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Industry Research Report on Solar Sector in India

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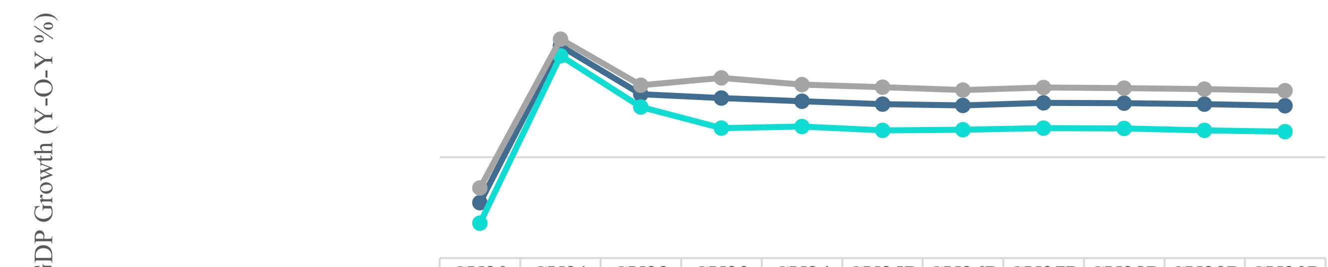
1 Economic Outlook

1.1 Global Economy

Global Economic Growth Expected to Sustain at ~3% in Near Term

Global growth, which reached 3.5% in CY23, stabilised at 3.3% for CY24 and is projected to decrease to 3.2% for CY25. Global trade is expected to be disrupted by new US tariffs and countermeasures from trading partners, leading to historically high tariff rates and economic growth projections with negative impact. The global landscape is expected to change as countries rethink their priorities and policies in response to these new developments. Central banks priority will be to adjust policies, while smart fiscal planning and reforms are key to handling debt and reducing global inequalities.

Chart 1: Global Economic Growth Outlook Projections (Real GDP, Y-o-Y change in %)



	CY20	CY21	CY22	CY23	CY24	CY25P	CY26P	CY27P	CY28P	CY29P	CY30P
World	-2.7%	6.6%	3.8%	3.5%	3.3%	3.2%	3.1%	3.2%	3.2%	3.2%	3.1%
Advanced Economies	-3.9%	6.0%	3.0%	1.7%	1.8%	1.6%	1.6%	1.7%	1.7%	1.6%	1.5%
Emerging Market and Developing Economies	-1.8%	7.0%	4.3%	4.7%	4.3%	4.2%	4.0%	4.2%	4.1%	4.1%	4.0%

Source: IMF – World Economic Outlook, October 2025; Note: P-Projection

Table 1: GDP Growth Trend Comparison - India v/s Other Economies (Real GDP, Y-o-Y Change in %)

	Real GDP (Y-o-Y change in %)										
	CY20	CY21	CY22	CY23	CY24	CY25E	CY26P	CY27P	CY28P	CY29P	CY30P
India	-5.8	9.7	7.6	9.2	6.5	7.3	6.4	6.4	6.5	6.5	6.5
China	2.3	8.6	3.1	5.4	5.0	5.0	4.5	4.0	4.0	3.7	3.4
Indonesia	-2.1	3.7	5.3	5.0	5.0	5.0	5.1	5.1	5.0	5.1	5.1
Saudi Arabia	-3.8	6.5	12.0	0.5	2.0	4.3	4.5	3.6	3.3	3.3	3.3
Middle East	-2.3	4.7	6.4	2.6	2.6	3.7	3.9	4.0	3.7	3.7	3.7
Latin America	-6.9	7.4	4.3	2.4	2.4	2.4	2.2	2.7	2.7	2.8	2.6
Brazil	-3.3	4.8	3.0	3.2	3.4	2.5	1.6	2.3	2.3	2.4	2.5
Euro Area	-6.0	6.4	3.6	0.4	0.9	1.4	1.3	1.4	1.3	1.2	1.1
United States	-2.1	6.2	2.5	2.9	2.8	2.1	2.4	2.0	2.1	1.9	1.8

Source: IMF- World Economic Outlook Database (January 2026); Note: E- Estimate P- Projections, India's fiscal year (FY) aligns with the IMF's calendar year (CY). For instance, FY24 corresponds to CY23.

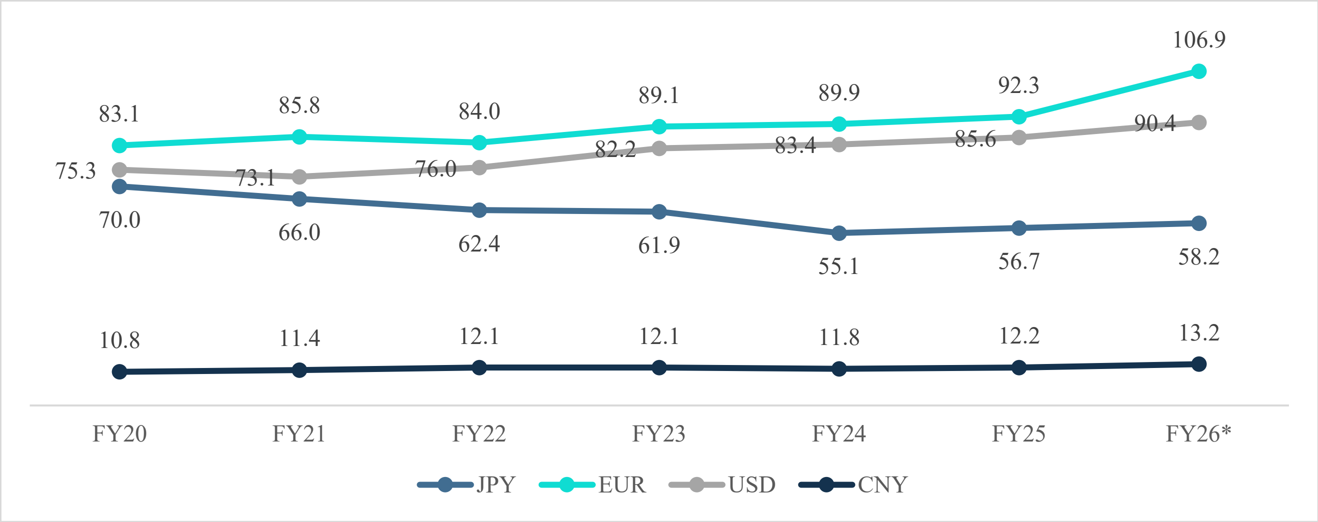
1.1.1 Comparison of GDP and Global Electricity Demand

Global GDP growth in 2025 is expected to be around 3 to 3.3%, with advanced economies growing slowly at about 1.6% and developing economies like India and China expanding swiftly at roughly 6.6% and 4.8% respectively. In contrast, global electricity demand grew by 4.3% in 2024 and is forecasted to rise by about 3.4% annually through 2026 outpacing GDP growth due to factors such as increased electrification, cooling needs, number of data centres and usage of electric vehicles. While GDP growth reflects economic expansion, electricity growth is accelerating even faster, driven by industrialisation and the global shift toward renewable energy sources like solar and wind, which now account for over 40% of power generation worldwide.

1.1.2 Exchange Rate

The Indian Rupee (INR) has moved materially against the U.S. Dollar (USD), Euro (EUR) and Japanese Yen (JPY) over FY20–FY26. The USD/INR rate increased from Rs 75.3 per USD in FY20 to Rs 90.4 per USD in FY26 (as on 3rd February 2026), indicating an appreciation of the USD and depreciation pressure on the INR. Similarly, EUR/INR rose from Rs 83.1 per EUR in FY20 to Rs 106.9 in FY26 (as on 3rd February 2026), reflecting a strengthening EUR against the INR. In contrast, the Yen weakened over FY20–FY24 as the INR per 100 JPY rate declined from Rs 70.0 per 100 JPY in FY20 to Rs 55.1 per 100 JPY in FY24, followed by a mild rebound to Rs 56.7 per 100 JPY in FY25 and Rs 58.2 per 100 JPY in FY26 (as on 3rd February 2026). Overall, the data indicates sustained depreciation pressure on the INR versus the USD and EUR, while the JPY showed a modest recovery after earlier weakening.

Chart 2: Exchange Rate of Indian Rupee against US Dollar, Japanese Yen, CNY and EUR



Source: CareEdge Research
Note: Exchange rate is as on the last date of the financial year. FY26* exchange rate is as on 3rd February 2026. INR is per 100 JPY

1.2 Indian Economic Outlook

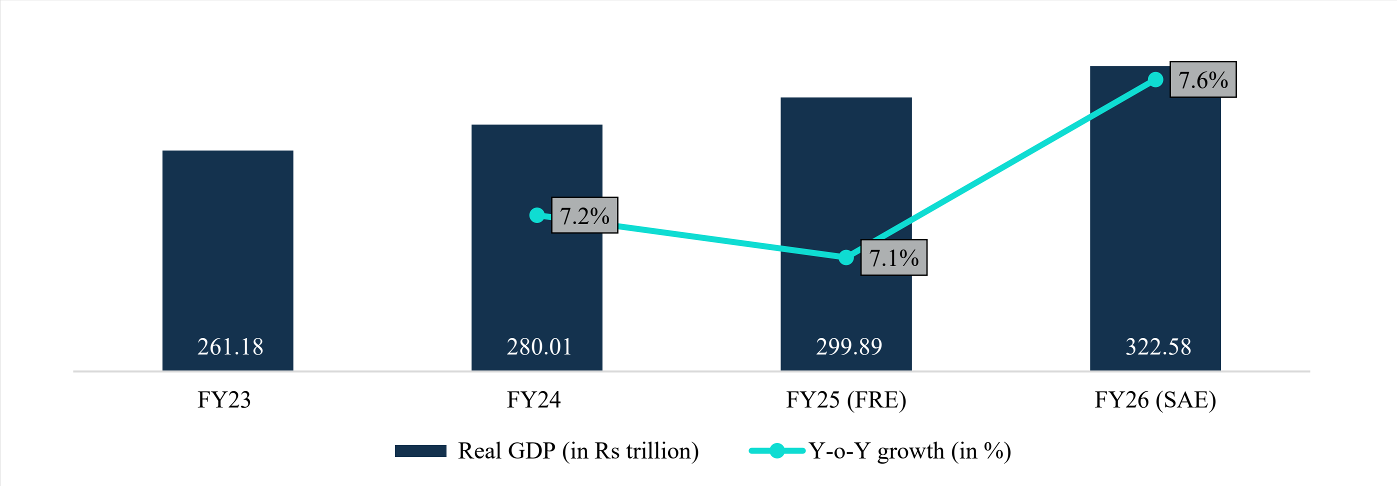
1.2.1 GDP Growth and Outlook

Resilience to External Shocks Remains Critical for Near-Term Outlook

India's economy continues to show rapid growth. For FY26, GDP is expected to grow by 7.4%, supported by rising rural demand, better job opportunities, and active business conditions.

In FY25, provisional estimates show a growth of 7.1% (Rs 299.09 trillion), led by robust performance in manufacturing, construction, and financial services. Consumer spending rose by 7.6%, and government spending increased by 3.8%, both contributing to the overall growth. In FY23, the GDP grew by 261.18 trillion, followed by 7.2% (Rs 280.01 trillion) in FY24.

Chart 3:Trend in Real Indian GDP Growth Rate



Source: MOSPI, RBI; Note: FRE- First Revised Estimates, SAE- Second Advanced Estimates, the trend for FY23-FY26 is based on new series base year 2022-23.

GDP Growth Outlook (February 2026)

FY26 GDP Outlook: The RBI projects real GDP growth at 7.4% for 2025–26, driven by industrial and services sectors. The upward trajectory of growth is also due to income tax and goods and services tax (GST) rationalization, softer crude oil prices, increase of government capital expenditure, and facilitative monetary and financial conditions lower inflation rates.

However, risks from prolonged geopolitical tensions, global trade disruptions, and weather-related uncertainties remain. Taking these into account, the RBI has reaffirmed its growth projections.

Table 2: GDP Growth Outlook (Y-o-Y %)

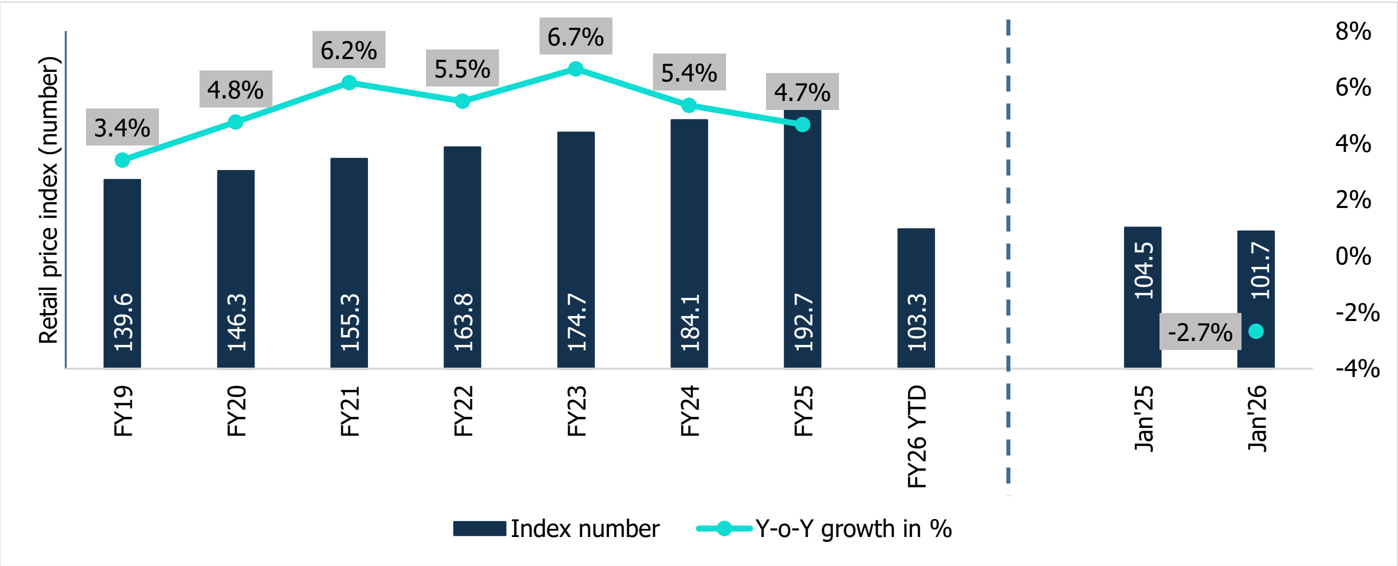
FY26P (complete year)	Q1FY27P	Q2FY27P
7.4%	6.9%	7.0%

Source: Reserve Bank of India; Note: P-Projected

1.2.2 Consumer Price Index

The Consumer Price Index (CPI) for January 2026 recorded a combined inflation rate of 2.75%, there was an increase of 36 basis points in January 2026 from December 2025 in inflation. The y-o-y food and housing inflation for the month of January is 2.13% and 2.05% respectively.

Chart 4: Retail Price Inflation in terms of index and Y-o-Y Growth in %
(Base: 2011-12=100, 2023-24=100)

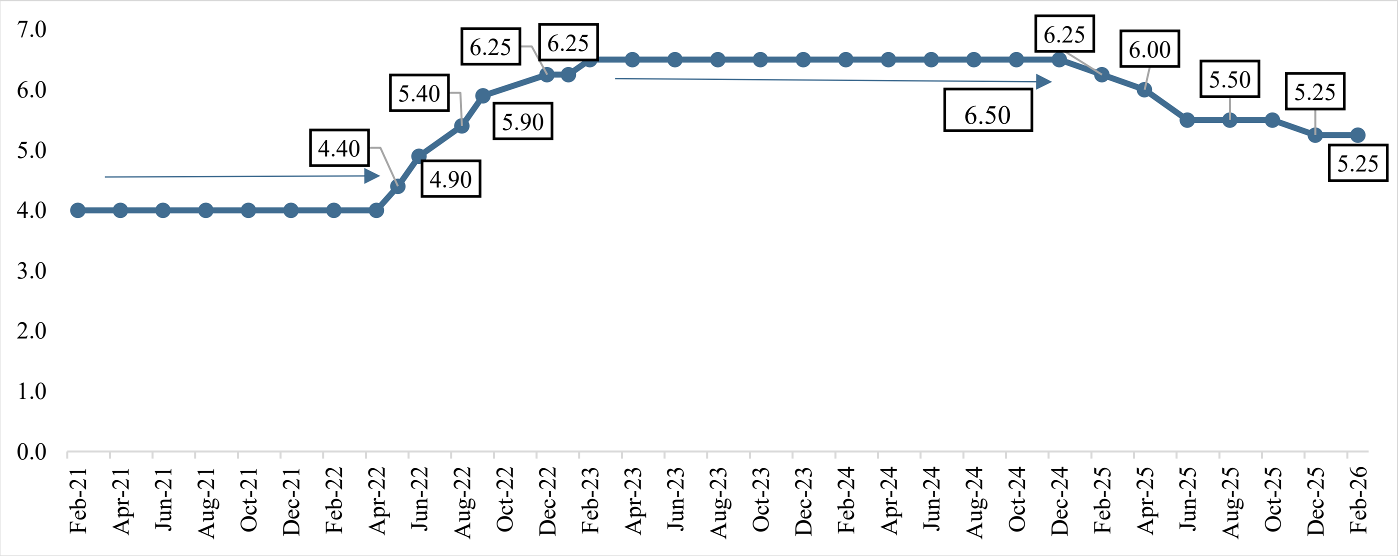


Source: MOSPI

The CPI is primarily factored in by RBI while preparing their bi-monthly monetary policy. At the bi-monthly meeting held in February 2026, RBI projected inflation at 2.1% for FY26 with inflation during Q4FY26 at 3.2%, Q1FY27 at 4.0% and Q2FY27 at 4.2%.

Considering the current inflation situation, the RBI has maintained the repo rate at 5.25% in the February 2026 meeting of the Monetary Policy Committee.

Chart 5: RBI Historical Repo Rate



Source: RBI

The RBI maintained a 'neutral' monetary policy stance, continuing to signal confidence that India's economic growth would remain resilient, underpinned by robust private consumption and sustained expansion in fixed capital formation, while also emphasizing persistent external risks. The domestic demand conditions remain supportive even as global uncertainties prevail.

The RBI has adopted for a non-inflationary growth with the foundations of strong demand and supply with a good macroeconomic balance. The domestic growth and inflation curve requires the policies to be supportive of the volatile trade conditions.

1.2.3 Gross Value Added (GVA) in the Industrial Sector

Gross Value Added (GVA) is the measure of the value of goods and services produced in an economy. GVA gives a picture of the supply side whereas GDP represents consumption. India's recovery in FY25 was powered by a broad-based rebound across sectors. The gap between GDP and GVA growth stood at 0.1 percentage point in FY25, with GDP growing at 7.2% and GVA at 7.3%, as per MoSPI's provisional estimates released in March 2026.

In FY26 (FAE), real GVA growth of 7.7% is primarily led by manufacturing, Trade, Repair, Hotels, Transport, Communication & Services related to Broadcasting, Storage. Industry is estimated at 8.8%, supported by a pickup in manufacturing and construction (11.5% and 7.1% respectively).

