunk contracted through EPC route and the rest through BoP. For a solar plant, solar modules and inverters constitute the maximum cost and may be contracted singularly whereas the supporting components and systems (wiring, switches, battery banks, power conditioners, mounting structures) may be procured from various manufacturers. Additionally, for the BoP project structure, the owner would have to appoint an external consultant or anoint the principal contractor for holistic project management and act as an interface between subcontractors.

## 6.3 What is an EPC contract in solar space?

Project development involves various risks such as construction risks, operational risks, legal risks, financial risks and political risks. EPC contracts are of primary importance, as they help in the bankability of the project by allocation of different risks. EPC contracting helps in the achievement of a coordinated approach among several stakeholders by establishing a single point of responsibility to the owner. In assessing the bankability of an EPC contract, investors and lenders look at a wide range of factors to assess the contract as a whole. The key features of an EPC contract are the following:

- Fixed construction price
- Fixed completion schedule
- Responsibilities and guarantees with respect to project performance and warranties
- Liquidated damages for delay and performance gaps
- Single point of responsibility on the EPC contractor
- Termination and dispute resolution

In terms of contract structuring for turnkey projects, a single contract is prepared, and the contractor owns full responsibility of the risks incidental to the project. In case of BoP projects, contracts may be structured in either of the three ways including: (a) procurement and project management services (PMS); (b) procurement only [P stage]; (c) procurement and construction [P + C stage].

a. *One 'wrapped' contract*: The solar panel supplier or the BoP contractor or an external project management consultant act as a third party and take full responsibility for coordination and delivery of the works. Such contract typically has lesser risk due to aggregation effects.

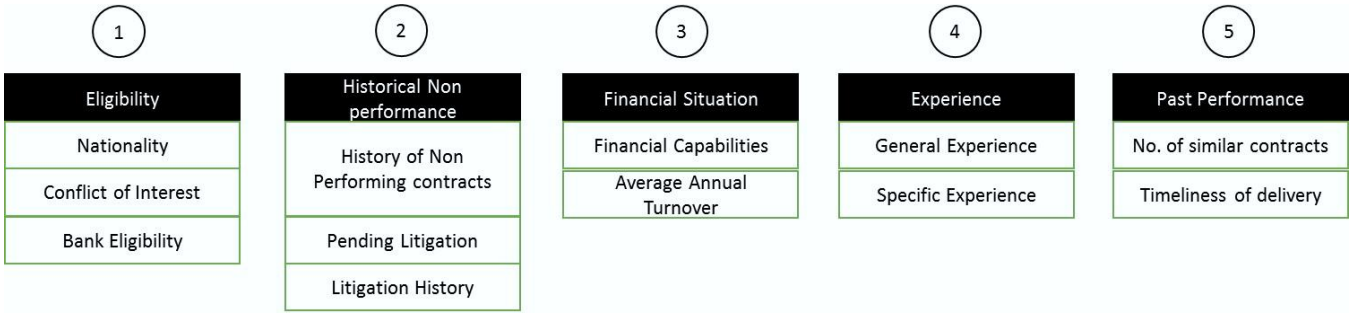
b. *Two or more different contracts (supply only):* Different components for the project are procured from different suppliers. The procurement (P stage) of BoP component is subcontracted. Potential suppliers are contacted and depending on quotations and technical specifications, works are awarded. The principal contractor is responsible for installation of the different works and deliver the plant in one piece.

c. *Two or more different contracts (Supply and installation):* Different components for the projects are procured from different suppliers and installed on site by the respective suppliers. The procurement and construction (P stage and C stage) of BoP components are subcontracted. The principal contractor monitors the works of the subcontractors. In case of noncompliance with performance specifications and /or time to delivery, the subcontractors are liable to pay liquidated damages.

## 6.4 What are the key criteria for selection of an EPC contractor?

Globally, the selection of an EPC contractor for any project is done in two stages:

- Initial selection: Using a checklist of qualification requirements and assessing the contractor on each of the points. The assessment may be done on a pass/fail basis against the criteria/ qualification requirements. Finally, the EPC contractor is selected if it surpasses the minimum pass/fail requirements.




*Source: World Bank, CRISIL Consulting*

- Once the bidder/ proposer is deemed qualified, submitted bids/proposals are evaluated. The final selection is based on the quality of the proposal and in some cases on the cost of services (as quoted).

**Methods of selection of EPC contractor:**

A. **Quality and cost-based selection (QCBS):** This is the most commonly used method, which takes into account the quality of the proposal as well as the cost of services. The technical and financial proposals are submitted by the bidders at the same time in two separate sealed envelopes. Using pre-assigned weightages on technical and financial proposals (e.g., weight assigned to technical proposal: 75%, weight assigned to financial proposal: 25%), the final weighted scores are determined. The highest final score is deemed to be the winning submission.

B. **Quality-based selection (QBS):** In this method, only the quality of technical proposals is evaluated to secure the most competent candidate. Once the best (highest ranked) technical proposal is determined, the corresponding financial proposal is opened, and the submitter is invited for subsequent negotiation of financial terms. After the conclusion of negotiations, the project is awarded to the contractor.

C. **Least-cost selection (LCS):** The winning submission is determined based on lowest-priced financial proposal. The technical proposals are evaluated only to the extent of assessing minimum technical score.

Using the two-step approach (as mentioned above), the EPC contractor is successfully selected.

The performance specification section of an EPC contract details the performance criteria that the contractor must meet. However, it does not dictate how they must be met and is left to the contractor to determine. Generally, a contract highlights technical and financial eligibility criteria for prospective bidders. It tests previous experience of contractors as well and checks for healthy balance sheets (minimum net worth/ average turnover/ average net gains).

In India, the qualification criteria also majorly consist of technical and financial requirements. The technical requirements for the contractor typically include all or some of the following

a. The bidder should have a minimum of xx MWp (This value xx is a % or higher of total bid capacity) designed, supplied, erected, supervised and commissioned of solar photo voltaic (SPV)-based grid-connected power plant(s), of which at least one plant should have been of AC xx MW (a reference number in the multiples of 5 or 10 MW depending on total project size); the reference plant must have been in successful operation for at least 6 to 12 months prior to the date of techno-commercial bid opening.

b. The bidder should be an Indian company registered in India and should be a group company / holding company / subsidiary company / JV company meeting the above requirements

c. The bids of the JV company shall only be considered in certain conditions, such as the JV formed should be firmed prior to bid submission; JV with only two partners, submit role/scope of all individual partner in JV, LoI, PO and contract agreement shall be carried out with JV company etc.

**Financial requirements typically include net worth and turnover requirements as stated below[1]:**

a. The bidder should have cumulative turnover of Rs. XXX for the past three financial years

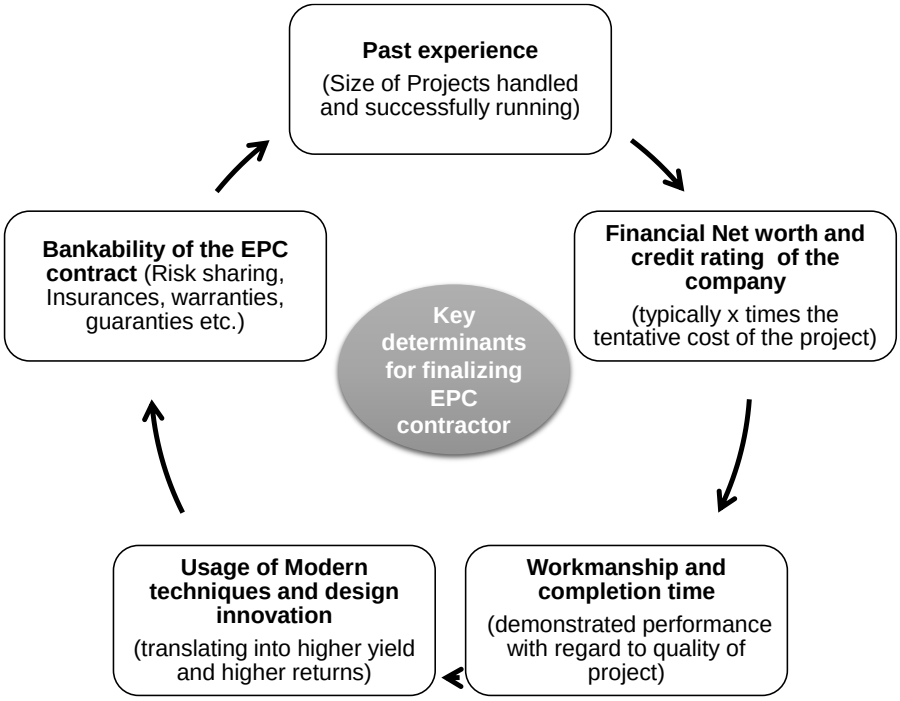
b. The net worth of the bidder during the last financial year shall be positive

c. The bidder should have a minimum Working Capital of Rs. X as per the last audited financial statement. In case of inadequate working capital, Bidder to submit letter from Bank having net worth not less than Rs. XX, confirming availability of the line of credit for more than or equal to minimum Working Capital of Rs. X.

The bidder may be required to submit a bank solvency certificate of an amount as mandated by the contract. Additionally, summarised sheets of turnover and/or financial statements of the past three years typically need to be furnished.

[1] Taken from various tenders

**Figure 77: Key Determinants for selecting EPC contractor**




*Source: CRISIL Consulting*

## 6.5 Key covenants of EPC contract

### 6.5.1 Construct of an EPC contract

**A. Scope of the project:** Defines the provisions, specifications and standards of the project that the contractor has to adhere to. In case of a solar EPC project, the scope typically consists of the following specifications:

- Aggregate capacity of the solar plant
- Type of solar plant (rooftop/ground-mounted/floating)
- Usage of battery bank (Yes/No). If yes, capacity and specifications of battery bank including model and make of battery, type of battery management systems, power condition unit
- Operation and maintenance for given number of years

Some examples of scope of work as written in EPC tenders are summarised below:

- *"Design, engineering, supply (except PV modules), construction, erection, testing & commissioning of 300 MA (AC) ground mounted solar PV project having 5 years plant O&M"*
- *Design, engineering, supply, erection, testing and commissioning of 62 MW (AC) cumulative capacity crystalline solar PV technology grid interactive solar PV power plant with associated HT overhead transmission line / underground cable along with all required electrical equipment, construction of bays up to the point of interconnection at 220kV bays including 5 years' O&M of solar power plant and evacuation system up to the point of interconnection on EPC basis"*
- *"Design, engineering, procurement & supply, construction & erection, testing, commissioning, associated transmission system and comprehensive O&M for 5 Years of 20 MW (AC) solar PV power plant"*
- *"Design, engineering, supply, construction, erection, testing & commissioning of 100 MW (AC) floating solar PV project having 10 years plant O&M"*

The scope also talks about suppliers' responsibilities for delivering equipment on site, insurance coverage covenants of materials, supervision of assembled and supplied goods, performance testing of the project,

comprehensive maintenance tenure of the project (as specified), coverage of risk liability of all personnel engaged with the project, training to O&M personnel for acquaintance of operations of the plant

**B. Obligations of the contractor:** Underlines the obligations which need to be fulfilled by the contractor, which may include all or few of the following: undertaking survey, investigation, design, engineering, procurement, construction, operation, maintenance of the solar plant. The contractor must also comply with applicable laws and applicable permits, as required, for the performance of its obligations. The section includes provisions and conditions for subcontracting works to other parties.

**C. Obligations of the authority:** Sets out the obligations of the authority, subject to receiving the performance security, towards the project like providing right of way for land, environmental and forest clearances, work permits to contractor, security on project site, implementing and/or administering safety precautions etc. Obligations of the authority majorly consist of four heads:

i. *Access and right to use of the site*: The authority grants the contractor right of access to, and make available the site to the contractor in accordance with the terms of property rights at the time of execution of the agreement

ii. *Notice to proceed*: The authority issues the notice to proceed to the contractor and the commencement date initiates thereof

iii. *Permits and real estate rights*: The contractor obtains and maintains all applicable permits necessary

iv. *Utilities*: The authority provides the facilities, components and services to be contractor, as required

v. *Safety precautions – protection of the project site:* The authority implements and administers a safety and health program for the contractor, other suppliers and contractors.

**D. Representation and warranties:** Highlights that the contractor is duly organised and validly exists under the laws of India to execute and deliver the performance obligations under the agreement. Additionally, the section warrants absence of breach of contract, absence of violation or default, injunction or decree of any court for the contractor and constitutes legal, binding obligation, enforceable and valid in a court of law.

**E. Force Majeure and Termination Clauses:** The parties (authority and / or contractor) are excused from performing their obligations if a force majeure event occurs. Such an event is beyond the reasonable control of the affected party, and the affected party could not have prevented or overcome by exercise of due diligence and has material adverse effect on the affected party. Such events include non-political events (act of God, epidemic, extremely adverse weather conditions, lightning, earthquake), indirect political events (an act of war, invasion, armed conflict or act of foreign enemy, blockade, embargo, riot, insurrection, terrorist or military action, civil commotion etc.) and political events (change in law, revocation/ refusal to renew approval, consent or exemption required by the contractor). On occurrence of a force majeure event, either party may issue termination notice or subsequently, termination payments will be payable after due assessment.

**F. Other provisions:** May include hypothecation of materials or plant provisions, liability and indemnity by the contractor, and dispute-resolution clauses

### 6.5.2 Features of an EPC contract

It is imperative to negotiate a well-defined contractual arrangement that sets out the rights and obligations of each party. In practice, lenders and investors are concerned not only about the written terms of the EPC contract, but also the ability of the EPC contractor to perform the terms of the EPC contract as per laid down norms. To shield the EPC contract from counter-party (contractor) risk, emanating from sub-par performance and/or non-adherence with contract obligations, it is standard for the contractor to include checkpoints

**1. Performance security/guarantee:** Irrevocable and unconditional guarantee for specified percentage of the contract price within ~21 to 30 days from the receipt of Letter of Award. Typically, performance guarantee is ~5 to 10% of the contract value. The performance security remains valid for a claim period after the expiry of the Defects Liability Period (DLP); explained below). The authority releases the performance security within the

claim period of the expiry of the DLP or issuance of final acceptance certificate. The authority will not be obliged to release the security until all defects identified within the DLP are not rectified by the contractor. Additionally, if a project fails to generate any power continuously for a specified time any time (as stated in the contract) during the O&M period, it may be considered as “an event of default” and the entire bank guarantee will be encashed. Any time during the tenure of the project, the nodal agency/authority reserves the right to forfeit the Performance Guarantee of the bidder, to blacklist the bidders and may also cancel the contract if the bidder is found to be providing false information regarding debarred / blacklisted or conceals the facts in this regard

2. **Defect liability period (DLP):** The period of validity of the warranties given by the contractor commencing at operational acceptance of the facilities, during which the contractor is responsible for correcting all defects and deficiencies with respect to the operation of the facilities. A Defect Liability Period may be for a duration up to the end of the O&M period or as for any duration extended by the mutual agreement of both the parties. The DLP may be extended upon repair/replacement of the facilities. At the end of the period, the contractor’s liability ceases except for latent defects (plant and equipment warranties, spare warranties, etc.).