Table 3: Industrial Sector Growth (Y-o-Y Growth) -at Constant Prices

At constant Prices	FY24 (FRE)	FY25 (PE)	FY26 (FAE)
Agriculture, Forestry & Fishing	**2.6**	**4.2**	**2.4**
Industry	**10.9**	**8.3**	**8.8**
Mining & Quarrying	2.4	11.7	4.1
Manufacturing	12.7	9.3	11.5
Electricity, Gas, Water Supply & Other Utility Services	10.7	2.9	1.5
Construction	9.9	7.3	7.1
Services	**7.0**	**7.9**	**9.0**
Trade, Hotels, Transport, Communication & Broadcasting	10.1	6.6	10.1
Financial, Real Estate & Professional Services	5.5	10.0	9.9
Public Administration, Defence and Other Services	6.8	5.0	5.8
GVA at Basic Price	**7.2**	**7.3**	**7.7**

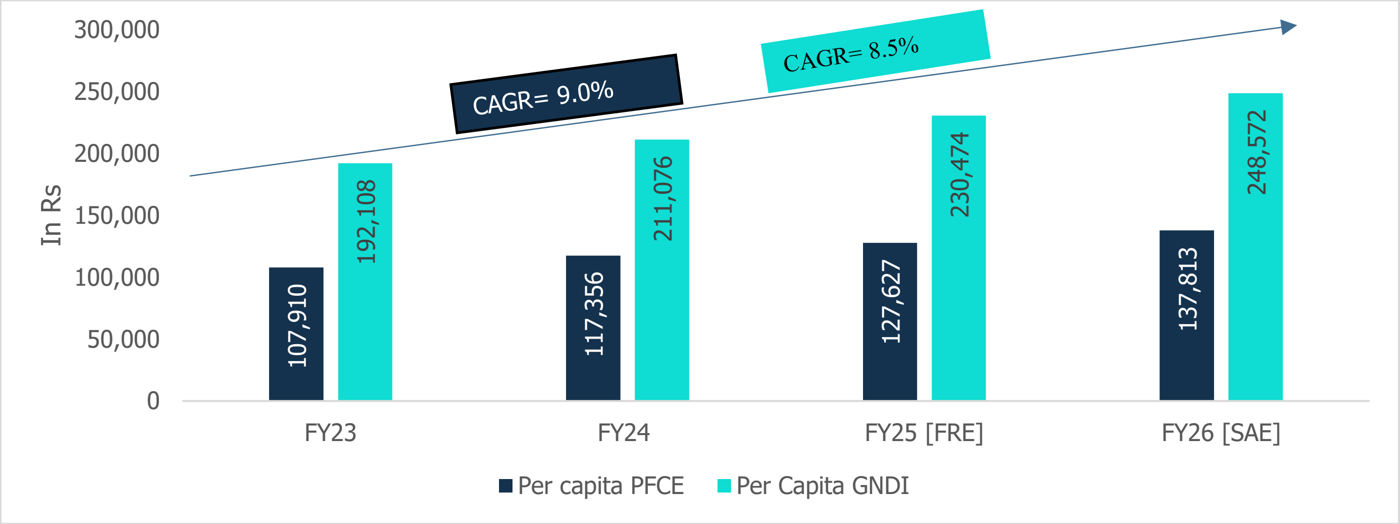
Source: MOSPI; Note: FRE- First Revised Estimates, SAE – Second Advanced Estimates; The trend for FY24-FY26 is based on new series base year 2022-23.

1.2.4 Per Capita PFCE and GNDI

Gross National Disposable Income (GNDI) is a measure of the income available to the nation for final consumption and gross savings. Between the period FY23 to FY26, per capita GNDI at current prices registered a CAGR of 8.5%. More disposable income drives more consumption, thereby driving economic growth.

With increase in disposable income, there has been a gradual change in consumer spending behaviour as well. Per capita Private Final Consumption Expenditure (PFCE) which is measure of consumer spending has also showcased significant growth from FY23 to FY26 at a CAGR of 9.0%.

Chart 6: Trend of Per Capita GNDI and Per Capita PFCE (Current Price)



Source: MOSPI; Note: FRE – First Revised Estimates, SAE- Second Advanced Estimates, The trend for FY23-FY26 is based on new series base year 2022-23.

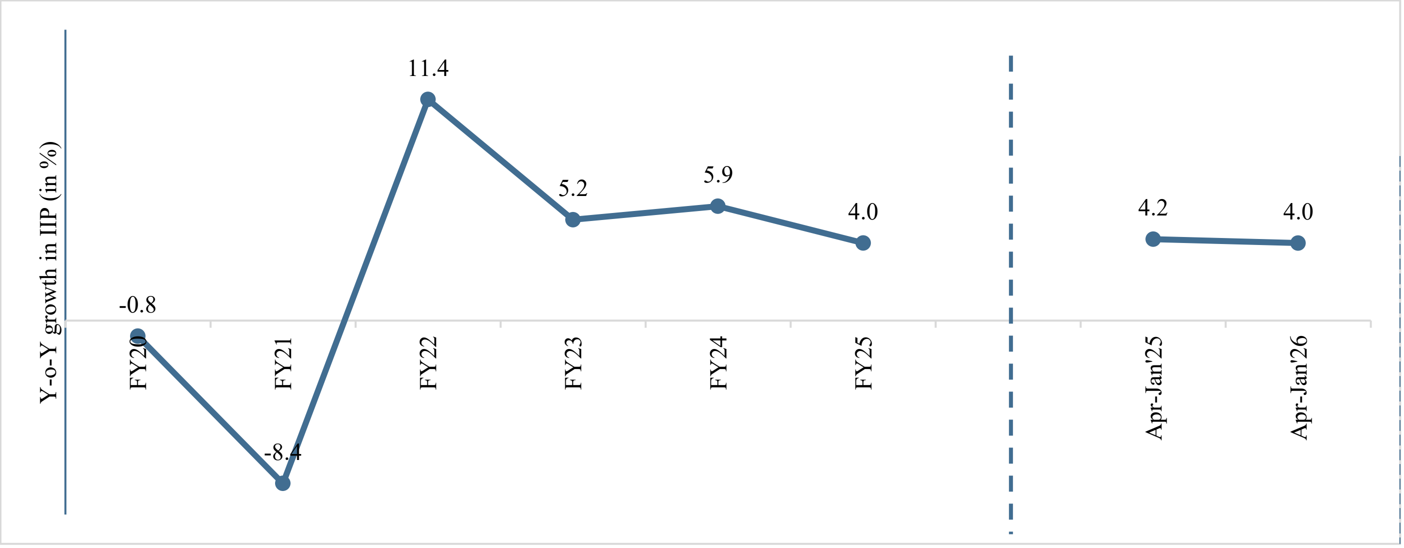
1.2.5 Industrial Growth

The Quick Estimates of the Index of Industrial Production (IIP) for January 2026 shows a growth of 4.8%, a decrease from 0.4% from January 2025. The year-on-year decline in IIP reflects weakness across major segments, primarily due to contractions in electricity, mining, and consumer non-durables.

In January 2026, industrial growth was mainly supported by Mining, Manufacturing and Electricity sectors with indices standing at 157.2, 167.2 and 212.1 respectively.

Use-based indices indicate the top three positive contributors to the growth of IIP for the month of January 2026 are Infrastructure/ construction goods, Intermediate goods and Primary goods.

Chart 7: Y-o-Y growth in IIP (in %)

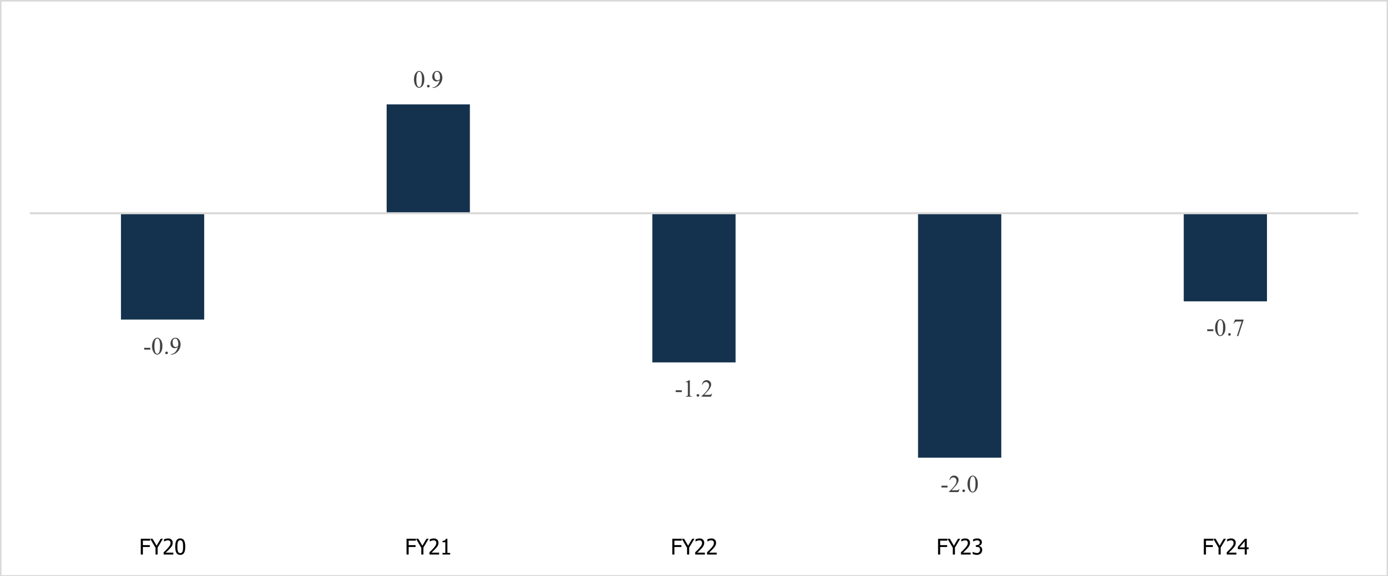


Source: MOSPI

1.2.6 Current Account Deficit

The Current Account Deficit (CAD), which reflects the difference between a country's total foreign income and expenditures, is a key indicator of the strength of a nation's external sector. Between FY20 and FY24, India's Current Account Deficit (CAD) exhibited a current account surplus in FY21 attributed to reduced import absorption amid GDP contraction. India's CAD widened post FY21 from 1.2% in FY22 to USD 67 billion, or 2% of GDP in FY23. However, the trend reversed in FY24, with the deficit narrowing to USD 31.1 billion, or 1.2% of GDP. This reduction was driven by a decrease in the merchandise trade deficit, a rise in net services exports, and increased remittances. Robust global demand for India's service sectors, including IT, accountancy and legal services, played a crucial role in facilitating this positive shift.

Chart 8: Current Account Deficit (%)

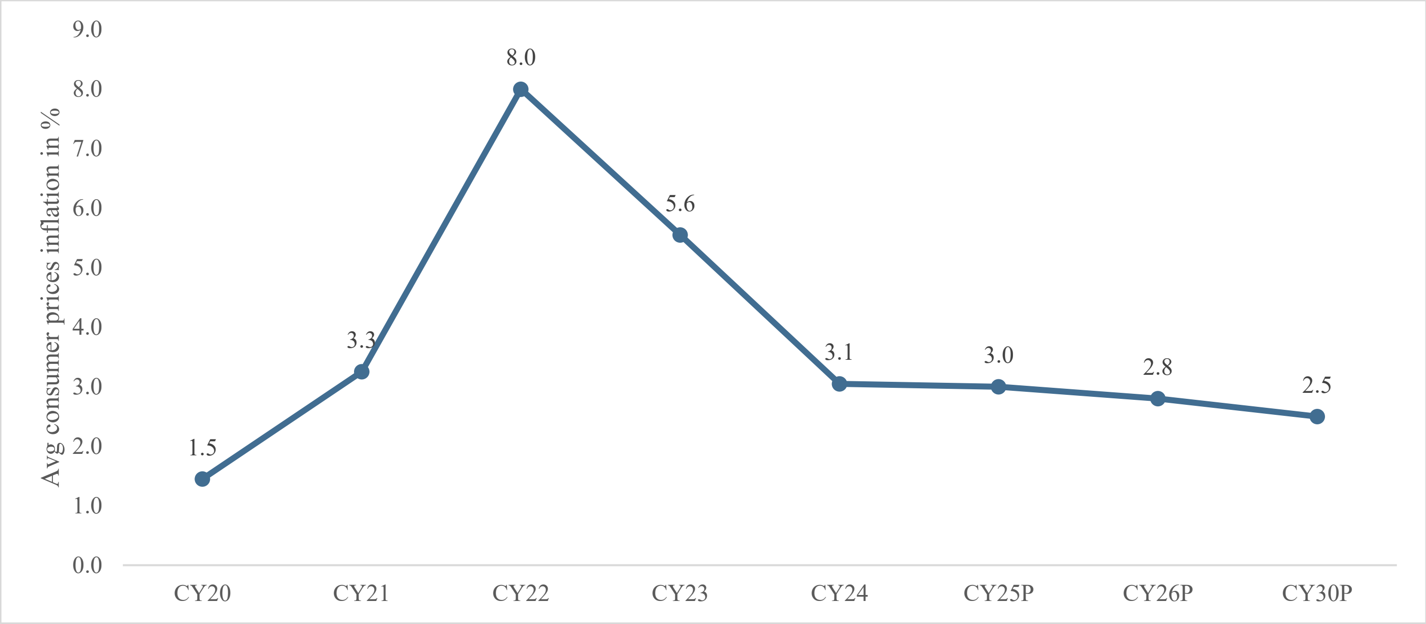


Source: MOSPI

1.2.7 Global inflation outlook

According to International Monetary Fund (IMF), global inflation is expected to decline slower than expected. It is forecasted to be 3.0% in CY25 and 2.8% in CY26. While inflation is projected to decrease slightly in advanced economies and developing economies in CY25. The ongoing global trade tensions can be one of the contributing factors for the projections for global inflation. Central banks are expected to adjust policies, while smart fiscal planning and reforms are going to be the key to handling debt and reducing global inequalities.

Chart 9: Global Inflation Outlook



Source: IMF – World Economic Outlook, October 2025; Note: P-Projection, E-Estimated

1.2.8 Fiscal Deficit (as a % of GDP)

From CY20 to CY24, fiscal deficits narrowed globally from pandemic highs but remain elevated in the US (6.5% in CY24P) and China (8.6%), with developing economies and advanced economies excluding the US showing smaller gaps. India's deficit, though declining from 12.9% in CY20 to 6.9% in CY24P, stays one of the highest deficits amongst major economies. Projections to CY29 suggest limited consolidation, with deficits broadly stabilising rather than returning to pre-pandemic lows.

Table 4: Fiscal Deficit as a % of GDP - India v/s Other Economies

Fiscal Deficit as a % of GDP											
	CY20	CY21	CY22	CY23	CY24	CY25P	CY26P	CY27P	CY28P	CY29P	CY30P
World	-9.5	-6.3	-3.7	-4.9	-5.0	-5.1	-4.7	-4.5	-4.5	-4.5	-4.6
Advanced Economies excl. US	-7.6	-4.3	-2.3	-2.5	-2.6	-2.5	-2.5	-2.4	-2.5	-2.6	-2.6
United States	-14.1	-11.4	-3.7	-7.2	-7.3	-6.5	-5.5	-5.4	-5.6	-5.5	-5.6
Emerging Markets excl. China	-7.8	-4.2	-2.9	-4.2	-4.3	-4.5	-4.2	-3.8	-3.5	-3.4	-3.3
China	-9.6	-5.9	-7.3	-6.7	-7.3	-8.6	-8.5	-8.1	-8.1	-8.0	-8.1
India	-12.9	-9.4	-9.0	-7.9	-7.4	-6.9	-7.2	-7.1	-7.0	-6.8	-6.7

Source: IMF Data Portal (October 2025), Note: P- Projections; India's fiscal year (FY) aligns with the IMF's calendar year (CY). For instance, FY24 corresponds to CY23.

1.2.9 Current Account Deficit (% of GDP)

The United States is projected to run a large current account deficit throughout CY20-CY30P (around -3.5% to -4.0% of GDP). The Euro Area and China are projected to remain in surplus, with China's surplus rising in CY25P and then easing gradually.

Middle East and Central Asia move from deficit in CY20 to strong surpluses in CY21-CY23, before settling near a small surplus by CY30P, while Saudi Arabia shifts from a large surplus in CY22 to deficits from CY25P onwards. India and Indonesia are projected to remain in modest deficit over the forecasted period, with India's deficit widening gradually to about -1.9% of GDP by CY30P.

Table 5: Current Account Deficit

	Current Account Balance (% of GDP)										
	CY20	CY21	CY22	CY23	CY24	CY25P	CY26P	CY27P	CY28P	CY29P	CY30P
United States	-2.8	-3.6	-3.8	-3.3	-4.0	-4.0	-3.6	-3.6	-3.6	-3.6	-3.5
Euro Area	1.8	2.8	-0.1	1.7	2.6	2.3	2.2	2.2	2.2	2.1	2.1
Middle East and Central Asia	-3.0	3.2	8.0	4.0	2.3	1.2	0.6	0.4	0.4	0.4	0.5
Saudi Arabia	-3.3	4.1	12.1	2.9	-0.5	-2.1	-2.5	-3.2	-3.1	-3.0	-2.8
India	0.9	-1.2	-2.0	-0.7	-0.6	-1.0	-1.4	-1.6	-1.7	-1.8	-1.9
Indonesia	-0.4	0.3	1.0	-0.1	-0.6	-1.1	-1.2	-1.2	-1.1	-1.1	-1.1
China	1.6	1.9	2.4	1.4	2.3	3.3	2.8	2.5	2.4	2.2	2.1

Source: IMF Data Portal (October 2025), Note: P- Projections; India's fiscal year (FY) aligns with the IMF's calendar year (CY). For instance, FY24 corresponds to CY23.

1.2.10 Key Global Initiatives and Policy Push Towards Clean Energy

Global momentum towards clean energy is being shaped by international commitments that set direction and targets alongside domestic measures that influence project economics, access to capital, disclosure expectations and trade conditions. For Indian industry, the practical effect is a progressively tighter operating environment for carbon intensive production and a stronger enabling framework for renewables, energy efficiency, electrification and low carbon fuels.

- **Multilateral Direction Setting and Targets**

The Paris Agreement establishes a five-year cycle for countries to submit and strengthen nationally determined contributions, with progress assessed through the global stocktake.

At COP28, the UAE Consensus and associated pledges reinforced a global policy signal to accelerate the transition, including ambitions to triple renewable energy capacity and double the rate of energy efficiency improvement by 2030.
Article 6 of the Paris Agreement provides pathways for international cooperation including market mechanisms and cooperative approaches intended to mobilise finance and support mitigation, subject to robust accounting and authorisations.

In parallel, targeted initiatives such as the Global Methane Pledge are increasing attention on near term methane abatement across sectors, supported by voluntary national actions and implementation platforms.

- **Carbon Pricing, Trade Measures and Competitiveness**

The EU is tightening its climate policy framework through the European Climate Law and the Fit for 55 packages, aligning instruments to deliver at least a 55% net emissions reduction by 2030 (vs 1990).

The EU Emissions Trading System remains a central price signal, operating as a cap-and-trade scheme with a declining cap over time.

The EU Carbon Border Adjustment Mechanism introduces embedded emissions reporting requirements in a transitional phase from 1 October 2023 to 31 December 2025, with the definitive regime starting from 1 January 2026, noting that implementation details have been subject to proposed revisions.

- **Fiscal Support and Industrial Policy for Clean Technologies**

In the United States, the Inflation Reduction Act provides a long horizon of tax incentives for clean electricity, manufacturing and low carbon technologies including clean hydrogen, which can influence global cost benchmarks and supply chain investment decisions.

At the cooperation level, the Clean Energy Ministerial and Mission Innovation support policy coordination and technology innovation, with an emphasis on accelerating deployment and lowering technology costs over time.

- **Disclosure and Sustainable Finance Expectations**

The International Sustainability Standards Board's IFRS S2 climate related disclosures are effective for annual reporting periods beginning on or after 1 January 2024, subject to jurisdictional adoption, increasing the emphasis on decision grade climate risk and metrics.

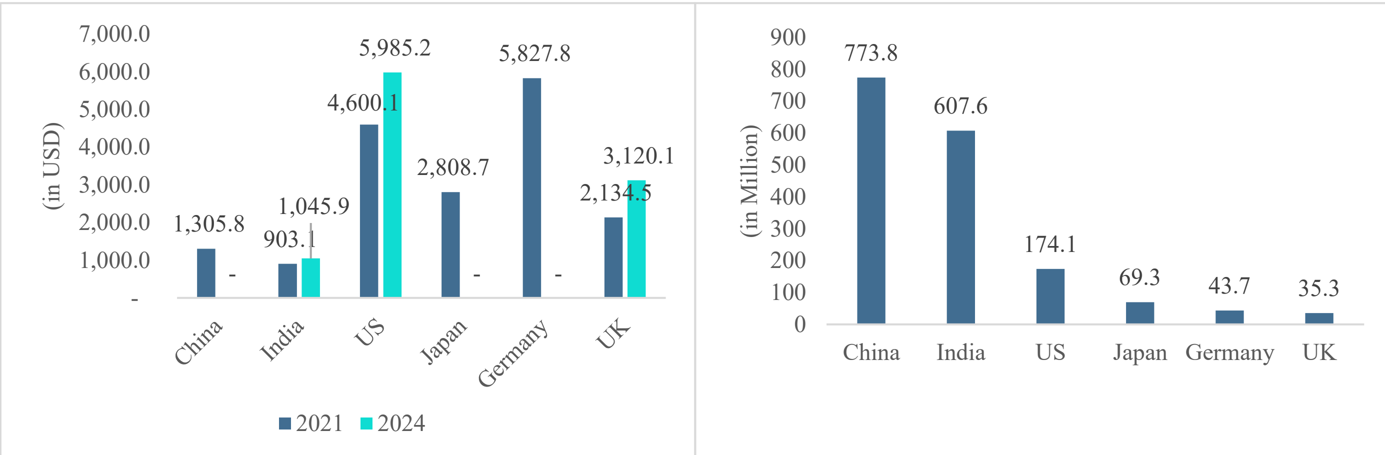
In the EU, the Corporate Sustainability Reporting Directive starts applying to the first set of companies for the 2024 financial year, with reports published in 2025, which is expected to cascade data requests through global value chains.