   Typical DLP clauses from one Tender are reproduced below:
   *“The Contractor shall also be undertaking the operation and maintenance of the Facility and consequently shall be required to rectify any defects that emerge during the operation of the Facilities for the entire term of this Contract.*
   *The Defect Liability Period shall be of twelve (12) months from the date of Operation Acceptance, during which the Contractor must repair any defect identified by the Project Manager / EIC after commissioning of the Plant. All the expenses to repair the defects shall be borne by the Contractor and no additional cost charged to the Owner.*
   *If during the Defect Liability Period any defect should be found in the design, engineering, materials and workmanship of the Plant and Equipment supplied or of the work executed by the Contractor, the Contractor shall promptly, in consultation and agreement with the Owner regarding appropriate remedying of the defects, and at its cost, repair, replace or otherwise make good (as the Contractor shall, at its discretion, determine) such defect as well as any damage to the Facilities caused by such defect.*
   *Furthermore, without prejudice to the generality of the foregoing, it is clarified that the Contractor shall also be responsible for the repair, replacement or making good of any defect, or of any damage to the Facilities arising out of or resulting from any of the following causes:*
   - *Improper operation or maintenance of the Facilities by the Contractor during operation and maintenance of the Facility; and*
   - *Operation of the Facilities outside specifications of the Facilities.*

   *If the Facilities or any part thereof cannot be used by reason of such defect and/or making good of such defect, the Defect Liability Period of the Facilities or such part, as the case may be, shall be extended by a period equal to the period during which the Facilities or such part cannot be used by the Owner because of any of the aforesaid reasons. Upon correction of the defects in the Facilities or any part thereof by repair/replacement, such repair/replacement shall have the defect liability period of twelve (12) months from such replacement.*
   *Latent defect liability: Notwithstanding, the defect liability period of 12 months above, the plant shall carry a latent defect liability of 5 years from date of operational acceptance towards any design/ manufacturing defects in the equipment supplied by the Contractor”*

3. **Delay liquidated damages (DLD):** The contractor is mandated to complete the facilities/ project pursuant to the time of completion. Typically, the timeline for the project is clearly highlighted in the contract and indicative milestones are mentioned.
   The table below is a snippet of the project timelines:

**Table 35: Typical project timelines**

| Stage | Reference from Zero Date ("D") |
|---|---|
| Handing over of project land. | Zero Date (D) |
| Site development work | D+45 days |
| Approval of all major drawings | D+100 days |
| Completion of civil works | D+150 days |
| Completion of supply of equipment | D+270 days |
| Installation of all equipment & Interconnection of all equipment and completion of installation | D+330 days |
| Achievement of Commissioning with entire contracted capacity | D+365 days |

*Source: Various Bid documents, CRISIL Consulting*

If the contractor is unable to achieve operational acceptance within the stipulated time, it is liable to pay liquidated damages for the delay as mentioned in the contract. Different types of pf DLD clauses are reproduced below:

- *"Subject to Force Majeure Clause, if the Contractor fails to comply with the Time for Completion /successful commissioning or any extension thereof of Plant facilities in accordance with timelines as mentioned under the SCC, then the Contractor shall pay to the Owner a sum equivalent to half percent (0.5%) per week of the Contract Price for the whole of the facilities as liquidated damages for such default and not as a penalty, without prejudice to the Owner's other remedies under the Contract subject to the maximum limit of five percent (05%) of Contract Price for the whole of the facilities……."*
- *"If the contractor fails to maintain the required progress in terms of the agreed time and progress chart or to complete the work and clear the site on or before the date of completion of contract or extended date of completion, he shall without prejudice to any other right or remedy available under the law to the company on account of such breach, pay as compensation/ Liquidated Damages @ half percent (1/2%) of the contract price per week of delay. The aggregate of such compensation/ compensations shall not exceed 10 (ten) percent of the total value as shown in the contract……."*
- *"In case of contractor fails to achieve milestone no.2 (Supply milestone) by the due date indicated in "Time of Completion' then the Owner shall levy the Liquidated Damages on the Contractor at the rate of 5% of total supply price (Milestone no.2) inclusive of taxes.*

  *In case the Contractor fails to achieve Milestone no.1, 3, 4 & 5 by the due date indicated in "Time of Completion' then the Owner shall levy the Liquidated Damages on the Contractor at the rate of 1.0% (one percent) per week of delay or part thereof, subject to a maximum of 5.0% (five percent) of total contract price inclusive of taxes (exclusive of O&M cost).*

  *LD amount will be inclusive of taxes. Also Goods & Service Tax (GST) if applicable on Liquidated Damages (LD) as per GST Law, shall be recovered from any due claim OR payment to the EPC Contractor……."*

4. **Performance liquidated damage (PLD):** Performance guarantees are backed by the output, efficiency and reliability of the project, as defined in the scope. Post operational acceptance and until the expiry of the O&M period, the bidder would be required meet the specified conditions in the contract. This may include performance requirements, minimum generation requirements, etc. In case of non-compliance, the bidder is liable to pay compensation in the form of liquidated damages. PLD is generally calculated on the basis of loss in energy incidental due to deviance. Different types of pf DLD clauses are reproduced below:

- *"If in any case the net actual units (kWh) generated for a year is below the quoted Guaranteed Electrical Energy Generation and up to 2% below quoted Guaranteed Electrical Energy Generation, the Contractor shall be liable to a penalty to the extent of 50% of the loss in revenue…*
  *Further if net actual units (kWh) generated is beyond 2% below quoted Guaranteed Electrical Energy Generation, the Contractor shall be liable to a penalty to the extent of 100% of the loss in revenue…."*
- *"Compensation for shortfall in Generation during O&M Period for the project: Shortfall in Generation x per unit rate"*
- *"If for any Contract Year, it is found that the 'Actual Delivered Energy' is less than 'Base NEEGG for the particular year, the Contractor shall pay the compensation equivalent to INR (PPA rate x 1.25) per kWh shall be charged for the under-generation."*

5. **Change of scope:** The authority may require the contractor to make modifications/alterations to the works before the issue of completion certificate. The contractor may be instructed or requested to make the change of scope involving additional cost or reduction in cost. After determining the time and money for the desired change, a change of scope notice will be issued to the contractor, highlighting modifications in design and/or construction, etc. However, both parties must mutually agree with the proposed changes.

### 6.5.3 Highlights of contract construct for BoP solar projects

a. **Construction scope and timelines:** A turnkey or full wrap agreement (E+P+C) places full responsibility on the contractor from start to finish, including design, supply, construction, and warranty of the solar plant. However, in many cases, the developer may enter into separate agreements, one for the principal component supply (solar panel) [installation inclusive/ exclusive] and others for procurement and installation of miscellaneous services. The BoP contracts with different equipment suppliers must be matched in major covenants: (a) delivery, (b) project completion, and (c) product and service warranties. The agreements must be aligned with each other such that the different component suppliers work in tandem to ensure completion of the plant on time. Delay at any one of the suppliers' end may jeopardise timely completion. Therefore, scope of work in the BoP agreements needs to clearly highlight timelines and design specifications to ensure standardisation and optimisation.

b. **Startup obligations:** In a typical contract, payments are scheduled depending on achieving specific milestones towards project completion. In a BoP project structure, the owner entrusts a consultant or the major contractor or the individual parts supplier to start and commission the products it supplies. Therefore, performance guarantees, retention money (for claims, repairs, liens) and payment schedules for each party need to be added in the different agreements. The parties may negotiate milestones to manage vendor specific risks and contingencies.

c. **Performance guarantees and warranties:** Warranties obligations for different parties will be to the tune of the service provided. If a contractor is supplying parts and installation services to the solar plant, the owner/developer typically has the right to assert direct claims for the warranties provided by the sub-contractors. In case the contractor is providing only installation services, warranties are limited in scope relative to an equipment provider. Therefore, the nature and scope of performance guarantees and warranties differ depending on the nature of work sub-contracted to the relevant party. The major differences may include: (a) term of the warranty, (b) type of defect covered in the warranty, (c) warranty limitations, and (d) remedial measures to be taken by the contractor/ sub-contractor in case of defects. The project developer may also include a pass-through clause such that all warranties obtained by the contractor with respect to any parts and systems used in the systems are assigned to the developer.

**Table 36: Summary of standard market practices in the solar EPC Industry**

| Sr. No. | Key determinants under the EPC contract | Tentative ranges based on the industry |
|---|---|---|
| **1** | Performance ratio | 75-80% |

| Sr. No. | Key determinants under the EPC contract | Tentative ranges based on the industry |
|---|---|---|
| **2** | Warranties and guarantees on solar modules and inverters | 5–10-year warranties on solar Inverters<br>Performance warranty on PV modules for peak output wattage, >= 90% at the end of 10 years and 80-85% at the end of 25 years) |
| **3** | Warranties and guarantees on balance of plants | To be provided by the EPC contractor (or under pass through) |
| **4** | Liquidated damage costs /delay penalties | ~0.5% to 1% per week of the Contract Price subject to the maximum limit of 5% to 10% of Contract Price |
| **5** | Advance bank guarantees | ~10% of the contract value, to be released within three months of the end of the contract/tenure |
| **6** | Insurance cost | Can be a part of the EPC contract (*To cover execution risk*) or taken separately by the developer (g*eneration loss due to grid unavailability)* |
| **7** | Power during construction | To be provided by the developer *(grid interconnection)* or EPC contractor *(diesel-based power)* |
| **8** | Liasoning and regulatory approvals | The responsibilities can be shared or can be taken up by either of the parties |

*Source: CRISIL Consulting*

## 6.6 Project execution using in-house EPC vs outsourcing to specialised EPC players

The Indian solar market has been booming, with capacity additions rising to average ~9000 MW in the past five years (fiscals 2019-23) from 780 MW in fiscal 2013. Several projects have been commissioned under the central schemes of NVVN Tranche 1 and JNNSM Phase II and Batch III. Complementary central and state government policies coupled with the increasing price competitiveness of solar power has led to a surge in solar installations. However, declining module prices and aggressive competitive bidding on the part of players has led to lower solar power tariffs. This has constrained margins for EPC players. To reduce costs, more developers are opting to carry out their own EPC rather than outsourcing to a contractor. Project developers are becoming system integrators, thereby providing holistic turnkey solutions. Standalone, large EPC firms are diversifying their portfolio towards building their own generation capacities to stay competitive. Smaller EPC firms without the financial prowess for project development are vertically integrating into captive projects and rooftop installations.

Following are some of the key considerations while making decisions.

- Size and complexity of the project
- Budget
- Timelines
- Own level of expertise
- Desired level of control over project

### 6.6.1 Pros and cons of different business models

| Factor | In-house EPC | Outsourcing to large, specialised EPC contractors |
|---|---|---|
| **Equipment costs** | 1. Players are likely to get bulk discounts on the prices of solar modules and inverters only if the project size of the developer is large enough (for the equipment supplier, typically | 1. In the case of turnkey EPC contracts, players with large order books benefit from bulk buying/import of components such as modules and inverters. Hence, they can |

| Factor | In-house EPC | Outsourcing to large, specialised EPC contractors |
|---|---|---|
| | >100 MW size). Hence, offering deep discounts is a challenge.<br><br>2. Availability of equipment financing possible only for large capacities and long-term relationship/tie-ups. | quote competitive rates, with minimal impact on margins.<br><br>2. Most large EPC players get the benefit of equipment financing from the module/inverter supplier. |
| **Project management and timelines** | 1. Project development and meeting deadlines in the case of in-house EPC projects could be a challenge for relatively new and smaller players in the market.<br><br>2. In-house EPC players tend to sublet more of their work to smaller contractors resulting in elongation of project completion deadlines. | Led by varied experience across various geographies, project sizes and teams, project management is smoother. Likelihood of timely project completion is higher owing to better supply chain management. |
| **Warranties, guaranties/ Spare part availability** | The developer and O&M contractor bear the entire risk arising due to loss of generation led by multiple technical factors. However, it can be controlled by reducing the replacement time of faulty equipment. The problem is aggravated since major components such as solar modules and inverters are imported, resulting in higher lead time.<br><br>Hence, in the case of in-house EPC projects, O&M contractors are appointed | As large EPC contractors also provide warranties and guarantees post commissioning, the lead time for spare parts to be available at the site is less. This reduces generation loss, especially in the peak power generation summer season. |
| **Risk diversification** | Although the solar industry is growing, it is still prone to volatility and uncertainty. Solar panels, the major component for a solar plant, are still majorly imported and susceptible to price fluctuations and local taxes (anti-dumping duty, safeguard duty). With capital costs as well as tariffs coming down due to maturing of the market and rise in competitors, solar project margins have also been coming down. In such a scenario, being vertically integrated across development and EPC contracting gives a company more scope to diversify risks and secure finance. | EPC players aim at playing with scale and cost to improve margins. However, with the top line for the companies falling on a per-project basis (developers not keen to raise EPC and O&M costs), stagnation tends to set in. Most EPC players have already reduced costs by taking strong efficiency measures and more breathing room is unlikely. This leads to risk aggregation and any untoward volatility in the market may distort margins. |
| **Horizontal expansion** | Horizontal expansion is restricted to the tune of business expansion. | In order to grab larger market share in the business, large and established EPC players foray abroad. With the emergence of international markets in the solar sector such as Africa, Middle East, South east Asia, and South America, these players are building upon efficiency and low-cost capabilities to win tenders and augment portfolios. |

| Factor | In-house EPC | Outsourcing to large, specialised EPC contractors |
|---|---|---|
| **Firm sustenance and continuity** | With solar development coming closer to EPC and concept-to-commissioning being offered in one suite, project developers will build on in-house solutions. However, merger deals for vertical integration are unlikely and companies would prefer investing in building in-house capabilities rather than buying specialised EPC firms | With the solar sector in India maturing, the sector may see consolidation and merger deals. With pricing pressures and thinning margins, only large and specialised EPC players are likely to remain in business. Bigger players like Sterling Wilson, Mahindra Susten, and Tata Power Solar will continue to have a strong market presence. However, small firms may not be able to sustain due to lower margins. |

| | |
|---|---|
| | Cons |
| | Pros |
| | Cannot be ascertained |

# 7 Overview of solar module manufacturing

**Executive Summary:**

- China's role in solar PV supply chain has become more critical as it holds more than 75% of cells and module lines, leading to high dependence from a global supply chain perspective.
- Global solar PV manufacturing capacity is projected to approach nearly 1000 GW by 2024 a capacity sufficient to cater to the expected annual demand of nearly ~650 GW by the year 2030 as projected by International Energy Agency (IEA).
- Currently, the solar PV market is predominantly dominated by monocrystalline silicon technology; in future more advanced cell designs such as heterojunction (HJT), TOPCon, and back contact will gain greater market shares
- Global solar PV manufacturers are present across the PV value chain, and operate on a larger scale; hence, enjoy significant cost advantages.
- India's solar PV manufacturing capacity to reach 90-95 GW by fiscal 2028 from 39.5 GW in fiscal 2023
- It is estimated that only 1/10 of the domestic demand to be import reliant by FY28
- Exports are expected to remain high between fiscal 2024 and 2028, reaching 25 GW
- Due to sharp decline in module prices, stabilisation of raw material prices and logistics costs, average module prices to remain in the range of $0.15-0.16 per Wp in CY2023 for mono-crystalline, lower than CY2022 prices.

## 7.1 Overview of Global PV Module manufacturing

Over the past decade, there has been a significant geographical transformation in solar PV manufacturing capacity and production. China reinforced its dominant position as a manufacturer of wafers, cells, and modules by increasing its share of global polysilicon production capacity nearly three times. China's role in supply chain becomes more critical as it holds more than 75% of cells and module lines, leading to high dependence from a global supply chain perspective.