1.2.11 India as an Emerging Manufacturing Hub

China plus one strategy: The China+1 strategy focuses on reducing over-dependence on China by diversifying manufacturing to alternative locations with cost and policy advantages. India has emerged as a preferred "+1" destination alongside Vietnam, Thailand, Malaysia and Mexico, driven by heightened trade volatility, rising costs, and regulatory tightening in China. Recent tariff actions by the United States on Chinese products and stricter entry barriers imposed by the European Union have accelerated supply-chain diversification. India's attractiveness is supported by government initiatives such as the Production-Linked Incentive (PLI) scheme and Make-in India, large domestic demand and improving manufacturing infrastructure. In February 2025, India and the U.S. discussed expanding bilateral trade from USD 200 billion to USD 500 billion by 2030, with discussions remaining positive as of September 2025.

Competitive Labour Costs and Skilled Labour: India is emerging as an attractive manufacturing destination for global companies seeking diversified and cost-efficient production bases. The country benefits from a large demographic advantage, with a young and abundant labour pool, providing a strong foundation for manufacturing growth. India's relatively competitive labour costs and supportive policy environment have encouraged investments across high-growth sectors such as electronics, automotive components, solar, pharmaceuticals and textiles. In addition, India is actively pursuing free trade agreements with key partners including the EU, the UK and Australia, which could enhance market access through more favourable tariff structures. As compared to other countries such as the United States, Germany and Japan where labour costs are higher due to stringent labour regulations and strong unions, India offers a more flexible and cost-competitive labour market. This advantage has made India an appealing location for companies looking to establish or expand manufacturing operations.

Chart 10:Average Monthly Earnings of Employees and Labour Force (2024)



Source: World Bank, International Labour Organization (ILO)

Note: Monthly earnings of China, Japan and Germany is not given available for 2024.

Labour force comprises people ages 15 and older who supply labour to produce goods and services during a specified period. It includes people who are currently employed and people who are unemployed but seeking work as well as first-time jobseekers. Not everyone who works is included, however. Unpaid workers, family workers, and students are often omitted, and some countries do not count members of the armed forces. Labor force size tends to vary during the year as seasonal workers enter and leave.

The global labour force stands at about 3,696.2 million, with India and China together accounting for nearly 37%, or roughly 1,381.4 million. This highlights India's large labour force, which makes it an attractive destination for global companies looking to set up or expand their operations.

Strong Government Push

India's emergence as a global manufacturing hub is strongly supported by proactive government initiatives aimed at improving ease of doing business, strengthening infrastructure and enhancing industrial competitiveness.

To support long-term economic growth and strengthen India's manufacturing ecosystem, the Government of India has launched the National Infrastructure Pipeline (NIP), a comprehensive infrastructure development programme with an estimated investment outlay of over Rs 110 lakh crore during FY20 to FY25. The national infrastructure pipeline focuses on expanding transport, power, urban infrastructure and logistics to improve connectivity, lower costs and enhance efficiency, creating a strong foundation for industrial growth and strengthening India's position as a competitive manufacturing hub. In line with these objectives, sectors such as roads, urban infrastructure, railways, power (both conventional and renewable) and irrigation have received the largest share of funding under the programme.

Make-in India: A flagship government programme aimed at transforming India into a global manufacturing and investment destination. It focuses on strengthening domestic manufacturing capabilities, improving ease of doing business, and encouraging both domestic and foreign companies to set up and expand production in India across key sectors. The initiative has played an important role in promoting industrial growth, boosting employment, and enhancing India's integration into global value chains.

PLI Scheme: India's Production Linked Incentive (PLI) schemes, driving significant investments and manufacturing growth across key sectors. By late 2025, the programme attracted over Rs 2 lakh crore in investments leading to substantial incremental production, exports and job creation. Electronics has emerged as the flagship sector, with strong momentum in mobile manufacturing and exports, while textiles, automobiles, and clean energy segments have also seen healthy traction. PLI scheme is expected to significantly boost industrial investment and revenue in key sectors. It is expected to attract around Rs 3 trillion in cumulative capital expenditure over its scheme period, accounting for roughly 5 % of total capex in major manufacturing segments. The incentives, totalling to around Rs 1.8 to 1.9 lakh crore, are expected to drive incremental revenue of nearly Rs 30 lakh crore, highlighting the scheme's strong potential to boost domestic manufacturing, scale up production, and improve export competitiveness.

Innovation and Technology Development: India is rapidly advancing in clean electricity and policy-driven energy transitions, creating significant opportunities for investment in sustainable energy. Key initiatives include the development of Green Energy

Corridors and grid modernisation, enabling better integration of renewable energy sources such as solar and wind into the national grid. Technological upgrades are enhancing grid stability and reliability, while the deployment of Battery Energy Storage Systems (BESS) supports demand management and intermittent renewable generation. Additionally, emerging technologies like green hydrogen are being promoted as a clean fuel alternative, positioning India at the forefront of innovation in sustainable energy and facilitating long-term energy security.

India's Competitiveness Ranking Shows Steady Improvement

The World Competitiveness Ranking, published annually by the International Institute for Management Development (IMD), assesses how effectively countries create and sustain an environment that supports business competitiveness and long-term economic growth. The ranking evaluates economies across four key pillars economic performance, government efficiency, business efficiency and infrastructure.

Table 6: The Global Competitiveness Ranking

Country	Overall		Government Efficiency		Business Efficiency		Infrastructure	
	2018	2025	2018	2025	2018	2025	2018	2025
US	1	13	26	33	12	19	1	11
China	13	16	46	37	15	18	19	15
Germany	15	19	19	27	19	29	11	13
Japan	25	35	41	38	36	51	41	19
India	44	41	50	45	29	25	56	51
UK	20	29	18	36	31	36	14	20

Source: International Institute for Management Development, World Economic Forum

India's competitiveness ranking improved to 41 in 2025 from 44 in 2018, reflecting a steady rise over the past seven years. This improvement highlights the impact of structural reforms, policy measures and efforts to strengthen infrastructure, governance and the business environment supporting India's progress as a more competitive economy.

2 Overview and Outlook of Power Sector in India

2.1 India's Position in Global Electricity Consumption

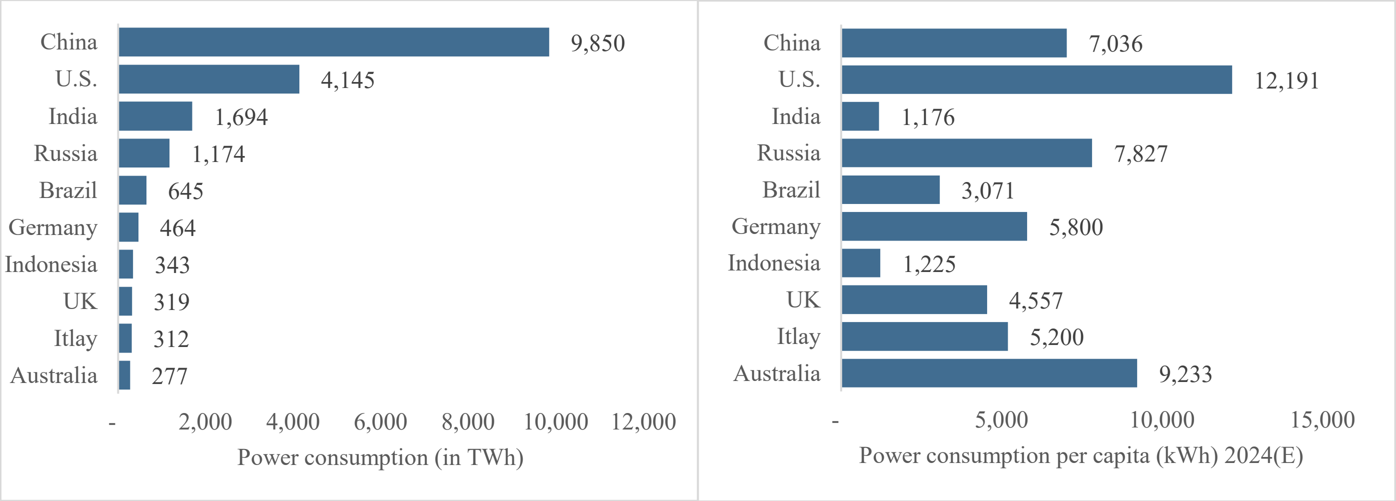
2.1.1 India's Per Capita Power Consumption and Comparison Across Key Global Markets

GDP and electricity demand in India and globally highlights a strong correlation between economic development and per capita power consumption. Advanced economies typically show higher electricity usage, driven by greater levels of urbanisation and industrialisation. While India's per capita electricity consumption has increased over time, it still remains below the global average and shows significant regional variation.

In 2024, India ranked as world's third-largest consumer of electricity, with total consumption of about 1,694 TWh, following China and the United States which recorded consumption of around 9,850 TWh and 4,145 TWh, respectively. Despite its large aggregate consumption, India has the lowest per capita electricity usage among the top ten power-consuming countries globally.

This relatively low per capita consumption, alongside an accelerating urbanisation, growing population and manufacturing activity indicates India's substantial long-term potential for power demand growth.

Table 7: India is The World's 3rd Largest Power Consumer in 2024, Low Per Capita Consumption Signals Strong Growth Potential



Source: World bank, IEA, CEA, respective government data sources, CareEdge Research

2.1.2 Global Trends in Electricity Generation and Installed Capacity

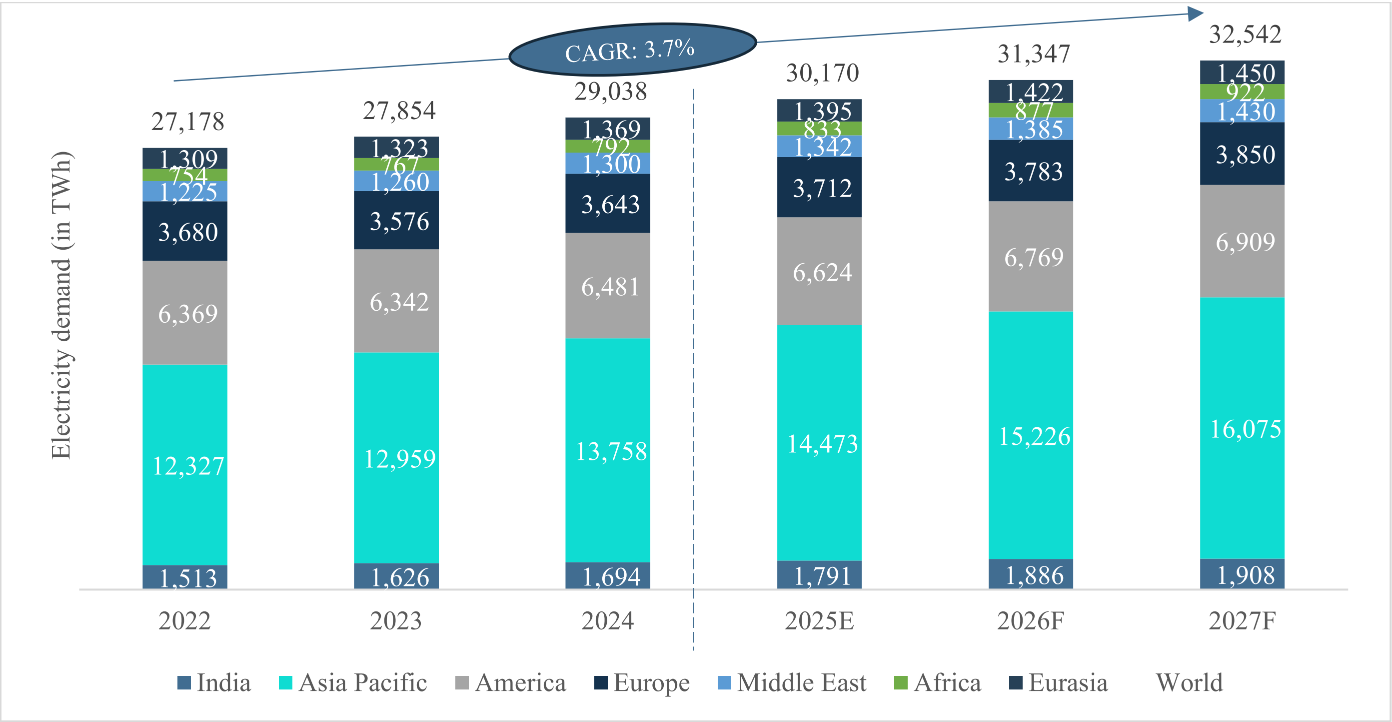
Strong Global Power Demand Growth From 2024 Through 2027

According to the International Energy Agency (IEA), electricity demand grew by 4.3% globally in 2024 compared to 2.5% in 2023. More than half of this growth came from China where electricity demand increased by 7% in 2024. While advanced economies also saw higher electricity use due to the rapid expansion of data centres and continued electrification of transport and heating, developing economies remained the main drivers of demand.

Moving ahead, global electricity demand is projected to grow at a CAGR of 3.9% over 2024–2027. Demand growth over 2025–2027 is expected to be driven by higher industrial output, increased air-conditioning usage, growing electrification and rapid expansion of data centres worldwide.

Developing economies are expected to account for about 85% of additional global electricity demand through 2027, while the share of advanced economies in additional demand is projected to rise to around 15%. China's electricity demand is forecasted to grow at an average of 6% annually through 2027, while India, Southeast Asia and other developing economies are also expected to record strong growth. India's electricity demand is projected to increase at an average annual rate of 6.3% over the next three years, exceeding its 2015–2024 average growth of 5%. In the United States, expansion in number of data centres remains a key demand driver, whereas in the European Union, uncertainty around the recovery of energy-intensive industries continues to influence electricity demand trends.

Chart 11: Global Electricity Demand is Set to Expand at a Strong 3.9% CAGR Over 2024–2027



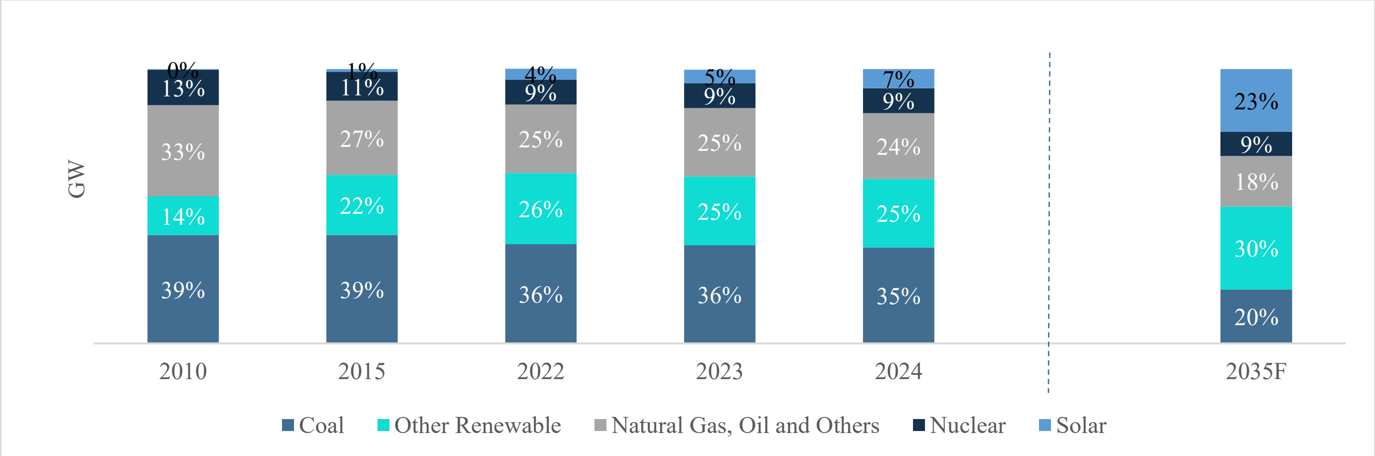
Source: IEA Global Energy Review 2025, CareEdge Research; Note: E: Estimated, F: Forecasted
The above chart is presented on a calendar-year basis, while India data is reported on a fiscal-year basis. The projected figures for India for FY25, FY26, and FY27 are based on CareEdge Research projections

Renewable Energy is Expected to Dominate Global Installed Capacity and Electricity Generation

Renewable energy is expected to meet most of the incremental demand. Global electricity generation from renewables grew by 10% Year-on-Year (Y-o-Y) in 2024, double the 5% Y-o-Y increase in 2023. According to IEA, renewable generation is expected to grow by about 10% annually through 2027, adding roughly 3,400 TWh of electricity generation globally and accounting for nearly 90% of total growth in electricity demand over this period.

Global Electricity Generation Increased by Over 1,200 TWh in 2024, Growing at a Faster Pace of 4%

Chart 12: Global Electricity Generation Mix (in %)

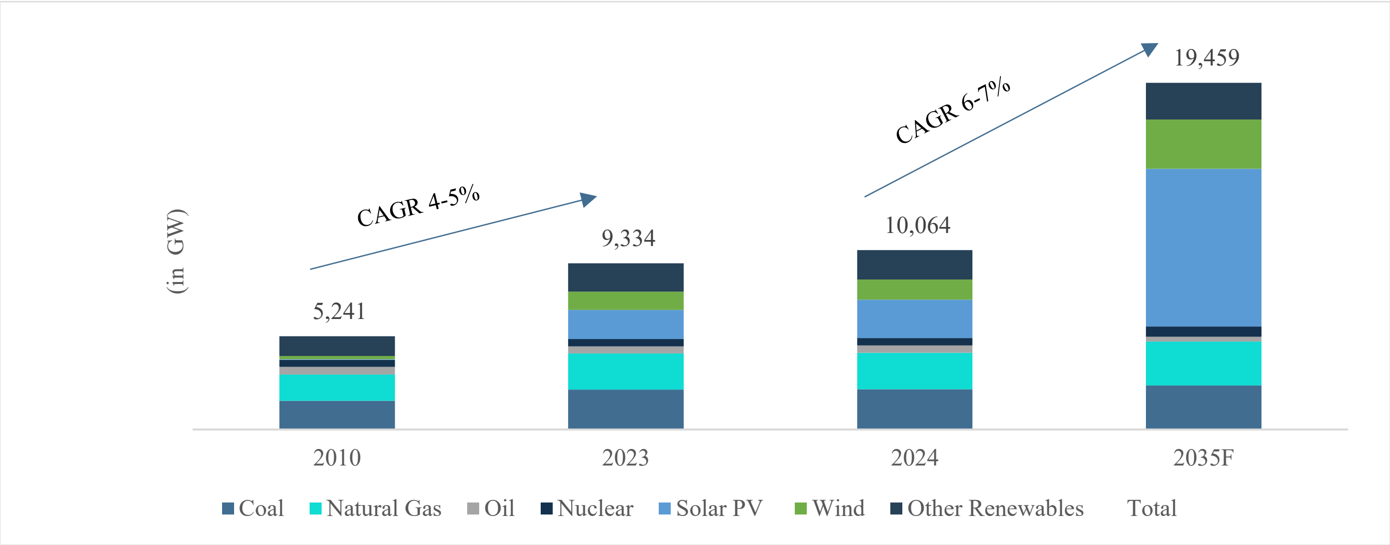


Source: IEA Global Energy Review 2025, IEA World Energy Outlook 2025, CareEdge Research, Note: F: Forecasted

According to IEA's World Energy Outlook 2025, global electricity generation is projected to reach about 44,274 TWh by 2035 and 49,114 TWh by 2040, with renewable energy playing a significantly larger role. Solar PV and wind are expected to account for a much higher share of electricity generation than today and to clearly surpass coal, the share of which is set to decline as renewables expand rapidly. Nuclear power generation is also projected to increase over this period.