In terms of wafers, China faces minimal competition as it dominates the manufacturing sector. However, when it comes to cells and modules, Southeast Asia, particularly countries like Vietnam, Malaysia, and Thailand, possesses significant manufacturing capacity. These countries have emerged as key players in cell and module production, offering strong competition to China in this segment of the solar PV industry.

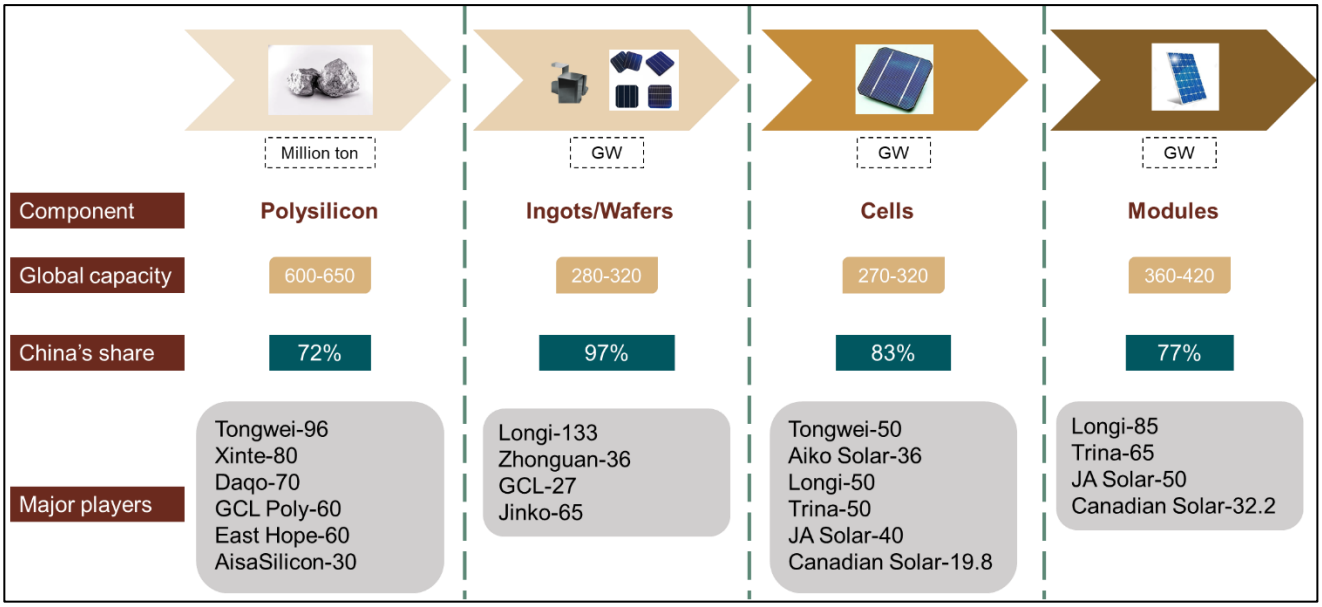
Germany maintains its status as a major supplier of polysilicon for the crystalline silicon (c-Si) PV module industry. In addition to Germany, the United States and Japan also possess significant polysilicon manufacturing capacity. However, these countries primarily focus their production on semiconductor-grade products, rather than specifically catering to the PV industry.

Module assembly in the solar PV industry has a relatively diversified geographic distribution. However, it is important to note that the majority of inputs required for module assembly, such as wafers, cells, and other components, are manufactured in China. Despite the diversified assembly locations, China remains the primary source for the manufacturing of essential PV components.

Having integrated solar PV manufacturing plants that produce wafers, cells, and modules all under one roof have certain advantages such as improved efficiency and cost reduction. With reduced transportation costs and economies of scale, these plants can optimize their production flow and have better quality control. Integrated solar

PV manufacturing plants also provide greater flexibility and supply chain security. The manufacturer can respond to changes in demand efficiently, dependence on external suppliers gets reduced and with access to advanced technologies, it can certainly gain competitive advantages in terms of quality as well as price.

**Figure 78: China's share in solar value chain**




*Source: Company websites, CRISIL Consulting*

First mover advantage combined with technological development under various incentive programs, has helped large scale integrated manufacturing base to be set up in China. Chinese dominance can be expected to continue as players such as Jinko are looking to expand their capacities more than 1.5 times, while polysilicon manufacturers such as Xinte have already booked orders for next 3-5 years for a facility yet to commission.

Over the past decade, China has emerged as the top destination for solar PV manufacture as a result of favourable government policies, continuous innovation and accelerated investments in the segment, surpassing Europe, Japan and the United States. Global PV shipments during 2022 crossed 300 GW, of which the top 10 players, including LONGi Solar, Trina Solar, Jinko Solar, accounted for a share of ~ 80% in shipments.

The global solar PV manufacturing capacity is projected to approach nearly 1000 GW by 2024 a capacity sufficient to cater to the expected annual demand of nearly ~650 GW by the year 2030 as projected by International Energy Agency (IEA). In 2022, global solar PV manufacturing capacity increased by over 70% to reach almost 450 GW, with China accounting for over 95% of new facilities throughout the supply chain. Governments in the US, Europe and India have already begun to prioritise solar PV supply chain diversification, implementing policies such as India's PLI scheme and the US IRA to provide direct financial incentives for domestic manufacturers to increase their competitiveness with Chinese counterparts. These country specific measures are expected to boost manufacturing capacities across the countries and would result in meeting the global demand by 2030.

Over the past decade, China has emerged as the top destination for solar PV manufacture as a result of favourable government policies, continuous innovation and accelerated investments in the segment, surpassing Europe, Japan and the United States. Global PV shipments during 2022 crossed 300 GW, of which the top 10 players, including LONGi Solar, Trina Solar, Jinko Solar, accounted for a share of ~ 80% in shipments.

**Table 37: Comparative summary of global module manufacturers**

| Parameter | LONGi Solar | Trina Solar | Jinko Solar | JA Solar | Canadian Solar | Risen Energy |
|---|---|---|---|---|---|---|
| **Number of manufacturing factories** | 8 in China | 4 in China, 1 each in Thailand and Vietnam | 14 in China, Vietnam, Malaysia and USA | 12 in China and Vietnam | 20 in Canada, China, Brazil, Thailand and Vietnam | 4 in China, 1 in Malaysia |
| **Experience in PV module manufacturing** | 23 years | 26 years | 17 years | 18 years | 22 years | 21 years |
| **Operational Capacity 2015** | NA | 5.1 GW Modules<br>3.7 GW Cells | 4.7 GW Modules<br>3.0 GW Cells | 4.0 GW Modules<br>4.0 GW Cells | 4.3 GW Modules<br>2.7 GW Cells | NA |
| **Operational capacity (As on Dec-22)** | 85 GW modules<br>50 GW cells<br>133 GW wafers | 65 GW modules<br>50 GW cells<br>7 GW trackers | 70 GW modules<br>55 GW cells<br>65 GW wafers | 50 GW modules<br>40 GW cells<br>40 GW wafers | 32.2 GW modules<br>19.8 GW cells<br>20 GW wafers | 25.1 GW modules |
| **Under-construction capacity** | 130 GW modules<br>160 GW cells<br>290 GW wafers | 30 GW modules<br>25 GW cells<br>6.5 GW wafers | 20 GW modules<br>20 GW cells<br>10 GW wafers | 20 GW modules<br>30 GW cells<br>30 GW wafers | 42.2 GW modules<br>40.2 GW cells<br>30 GW wafers<br>30 GW ingots | 16 GW modules<br>19 GW cells |
| **Product shipments (CY 22)** | 42.5 GW wafers<br>46.1 GW modules | 43.1 GW modules | 44.5 GW modules, 2.1 GW cells and wafers | 39.8 GW modules and cells | 21.1 GW modules | 16 GW modules |
| **Key Products and services** | Solar PV modules, wafers, solutions for | Solar PV modules, solar trackers, utility | Solar PV modules, energy storage | Solar PV modules, energy storage | Solar PV modules, energy storage, inverters, EPC | Solar PV modules, energy storage systems, EPC services |

| Parameter | | LONGi Solar | Trina Solar | Jinko Solar | JA Solar | Canadian Solar | Risen Energy |
|---|---|---|---|---|---|---|---|
| | | C&I, utility, and rooftop use | solutions, EPCM services | systems, C&I and rooftop solutions | systems for domestic and C&I use | | |
| **Ky Technologies offered** | | TOPCon, Mono PERC, bi-facial module, half-cut cells | Bi-facial PERC, TOPCon, HJT, half-cut cells | Half-cell, bi-facial and tilling ribbon technologies, PERC and TOPCon | TOPCon, Mono PERC, bi-facial module, half-cut cells | TOPCon Bifacial and Monofacial, HJT modules, Dual Cell PERC, | Mono PERC, bi-facial PERC, bi-facial HJT modules, TOPCon |
| **Key Financials (CY 22)** | **Revenue** | $19.3 bn | $11.9 bn | $12.1 bn | $10.2 bn | $7.5 bn | $4.2 bn |
| | **Net profit** | $2.2 bn | $515.3 mn | $226.9 mn | $774.6 mn | $298.6 mn | $136.5 mn |

*Source: Company websites, CRISIL Consulting*

While China dominates solar PV manufacturing, the United States and the European Union have also emerged as global PV hubs. The US imported ~75%% of its cells and modules requirements from Southeast Asian countries namely, Malaysia, Thailand, Vietnam and Cambodia. In order to reduce dependence on imported products, the government announced several measures such as anti-dumping duty on shipments from China and Taiwan, 18% safeguard duty on cells and modules, as well as the passing of the Inflation Reduction Act (IRA) in 2022. US PV module production stood at ~5 GW in 2022 and the Department of Energy has targeted an integrated manufacturing capacity of 50GW by 2030. In order to achieve this goal, several key players have announced their expansion plans as follows:

**Table 38: Planned capacity additions for PV module manufacturing in US**

| US Market | PV Capacity Addition (GW) | Year of Commissioning |
|---|---|---|
| **Q Cells** | 6.7 | 2024 |
| **SPI Energy** | 4.7 | 2024 |
| **First Solar** | 4.4 | 2025 |
| **3Sun** | 3.0 | 2024 |
| **Toledo Solar** | 2.8 | 2027 |
| **Mission Solar** | 0.7 | 2024 |
| **Meyer Burgur** | 0.4 | 2024 |
| **TOTAL** | **22.7** | |

*Source: Company websites, CRISIL Consulting*

The European Union is another key destination for module manufacture with a target to reach 30 GW solar module production by 2025, from its current capacity of 9.4 GW. As per announcements by key manufacturers, 15-20 GW of expansion is expected for modules, cells and wafers/ingots each, in addition to 30 GW of polysilicon manufacture by 2025. Expansion plans for cell and module manufacture by major players are given below:

**Table 39: Planned capacity additions for PV module manufacturing in EU**

| EU Additions | Modules (GW) | Cells (GW) | Year of Commissioning |
|---|---|---|---|
| **MCPV** | 6.0 | 6.0 | 2025 |
| **CARBON Solar** | 3.5 | 5.0 | 2025 |
| **Oxford PV** | 1.9 | 1.9 | 2024 |
| **Astrasun Solar** | 1.2 | 1.5 | 2024 |
| **Meyer Burgur** | 2.8 | - | 2024 |
| **Enel 3Sun** | 2.8 | - | 2024 |
| **FuturaSun** | 2.0 | - | 2024 |
| **SoliTek** | 0.6 | - | 2024 |
| **Voltec Solar** | 0.2 | - | 2023 |
| **TOTAL** | **21.0** | **14.4** | |

*Source: Company websites, CRISIL Consulting*

**Global solar capacity additions will be largely policy driven across key markets:**

**China:** NEA's "Guideline on Energy Work In 2023" targets to increase China's installed capacity of wind power and photovoltaic power by 160 GW over the year. Capacity additions will further be driven by $140,000 allocated to support feed-in-tariff (FiT) based projects, R&D programs & fiscal incentives.

**USA:** The extension of production tax credit (PTC) and investment tax credit (ITC) proposed by US government is envisaged to promote capacity additions. However, the planned phase out of tariffs on solar imports from China and full restrictions on imports from Xinjiang region, remain monitorable. The IRA aims to reduce domestic inflation and established an Advanced Manufacturing Production Credit to promote domestic manufacture of solar modules and its components offering solar tax credit of 30% till 2032.

**Japan:** Latest feed in tariffs unveiled in February 2022 were reduced from before and may cause capacity additions to slow down or even stagnate.

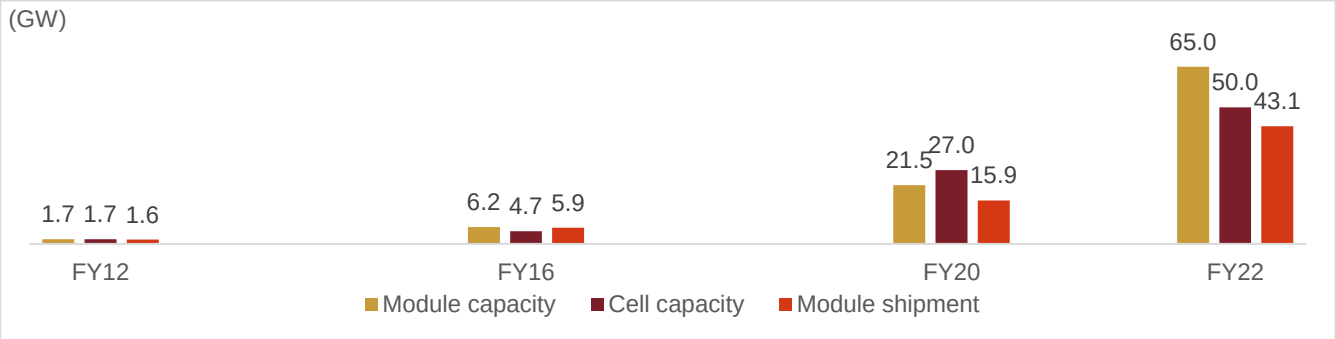
**Germany:** It is expected to record 4-5 GW of capacity additions annually, which may increase as the government is looking to move away from gas-based generation owing to geopolitical factors. Additionally, removal of cap on solar subsidies may also bolster capacity additions.

## 7.2 Case study of Trina Solar

Trina Solar was founded in 1997 in China. The company initially started as a small manufacturer of solar PV modules and systems. During its early years, Trina Solar focused on research and development to improve the efficiency and cost-effectiveness of solar panels. Subsequently, the company got engaged in the production and sales of PV modules, power stations and system products, PV power generation, O&M services.

As of 2022, the Company has 7 manufacturing bases spread across 3 countries and has 65 GW of module production capacity and 50 GW of cell production capacity cumulatively. The manufacturing capacity of solar cells and modules has increased at CAGR of 40% and 44%, respectively, over the past 10 years. The annual shipment has also increased to 39% CAGR over the same period. The total module shipment exceeded 140 GW as of March 2023.

**Figure 79: Solar module and cell production capacity**




**Key Milestones and growth drivers for scaling up the manufacturing portfolio:**

**Technological Innovation:** Trina Solar has consistently invested in research and development to enhance the efficiency of its solar panels. They were one of the first companies to mass-produce high-efficiency solar panels, which helped them gain a competitive edge in the market.

**Global Expansion**: In the mid-2000s, Trina Solar expanded its reach beyond China and started exporting its products to international markets. The company established a presence in Europe, the United States, and other parts of Asia. This global expansion strategy allowed them to tap into growing solar energy markets worldwide. It has set up regional headquarters in various parts of the world.

**Vertical Integration:** Trina Solar adopted a vertically integrated business model. The Company has announced 6.5 GW of silicon wafer facility in Vietnam This integration helped ensure quality control and cost-efficiency, making them competitive in the global solar market.

**Technological Advancements and investments in R&D:** The company continued to invest heavily in research and development, striving to produce higher efficiency solar panels and reduce the cost of solar energy. Trina Solar was an early adopter of advanced solar technologies, such as Mono PERC, Bifacial, HJT and TOPCon modules. These innovations improved the efficiency and performance of their solar panels which help them remain competitive in an evolving market.

**Market Leadership:** Through continuous innovation, a strong commitment to quality, and a competitive pricing strategy, Trina Solar gained a reputation as a leading solar PV manufacturer. The Company has a strong presence

of 15-18% in global market share as of 2022 based on module shipments. This leadership position helped them secure partnerships with major solar project developers and utilities worldwide.

**IPO and Global Recognition:** In 2006, Trina Solar went public on the New York Stock Exchange (NYSE). This move not only provided capital for further expansion but also increased their global visibility.

Trina Solar's success story is a testament to the company's dedication to innovation, quality, and sustainability. Their journey from a small firm to a global leader in the solar industry demonstrates the potential for companies in the renewable energy sector to scale up and contribute to the global transition toward clean energy solutions.

## 7.3 Global technology trends

In 2020, COVID-19 and subsequent lockdowns posed considerable challenges globally. Despite the slowdown, PV deployment will continue to flourish due to its competitive cost. Solar technology is evolving every year and prices of modules are decreasing, both monofacial and bifacial modules. As a result, bifacial modules are preferred even in utility-scale projects. The global PV industry is moving towards monocrystalline cell technology from polycrystalline cells. The share of monocrystalline technology is now about 84%[2] (compared with 66% in 2019) of total crystalline silicon (c-Si) production. The performance ratio has also been improved in the 80-90% range. The c-Si segment is expected to grow substantially due to c-Si's long life and light weight. Monocrystalline solar PV panels possess high efficiency, and hence, preferred.

The future of PV modules is heavily reliant on technological innovations. Innovation plays a vital role in driving technological advancements throughout the clean energy supply chains. Within the solar PV sector, continuous technological innovation has led to notable improvements such as increased conversion efficiency of solar cells, reduced material usage, and enhanced energy efficiency per module.

Over the past decade, solar PV cells have become approximately 60% more efficient, while generation costs have seen a remarkable decline of almost 80%. These achievements have been made possible through the combination of public and private investments in research and development (R&D) efforts across the entire solar PV supply chain.

The affordability of solar PV as an electricity generation technology in various parts of the world can be attributed to these investments in R&D. Without such dedicated support, the cost reductions and advancements witnessed in the solar PV industry would not have been attainable. Hence, ongoing investments in R&D, both from the public and private sectors, continue to be essential to drive further innovation, cost reduction, and efficiency gains in the solar PV sector.

Currently, the solar PV market is predominantly dominated by monocrystalline silicon technology. This is primarily due to its high efficiency levels and competitive pricing. However, ongoing technology innovation in manufacturing processes is crucial to reduce material intensity, especially for critical minerals like silver and copper. These efforts aim to minimize vulnerabilities in the supply chain.

In addition to process improvements, the development of new solar cell designs is essential for achieving further efficiency gains while simultaneously reducing material intensity and manufacturing costs. Multiple companies are actively working on tandem and perovskite technologies. These innovative designs hold the potential to enhance

[2] Fraunhofer ISE: Photovoltaics Report, updated: 22 September 2022

the performance of solar cells. However, additional investment in R&D will be required to bring these technologies to full commercialization.

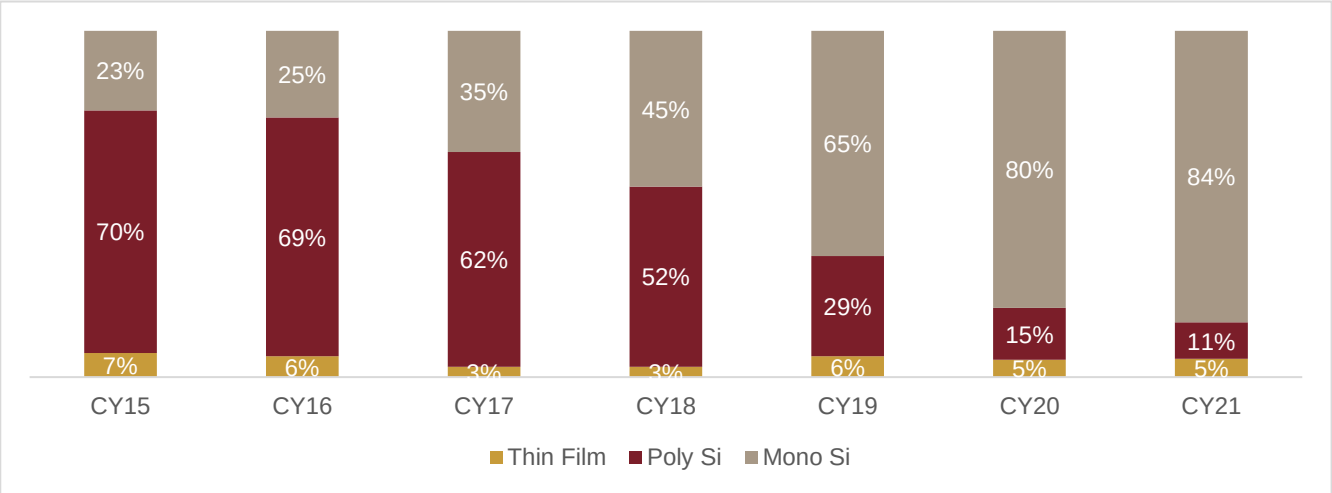
**Figure 80: Existing vs upcoming technologies**

| | Mono PERC | TOPCON | HJT |
|---|---|---|---|
| Initial capex | $ 31-38 mn./ GW | $ 38-46 mn./ GW | $ 69-75mn./ GW |
| Efficiency | 22-23% | 23-24% | 23-25% |
| Losses and Damages | p-type Mono Perc cells are prone to LID and PID losses. Such losses are high compared to peers | PID and LID losses in Topcon are lower compared to Mon o PERC, bit higher compared to HJT | Not prone to PID and LID losses, since general cell construction is n-type |

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

In the coming years, it is expected that more advanced cell designs such as heterojunction (HJT), TOPCon, and back contact will gain greater market shares. These cell designs hold the potential for achieving additional efficiency gains in solar panels.

**Figure 81: Module technology share**




*Source: Industry, CRISIL Consulting*

More than 85-90% of Indian solar module manufacturers have shifted to Mono-PERC and Mono-PERC is expected to dominate the technology for the next 2-3 years. Most of the Indian manufacturers have set up or planning to set up new facilities with an option of upgradation to newer technologies. Some of the Companies have existing manufacturing facilities which can be upgraded to TOPCon technology. Reliance New Energy Solar will leverage HJT for improved module efficiency. TOPCon technology is slowly getting prominence in Indian solar manufacturing Industries. Most of the leading players have already started offering TOPCon modules. Some of them are planning to switch to TOPCon from existing Mono-PERC or set up greenfield TOPCon manufacturing facilities. e.g. Adani, Emvee, Gautam Solar, TATA Power, Saatvik Green etc.

In addition, there are ongoing considerations for mass manufacturing of multilayer and tandem silicon-perovskite or silicon-CdTe hybrid solar panels. These innovative solutions have the potential to significantly increase cell efficiency, surpassing the 30% mark, while maintaining competitive production costs.

**LONGi Solar:** During 2022, LONGi effectively met customers' market demand for mono products. The sales of main products (i.e., mono wafers and modules) increased significantly over the same period last year, bringing steady growth of operating revenue and profit. In 2022, LONGi achieved wafer shipments of 85.06 GW, split between external sales of 42.52GW and 42.54 GW for internal use and shipped 46.76 GW of mono-crystalline modules, of which external sales accounted for 46.08 GW and internal use 0.68GW. Thus, almost entire sale of LONGi Solar was from mono type modules.

**Jinko Solar:** During 2022, Jinko Solar shipped 44.33 GW modules. The following table summarises the sales volumes by solar module types.

| Sales volume | CY18 | | CY19 | | CY20 | | CY21 | | CY22 | |
|---|---|---|---|---|---|---|---|---|---|---|
| | MW | % | MW | % | MW | % | MW | % | MW | % |
| Solar modules – Poly | 6,420 | 57% | 3,554 | 25% | 385 | 2% | 40.8 | 0% | 1.3 | 0% |
| Solar modules – Mono | 1,911 | 17% | 944 | 7% | 115.2 | 1% | 7.3 | 0% | 13 | 0% |
| Solar modules – N Type | | | | | | | | | 10,684 | 24% |
| Solar modules – Mono PERC | 2,840 | 25% | 9,710 | 68% | 18,270 | 97% | 22,185 | 100% | 33,636 | 76% |
| Total | 11,171 | 100% | 14,208 | 100% | 18,771 | 100% | 22,233 | 100% | 44,334 | 100% |

*Source: Annual Report 2022, CRISIL Consulting*

From the above table, the mono PERC share for Jinko Solar increased from 25% in 2018 to ~100% in 2021. Thus, mono products have almost replaced poly products. However, recently there is a demand for N-type solar panels and Mono PERC panels are losing more and more ground compared to them. Although the N-type solar panel technology has reached a mature stage, the supply of these panels still falls slightly short of the existing demand. 80% of the upcoming capacities, more than 80% are Mono PERC lines, indicating continued dominance for the technology in the medium-term. An increased number of Mono PERC lines does not necessarily rule out quicker TOPCon adoption, as these lines can be upgraded to TOPCon at an additional investment of 10-15% of the base capital expenditure.

## 7.4 Overview of solar module manufacturing value chain in India

Crystalline silicon (c-Si) technology is largely deployed in solar PV globally as well as in India. The technology is also expected to comprise the largest pie in India's ambitious target of 280 GW solar capacity addition by 2030. However, currently, 80-85% of the solar modules need be imported as domestic capacity is inadequate to meet demand. India does not have a manufacturing base for polysilicon ingots and wafer; hence, players import these components, incurring high cost.

**Figure 82: Schematic of c-Si PV module supply chain**


*Source: CRISIL Consulting*

Only few GW-scale companies are present in India. Many of the smaller companies have capacities in the 100-500 MW range, with very high operational costs.

**Table 40: Key domestic solar module manufacturers with capacity**

| Sr. no. | Name | Installed capacity (MW) |
|---|---|---|
| 1. | Waaree Energies | 12,000 |
| 2. | Adani Mundra PV | 4,000 |
| 3. | ReNew Power | 4,000 |
| 4. | Vikram Solar | 3,500 |
| 5. | Renewsys | 2,750 |
| 6. | Goldi Solar | 2,500 |
| **7.** | Premier Energies | 2,400 |
| 8. | Rayzon | 1,500 |
| 9. | Saatvik | 1,500 |
| 10. | Emmvee Photovoltaic | 1,250 |
| 11. | Solex | 1,200 |
| 12. | Pixon Green Energy | 1,000 |

*As on June 30, 2023,*
*Source: Company websites, CRISIL Consulting.*

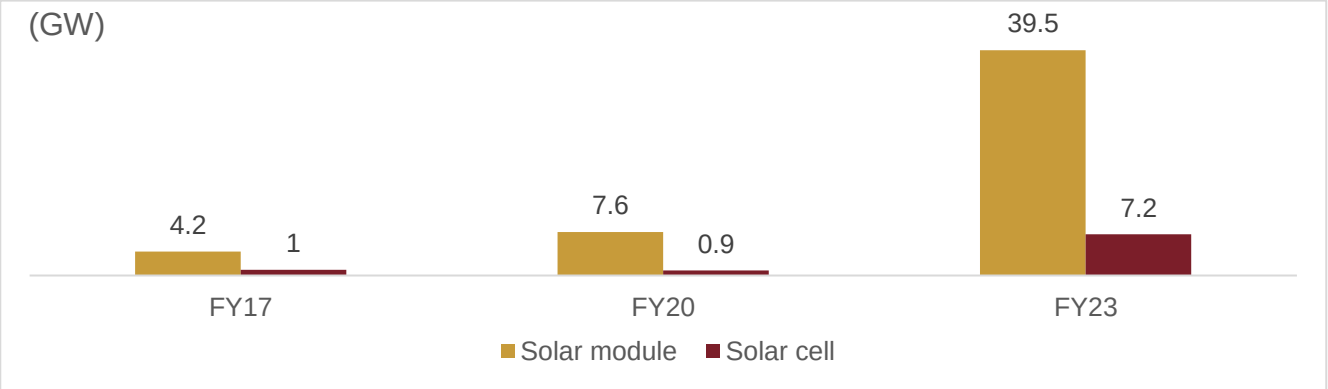
In contrast, global manufacturers such as LONGi Solar, Trina Solar, JA Solar, Jinko Solar, etc are present across the PV value chain, and operate on a larger scale; hence, enjoy significant cost advantages.

The development of the Solar PV industry in India is at a critical point. Following COVID-19, it underwent an expedited change that was largely made possible by a supportive policy initiative. As a result, the sector is preparing to meet the growing demand for solar energy on both domestic and global markets.

India and other net PV importers, like the U.S., have implemented several policies throughout time to reduce their reliance on China for PV products. The use of tariff barriers, such as safeguard duties (SGD) in India and anti-dumping taxes in the US, is one of them.

India's cumulative module manufacturing nameplate capacity has reached ~40 GW in fiscal 2023 and the cumulative cell manufacturing capacity is about ~7.2 GW. The difference in the manufacturing capacities of solar cell and module is partly due to the lack of vertical integration of domestic solar fabs. However, the operational capacity could be less than 50% of the nameplate capacity.

**Figure 83: Solar module and cell manufacturing capacity**




*Source: CRISIL Consulting*

Further, regarding ingots/wafer manufacturing, Adani Solar in December 2022 introduced a large-sized monocrystalline silicon ingot in its Mundra (Gujarat) facility. This development led the company to become India's first manufacturer of monocrystalline silicon ingots, capable of producing M10 (182mm) and M12 (210mm) size wafers. Lastly, Polysilicon, the first stage in the PV manufacturing chain involves the most complex manufacturing process. Currently there are no manufacturers for domestic polysilicon manufacturing, but it is expected that under the PLI scheme the winners would setup the first of the future polysilicon production capacities within the next two-three years through integrated factories.

While moving up the value chain, from solar modules and cells to ingots/wafers and polysilicon, India's PV manufacturing skills substantially decline. Proceeding upstream in the PV supply chain, the complexity and manufacturing capex requirements increase. Polysilicon and ingots/wafers have historically played a negligible role in India's overall PV commodities/products trade. For these components, the domestic industry has solely depended on imported products from international marketplaces.