Global Installed Electricity Capacity is Expected to Grow at Around 6% CAGR Till 2035

Chart 13: Global Installed Electricity Capacity



Source: IEA Global Energy Review 2025, IEA World Energy Outlook 2025, CareEdge Research
Note: F: Forecasted

According to the IEA World Energy Outlook 2025, global installed electricity capacity nearly doubled from 5,241 GW in 2010 to 10,064 GW in 2024. This growth was largely driven by renewables, which accounted for about 74.7% of total capacity additions from 2010 to 2024, translating to nearly 3,600 GW of new capacity addition. Solar PV emerged as the key growth driver, with global capacity reaching 2,164 GW in 2024, led by China, the United States and the European Union. Looking ahead, the IEA expects global installed electricity capacity to grow at a CAGR of 6–7% between 2024 and 2035, supported by faster renewable expansion at a CAGR of 9-10%, with solar PV playing a crucial role and projected to grow at a CAGR of 14-15%.

Table 8: Increase in Renewable Share Driven by Solar Growth

Sources	2010	2023	2024	2035F
Coal	31%	24%	22%	13%
Natural Gas	28%	22%	20%	13%
Oil	8%	4%	4%	1%
Nuclear	8%	4%	4%	3%
Solar PV	1%	17%	22%	46%
Wind	3%	11%	11%	14%
Other Renewables	21%	17%	16%	11%

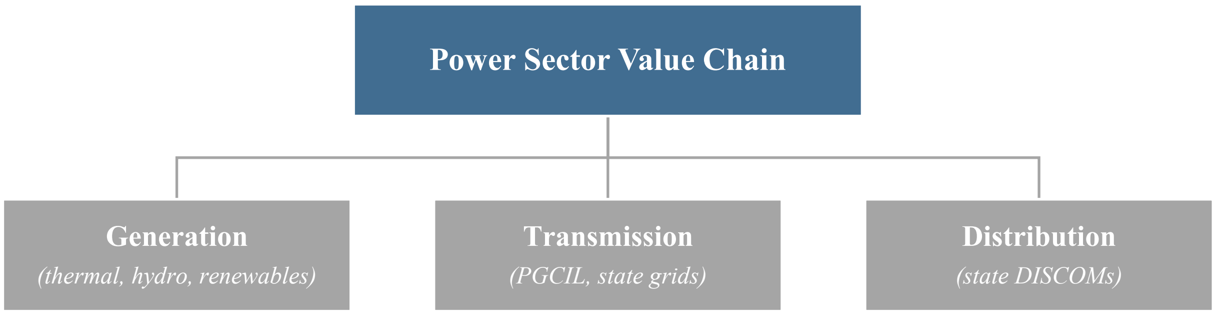
Source: IEA Global Energy Review 2025, IEA World Energy Outlook 2025, CareEdge Research
Note: F: Forecasted

2.2 Overview of Indian Power Sector

2.2.1 Evolution of Power Sector and Its Structure

India's power sector reforms have evolved steadily from a state-controlled framework under the Electricity Supply Act, 1948 to a more competitive and market-oriented structure. Key milestones include private sector entry in generation during the 1990s, the establishment of independent regulators in 1998 and comprehensive restructuring through the Electricity Act, 2003, which enabled competition and open access. Subsequent initiatives such as DDUGJY, UDAY and RDSS focused on rural electrification, DISCOM financial health and operational efficiency. These reforms collectively support grid modernisation and India's long-term transition into a clean energy nation aligned with the target of 500 GW non-fossil capacity.

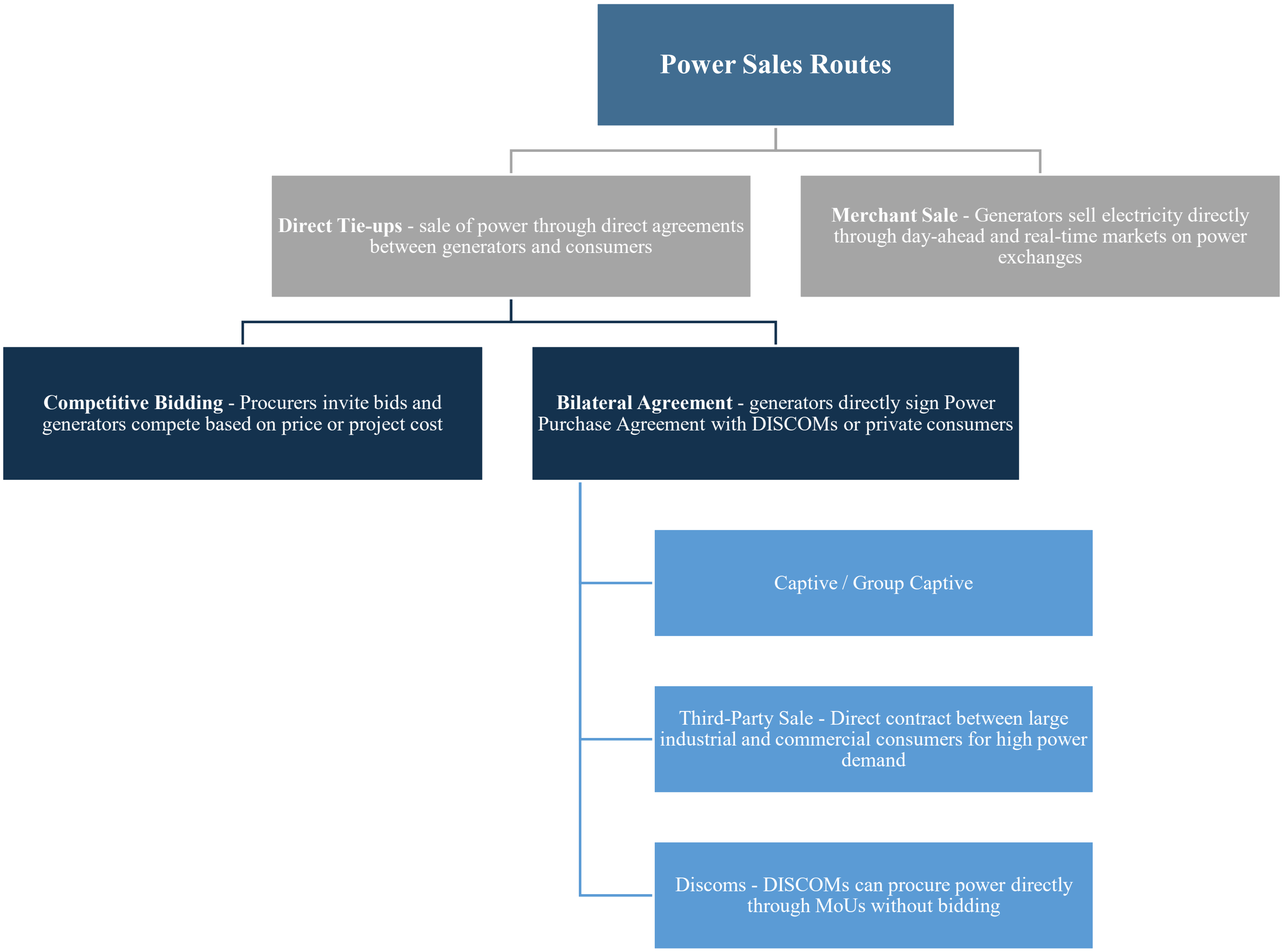
The structure of the power industry is depicted in the figure below:



Power industry is divided into three segments

- Generation - Generation is the production of electricity from sources such as thermal, nuclear and renewables like solar and wind.
- Transmission - Transmission utilities transport large amount of electricity from power plants to distribution substations via a grid at high voltages.
- Distribution - Retail electricity distribution involves supplying power to consumers at lower voltage levels.

Sale of Power



Source: CareEdge Research

India's power and renewable energy sector is regulated by several key institutions. These include the Central Electricity Regulatory Commission (CERC) and State Electricity Regulatory Commissions (SERCs), which oversee tariffs and market operations, along with the Ministry of Power (MoP) and the Ministry of New and Renewable Energy (MNRE), which shape overall policy direction.

SECI, a Navratna PSU under MNRE, drives India's renewable energy agenda by facilitating solar, wind and hybrid projects ,as well as acting as an intermediary between developers and DISCOMs through PPAs and PSAs.

2.2.2 Operating and Regulatory Structure

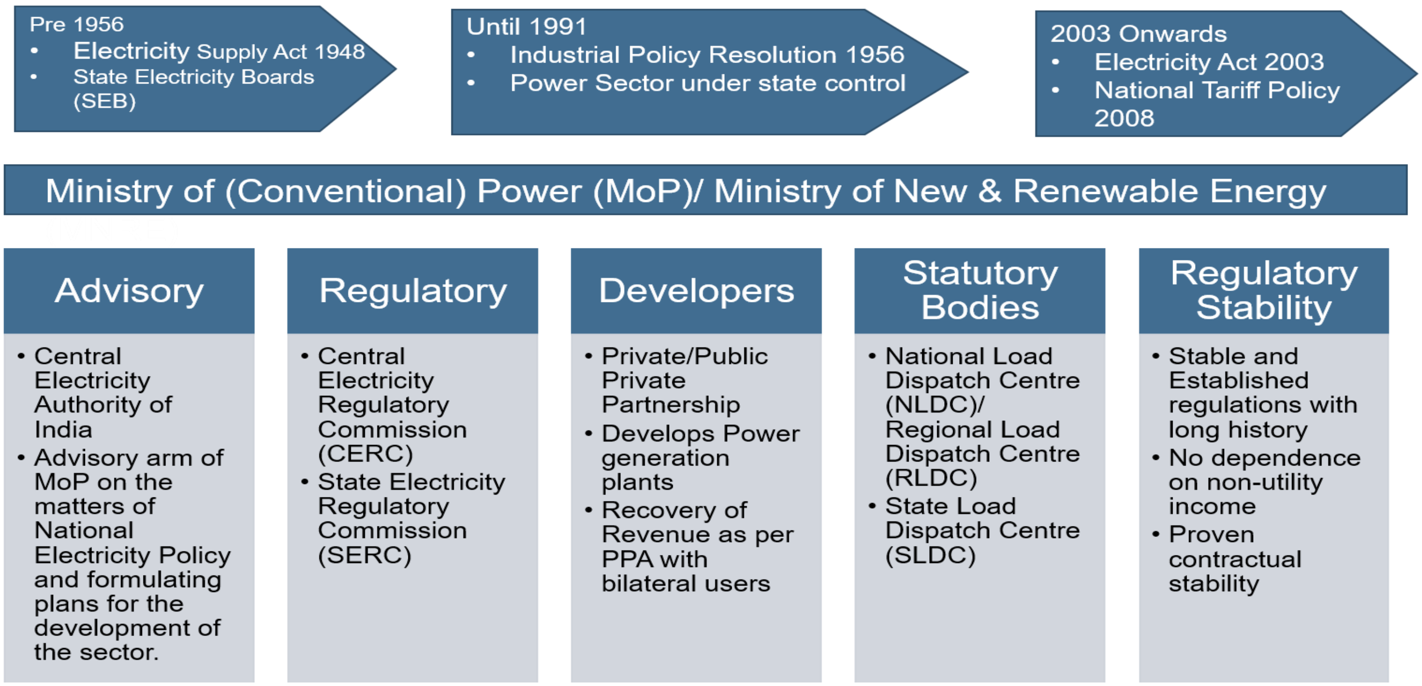


Table 9: Regulatory Capabilities of Different Bodies

	Centre		State/Private		
Policy	Ministry of Power		State Government		
Plan	CEA - governs the generation, transmission, distribution, exchange and use of electricity				
Regulations	CERC; MNRE		SERC		
System Operations	National Load Dispatch Centre, Regional Load Dispatch Centre		State Load Dispatch Centre		
Generation	Central Generation Stations, MNRE, Department of Atomic Energy		State Gencos	Captive and Co-Generation Plants, Independent Power Producers	Private Licensees in Ahmedabad, Kolkata, Mumbai, Surat, Delhi, Noida, etc.
Transmission	Central Transmission Utility (PGCIL)	Transmission Licensee	State Transmission Utility	Transmission Licensee	
Distribution	-		State Distribution Company		Private Discoms
Trading	Trading Licensee	Power Exchanges	Bilateral Markets		
Appeal	Appellate Tribunal (APTEL)				

Electricity generation, transmission and distribution are regulated and overseen by regulatory bodies at the federal and state levels. They are self-contained entities with responsibilities outlined in the Electricity Act.

2.2.3 Recent Regulatory Updates

In the recent years, India's power sector has witnessed several regulatory updates aimed at promoting efficiency, fostering competition and supporting the country's energy transition, particularly the integration of renewable energy into the grid. Below is an overview of the most significant regulatory updates:

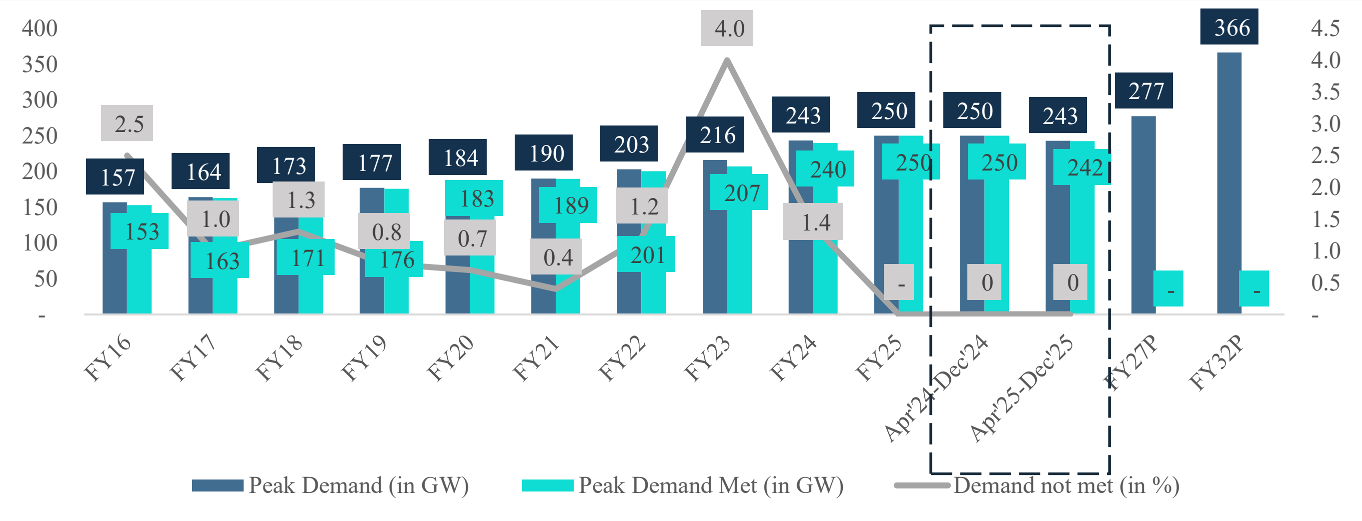
Regulation/Initiative	Details
General Network Access (GNA) Regulations, 2022	Introduced by CERC to streamline access to the transmission network, enhancing efficiency and transparency. Features include a single-window system for capacity applications, congestion reduction, and inflation-adjusted tariffs. Especially beneficial for renewable energy integration.
Draft Electricity (Amendment) Bill, 2025	Promotes cost-reflective tariffs to ensure financial viability of the sector, while fully protecting subsidised tariffs for farmers and low-income households
Inter-State Transmission System (ISTS) Charges for Renewable Energy	Waiver on ISTS charges for renewable energy projects until June 30, 2025, reducing costs and encouraging investment in renewable energy. Complements initiatives like the Green Energy Corridor project.
Real-Time Market (RTM) for electricity	Launched in 2020 by CERC, RTM facilitates 30-minute interval trading of electricity to balance real-time supply and demand fluctuations. Ensures better transmission system utilisation and reduced congestion.
Implementation of Ancillary Services Regulations, 2021	Updated by CERC to enhance grid stability through reserve power, frequency control, and voltage regulation. Addresses challenges posed by the intermittent nature of renewable energy sources.
CERC's Guidelines for Cross-Border Electricity Trade, 2021	Introduced to enable electricity trade with neighbouring countries. Promotes regional grid integration and bilateral agreements, enhancing market opportunities for Indian transmission utilities.
Green Energy Open Access Regulations, 2022	Aims to simplify grid access for renewable energy producers and consumers. Reduces the access limit from 1 MW to 100 kW and prioritises green energy integration into the grid.
Regulatory Focus on Smart Grids and Digitalisation	Encourages the adoption of smart meters, real-time monitoring, and automated control systems. Modernises transmission infrastructure for improved efficiency, reliability, and reduced losses.

Amendments to the Connectivity Regulations	Streamlines grid connectivity for renewable energy projects, prioritising government-designated renewable energy zones. Ensures faster connectivity and readiness of transmission infrastructure for new projects.
National Policy on Geothermal Energy	Aims to establish India's first comprehensive framework for exploring, developing, and utilising geothermal energy resources as a clean, renewable, and baseload power source. The policy promotes scientific assessment and mapping of geothermal potential across high-priority zones, encourages public and private sector participation through clear licensing and regulatory mechanisms, and establishes institutional frameworks for technology development, capacity building and project financing
Sustainable Harnessing and Advancement of Nuclear Energy for Transforming (Shanti) Bill 2025	Proposes a unified law governing the production, use, regulation and expansion of nuclear energy and ionising radiation in India. Seeks to repeal the Atomic Energy Act, 1962 and the Civil Liability for Nuclear Damage Act, 2010, and to replace them with a single, comprehensive law aligned with India's present and future energy requirements.

2.2.4 Power Demand, Supply and Deficit in India

Power demand in the country has been on a rise in the past decade, with an exception during FY21 due to the Covid-19 pandemic. Peak energy demand grew at a CAGR of 5.3% from FY16 to FY25, while peak supply grew at a CAGR of 5.6% over the same period.

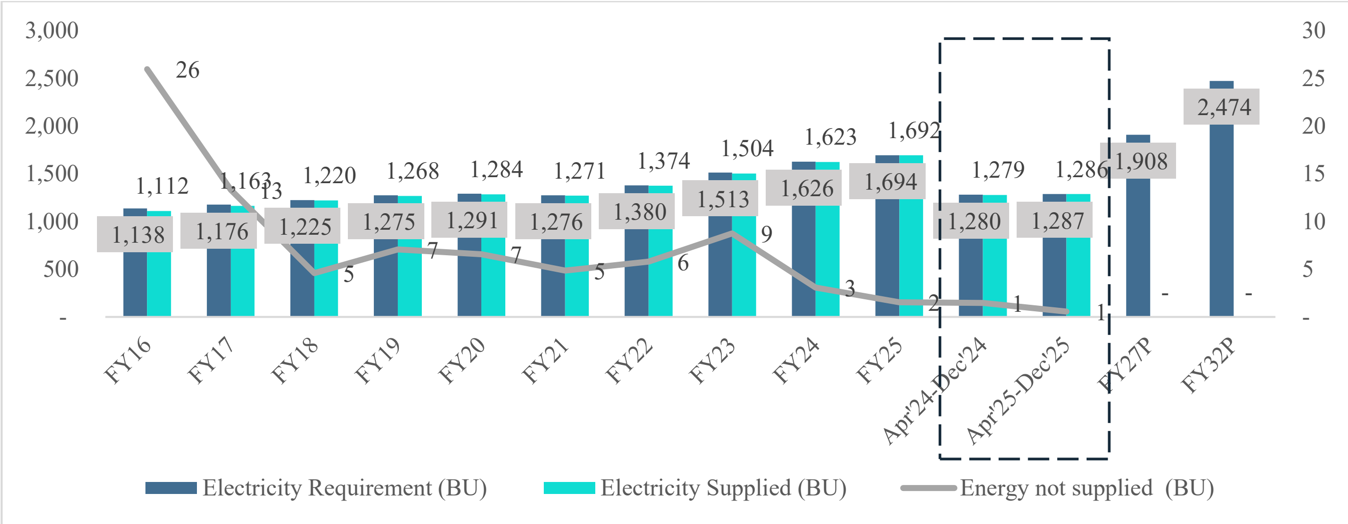
Chart 14: Power Demand, Supply and Deficit in India



Source: ICED, CEA, National Electricity Plan (NEP) March 2023
Note: P indicates Projected

India's power requirement recorded a steady growth of around 5.6% during FY16-FY25. Over the same period, the gap between electricity requirement and supply narrowed sharply, declining from 26 BU in FY16 to nearly 2 BU in FY25, reflecting a significant improvement in supply adequacy and system reliability. Rapid capacity addition, especially in renewable energy and flexible thermal power improved overall power availability.