It is also noteworthy that the majority of solar module production is centred on a small number of states. Manufacturing of solar modules is concentrated in these states for a number of reasons, including easy access to ports (for international trade), affordable land, and readily available power close to special economic zones (SEZ). Gujarat will still house most of the manufacturing capacity.

## 7.5 Outlook for solar module manufacturing

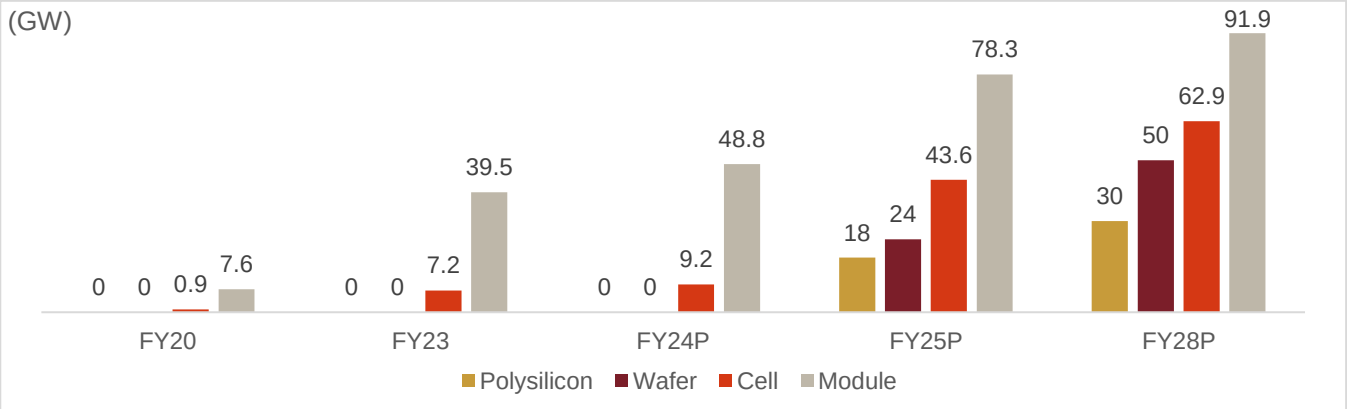
India aims to build its presence across all stages of PV manufacturing over the next two to three years. In November 2020, the GoI introduced the PLI scheme for manufacturing high-efficiency solar PV modules with a financial outlay of Rs 45 billion. It later enhanced the outlay by Rs 195 billion under the Union Budget for fiscal 2023.

In May 2021, the IREDA issued a tender to set up 10 GW of high-efficiency solar module manufacturing capacities. The total PLI granted across the three final awardees (Reliance, Shirdi Sai Electricals and Adani) was Rs 44.55 billion, which would lead to the setting up of 8,737 MW of PLI-linked capacity. The second bid conducted by SECI under PLI scheme concluded in February 2023. A total capacity of 39.6 GW of domestic Solar PV module manufacturing capacity has been awarded to 11 companies, with a total outlay of Rs 140 billion. As per the government estimates, manufacturing capacity totaling 7.4 GW is expected to become operational by October 2024, 16.8 GW by April 2025 and the balance 15.4 GW by April 2026. Considering the two tranches together, the total domestic solar PV module manufacturing capacity allocated under the PLI Scheme is 48,337 MW, with a cumulative support of more than Rs. 185 billion by the Government.

CRISIL Consulting expects solar PV manufacturing Capacity to reach 90-95 GW by fiscal 2028, with full integration from polysilicon to modules expected to account for 30% of capacities, largely driven by PLIs. Achieving this is

expected to require an investment of Rs 1.5 lakh crore by fiscal 2028.CRISIL Consulting expects module manufacturing capacity to grow ~2.5 times by FY28 with ~30% of the capacity to be fully integrated and integrated units to come only post FY25. Gujarat will be at the epicenter of additions with ~55-60% additions in the next 5 fiscals.

**Figure 84: Estimated solar module and cell manufacturing capacity**




*Source: Industry, CRISIL Consulting*

## 7.6 Scheme and incentives supporting solar module manufacturing in India

The Indian government has taken several policy initiatives to promote solar module manufacturing in India. These initiatives include DCR mandate for use of domestically manufactured solar cell and modules, PLI Scheme, imposition of BCD on import of solar PV cells & modules, mandated registration of solar cell and module under the ALMM for complying with BIS standards, incentives for research and development, and support for training and skill development. Some of the key government initiatives to support a domestic PV manufacturing industry are as follows:

a) *Domestic content requirement* - The DCR mandates the use of solar cells and modules manufactured domestically as per specifications and testing requirements fixed by MNRE. There are various schemes announced by the government to promote the use of domestically manufactured modules such as CPSU scheme, PM-KUSUM scheme, grid connected rooftop solar programmes. All these schemes have a Central Financia Assistance (CFA)/VGF component to cover the cost difference between imported and domestic solar cells and modules It is mandatory to use DCR cells and modules to avail the financial aid provided by the central/state government.

b) *Performance linked incentive scheme* – The National Program on High-Efficiency Solar PV Modules is a government-backed initiative to promote domestic manufacturing of Solar PV modules and cells in India. The PLI scheme offers incentives to eligible manufacturers based on their annual production of high-efficiency solar PV modules and cells. The incentive amount is calculated as a percentage of the manufacturing cost of the modules or cells and is capped at Rs 400 per watt for modules and Rs 150 per watt for cells. The scheme is being implemented in two tranches. Tranche-I, with an outlay of Rs 4,500 crore, was launched in February 2022. Tranche-II, with an outlay of Rs 19,500 crore, was launched in September 2022. The scheme is expected to reduce India's dependence on imported solar modules, and to make solar power more affordable for Indian consumers.

c) *Safeguard duty* - The government imposed a safeguard duty on solar cells and modules imported from China, Malaysia, Thailand, and Vietnam in July 2018. The duty was initially set at 25% for the first year, followed by a phased down approach for the second year, with the rate reduced by 5% every six months until it ended in July 2020. The purpose of the duty was to protect the domestic solar manufacturing industry from cheap imports from China. In July 2020, the government extended the safeguard duty for another year, with the rate set at 14.90% from July 30, 2020, to January 29, 2021, and 14.50% from January 30, 2021, to July 29, 2021.

d) *Basic customs duty* - The government imposed a basic customs duty of 40% on solar modules and 25% on solar cells on April 1, 2022. This was done in an effort to boost domestic manufacturing of solar components and reduce India's reliance on imports. The BCD applies to all imports of solar modules and cells, regardless of the country of origin.

e) *Approved list of models and manufacturers* - The ALMM was introduced in 2019 to ensure the quality and performance of solar modules used in India. It is a list of solar cell and module types and manufacturers in India that have been certified by the Bureau of Indian Standards. Only modules that are listed on the ALMM are eligible for use in government sponsored solar projects.

## 7.7 Price trend of solar PV cells and modules

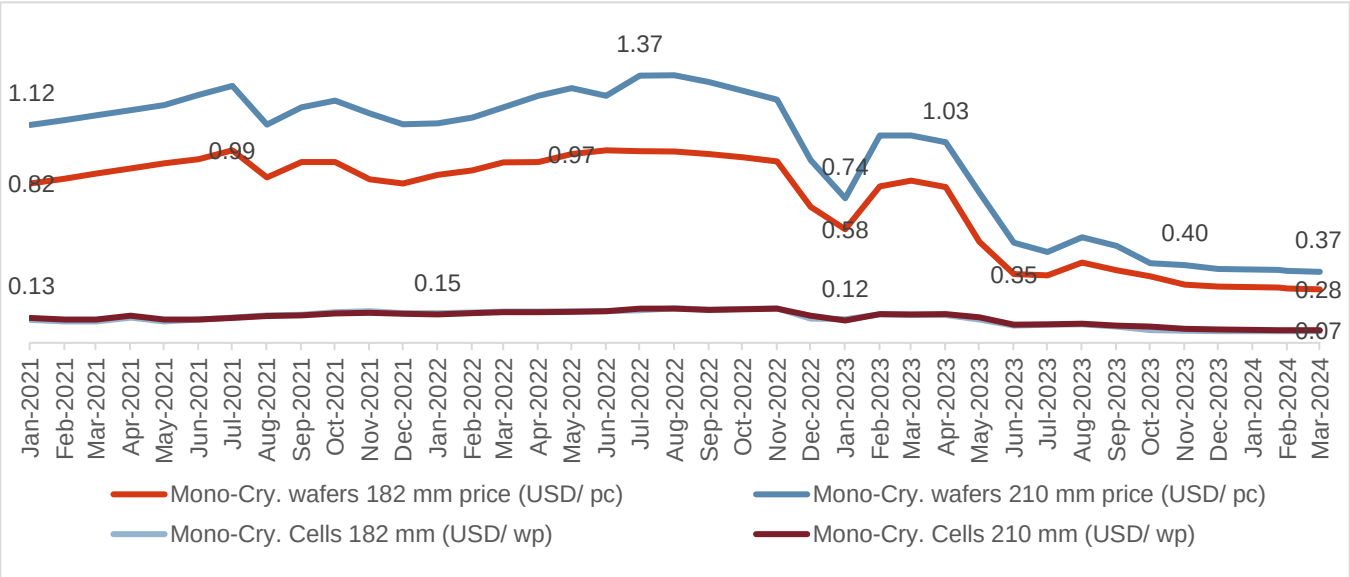
**Module prices to fall in fiscal 2024**

On a global scale, the polysilicon base expanded by 68% year-on-year by the end of December 2022, reaching a range of 1000-1100 metric tons from the previous 600-650 metric tons. Weakened demand and lower consumption in the first half of 2023 in China, coupled with oversupply, resulted in a dramatic price drop of 72% to $8 per kg in July 2023, down from $28 per kg in December 2022. Consequently, downstream components also witnessed significant price reductions, with wafer prices plummeting by 50-55% to $0.35 per piece from $0.70 per piece.

The oversupply of polysilicon also prompted the world's largest monocrystalline solar wafer supplier to cut the prices of its photovoltaic wafers twice between April and May 2023, reducing prices by 33% as cell manufacturers sought to fulfill their order requirements.

Cell prices also saw a decrease of 43% in July 2023, reaching $0.09 per Wp from December 2022, while module prices fell by 25% during the same period. Additionally, spot prices for bifacial mono perc modules continued to decline, reaching $0.18 per Wp in the first half of August 2023 as suppliers offered lower prices to clear their inventory. The combination of weak European demand and an accumulation of Chinese module inventory is expected to keep global module prices subdued in the current fiscal year. .

**Figure 85: Wafer and cell prices have trended down**

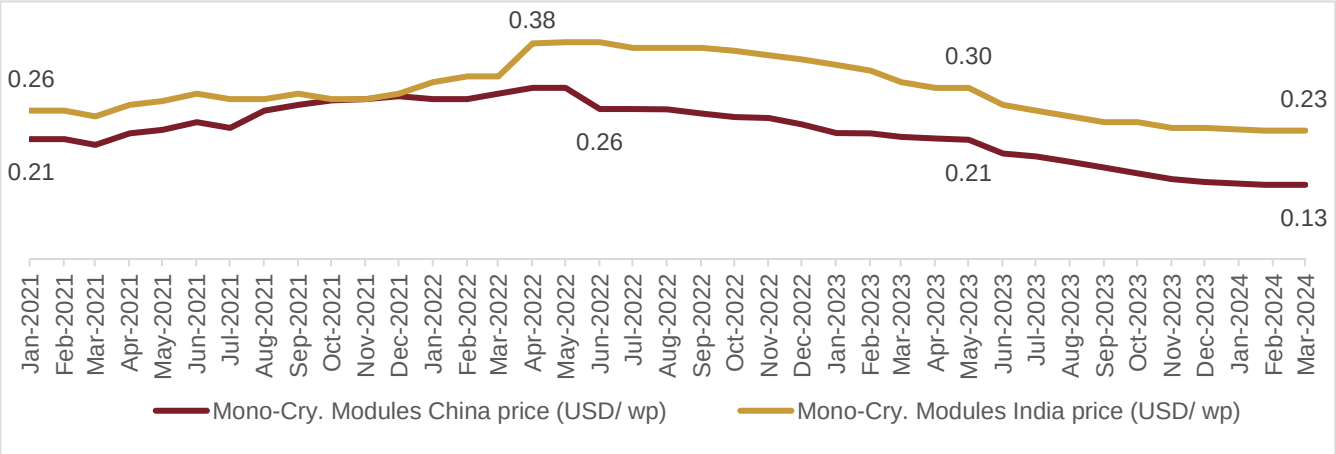



*Source: Industry, CRISIL Consulting*

**Declining module prices**

Module prices experienced a remarkable surge of 22% in fiscal 2022 and a subsequent 7% increase in fiscal 2023. However, in the first five months of fiscal 2024, they have undergone a significant decline, dropping by 21% compared to fiscal 2023, reaching a level of $0.19 per Wp. This sharp decrease is primarily attributed to an oversupply of upstream components, particularly polysilicon. Domestic module prices in India also experienced a significant drop, falling from $0.30 per Wp to $0.25 per Wp, primarily due to the country's reliance on imported cells. As of March 2023, India had approximately 39 gigawatts of module capacity, in contrast to only around 7 gigawatts of cell capacity, leading to a doubling of cell imports year-on-year between January and June 2023.

**Figure 86: Module prices plummeted in 2023**




*Source: Industry, CRISIL Consulting*

Domestic module prices in India also experienced a significant drop, falling from $0.30 per Wp to $0.25 per Wp, primarily due to the country's reliance on imported cells. As of March 2023, India had approximately 39 GW of module capacity, in contrast to only around 7 GW of cell capacity, leading to a doubling of cell imports year-on-year between January and June 2023. CRISIL Consulting anticipates that global average module prices will remain in the range of $0.15 to $0.16 per Wp for fiscal 2024.

## 7.8 Share of domestic and imported modules

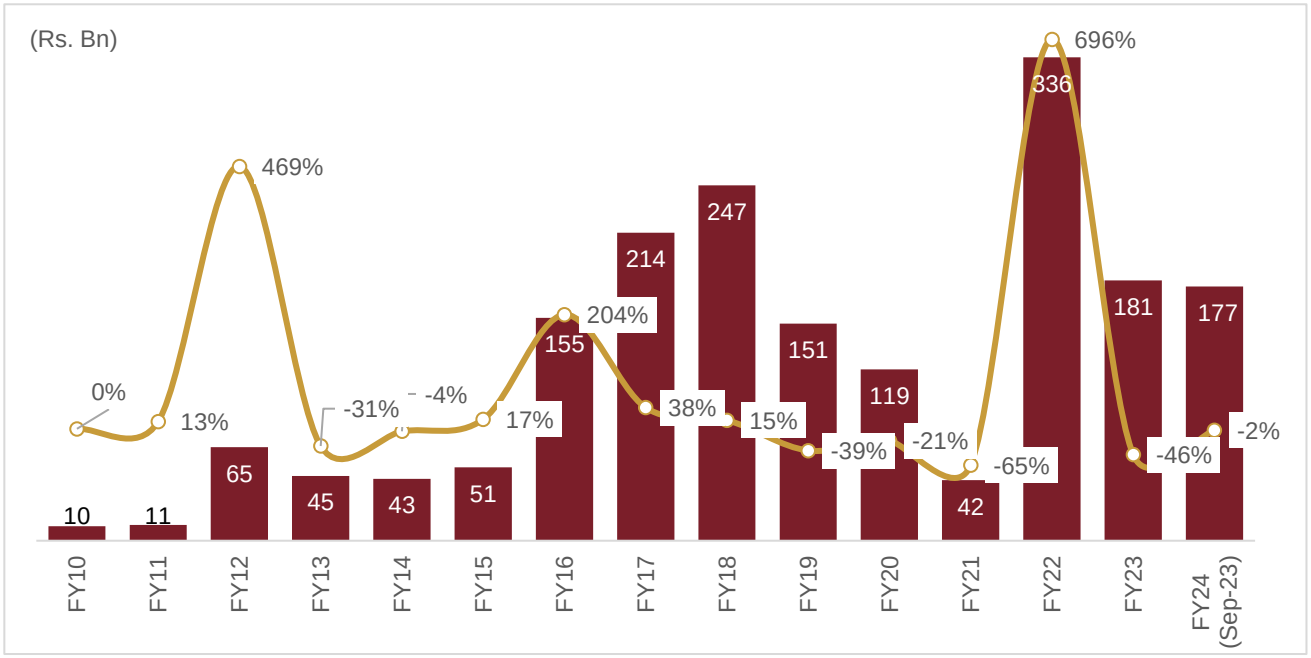
During 2000-2010, the Indian cell and module manufactures were as competitive as their global counterparts. They exported majority of their production due to robust overseas demand. Players such as Moser Baer, Tata BP Solar (now Tata Power Solar), Jupiter Solar Power, and Indosolar made substantial investments in solar cells and modules manufacturing. However, the Indian market still relied heavily on imported modules that were cheaper and more efficient than domestic modules.

As of March 2023, India has ~7.2 GW installed capacity of solar cells and ~39.5 GW of modules. Even though India is one of the top ten solar module producers, it is far behind its biggest competitor China. Considering this, 80-85% of solar modules need to be imported due to inadequate capacity as well as technology. In fiscal 2022, imports increased by a staggering 696% on-year to Rs 336 billion (from Rs 42 billion). The sudden and sharp surge in import was mainly due to ease in restrictions coupled with expiration of time extensions provided to projects under COVID-19 relief.

Despite price surge across the value chain for solar components, imports have been robust as seller and developers availed duty free period after July 2021 and imported modules for commissioning planned even in fiscals 2022 and 2023 in advance.

However, during fiscal 2023, the module import declined due to imposition of BCD on imported solar module, DCR and increased domestic production capacity.

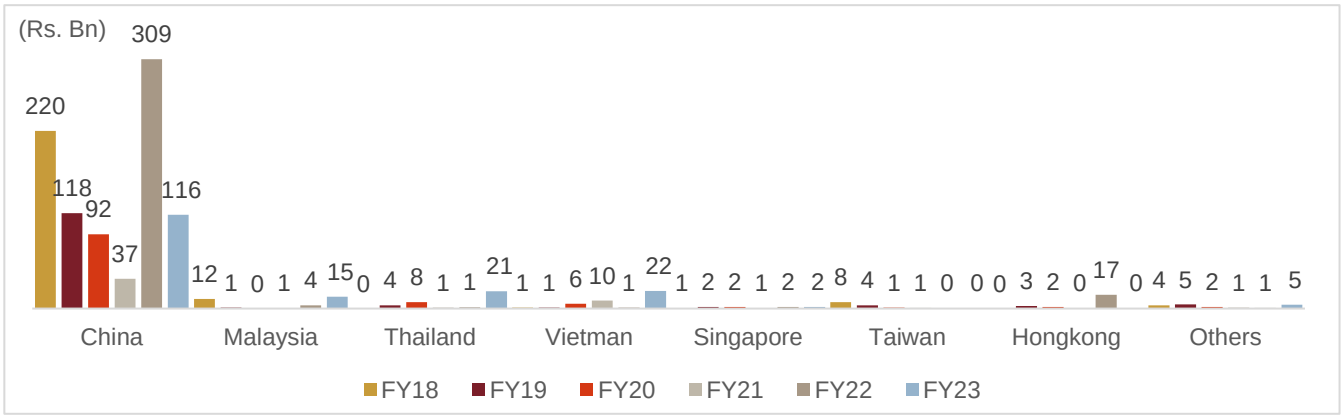
**Figure 87: Solar module imports (Rs. billion)**




*Note: FY 22 (HS Code 85414011+85414012); FY 23 (HS Code 85414300 +85414200)*
*Source: Ministry of Commerce, CRISIL Consulting*

China continues to be the largest module exporter to India, followed by Malaysia. BCD along with the PLI scheme is expected to improve the demand for domestic modules. However, till that time imports will continue to form majority portion of domestic demand due to technological advantage.

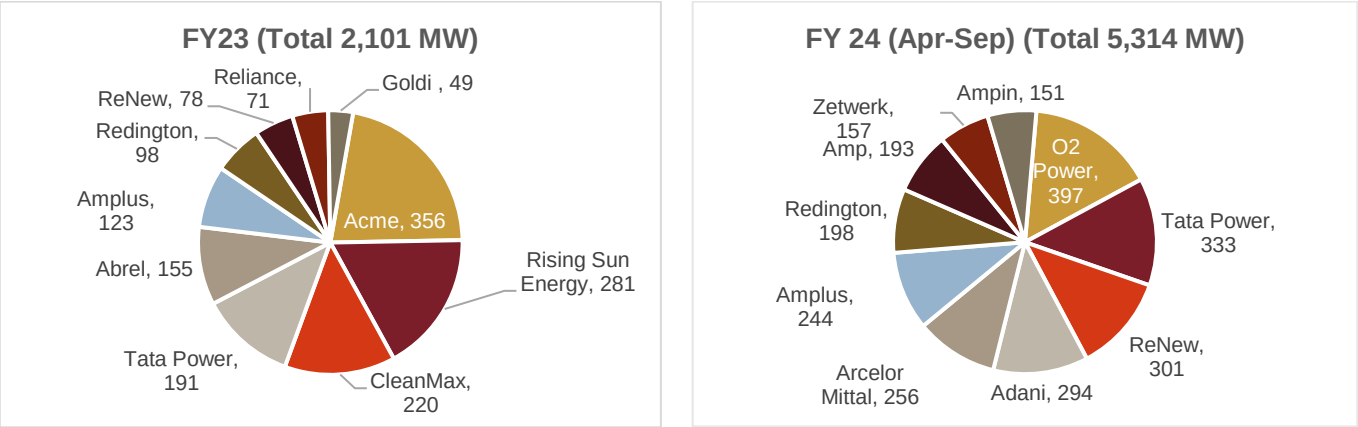
**Figure 88: Country-wise module imports**




*Note: FY 22 (HS Code 85414011+85414012)*
*Source: Ministry of Commerce, CRISIL Consulting*

Imports have been the primary source of modules installed in the country over the past 7-8 years, with China's share reaching 64% in fiscal 2023. Import dependence in fiscal 2024 is projected to be around 67%. However, reliance on China is likely to decrease to less than 50% as other nations like Vietnam, Thailand, and Malaysia gain traction due to supply chain diversification. Moreover, reliance on module imports is expected to decrease further after fiscal 2024 due to the reemergence of ALMM and the growth of domestic manufacturing capacity. CRISIL Consulting anticipates that import dependency for modules will decline to 8-10% by fiscal 2028. Nevertheless, India will continue to depend on imports for upstream components such as polysilicon, wafers, and cells.

**Figure 89: Top 10 importers (MW capacity)**



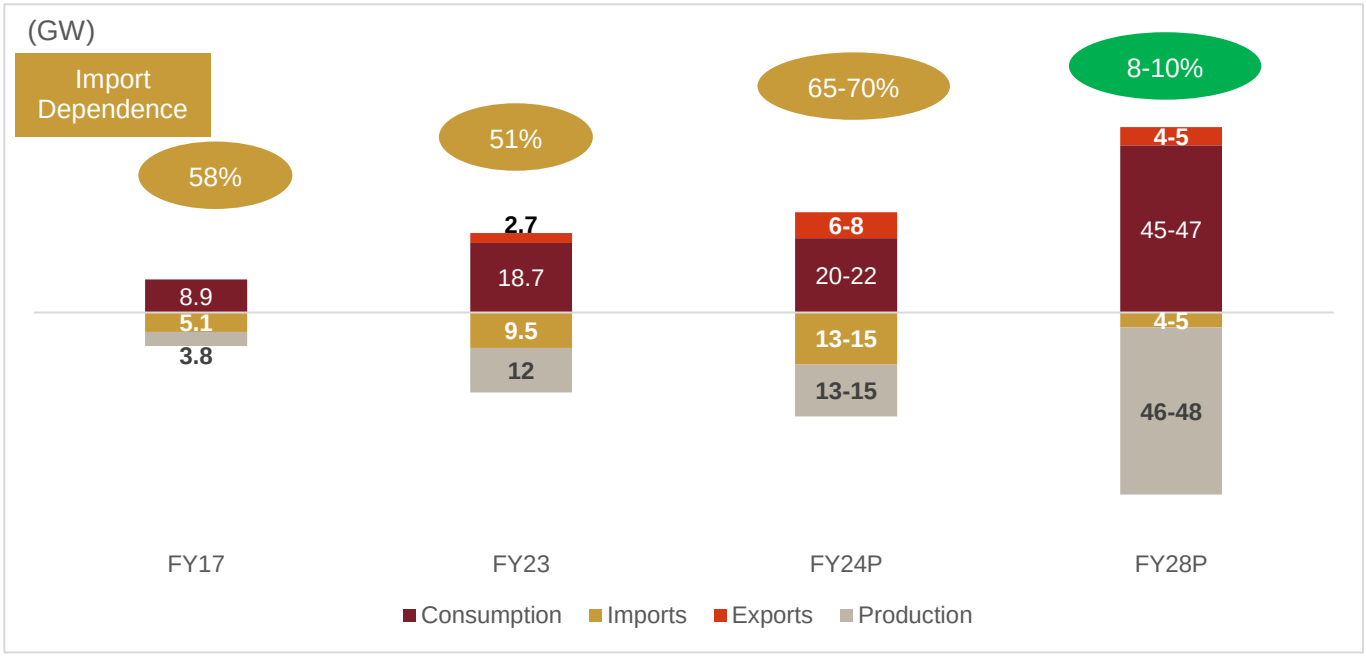

*Source: Industry, CRISIL Consulting*

## 7.9 Domestic versus export demand potential

Exports experienced explosive growth, increasing by 11 times year-on-year in fiscal 2023, driven by demand from the USA. The ban on China's region has enabled Indian module makers to fill the void by supplying approximately 2.7 GW. This momentum continued into the first quarter of fiscal 2024, with exports alone reaching 2.1 GW. While the suspension of ALMM has led to the import of affordable global modules, it has also provided space for Indian manufacturers to meet the import demands of the US. Exports are expected to remain high between fiscal 2024 and 2028, reaching 25 GW, driven by domestic capacity additions of 60-65 GW. Export demand will also be supported by other key renewable energy markets, such as the Middle East, the European Union, and Latin American nations.

Ban on modules linked to Xinjiang due to notification of the UFLP Act in June 2022 by US could ideally provide Indian manufacturers with an opportunity to increase market share in US, however, withdrawal of tariffs on non-Xinjiang Chinese modules in February 2022 could prove to be roadblock and this continues to remain a monitorable. USA continues to be top consumer of Indian made modules 60% of FY 23 exports to US already achieved in Q1 FY 24 owing to ban on Chinese module imports The European Union is also expected to contribute to future demand. Post BCD levy, domestic project developers may tie up with domestic module manufacturer to import cell at 25% duty for local assembly of modules to avoid 40% duty levied on panels and, rather face 25% duty levied on imported cells. Also, on February 4, 2022, the Biden administration extended the Section 201 tariffs imposed on the import of solar modules from China for four years. This is a growth driver for domestic module exports. Ban on Chinese region and ALMM abeyance to surge Indian exports in fiscal 2024 and domestic usage to be largely preferred till 2028.

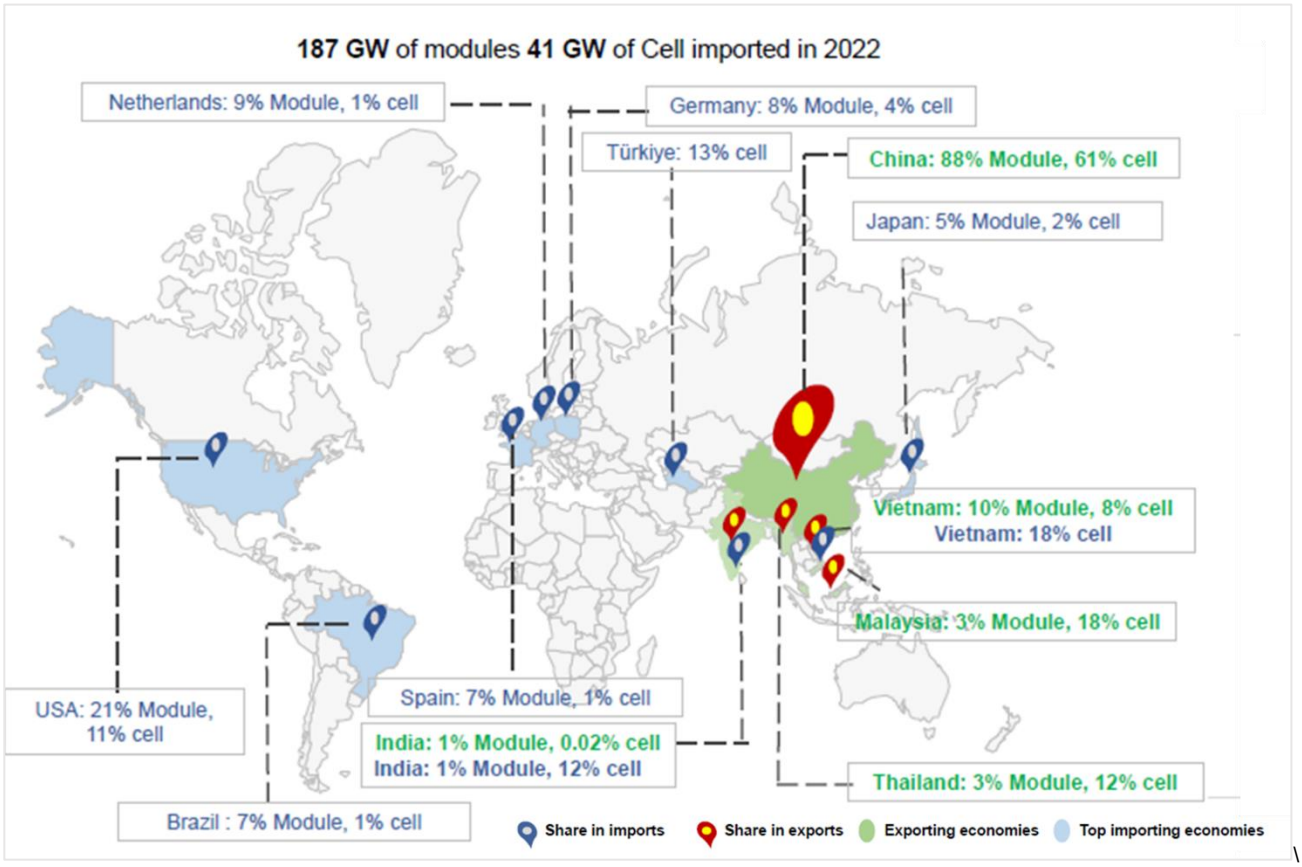
**Figure 90: Only 1/10 of the domestic demand to be import reliant by FY28 (annual figures)**




*Source: CRISIL Consulting*

With the ban on imports from Xinjiang region and PV grade polysilicon being designated “high priority” item to enforce ban, ~ 45% of global PV grade polysilicon facilities could come under scrutiny. USA imported 26GW of modules in 2022, of which import from China constituted merely ~52 MW. This fell sharply from 750 MW in the previous year. Module manufacturers like Longi, Jinko, JA and their ties with Xinjiang based polysilicon providers have come under special scrutiny for use of forced labour and could look for an alternative market like India to off load surplus panels. However, off late module shipments worth 600 MW of Trina was cleared. Indian manufacturers on other hand could be looking to capitalise on this and increase their market share in USA by exporting more and supplying less locally.