Chart 15: Power Position in India



Source: Power Ministry, CEA, CareEdge Research

According to the National Electricity Plan Vol 1, all India peak electricity demand is projected at 277 GW and energy requirement is projected at 1,908 BU for FY27. The power demand is further expected to rise with the growing population and increased economic activities. For FY32, the peak electricity demand is projected at 366 GW and energy requirement at 2,474 BU.

The energy requirement is expected to grow at a CAGR of 6.1% and peak demand is expected to grow at CAGR of 5.3% between FY25-FY27. For FY27 to FY32, the CAGR is almost same at 5.3% for energy requirement and 5.7% for peak demand.

The government has taken various steps to meet the peak demand of power such as:

- Since April 2014, the country's transmission network has grown by 71.6% with the addition of 2.09 lakh ckm of transmission lines (220 kV and above), boosting transformation capacity (220 kV and above) by 876 GVA. The inter-regional power transfer capacity stands at 1,20,340 MW as of December 2025, has enabled seamless transfer of electricity across regions, successfully realising the vision of "One Nation-One Grid-One Frequency."
- The inter-state transmission projects presently under implementation will add approximately 40,000 ckm of transmission lines and 399 GVA of transformation capacity, in addition to these, the intra-state transmission projects under implementation are expected to add another 27,500 ckm of transmission lines and 134 GVA of transformation capacity, which will further enhance grid reliability and power evacuation capability.
- Strengthening the distribution system through schemes such as the Deen Dayal Upadhyaya Gram Jyoti Yojana (DDUGJY), Pradhan Mantri Sahaj Bijli Har Ghar Yojana (SAUBHAGYA) and the Integrated Power Development Scheme (IPDS).
- Allowing 100% FDI in power generation projects through the automatic route.
- Encouraging private sector participation in generation and transmission by notifying the revised tariff policy on 28th January 2016.
- Promoting the generation, purchase and consumption of green energy through the Green Open Access Rules, notified on 6th June 2022. Launching the Revamped Distribution Sector Scheme (RDSS) in 2021 to improve financial sustainability and enhance the operational efficiency of the distribution sector.

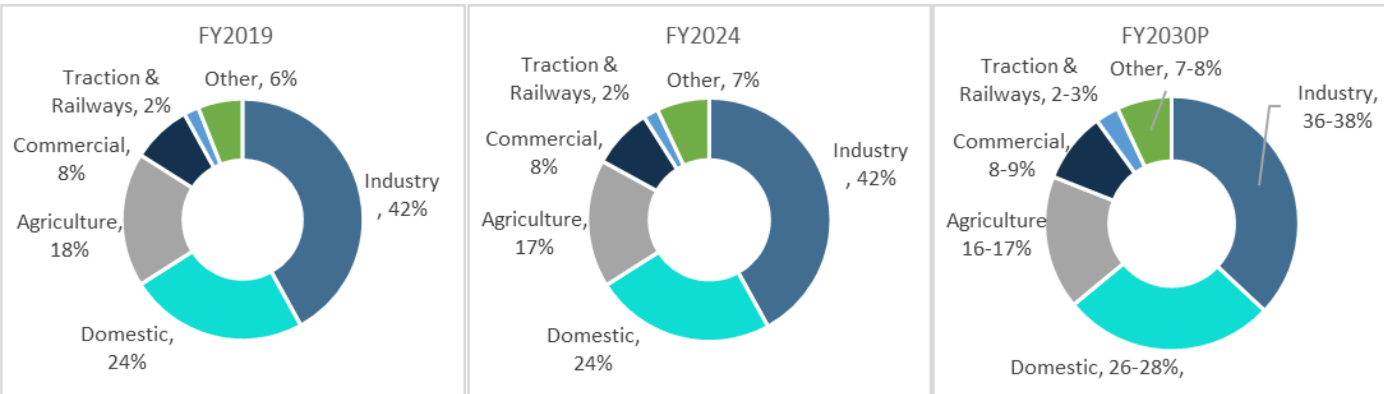
2.2.5 Power Supply Mix in India

India, the world's third-largest energy producer and electricity consumer, has witnessed a significant shift in its power mix in the recent years. Renewable capacity addition grew sharply led by solar and wind, which recorded strong growth between FY16 and FY25, far outpacing conventional sources. Solar power capacity experienced remarkable expansion between the fiscal years 2015 and 2025. The capacity increased nearly twenty-eight-fold during this period achieving a substantial CAGR ~40%.

As renewable energy share continues to rise, the role of battery energy storage systems becomes increasingly critical in mitigating intermittency, smoothing power supply fluctuations and strengthening grid stability, thereby enabling reliable integration of large-scale renewable capacity into the power system. This transition underscores a power sector that is increasingly driven by clean energy expansion, supported by storage solutions, while maintaining energy security through conventional generation.

Commercial and Industrial Consume Nearly Half of India's Electricity Demand

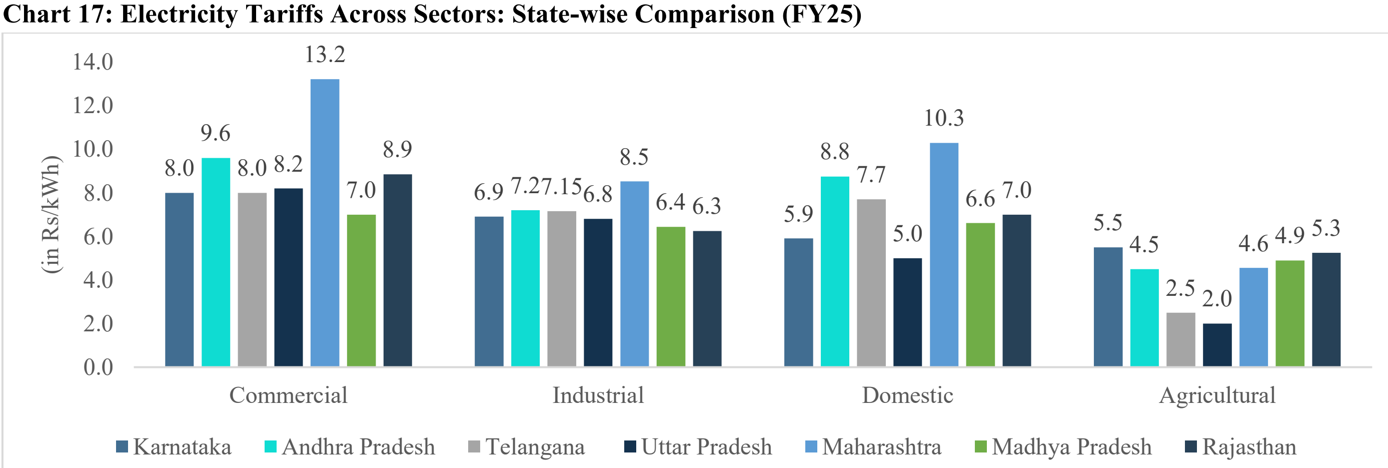
Chart 16: Electricity Consumption by Key Sectors in India (% share)



Source: MOSPI, CareEdge Research, Note: P: Projected, Other includes EVs and other sectors

Electricity Requirement in FY25 reached 1,694 BU, with an average of 7.1% growth rate in last three years, which together added nearly 315 BU of incremental demand. Going ahead, climate-driven temperature variations and rapid urbanisation are expected to accelerate growth in residential power demand. Industrial consumption is likely to remain the largest contributor, supported by the manufacturing push and government-led infrastructure investments. Meanwhile, measures such as reduced power outages, feeder segregation for agriculture and solarisation of distribution feeders and pumps are set to drive growth in agricultural electricity demand. With increasing electrification in the railways and the expansion of high-speed metro networks, electricity consumption in the traction and railways sector is expected to rise. Considering these developments, CareEdge estimates that this segment's energy consumption share will reach to nearly 2-3% by the end of FY30.

Chart 17: Electricity Tariffs Across Sectors: State-wise Comparison (FY25)



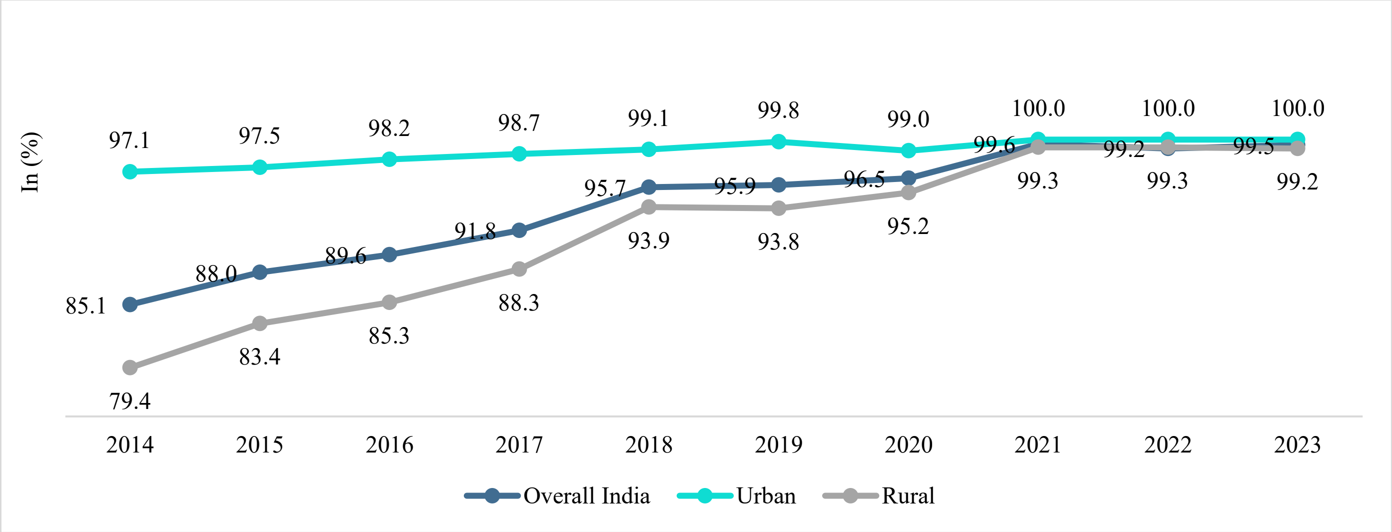
Source: CEA, Electricity Tariff & Duty & Average rates of electricity supply in India 2025, CareEdge Research
Note: The above charges include energy charges as applicable in FY25, the tariff excludes fixed charges and duties

Commercial and industrial (C&I) consumers pay much higher electricity tariffs compared to domestic or residential users. An analysis of tariffs across key states shows a clear gap between domestic and C&I energy charges, which increases the overall cost of power for commercial and industrial consumers. This higher cost burden is a major factor driving C&I users to shift toward open access power procurement. Increasingly, these consumers are opting for renewable energy sources under open access arrangements to lower power costs and achieve more stable and predictable electricity expenses over the long term.

2.2.6 Access to Electricity in Both Rural and Urban Households in India

Electricity is essential for India's economy and daily life requirements of power. Access to electricity in homes increased from 85.1% in 2014 to 99.5% in 2023, and the gap in electricity access between urban and rural households has reduced due to schemes like SAUBHAGYA.

Chart 18: Access to Electricity in India



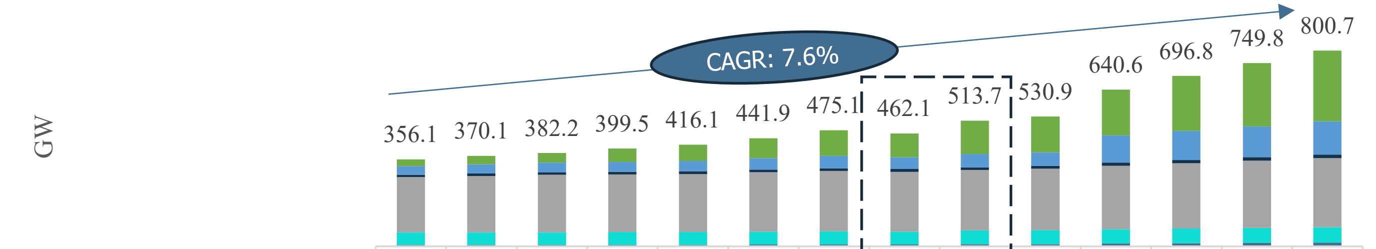
Source: World Bank Group, Data in Calendar Year Basis

2.2.7 Outlook on Installed Capacity Additions

Total installed power capacity is projected to grow at a CAGR of ~11% between FY25 and FY30, driven primarily by rapid expansion in renewable energy. Renewable capacity is expected to grow at a faster CAGR of around ~20.9%, with solar emerging as the fastest-growing segment across all energy sources and is projected to expand at a CAGR of approximately 22.4% during FY25-FY30. Incremental demand is therefore expected to be met largely through renewables, supported by rising energy storage deployments to manage intermittency and shift supply to peak hours. Thermal capacity is expected to remain in the mix primarily to provide peak support, system flexibility and reliability rather than to drive baseload growth.

Overall renewable capacity (including small hydro) is expected to add ~226 GW during FY27P-FY30P

Chart 19: Power Installed Capacity

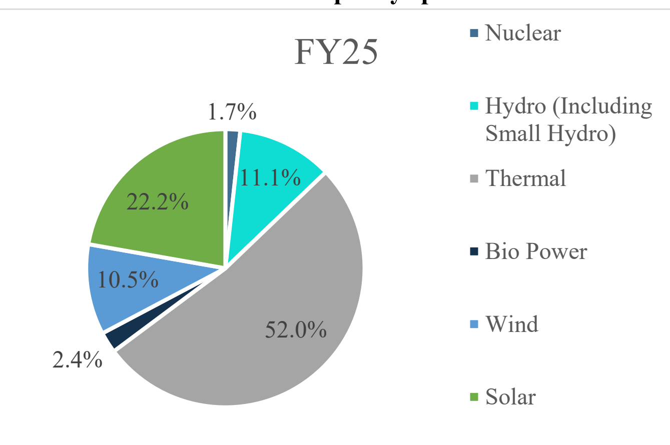


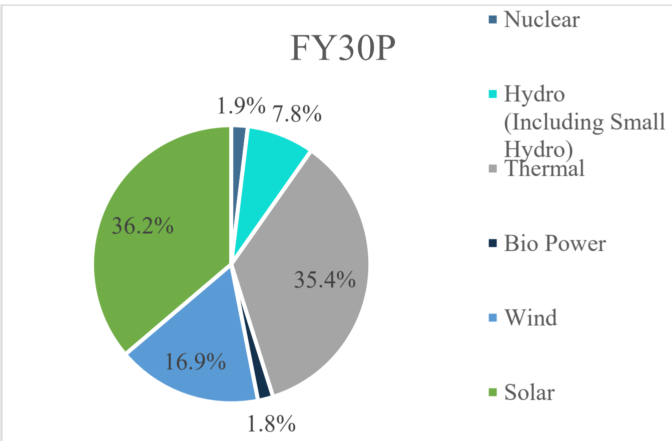
	FY19	FY20	FY21	FY22	FY23	FY24	FY25	Apr'24 - Dec'24	Apr'25 - Dec'25	FY26 E	FY27 E	FY28 E	FY29 E	FY30 E
Total	356.1	370.1	382.2	399.5	416.1	441.9	475.1	462.1	513.7	530.9	640.6	696.8	749.8	800.7
Solar	28.2	34.6	40.1	54.0	66.8	81.8	105.6	97.9	135.8	147.0	187.0	225.0	259.0	290.0
Wind	35.6	37.7	39.2	40.4	42.6	45.9	50.0	48.2	54.5	55.0	111.0	118.5	126.5	135.1
Bio Power	9.2	10.0	10.3	10.7	10.8	10.9	11.6	11.3	11.6	11.9	13.0	13.4	13.8	14.2
Thermal	226.3	230.6	234.7	236.1	237.3	243.2	246.9	244.4	246.9	251.0	260.0	267.5	275.3	283.2
Hydro (Including Small Hydro)	50.0	50.4	51.0	51.6	51.8	51.9	52.8	52.1	56.1	57.0	57.6	59.3	61.0	62.7
Nuclear	6.8	6.8	6.8	6.8	6.8	8.2	8.2	8.2	8.8	9.0	12.1	13.1	14.2	15.4

Source: CEA, National Electricity Plan (NEP) October 2024, CareEdge Research, Note: Others RE include PSP, CEA does not provide separate data for PSP

Overall Solar is expected to add ~143 GW during FY27P-FY30P making ~53% of total capacity additions

Chart 20: Power Installed Capacity split in FY25 vs FY30P





Source: CEA, National Electricity Plan (NEP) October 2024, CareEdge Research; Note: Others RE include PSP, CEA does not provide separate data for PSP

2.2.8 Key Growth Drivers and Constraints of RE

Growth Drivers	• Declining prices of modules and other system components • Fiscal and regulatory incentives • Renewable purchase obligation • Infrastructure support from government • Traction in C&I segment • Green-Term ahead market • Low cost, construction and operation risk • Waiver of ISTS charges • Fewer environmental concerns unlike thermal power • Advancement of module technology
Constraints	• Counterparty risk in payment and signing of PPAs • High dependency on imports • Increase in capital costs due to material costs • Grid integration • Unavailability round-the-clock

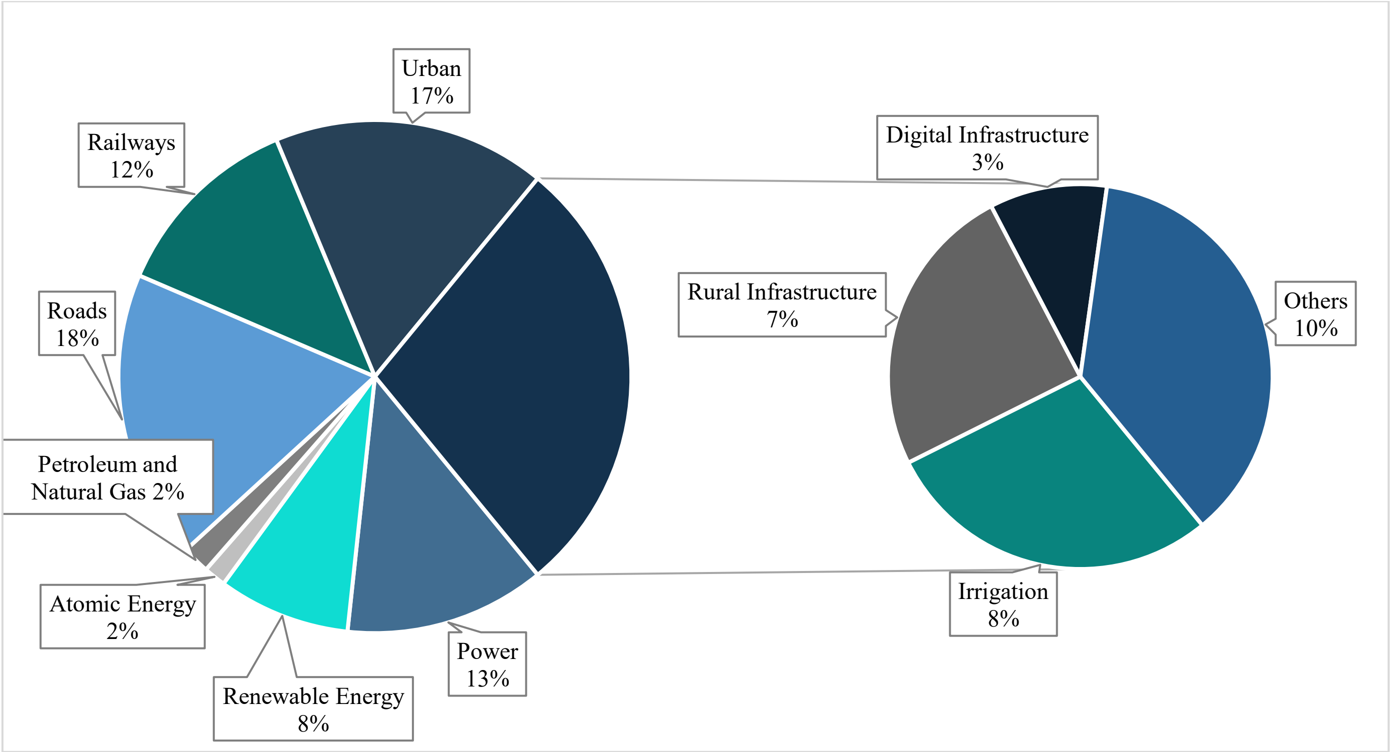
2.2.9 Stimulus Packages

National Infrastructure Pipeline

National Infrastructure Pipeline (NIP) was launched in December 2019 with a focus on infrastructure development to enable India to achieve its target of becoming a USD 5 trillion economy by FY25 and USD 10 trillion economy by FY30. Infrastructure to play a major role with 3% contribution to the GDP by FY25 (Rs 11.21 lakh crores) and is expected to remain same or increase its share by FY30 (Rs 25.00 lakh crores).

A taskforce was created to set up the pipeline. In the final report submitted by the task force in April 2020, the pipeline covers multiple sectors such as urban infrastructure, renewable and conventional energy. Roads and railways constitute nearly 71% of the projected total capex of Rs 11.21 lakh crores. It also includes investments in other sectors such as rural infrastructure, ports and airports among others. The proposed investments will be implemented by both the government and the private sector.

Chart 21: National Infrastructure Pipeline Sectoral Split (in %)



Source: NITI Aayog's report on National Infrastructure Pipeline

During FY20–25, the power sector received investments of around Rs 1,410 billion, accounting for nearly 13% of the total National Infrastructure Pipeline (NIP) outlay. The investments focused on improving supply reliability, reducing AT&C losses from 22.3% to about 10%, and achieving universal electricity access. Renewable energy capacity also saw strong growth with solar and wind installations reaching around 105.6 GW and 50.0 GW respectively, raising the share of renewables in total power consumption to 25%.

Atmanirbhar Bharat

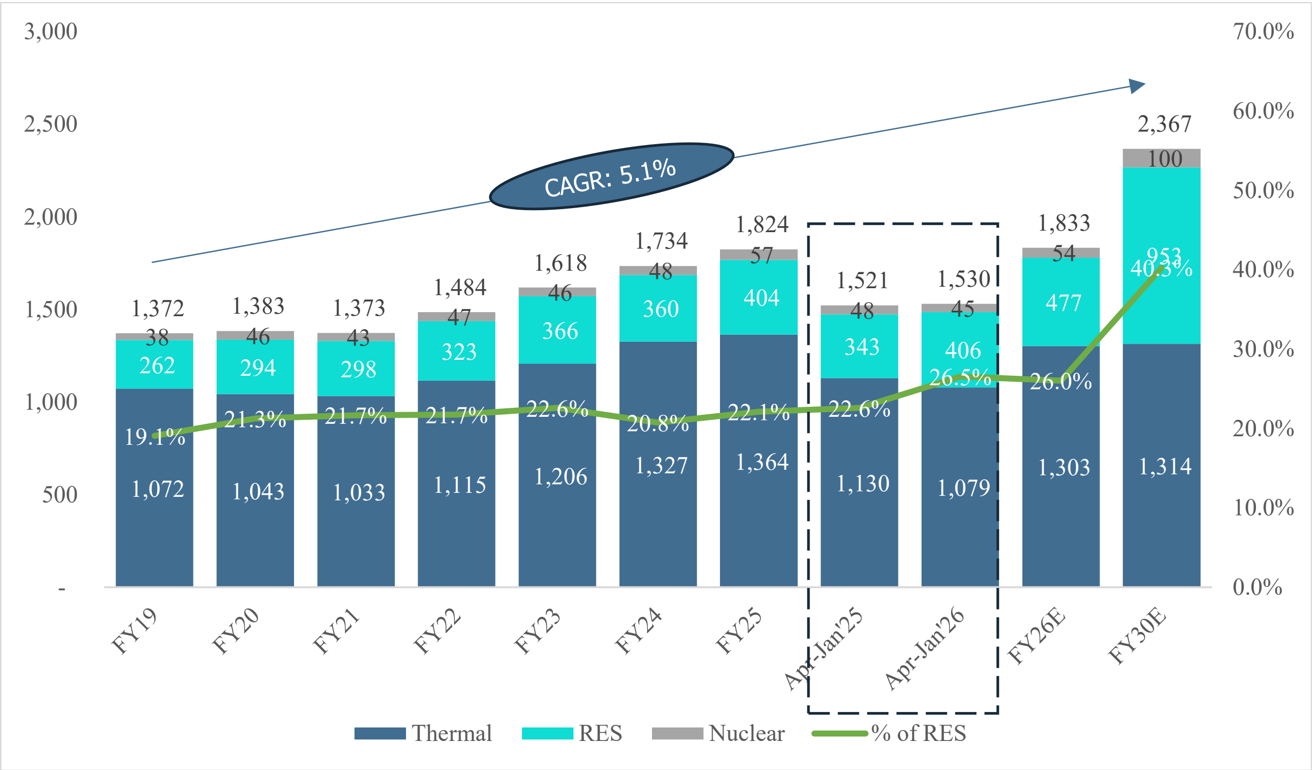
Atmanirbhar Bharat was launched in May 2020 with the objective of reducing import dependence, strengthening domestic manufacturing and building resilient supply chains across critical sectors including renewable energy. Under this initiative, solar module manufacturing has been identified as a priority area due to India's historically high reliance on imported cells and modules. Policy measures such as the Production-Linked Incentive (PLI) scheme for high-efficiency solar PV modules, imposition of Basic Customs Duty (BCD) on imports and domestic content requirements (DCR) have been introduced to promote large-scale, integrated manufacturing in India. These interventions have led to a significant expansion in domestic solar module capacity and are expected to improve self-reliance, support advanced technology adoption and position India as a competitive solar manufacturing hub in the medium to long term.

2.2.10 Power Generation

As per the NEP, total power generation is expected to increase to 2,367 BU by FY30 from 1,824 BU in FY25 with CAGR of 5.3%.

Power generation is anticipated to add 543 BU during FY25-FY30P

Chart 22: Power Generation in India (BU)



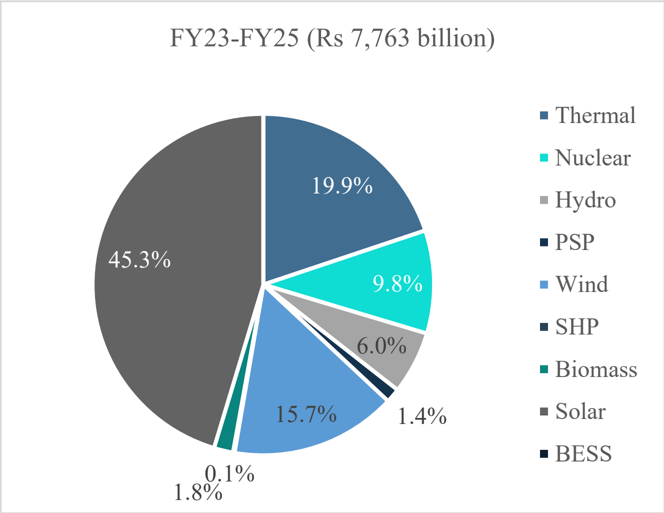
Source: ICED, National Electricity Plan (NEP) March 2023

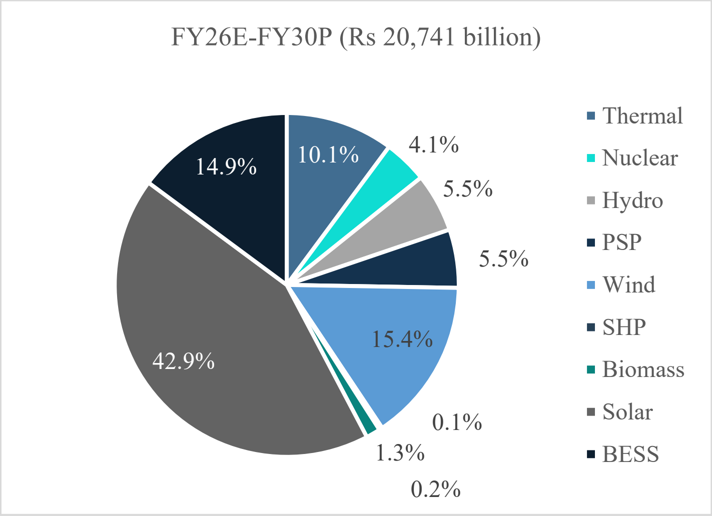
Solar energy is set to be the fastest-growing source of power generation in the coming years, reflecting its strong momentum and increasing importance in the renewable energy mix. Between FY25 to FY30, solar power generation is projected to grow at an impressive CAGR of 24.4%, the highest among all energy sources.

The expected investments in the generation sector between FY23-FY25 and FY26E-FY30P are given in the following chart.

Investments in Solar, BESS and pumped storage projects (PSP) are expected to total around Rs 9.4 trillion over FY26E–FY30P, accounting for nearly 73% of overall power generation capex during the period.

Chart 23: Power Generation Investments in India





Source: National Electricity Plan (NEP) Vol-1, CEA, CareEdge Research

As per the Central Electricity Authority (CEA), the total fund requirement for power generation is Rs 7.7 trillion for FY23-25 and Rs 20.7 trillion for FY26-30.

Generation investments in FY26–30 are expected to be strongly renewable led, driven by large scale solar and wind capacity additions. This is primarily due to India's accelerated push toward non-fossil capacity targets for 2030 and the need for large-scale, cost-effective capacity addition. Impact of Large Renewable Energy Capacity Additions on the Power Sector in India.

The power sector is undergoing a significant transformation, with renewable energy poised to drive future capacity additions. CareEdge believes that while thermal capacity additions will remain critical to support base load requirements until renewable energy with storage solutions scales up, the generation mix is set to evolve rapidly. The share of non-fossil sources in total energy generation is expected to rise to over 35% by FY30, compared to 25% in FY25 with new capacity additions led by solar and followed by wind. This will support India's NDC targets on emission-intensity reduction and the 500 GW non-fossil capacity goal by 2030.

Apart from this, procurement patterns are shifting as DISCOMs rely more on low-cost SECI/NTPC RE tenders, while C&I consumers migrate to green open access. This is putting pressure on legacy high-cost coal PPAs and changing the revenue model of DISCOMs. Overall, renewable additions are driving a structural transition toward a more efficient, flexible and diversified power system with long-term benefits in energy security and reduced fuel imports.

Large renewable energy additions are also lowering the overall cost of electricity in India by replacing high variable-cost coal generation with zero-fuel-cost solar and wind, improving tariff competitiveness for DISCOMs and consumers. Central and state subsidies such as rooftop CFA, PM-KUSUM support, PLI incentives and concessional financing further accelerate adoption and reduce delivered energy costs. Higher RE penetration also improves environmental outcomes by reducing emissions, air pollution and water consumption associated with coal plants. As solar and wind scale up, they reduce India's dependence on imported coal and gas, strengthening energy security and lowering exposure to global fuel volatility. Renewable growth is also expanding green jobs, domestic manufacturing and investment in backward-integrated supply chains. Together, these trends are steering the power sector toward cleaner, cheaper and more resilient long-term growth.

2.2.11 Progress on T&D Infrastructure

India has a target of 500 GW of non-fossil fuel capacity by 2030, and hence, significant investments have commenced towards increasing and upgrading the transmission infrastructure. Transmission system has been planned for following RE capacity to be commission by 2030.

For integration of additional wind and solar capacity by 2030, the estimated length of transmission line and sub-station capacity planned is around 50,890 ckm and 4,33,575 MVA, respectively. The investment required for the green transmission is estimated to be around Rs 2,440 billion as per the Ministry of Power. Out of this, Rs 281 billion will be required for integration of offshore wind capacities while Rs 2,160 billion will be required for new solar and wind (onshore) plants.

Table 10: Tentative Cost of Additional Transmission System

	RE Capacity (GW)	BESS (GW)	Requirement of Transmission System (GW)	Tentative Cost of Transmission System (Rs billion)	Average Cost of Transmission System (Rs Million/MW)
On shore RE Capacity (Solar & Wind)	268.68	51.5	217.18	2,161	9.95
Offshore RE capacity (Wind)	10	0	10	281	28.1
Total RE capacity	**278.68**	**51.5**	**227.18**	**2,442**	**10.75**

Source: CEA Report- Transmission System Integration of over 500GW RE Capacity by 2030, CareEdge Research
The tentative cost includes the cost of ISTS transmission schemes for (i) 66.5 GW RE capacity (excluding commissioned transmission schemes and associated RE capacity) (ii) 55.08 GW RE capacity and (iii) 181.5 GW RE capacity

On the distribution front, there are various initiatives taken by government for providing 24X7 power supply to all households like the Integrated Power Development Scheme (IPDS) for development of urban distribution sector, Deen Dayal Upadhyaya Gram Jyoti Yojana (DDUGJY) for covering all aspects of rural power distribution, Pradhan Mantri Sahaj Bijli Har Ghar Yojana (Saubhagya) for universal household electrification covering every village and district, Ujwal DISCOM Assurance Yojana (UDAY) for financial turnaround of the DISCOMs and Revamped Distribution Sector Scheme (RDSS) to improve operational efficiency and financial sustainability of DISCOMs.

2.2.12 Risk and Challenges of Conventional Power

Thermal power, which primarily relies on coal, is a significant source of electricity in India. However, it comes with several risks and challenges:

Table 11:Conventional Power Sector- Risks and Challenges

Risk Category	Key Issues (Thermal-specific)	Description / Impact
Market & Demand	**RE priority dispatch**	Renewables enjoy must-run status, pushing thermal plants to operate as balancing or residual capacity
	Structural surplus risk	High installed thermal capacity combined with rising RE penetration limits incremental offtake for thermal plants
Regulatory	**Tariff uncertainty**	Cost recovery for fuel, FGD and fixed charges depends on regulatory approvals
	PPA renegotiation risk	DISCOMs seek tariff rationalisation due to surplus power and availability of cheaper RE
	Policy Shifts	Regulatory focus increasingly favours RE, storage and flexible resources
Fuel Risks	**Coal logistics dependency**	Reliance on railways and ports creates supply-side vulnerabilities
	Low-GCV domestic coal	Poor fuel quality increases heat rate, emissions and variable cost
	Gas availability constraints	Limited domestic gas supply and high LNG prices restrict PLF recovery for gas-based plants

Environmental & ESG	**Emission compliance norms**	Stricter SOx, NOx and PM norms increase compliance burden
	FGD implementation costs	Significant capex and higher O&M costs for thermal assets
	Carbon transition risk	Long-term decline in coal-based generation amid investor and policy scrutiny
Financial	**High upfront capex**	Thermal plants require large initial investments with long payback periods
	DISCOM payment delays	Working capital stress due to delayed receivables
	Stranded asset risk	Energy transition increases risk of under-utilisation or early retirement
Operational & Resources	**Ageing fleet**	Higher forced outages and declining efficiency
	Flexibility stress	Frequent ramp-up and ramp-down increases wear and maintenance costs
	Water dependency	Cooling water availability remains a key operational constraint

The cumulative risk profile outlined above indicates a clear structural tilt in favour of renewable energy in relation to thermal power generation. Preferential policy support, priority grid dispatch and falling technology costs have positioned renewables as the primary source for incremental capacity addition, while thermal assets increasingly serve as balancing capacity rather than baseload generation.

3 Solar Power Market in India

3.1 Historical and Projected Growth of India's Installed RE Capacity

As of January 2026, India's renewable capacity (including hydro) reached 263.2 GW, up sharply from 134 GW in FY20, increasing its share of total installed capacity from 36% to 50.6%. Between FY20 and FY25, renewable energy capacity grew at a CAGR of 14%, while solar capacity grew at a higher CAGR of 24%.The increase was driven by solar power, which grew more than threefold from 35.6 GW in FY20 to 140.6 GW in FY26 (Till Jan 26) and is projected to scale further to 208.3 GW by FY27E and an impressive 385.2 GW by FY32E, making it the backbone of India's energy transition.

In 2025, India achieved a major climate milestone by reaching 50% non-fossil fuel installed power generation capacity, fulfilling its Paris Agreement commitment five years ahead of schedule.

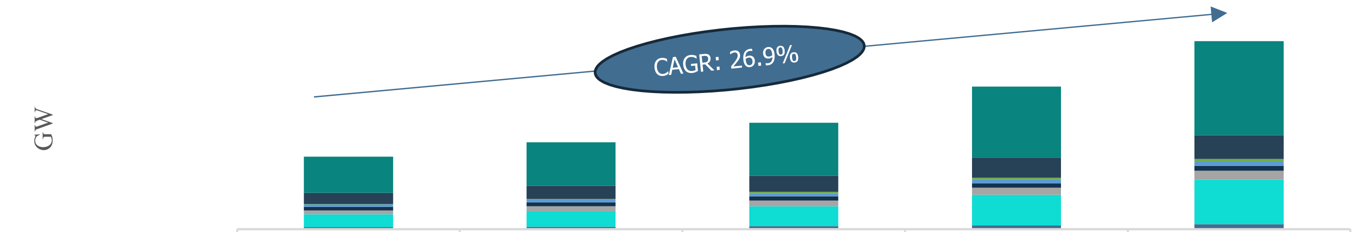
The Global Climate Challenge and the Shift to Clean Energy

The transition toward renewable energy has become a critical component of global decarbonisation efforts aimed at mitigating climate change. International initiatives, notably the Paris Agreement, have provided a strong policy framework to support this shift by encouraging countries to commit to measurable emission reduction targets. Through their nationally determined contributions, nations have outlined strategies to limit global temperature rise, underscoring the essential role of renewable energy in achieving long-term climate objectives and sustainable economic development.

Global installed solar capacity has increased from 719 GW in CY20 to 1,866 GW in CY24 capturing a 2.6x growth in 5 years. Strong government support through policies such as feed-in tariffs, tax incentives and subsidies has accelerated the growth of the solar PV sector, enabling solar power to emerge as a major contributor to the global renewable energy mix.

Global Landscape for Solar Power

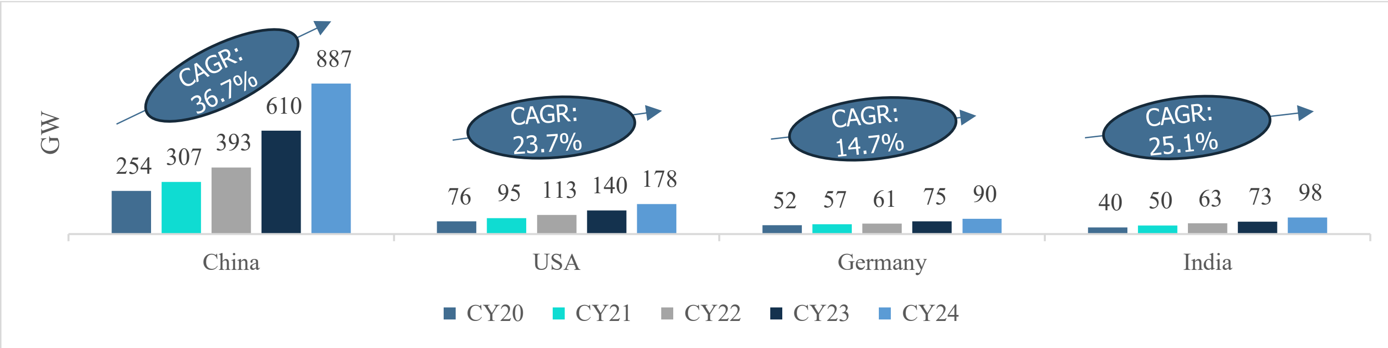
Chart 24: Country-wise Solar Installed Capacity



	CY20	CY21	CY22	CY23	CY24
World	719.66	862.99	1,056.37	1,413.47	1,866.31
Rest of the world	218.16	260.86	317.38	390.68	471.38
Brazil	8.49	14.51	25.40	37.94	53.12
Germany	51.78	57.46	61.19	74.88	89.94
Japan	71.87	78.41	83.06	87.07	89.60
USA	75.79	94.79	112.84	139.93	177.59
China	253.86	306.97	393.03	609.92	887.10
India	39.71	49.98	63.48	73.05	97.58

Source: International Renewable Energy Agency (IRENA)

Chart 25: Country-wise Installed Capacity for Top 4 Countries



Source: International Renewable Energy Agency (IRENA)

China: China's solar installed capacity expanded sharply from 254 GW in CY20 to 887 GW in CY24, reinforcing its global leadership. The country achieved its 2030 wind and solar capacity target in 2024, six years ahead of schedule. While renewable installations are set to continue, investment growth is expected to slow in 2025 and, in the case of solar PV, even to fall back slightly. Chinese energy investment has traditionally been dominated by state-owned enterprises and characterised by large-scale infrastructure projects by government financing. However, the landscape is beginning to shift. In recent years the government has increasingly encouraged greater private sector participation in energy development.

The United States: The US added a record 38 GW of solar capacity in 2024, taking total installed capacity to 178 GW in CY24. Growth was driven by strong policy support under the Inflation Reduction Act (IRA), which provided 30% investment and production tax credits for solar installations and clean-energy manufacturing. These incentives accelerated utility-scale deployments and expanded domestic PV supply chains.