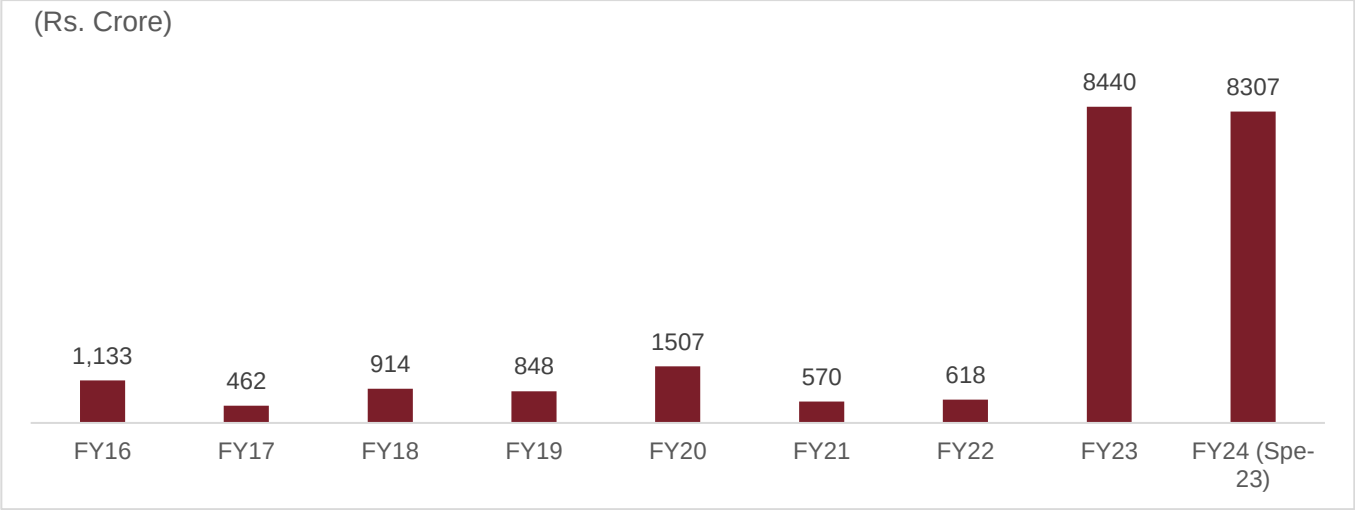
**Figure 91: India's exports face tough ASEAN competition, limiting market share**




*Source: ITC Trademap, CRISIL Consulting*

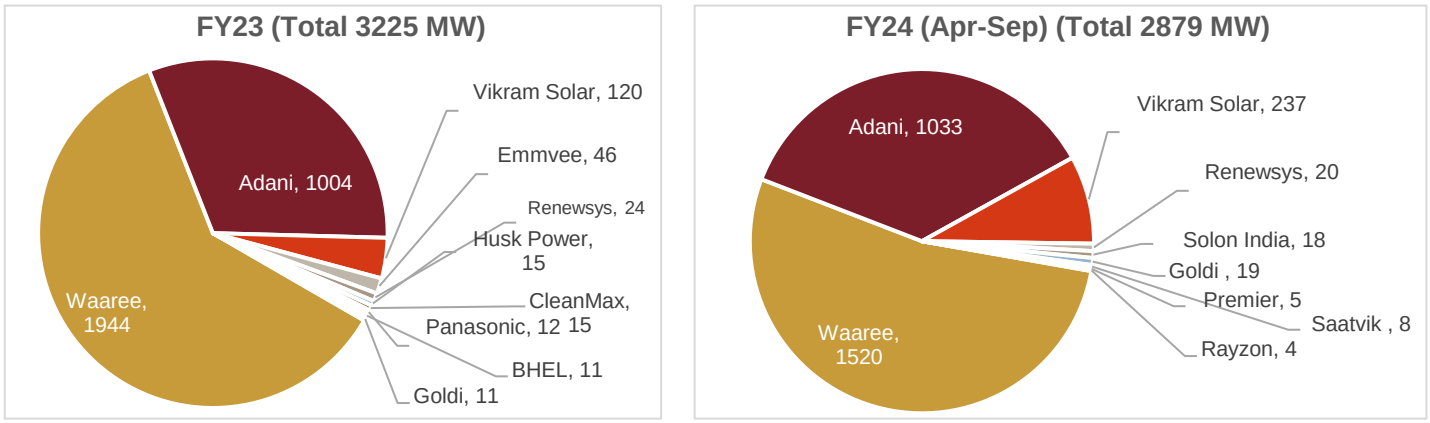
Ban on Chinese region and ALMM abeyance is expected to surge Indian exports in fiscal 2024; however, domestic usage to be largely preferred till 2028. India exported solar cells and modules worth Rs. 8307 in the first half of fiscal 2024 which is almost 98% of fiscal 2023 exports. Solar PV modules accounted ~98% of the exports and the US remained the top buyer for Indian solar products in H1 of fiscal 2024 accounting for ~98% of the total solar export.

**Figure 92: H1FY24 exports already at 98% of FY23 exports**




*Note: FY 22 (HS Code 85414011+85414012); FY 23 onwards (HS Code 85414300 +85414200)*
*Source: Ministry of Commerce, CRISIL Consulting*

**Figure 93: Top 10 exporters (MW capacity)**




Source: Industry, CRISIL Consulting

Waaree Energies has been a leading player in the solar module export market followed by Adani Mundra Solar.

## 7.10 Distribution Channels for PV Modules

To reach out to the end users such as residential, commercial, and industrial consumers, various module manufacturers have their distributor network or have appointed franchisee. Retail consumers are relatively price-sensitive when it comes to solar installations due to smaller project sizes, expected shorter payback period and more competition.

Availability of local contact is very important for these consumers while accepting the solar products. With increased awareness, more and more consumers are showing interest in solar installations. The distribution channel partner help in reaching out to consumers as well as for informing them about the new technology. Due to diverse geographical presence, local support and to build customer relationship, a strong distribution network become essential.

Further, the end user generally does not have technical knowledge of complex products such as modules and hence have very little say in selection. However, through a known partner, the consumers can be convinced to a large extent and such network can be utilized for enhancing the consumer reach. By addressing price sensitivity and leveraging their distribution networks, module suppliers can increase their market share in the retail segment.

Waaree Energies has 388 unique franchisee networks across India. This model provides different opportunity than just dealership or distributorship of products. These are exclusively tied up traders which help in end-to-end product plus service. They help in reaching the last mile connectivity and help in increasing consumer awareness about various offerings in residential and C&I consumers specially in tier-1 and tier-2 cities. Vikram Solar has distribution network connecting more than 40 cities, ensuring the availability of solar products and solutions across 600+ locations Pan-India. Similarly, Adani solar with Roofsol Energy has retail distribution of its solar panels to more than 2,500 towns in India.

## 7.11 Competitive mapping of solar module manufacturers in India

Competitive mapping covers the details of companies, their products and services within a given market to understand competitive intensity. The top 5 players namely, Waaree Energies, Adani Solar (Mundra), Goldi Solar, Vikram Solar, and Emmvee Photovoltaic account for about 45% of the total domestic ALMM enlisted module manufacturing capacity of ~19.5 GW.

**Table 41: Comparative summary of domestic module manufacturers**

| Parameter | Waaree Energies | Vikram Solar | Mundra Solar PV | Premier Energies | RenewSys India | Emmvee Photovoltaic | Alpex Solar |
|---|---|---|---|---|---|---|---|
| **Number of manufacturing factories** | 4 in Gujarat | 1 each in West Bengal and Tamil Nadu | 1 in Gujarat | 2 in Telangana | 1 each in Karnataka, Telangana and Maharashtra | 2 in Karnataka | 1 each in HP and UP |
| **Experience in PV module manufacturing** | 16 years | 17 years | 8 years | 26 years | 12 years | 16 years | 18 Years |
| **Operational capacity (as on Sept-23)** | 12 GW modules | 3.5 GW modules | 4 GW cells and modules | 2.4 GW modules, 2 GW Cells | 2.75 GW modules, ~0.1 GW cells | 1.25 GW modules | 450 MW modules |
| **Under-construction capacity** | 6 GW Modules 5.4 GW Cells **Proposed-** 6 GW modules, 6 GW cells, 6 GW Ingot-Wafer capacity | Proposed 2.8 GW integrated cells & modules | 10 GW cell and module | 3.4 GW modules, 1.25 GW cells | 2 GW Modules ~1.9 GW | 1.75 GW including 1.5 GW wafer-to-module capacity | 300 MW |
| **NABL Accredited Lab** | For modules | For modules | - | - | For encapsulants and backsheets | - | - |

| Parameter | Waaree Energies | Vikram Solar | Mundra Solar PV | Premier Energies | RenewSys India | Emmvee Photovoltaic | Alpex Solar |
|---|---|---|---|---|---|---|---|
| **Enlisted Capacity as ALMM List Nov-23** | 2,650 MW | 1,287 MW | 2,036 MW | 1,116 MW | 565 MW | 1,183 MW | 240 MW |
| **Market share as a % of total enlisted capacity as per ALMM List Nov-23** | 11.98% | 5.82% | 9.20% | 5.04% | 2.55% | 5.35% | 1.08% |
| **Key Products and services** | Solar PV modules, Inverters, Batteries, EPC services, rooftop solutions, O&M Services, and solar water pumps | Solar PV modules, EPC services, solar O&M services, and water pumps | Solar PV cells and modules, EPC services, O&M services, | Solar PV cells and modules, EPC services, O&M services, and water pumps | Solar PV modules and cells | Modules, EPC, rooftop solutions, and solar water heater solutions | Solar modules, EPC services, Water Pumps |
| **Cumulative Installed capacity in EPC** | 1000+ MW | 1,420 MW | NA | 650+ MW | NA | NA | NA |
| **Key Technologies offered** | TOPCon, Mono and poly crystalline PV modules, Mono PERC, Bifacial, Flexible modules, BIPV | TOPCon, Mono PERC, mono-facial & bifacial, poly-Si modules | TOPCon, Multi crystalline, Mono PERC and Bifacial modules | TOPCon, Polycrystalline Si cells, mono PERC, poly Si modules | TOPCon, Mono/Multi PERC, Bi-facial | TOPCon, Mono PERC, polycrystalline modules, bi-facial module | TOPCon, Monocrystalline, polycrystalline Modules |

*NA: Not available*

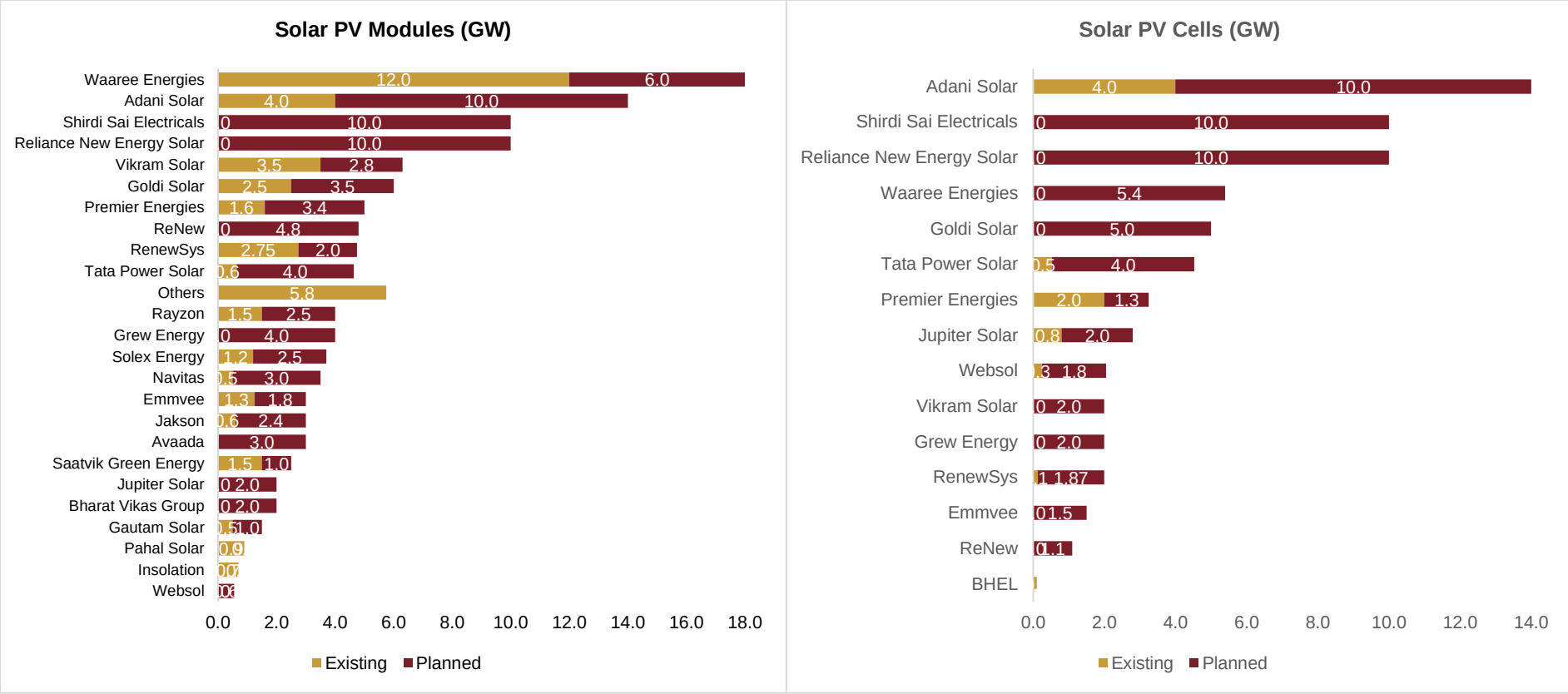
*Source: Company websites, MNRE ALMM* 16-Nov-*2023, CRISIL Consulting*

**Capacity addition plan of Indian solar PV manufacturers**

In order to boost domestic production and reduce imports, the central government initiated the first tranche of the PLI scheme in April 2021 with a target of 8,737 MW module manufacturing capacity as well as introduced basic customs duty on imports. The second tranche of the scheme targets a capacity addition of 39,600 MW by April 2026. Considering the favourable environment, various Indian solar PV manufacturers have planned for capacity expansion. As of December 2022, 70-75 GW module and 50-55 GW cell capacity expansion plans have been announced by various players. Also, with the announcement in Union Budget 2023 on the enhancement of the outlay of Rs 19,500 crore under the PLI scheme for high efficiency modules under the

second tranche of the scheme, the segments could see a further boost. Moreover, the ALMM (Approved List of Models and Manufacturers) order issued by MNRE acts as a trade barrier by encouraging domestic manufacture of solar modules, thus making it one of the key drivers for the development of domestic PV manufacture.

**Figure 94: Existing and planned capacity additions**




*Source: Company websites, Industry, Waaree* from Company (Additionally, it has planned 2 GW capacity in USA); PLI Scheme results, CRISIL Consulting*

To analyse competitiveness, productivity and efficiency, it is imperative to run a financial analysis of the company's books and then compare the performance standards with that of industry peers. Five major players have been analysed and benchmarked.

**Table 42: Financial summary of domestic module manufacturers**

| Company | FY | Operating income (Rs. crore) | Revenue Growth (%) | OPM (%) | NPM (%) | ROCE (%) | Gearing (times) | Interest coverage |
|---|---|---|---|---|---|---|---|---|
| Waaree Energies Ltd. | FY23 | 6,533 | 136% | 13% | 7% | 32% | 0.1 | 11.0 |
| Vikram Solar Ltd. | FY23 | 1,578 | -7% | 11% | 2% | 16% | 1.6 | 1.8 |
| Tata Power Solar Systems | FY23 | 6,876 | -19% | 8% | 3% | 39% | 0.7 | 3.9 |
| Websol Energy Systems Ltd. | FY23 | 17 | -92% | -72% | -138% | -6% | 0.1 | -3.2 |
| Mundra Solar PV Ltd. | FY22 | 2572 | -12% | 14% | 4% | 11% | 1.8 | 4.5 |

*Source: Annual accounts, CRISIL Consulting*

Most of the companies reported significant revenue growth in fiscal 2022, however fiscal 2023 witnessed a downward trend with players with diversified businesses faring better. Operating profits are sufficient to cover interest and finance costs. While Websol was the most profitable player in the previous year, it saw poor margins in fiscal 2023 on account of a discontinuation of operations following the decision to graduate to a superior technology (TOPCON). Tata Power Solar Systems witnessed a decline in operating income on account of a fall in revenue earned from turnkey projects which accounted for 88% of the company's operating income in fiscal 2023. Waaree Energies recorded a revenue growth of 39% with a healthy ROCE of 39% in fiscal 2022. The interest coverage ratio remained above 1 for most players, suggesting these companies' capability to pay the interest due on outstanding debt.

Following table summarises the competitive analysis of Waaree Energies with a publicly listed Indian module manufacture company.

**Table 43: Competitive analysis with a publicly listed Indian module manufacturer**

| Parameters | Waaree Energies | | | | Websol Energy Systems | | | |
|---|---|---|---|---|---|---|---|---|
| | FY21 | FY22 | FY23 | Q1FY24 | FY21 | FY22 | FY23 | Q1FY24 |
| Revenue from operations (₹ million) | 19,530 | 28,543 | 67,509 | 33,283 | 1,536 | 2,132 | 172 | 2 |
| Direct Sales to Utilities and Enterprises[(1)] | 8,144 | 15,963 | 13,168 | 6,782 | 1,505 | 2,132 | 153 | 2 |
| Franchisee Sales[(2)] | 3,888 | 5,825 | 6,725 | 1,975 | NA | NA | NA | NA |
| Export Sales[(3)] | 4,809 | 6,578 | 46,165 | 24,412 | NA | NA | 20 | NA |
| Other Revenue from Operations[(4)] | 2,689 | 176 | 1,450 | 114 | 31 | NA | NA | NA |
| Other Income | 300 | 916 | 1,095 | 867 | 43 | 46 | 30 | 1 |

| Parameters | Waaree Energies | | | | Websol Energy Systems | | | |
|---|---|---|---|---|---|---|---|---|
| | FY21 | FY22 | FY23 | Q1FY24 | FY21 | FY22 | FY23 | Q1FY24 |
| Total Income | 19,830 | 29,459 | 68,604 | 34,150 | 1,579 | 2,178 | 202 | 3 |
| Profit for the Year (₹ million) | 456 | 797 | 5,003 | 3,383 | 494 | 97 | -237 | -50 |
| EBITDA[5] (₹ million) | 1,257 | 2,025 | 9,441 | 5,543 | 381 | 310 | -99 | -12 |
| EBITDA Margin[6] (%) | 6.34% | 6.88% | 13.76% | 16.23% | 24.10% | 14.24% | -48.77% | -410.00% |
| Debt to Equity Ratio[7] | 0.79 | 0.72 | 0.15 | 0.08 | 0.22 | 0.22 | 0.15 | NA |
| Debt to EBITDA Ratio[8] | 2.24 | 1.55 | 0.29 | 0.42 | 0.91 | 1.17 | -2.75 | NA |
| Return on Average Capital Employed[9] (%) | 17.71% | 23.49% | 48.83% | 17.75% | 21.41% | 7.21% | -11.67% | -4.05% |
| PAT Margin[10] | 2.30% | 2.70% | 7.29% | 9.91% | 31.28% | 4.44% | -117.06% | -1666.67% |
| ROE[11] | 13.22% | 17.69% | 26.26% | 12.36% | 28.40% | 5.05% | -12.38% | -12.89% |
| ROCE[12] | 14.87% | 21.89% | 31.61% | 15.86% | 10.70% | 7.03% | -12.05% | -12.96% |
| Capacity in MW | 2,000 | 4,000 | 9,000 | 12,000 | 250 | 250 | 250 | 250 |
| Order Book in GW | 0.41 | 6.14 | 18.06 | 17.19 | 0.15 | (3 months of sales) | NA | NA |

*Source: Company, Company websites, Annual Reports, Filings, CRISIL Consulting*

*Notes: NA-Not available*

1. *Direct Sales to Utilities and Enterprises refers to our sales to utilities and enterprise customers.*
2. *Franchisee Sales includes module sales through our franchisee network focused on rooftop and MSME customer segments as well as franchisee EPC revenue*
3. *Export Sales includes module sales to international customers as well as international EPC revenue*
4. *Other Revenue from Operations includes EPC services for domestic utilities and enterprise customers, O&M services, trading in ancillary products, export incentives, generation of electricity from renewable resources and scrap sale.*
5. *EBITDA has been calculated as profit for the year before exceptional items and taxes plus finance cost, depreciation and amortization*
6. *EBITDA margin has been calculated as EBITDA divided by total income.*
7. *Debt to equity ratio has been calculated as total borrowings (including current maturities of long-term debt) divided by total equity (excluding non-controlling interest) (less)/add (deferred tax assets)/deferred tax liability (net).*
8. *Debt to EBITDA ratio has been calculated as total borrowings (including current maturities of long-term debt) divided by EBITDA for the relevant fiscal year/ period.*
9. *Return on average capital employed has been calculated as profit before exceptional item and tax plus finance costs divided by average of opening and closing capital employed calculated as total equity (excluding non-controlling interest) add non-current liability.*
10. *PAT Margin has been calculated as profit for the year/ period divided by total income*
11. *Return on equity has been calculated as net income (owners share) divided by total equity (excluding non-controlling interest)*
12. *Return on capital employed has been calculated as profit before exceptional item and tax plus finance cost divided by total equity (excluding non-controlling interest) add non-current liability*

## 7.12 India opportunity-Energy security and manufacturing renaissance

### 7.12.1 MNRE Tendering trajectory-50 GW annual RE capacity to be tendered

The Government has decided to invite bids for 50 GW of renewable energy capacity annually for the next five years i.e., from Financial Year 2023-24 till Financial Year 2027-28. Considering the fact that RE projects take around 18-24 months for commissioning, the bid plan will add 250 GW of renewable energy and ensure 500 GW of installed capacity by 2030. The Ministry of Power is already working on upgrading and adding the transmission system capacity for evacuating 500 GW of electricity from non-fossil fuel.

In addition to this, the Ministry has declared a quarterly plan of the bids for fiscal 2024, which comprises of bids for at least 15 GW of renewable energy capacity in each of the first and second quarters of the financial year (April-June 2023 and July-September 2023 respectively), and at least 10 GW in each of the third and fourth quarters of the financial year (Oct-December 2023 and January-March 2024 respectively).

Among the four PSUs designated as Renewable Energy Implementing Agencies (REIAs), the SECI and NTPC will float bids of 15 GW each of solar, wind, hybrid and round-the-clock projects during the current financial year. Similarly, hydro power generators NHPC and SJVN will float RE projects bids of 10 GW each in FY24.

**Table 44: Renewable Energy Implementing Agency wise bidding calendar for fiscal 2024**

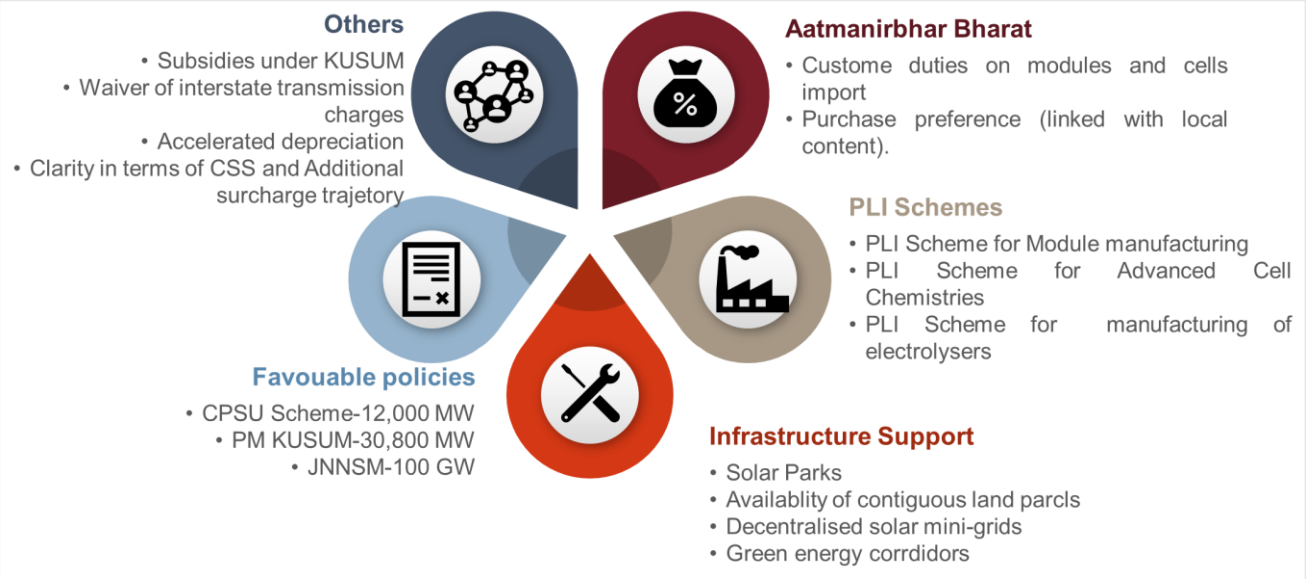
| Bidding Agency | Type | Q1FY24 | Q2FY24 | Q3FY24 | Q4FY24 | Total |
|---|---|---|---|---|---|---|
| SECI | Solar, Hybrid, RTC etc. | 3.5 | 6 | 2 | 1 | **12.5** |
| | Wind | 2.5 | | | | **2.5** |
| NTPC | Solar, Hybrid, RTC etc. | 3 | 3 | 3 | 3.5 | **12.5** |
| | Wind | | 2.5 | | | **2.5** |
| NHPC | Solar, Hybrid, RTC etc. | 3 | 1.5 | 1.5 | 1.5 | **7.5** |
| | Wind | | | 2.5 | | **2.5** |
| SJVN | Solar, Hybrid, RTC etc. | 3 | 2 | 1 | 1.5 | **7.5** |
| | Wind | | | | 2.5 | **2.5** |
| **Total** | | **15** | **15** | **10** | **10** | **50** |

Source: MNRE, CRISIL Consulting

### 7.12.2 Government provides various incentives for promotion of renewable energy

Several incentives are being provided for growth of the renewable energy sector in the country. In order to promote local manufacturing of solar panels, the Government has taken a number of steps. Government of India has been consistently bringing out policies for developing and facilitating domestic renewable energy equipment manufacturing in the country. Some of the recent initiatives undertaken to promote solar energy domestic equipment manufacturing in the country are summarised in following figure:

**Figure 95: Government incentives are aligned for manufacturing renaissance**




Source: MoP, MNRE, Various ministries, CRISIL Consulting

### 7.12.3 Manufacturing capacity additions

As discussed earlier, CRISIL Consulting expects solar PV manufacturing Capacity to reach 90-95 GW by fiscal 2028, with full integration from polysilicon to modules expected to account for 33% of capacities, largely driven by PLIs (Production-Linked Incentives).

India is the world's third-largest energy consumer, and its energy demand is expected to grow rapidly in the coming years. To meet this demand, India will need to diversify its energy mix and reduce its reliance on fossil fuels. Solar energy is a clean and abundant resource that can help India achieve its energy security goals.

### 7.12.4 Export opportunity

China is the world's largest manufacturer of solar modules, but it is also facing several challenges, including trade tensions with the US and EU, rising labor costs and environmental concerns. These challenges are making it more difficult for Chinese solar module manufacturers to compete in the global market. This is creating an opportunity for Indian solar module manufacturers to gain market share. The US and EU are implementing several regulations to promote the use of renewable energy, including solar energy. These regulations are creating a large market for solar modules in the US and EU.

India has the potential to become a global leader in the manufacturing of solar modules. The country has a large pool of skilled labor, a growing manufacturing ecosystem, and abundant access to raw materials. Additionally, the Indian government has introduced several policies to support the domestic solar industry. India's solar module manufacturing capacity is expected to reach 90-95 GW by 2028. Domestic demand for solar modules is estimated to be around 40-45 GW in the same year. This means that India will have a surplus of solar modules that can be exported to other countries.

The global solar market is expected to grow rapidly in the coming years, driven by increasing demand for renewable energy and government policies to support solar deployment. This presents a significant export opportunity for Indian solar module manufacturers.

### 7.12.5 Increased ESG Awareness

Increased ESG awareness is leading to increased demand for solar modules, as solar energy is a clean and renewable energy source that can help companies and governments reduce their carbon footprint. With increased focus on climate change, Companies and governments are looking for ways to reduce their environmental impact. Meeting international energy and climate goals requires the global deployment of solar PV to grow on an unprecedented scale. In addition to the environmental benefits, solar energy can also provide social and economic benefits. For example, solar energy can create jobs in the solar industry and can help to reduce energy poverty.

### 7.12.6 India as Global supplier

Developing countries are increasingly investing in solar energy to meet their growing energy demand. This presents a significant export opportunity for Indian solar module manufacturers. The Indian government is providing several incentives to support the export of solar modules. Indian solar module manufacturers can diversify their markets by exporting to countries where there is high demand for solar modules and low import duties.

India has an immense opportunity to export solar modules. This can help the country achieve its energy security goals and usher in a manufacturing renaissance. Indian solar module manufacturers need to overcome a few challenges, such as competition from China and high import duties in some countries. However, there are several opportunities for Indian solar module manufacturers to export their products, such as growing demand in developing countries, government support, and diversification of markets. Overall, the export demand for Indian solar modules is potentially on the rise due to anti-China sentiment and government support.

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