Germany: Germany's solar capacity rose from 52 GW in CY20 to 90 GW in CY24, supported by consistent policy frameworks and strong rooftop solar adoption. Capacity additions were aided by competitive auctions, simplified permitting and rising power prices encouraging self-consumption. Growth remained steady despite land and grid constraints, reinforcing Germany's position as a leading European solar market.

India: India's installed solar capacity more than doubled from 40 GW in CY20 to 98 GW in CY24, supported by the temporary abeyance of the Approved List of Models and Manufacturers (ALMM) and a sharp decline in module prices, which drove strong project commissioning despite the basic customs duty (BCD) on imports. By 2024, India emerged as the fourth-largest solar PV market globally. Growth was further aided by policy initiatives such as PM Surya Ghar Yojana, boosting residential adoption.

Looking ahead, the share of renewables in total installed capacity is expected to cross 57% by FY27E and 65.6% by FY32E, with solar accounting for nearly 60% of all renewable capacity additions. This firmly positions India as one of the fastest-growing clean energy markets globally and highlights solar as the dominant driver of decarbonisation and investor opportunity.

The rapid growth is being supported by declining solar tariffs, a strong pipeline of utility-scale projects and policy incentives such as the PLI scheme and ALMM framework, alongside increasing participation from private investors. A significant push is also coming from the commercial and industrial segment, where corporate PPAs and rooftop solar installations are expanding rapidly. Further, the Renewable Purchase Obligation (RPO) is ensuring steady adoption of clean energy, backed by clear targets laid out for FY27 and FY32.

As the world's most populous country and a fast-growing economy, achieving net-zero emissions by 2070 requires urgent action across policies, technologies and reforms. With an installed renewable capacity of 263.2 GW (as of January 2026), 50.6% from renewables, India's energy transition is key to strengthening energy security, mitigating climate risks and driving economic growth, positioning the country as a global leader in clean energy.

3.2 Review of Solar Energy Capacity Additions in India

3.2.1 Potential of Solar Power

India is one of the world's most promising regions for solar energy development considering it being a tropical country with ample solar energy availability throughout the year. The wide range of solar energy availability ensures that nearly every part of the country is suitable for solar power generation, and such abundance and diversity positions India as a significant player in global solar landscape.

Recognising the immense potential MNRE in 2014 had estimated India's solar potential at 748.9 GW. However, considering the growing demand, the advent of new solar applications and the limitation posed, NISE has updated the solar potential which would serve as a foundation for moving towards energy independence, ultimately realising the vision of net-zero emissions.

As per NISE's feasibility analysis, a total grounded-mounted solar PV potential (DC capacity) is pegged at **3,343.4 GW** across India.

Table 12: Top 10 States by Ground Mounted Solar PV Potential

States	Potential (GW)
Rajasthan	828.8
Maharashtra	486.7
Madhya Pradesh	319.0
Andhra Pradesh	299.3
Gujarat	243.2
Karnataka	223.3
Tamil Nadu	204.8
Telangana	140.5
Odisha	139.5
Chhattisgarh	126.5
Sub-total Top 10 States	**3,011.4**
Other states	331.9
Total	**3,343.4**

Source: NISE Solar PV Potential of India Report, September 2025, CareEdge Research

The following points demonstrate India's solar potential illustrating significant spatial variability, shaped by regional solar resource availability, terrain conditions and infrastructure access:

- Rajasthan (828.8 GW) is expected to lead Western India, followed by Maharashtra (486.7 GW), and Gujarat (243.2 GW), contributes to over 45% of the national share. These states benefit from vast, contiguous wasteland and high solar irradiance.
- Southern states led by Andhra Pradesh (299.3 GW), followed by Karnataka (223.3 GW), Tamil Nadu (204.8 GW), and Telangana (140.5 GW) show significant contributions despite moderate wasteland area.
- This is attributed to favourable solar geometry, dense irradiance levels and high land-use efficiency.
- Northeastern and Himalayan states such as Nagaland, Mizoram, Arunachal Pradesh and Uttarakhand present low ground-mounted potential due to lower solar irradiance, rugged terrain and high forest cover, and scattered, less-accessible wastelands.

3.2.2 Evolution of Solar Power in India (Government support and other key factors)

India's solar power sector has undergone a rapid transformation over the past decade, evolving into the central pillar of country's renewable energy strategy. This shift was driven by the launch of the Jawaharlal Nehru National Solar Mission (JNNSM) in 2010, which established a clear policy roadmap for large-scale solar deployment. The Mission's target was progressively scaled up from 20 GW to 100 GW, reflecting growing ambition and confidence in solar as a mainstream power source. Since then, a combination of policy clarity, competitive bidding and institutional support has driven strong capacity addition across utility-scale and rooftop segments.

Key Policy Enablers and Supply-side Support

- MNRE and SECI-led auctions with long-term PPAs ensuring revenue visibility
- CPSU Scheme, PM-KUSUM, and Rooftop Solar Programme supporting centralised and decentralised deployment
- Fiscal and regulatory incentives such as accelerated depreciation, ISTS transmission charge waivers and renewable purchase obligations (RPOs)
- Manufacturing-focused initiatives including the PLI scheme and ALMM, aimed at strengthening domestic supply chains and reducing import dependence
- Infrastructure support through solar parks and the Green Energy Corridor, improving grid connectivity and evacuation

Demand Drivers

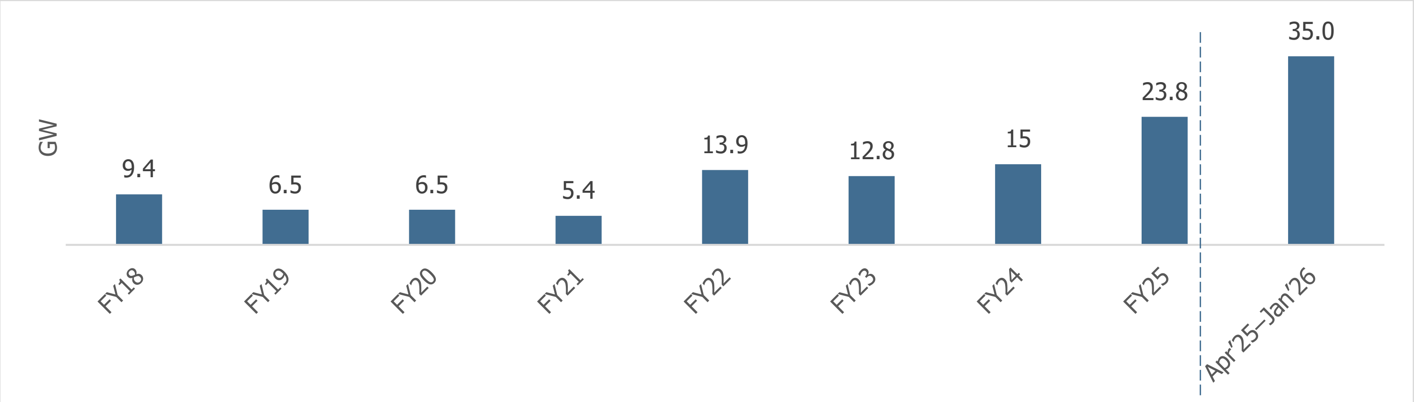
- Rising electricity demand driven by urbanisation, industrial growth and electrification
- Declining solar tariffs, making solar one of the most cost-competitive power sources
- State-level policy support in high-irradiance regions such as Rajasthan, Gujarat and Tamil Nadu
- National clean energy targets, including 500 GW of non-fossil capacity by 2030

Cost and Technology Trends

- Sharp decline in module prices due to global scale and technology improvements
- Solar tariffs reduced from Rs 17/kWh in early JNNSM phases to nearly Rs 2.55/kWh through competitive bidding

Solar energy is an integral part of India's National Action Plan on Climate Change with the National Solar Mission (NSM) being one of the key solar-focused programs. The NSM is an initiative of the Indian government with strong participation from states to encourage environmentally sustainable growth while addressing India's energy security issues.

Chart 26: Trend in Yearly Solar Capacity Additions



Source: Central Electricity Authority, MNRE, CareEdge Research

Installed capacity additions stood at 9.4 GW in FY18, reflecting early momentum in utility-scale solar development. Installations declined to 6.5 GW in FY19 due to the imposition of Safeguard Duty (SGD) and GST, which increased project costs and delayed commissioning. Capacity remained flat at 6.5 GW in FY20 as developers continued to face policy uncertainty and further declined to 5.4 GW in FY21 owing to COVID-19-related disruptions, supply-chain challenges, and construction delays. A sharp recovery was observed in FY22 with additions of 13.9 GW, driven by post COVID-19 pandemic normalisation, execution of backlog projects and renewed auction activity along with accelerated project commissioning ahead of the implementation of Basic Customs Duty (BCD). Installations remained healthy at 12.8 GW in FY23 despite global module price volatility and supply constraints and accelerated further to 15.0 GW in FY24 as supply conditions improved and policy support strengthened. Solar additions rose sharply to 23.8 GW in FY25, partly due to developers executing projects earlier than planned and procuring modules in advance to manage ALMM compliance requirements and improved financing conditions. Momentum remained strong in Apr25–Jan26, with 35.0 GW of capacity added, underscoring sustained growth driven by ambitious renewable targets, enhanced grid readiness and a robust project pipeline.

Key Drivers of Solar Energy

Scalability and Ease of Deployment: Solar projects are modular, less capital-intensive and faster to deploy, allowing capacity to be scaled up quickly compared to traditional power projects.

Table 13: Comparison of Solar, Wind and Conventional (Coal-Thermal) Power Projects

Particulars	Solar	Wind		Conventional (Coal Thermal)
		On Shore	Offshore	
Capex (in Rs crore/MW)	4.5-4.8	8-8.5	13-13.5	9.02
O&M Fixed Cost (in Rs lakhs/MW)	10-11	60	13.7	20-23
Construction Time (years)	0.5	1.5	1.5	4
PPA Duration (years)	~25	20–25	20–25	5-25
Plant Life (years)	25			
PLF / CUF (FY25)	15.58%	19.01%		68.54%
Tariff (recent)	~Rs 2.5/Kwh	~Rs 3.1/Kwh		~Rs 5.3/Kwh

Source: NEP Vol – I, India Climate and Energy Dashboard NITI Aayog, CareEdge Research

Strong ESG Alignment and Financing Support: Solar energy strongly aligns with ESG objectives, attracting global climate-focused investors, concessional financing and long-term debt at competitive rates.

Leadership in Emerging Business Models: While new models such as wind-solar hybrids, RTC, and firm renewable power are gaining traction, solar energy continues to command a higher share of capacity due to its pricing advantage. Hybrid projects typically achieve competitive tariffs in the range of Rs 2.4–Rs 3.4 per kWh, reinforcing Solar's central role.

Technology	% of Solar
Wind Solar Hybrid	55-65%
RTC	60–70%
FDRE	65–75%

Source: CareEdge Research

According to the India Energy Storage Alliance (IESA), nearly 11 GW of Firm and Dispatchable Renewable Energy (FDRE) capacity was awarded between June 2024 and November 2025. This reflects a strong acceleration in hybrid and dispatchable renewable procurement, driven by the increasing need for round-the-clock clean power, improved grid reliability, and integration of energy storage systems.

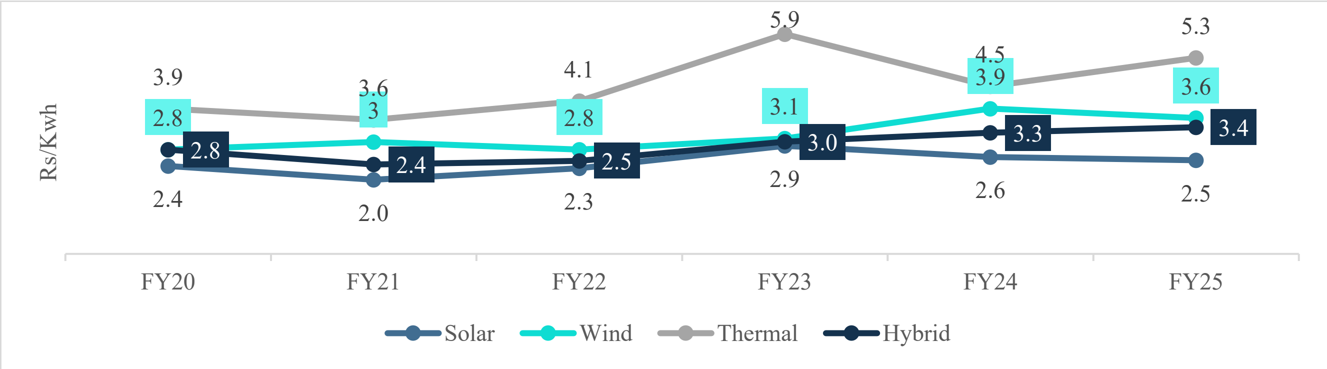
Storage Cost Declines Enhancing Solar Demand: BESS costs have declined to Rs 1.4-3.5 lacs/MW/month in 2025 from Rs 10.6-11.5 lacs/MW/monthin 2022. This leads to improvement in the dispatchability of renewable power, enabling higher solar penetration and supporting firm power solutions.

Hybridisation with Wind Unlocking Value: Co-locating solar with wind farms enhances land use efficiency, improves capacity utilisation, and supports grid balancing, making hybrid configurations increasingly attractive.

Operational Stability and Grid Integration Advantages: Solar energy is generally more predictable and grid-friendly than wind energy due to its relatively stable and less seasonal generation profile. Solar output is primarily linked to sunlight availability, which follows a more consistent and forecastable pattern, with variations mainly driven by changes in daylight hours across seasons. In regions with high solar irradiation, generation remains relatively steady through the year. In contrast, wind power output is more volatile, with significant fluctuations depending on seasonal wind patterns, location and prevailing weather and atmospheric conditions, resulting in pronounced peaks and troughs in generation. The wind and solar PLF comparison trends is explained in Plant Load Factor (PLF) section below.

Lower Tariff Compared to Other Sources: Continuous technological improvements, economies of scale and efficient manufacturing have driven a sustained decline in solar tariffs. Clean energy technologies like solar and wind are increasingly cost-competitive compared to conventional generation. Between FY20 and FY25, solar power remained the most economical, with tariffs ranging from Rs 2.0 to Rs 2.9 per kWh, driven by falling module costs, favourable bidding frameworks, and strong developer participation. Minor fluctuations due to global supply-chain constraints did not affect Solar's consistent cost advantage over thermal power.

Chart 27: Trend in Tariff of Solar, Wind and Hybrid as Compared to Thermal Power Projects (Rs /kWh)



* Tariff represents average of bids during the respective periods
Source: MNRE Annual Report, Maia Research, CareEdge Research

The decline in solar tariff is mainly because the cost of solar modules and cells have come down sharply from Rs 33/Wp in FY22 to 15.39 in FY25.

Demand From Data Centres and Green Hydrogen
Increasing internet penetration, mobile use, e-commerce, electric vehicles, data centres and AI will accelerate this demand in coming years, adding to the pressure on networks. The country's data centre capacity is expected to grow exponentially from 1.4 gigawatts (GW) in 2024 to 9 GW in 2030, and in doing so, they are likely to consume about 3% of India's electricity in 2030, up from less than 1% currently.

Additionally, India's hydrogen demand is expected to double to around 12 million metric tonnes per annum (MMTPA) by 2030. By 2030, financial incentives and declining solar and wind tariffs could reduce the cost of green hydrogen to about USD 3–USD 3.75 per kg. This scale-up is also expected to accelerate renewable capacity additions, particularly utility-scale solar, to supply low-cost round-the-clock power for electrolyser operations.

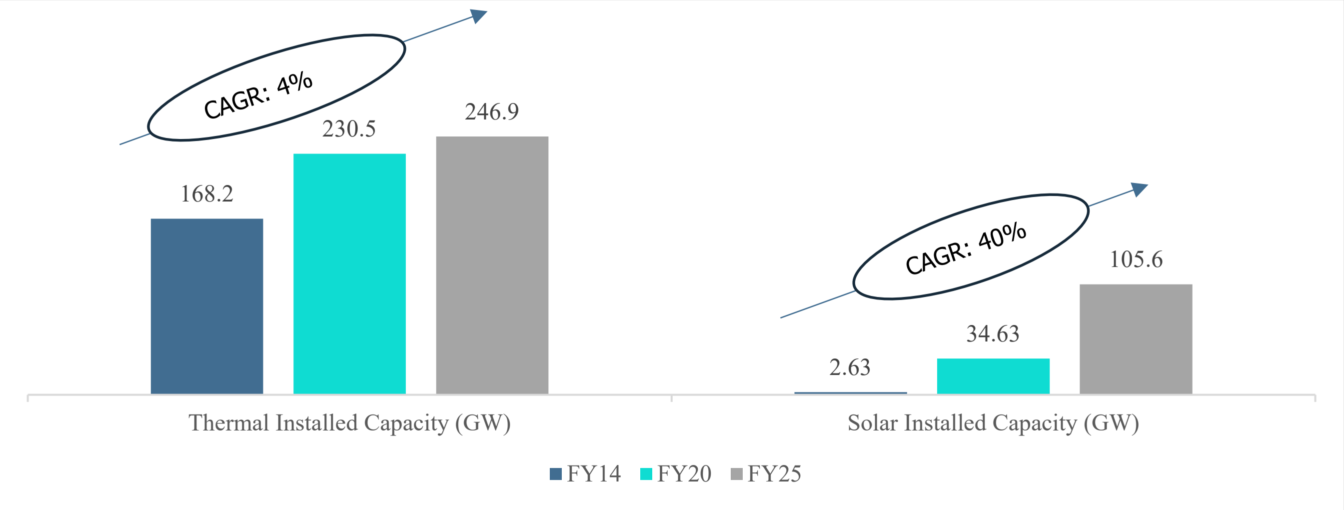
Financing Options

While loans from financial institutions (banks, non-banking financial companies, etc.) remain the main source of financing renewable energy projects in India, some new funding mechanisms have evolved such as Green Bonds, Masala Bonds and Infrastructure InvITs (explained in detail in Availability of Finance and Evolution of Funding mechanisms.

3.2.3 Speed of Installation of Solar Has Far Outpaced Conventional Energy

Thermal capacity grew moderately from 168.2 GW in FY14 to 230.5 GW in FY20 but showed limited growth, thereafter, reaching 246.9 GW by FY25, with its CAGR slowing from 5% during FY2014-20 to just 1% during FY2020–25. In contrast, solar capacity expanded rapidly from a very low base in FY14 to nearly 35 GW in FY20 and surged further to surpass 105 GW by FY25.

Chart 28: Installed Capacity of Thermal Vs Solar



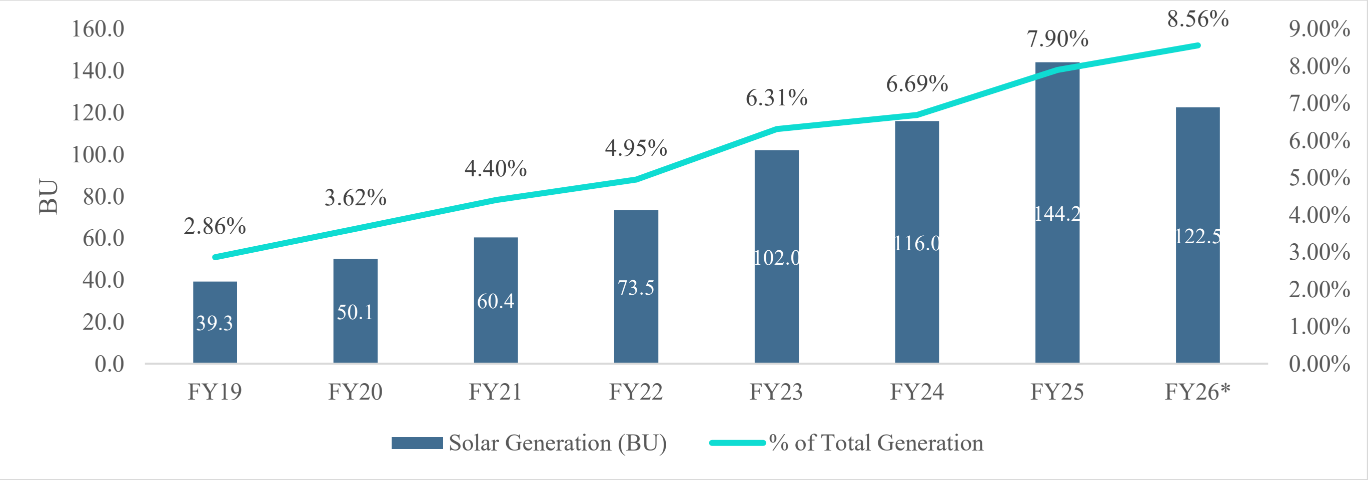
Source: Central Electricity Authority (CEA)

Despite moderation in growth from earlier peaks, solar capacity additions have consistently outpaced thermal power, highlighting a structural shift in India's power generation mix. Faster project execution, declining costs and strong policy support have enabled solar installations to surpass conventional sources, which face longer timelines and fuel-related challenges. This trend underscores solar energy's emergence as the primary driver of new capacity addition, reinforcing India's transition toward a cleaner, more sustainable, and energy-secure power sector.

3.2.4 Solar Generation

India's renewable energy capacity has expanded steadily over the years. Solar capacity recorded a strong CAGR ~24% during FY19-FY25, while wind capacity grew at a more moderate CAGR of 5.8% over the same period. Additionally, the share of solar in India's total installed power capacity increased from around 2.9% in FY19 to nearly 7.9% by FY25

Chart 29: Solar Generation in India



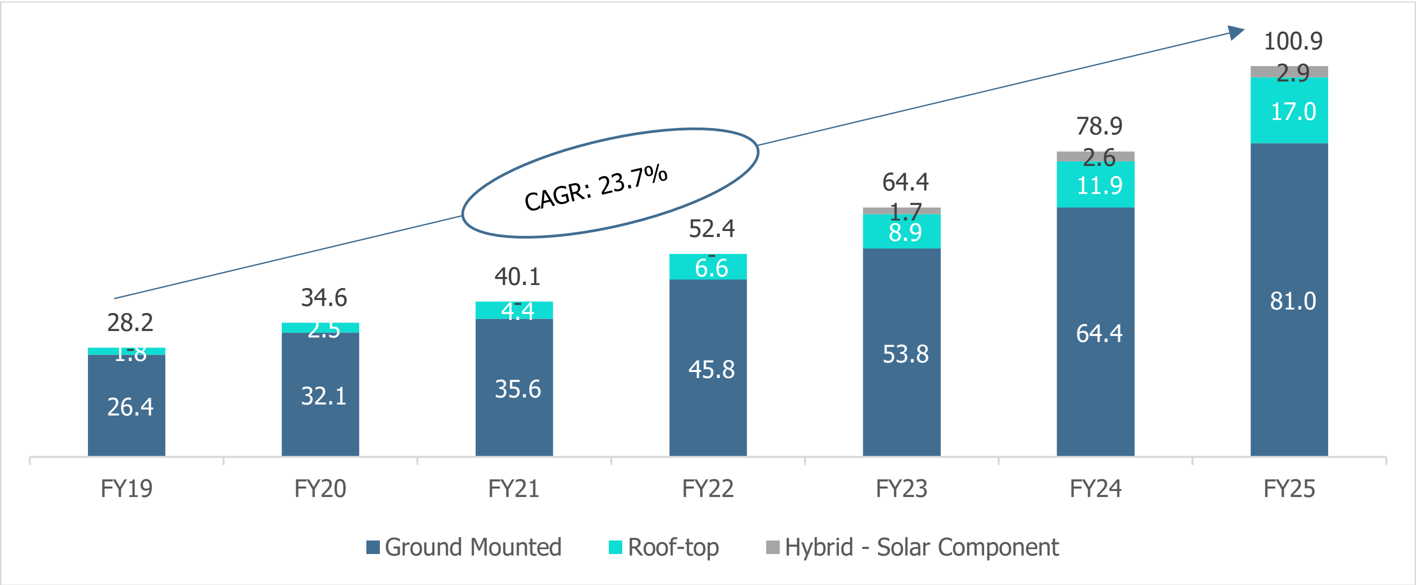
Source: India Climate & Energy Dashboard, *FY26 Data is as of December 2025

3.2.5 Review of Overall Grid Connected Solar Energy Capacity Additions

Grid-connected solar capacity refers to the solar power generation capacity which is connected to the utility grid. The grid-connected solar capacity has increased from 28.2 GW in FY19 to 100.9 GW as of FY25, representing 95.5% of the total installed solar power generation capacity.

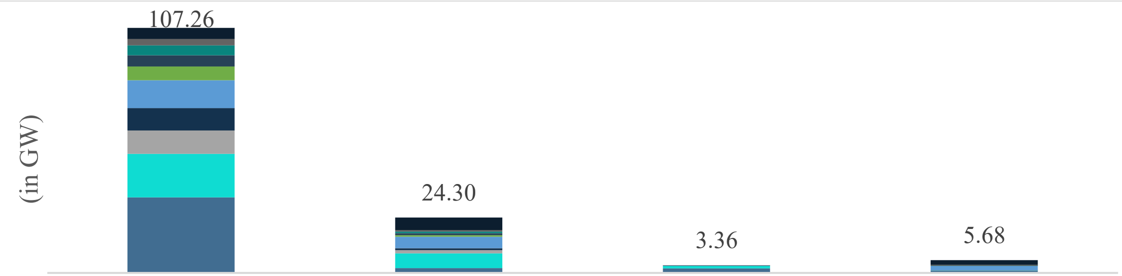
Despite suffering from supply chain constraints and increasing shipping costs, the capacity installations have been high due to rapid technological improvements and a significant decline in module costs. Other drivers include increased competitiveness, faster completion of projects in pipeline during COVID-19 period, consistent focus of Government of India, greater demand from the commercial and industrial segments, etc.

Chart 30: Grid-connected Solar energy capacity additions (GW)



Source: India Climate & Energy Dashboard (Niti Aayog), MNRE, CareEdge Research, Note: Excludes Off-grid Solar/KUSUM.

Chart 31: State-wise Solar Capacity as of January'26 (GW)



	Ground Mounted Solar	RTS (including PMSurya Ghar Yojana)	Hybrid Solar Comp.	Offgrid Solar/ KUSUM Comp
Total	107.26	24.30	3.36	5.68
Others	4.79	5.55	0.00	2.08
Uttar Pradesh	2.79	0.68	0.00	0.36
Telangana	4.36	0.70	0.00	0.01
Madhya Pradesh	4.93	0.82	0.00	0.10
Andhra Pradesh	6.09	0.76	0.00	0.09
Maharashtra	12.15	5.02	0.00	1.93
Karnataka	9.76	0.81	0.21	0.04
Tamil Nadu	10.32	1.34	0.00	0.07

Source: MNRE, CareEdge Research

Rajasthan is India's leading contributor to the solar energy sector, with the highest cumulative installed capacity of nearly 38 GW. This leadership is driven by exceptional solar irradiance, vast availability of barren land, and strong policy support under the

Rajasthan Renewable Energy Policy, 2023, which targets 65 GW of solar capacity by FY29-FY30. Large solar parks like Bhadla along with streamlined land and evacuation infrastructure, have accelerated large-scale deployment.

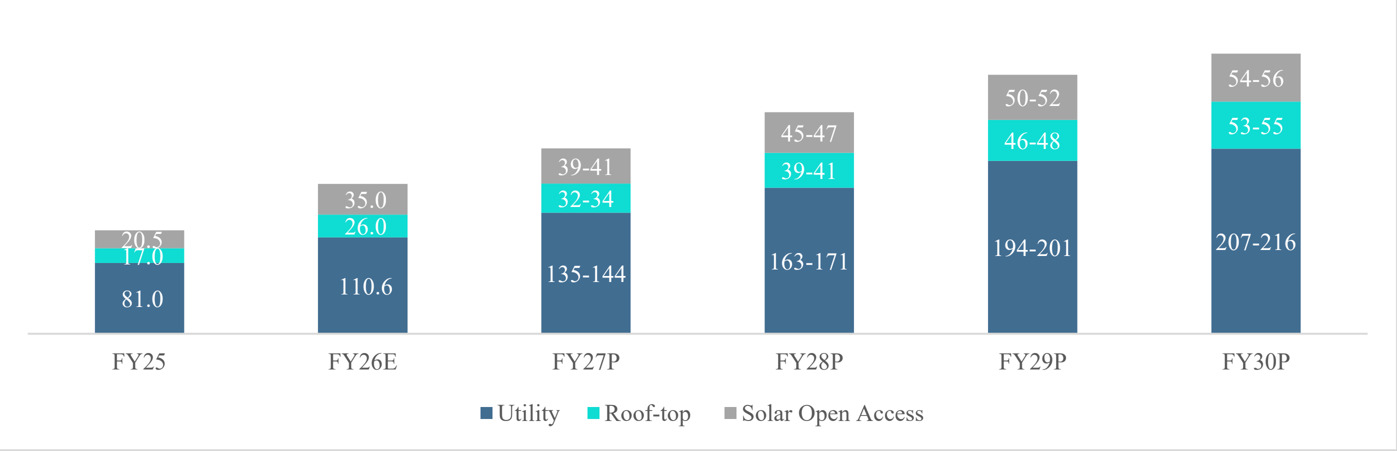
Outlook

In FY25, the total **PPA signed capacity for solar** utility scale projects **is ~10 GW_{AC}**. Utility-scale projects will continue to anchor India's solar additions by growing at CAGR of ~20-22% during FY25-FY30, supported by regular central and state tenders, large solar parks and expanding transmission infrastructure. States such as Rajasthan, Gujarat, Tamil Nadu, Maharashtra and Madhya Pradesh account for a significant share of installed utility-scale capacity. This segment is expected to contribute most annual additions through FY30.

Rooftop solar is likely to grow at CAGR of ~25-26% during FY25-FY30, driven by the PM Surya Ghar Muft Bijli Yojana and simplified approval processes. Supportive state-level policies on net metering, subsidies and single-window clearances are further accelerating adoption across residential and C&I consumers.

During FY25 ~6GW of Open-access solar projects were signed by private players. The segment is gaining traction and is estimated growing at ~21-23% during FY25-FY30 as C&I consumers seek cost optimisation and sustainability benefits. Karnataka, Maharashtra, Tamil Nadu, Gujarat and Rajasthan remain key markets due to relatively favourable regulatory frameworks. Proposed reforms under the Electricity (Amendment) Bill, 2025 are expected to improve regulatory certainty and ease open-access adoption. Overall, grid-connected solar additions are expected to remain strong over the next decade. While challenges such as DISCOM finances and transmission constraints persist, the policy environment remains supportive of sustained growth through FY30.

Chart 32: Outlook of Overall Grid-connected Solar Energy Capacity Additions (GW)



Source: MNRE, CareEdge Research, Note: There is overlap between Utility and Open Access, Ground-mounted is considered as Utility

The expansion of green hydrogen and data centres is driving strong growth in solar demand in India. The National Green Hydrogen Mission aims to produce 5 MMT of hydrogen by 2030, which will require around 125 GW of new renewable capacity. At the same time, data centre load is projected to increase from 1.4 GW in 2024 to 9 GW by 2030, with a large share of this additional power demand expected to be met by the solar sector. Under the ALMM framework, projects must use domestically produced modules, creating strong order inflows and opportunities for Indian manufacturers.

India's December 2022 rooftop solar target of 40 GW was not met, with a shortfall of nearly 57%. The residential segment grew slowly due to high upfront costs, complex subsidy procedures and limited financing. The launch of PM Surya Ghar: Muft Bijli Yojana, with a budget of Rs 75,021 crore, improved the situation. The scheme offers a subsidy of up to Rs 78,000 for a 3kW system (around 60% of the cost), direct benefit transfer through a National Portal, and collateral-free loans at about 7% interest.

The government increased support for the rooftop solar programme by allocating Rs 22,000 crore to provide subsidies of up to Rs 78,000 for household systems. Along with collateral-free, low-interest loans and simplified digital approvals, this higher budget allocation is expected to support the target of supplying rooftop solar to 1 crore (10 million) households by March 2027.

3.2.6 Availability of Finance and Evolution of Funding Mechanism

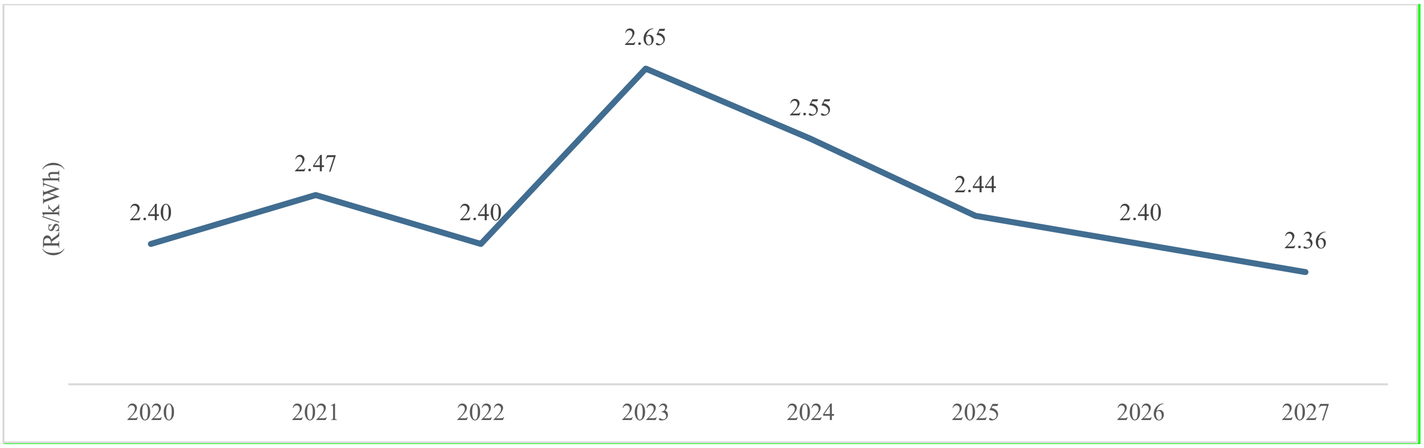
While loans from financial institutions (banks, non-banking financial companies, etc.) remain the main source of financing renewable energy projects in India, some new funding mechanisms have evolved as detailed below:

Instrument	Description
Green Bonds	Green Bonds Debt instruments designed to raise capital for projects that are environmentally sustainable and support climate initiatives. In 2024, India issued green bonds worth Rs 26,000 crores, with proceeds allocated to renewable energy, energy efficiency, waste management and more.
Masala Bonds	Rupee-denominated bonds that are issued outside of India. Corporations such as NTPC have launched green masala bonds specifically for renewable energy projects, although this market is still largely untapped.
Infrastructure InvITs	Infrastructure InvITs Investment vehicles focused on income-generating infrastructure, such as power plants. Developers have the option to bundle their projects into InvITs, allowing them to monetise their assets and secure funding for future developments.

3.2.7 Outlook on Levelised Tariffs for Solar PV Power Plants in India

The levelised tariff shows the average cost of electricity generation over the lifetime of a solar project, factoring in capital, operating and financing costs.

Chart 33: Levelised Tariffs for Solar Power Plant



Source: Industry Source, CareEdge Research, Data on FY Basis
Assumption: Equity IRR (Post-tax) 9.51%, Interest on term loan 7.57%, Escalation rate of O&M and Lease rent 5%

In 2023, tariffs increased due to higher module prices, supply chain disruptions and elevated financing costs. From 2025 onwards, tariffs are expected to decline gradually, supported by easing cost pressures, improved supply chains, and efficiency gains. Overall, the chart indicates that solar power remains a cost-competitive source of electricity despite temporary cost fluctuations.

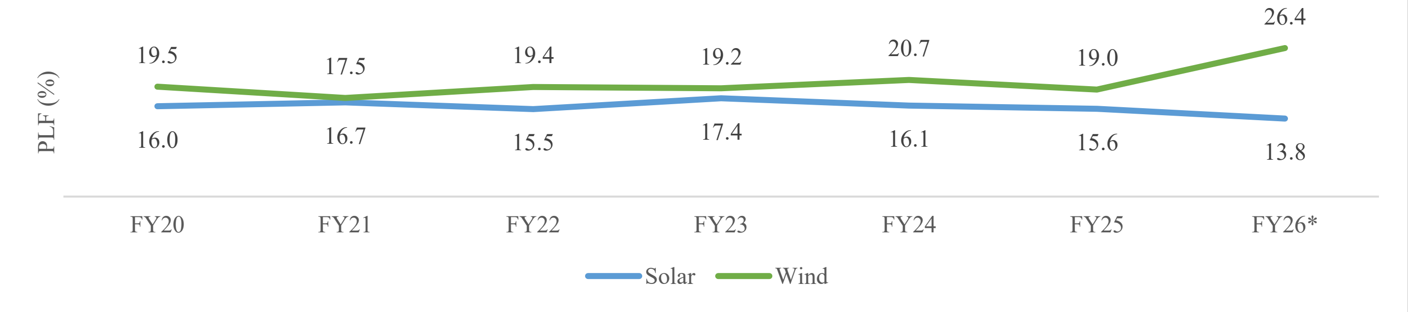
The weighted average solar tariff fell from above Rs 17/unit to around Rs 2.4 - Rs 2.9/unit due to lower module prices, improved supply chains, and reduced financing costs. Imported non-DCR modules (around Rs 15–16/W) kept costs lower than earlier domestic DCR modules (Rs 23-28/W), though incentives like PLI and ALMM have improved domestic competitiveness. The total effective customs duty on imported solar modules has reduced from 61.28% to 56.8% after restructuring. Basic Customs Duty was cut from 40% to 20%, a new Agriculture Infrastructure Development Cess of 20% was introduced, Social Welfare Surcharge was removed, and Integrated Goods and Services Tax slightly declined. Overall, the import duty burden has reduced marginally.

The Indian government's decision to reduce GST on solar photovoltaic (PV) modules, cells and other renewable energy equipment from 12% to 5%, effective from 22 September 2025, is expected to significantly lower project costs across the sector. This rationalisation could reduce the overall capital cost of solar projects by around 5%, translating into a decrease of approximately Rs 0.8-0.10 per kWh in the cost of solar power generation. On the equipment front, key manufacturers estimate direct savings of up to Rs 10 lakh per MW for non-DCR modules and Rs 15 lakh per MW for DCR modules. Similarly, rooftop solar installations are projected to become more affordable, with a typical 3 kW system expected to cost Rs 9,000–10,500 less following the GST reduction.

3.2.8 Plant Load Factor (PLF)

Solar energy is generally more predictable and grid-friendly than wind energy due to its relatively stable and less seasonal generation profile. Solar output is primarily linked to sunlight availability, which follows a more consistent and forecastable pattern, with variations mainly driven by changes in daylight hours across seasons. In regions with high solar irradiation, generation remains relatively steady through the year. In contrast, wind power output is more volatile, with significant fluctuations depending on seasonal wind patterns, location and prevailing weather and atmospheric conditions, resulting in pronounced peaks and troughs in generation.

Chart 34: Solar and Wind PLF



Source: India Climate & Energy Dashboard - NITI Aayog, CareEdge Research
*FY26 Data is as of November 2025

3.2.9 Government Initiatives

Segment	Source of Capacity Addition	Key Growth Drivers
Utility-Scale	Solar Parks & Ultra-Mega RE Parks	Plug-and-play infrastructure significantly lowers land acquisition and evacuation risk, enabling faster execution and scale-led cost reductions. Policy momentum is strong with 55 solar parks approved across 13 Indian states (41.2 GW capacity), 16.8 GW already commissioned across 26 parks. Solar parks benefit from superior access to supply chains due to project clustering, which attracts EPC contractors, equipment suppliers and logistics providers.
	SECI / Central Agency Tendering	Centralised tendering provides long-tenor (25-year) bankable PPAs, transparent tariff discovery and consistent large-scale auctions. Solar remains the anchor technology in hybrid and RTC bids, with tariffs largely stabilizing in the Rs 2.5 – Rs 2.8/kWh range and a sustained tender pipeline.
	CPSU Scheme (DCR)	The CPSU scheme ensures assured demand for domestically manufactured cells and modules through mandatory DCR usage, supported by VGF. PSU-led execution strength and alignment with domestic manufacturing objectives improve project viability and returns.
	ISTS Waiver & Payment Security	Waiver of ISTS charges lowers delivered power costs and enables geographic flexibility in project siting. Mandatory payment security mechanisms such as LCs or advance payments reduce counterparty risk and enhance bankability.

Open Access (C&I)	Green Open Access Regulations	Regulatory reforms have expanded consumer eligibility, reduced minimum load requirements, introduced time-bound approvals, and improved banking and settlement mechanisms, significantly easing adoption for C&I consumers.
	Captive / Group Captive Solar	Captive and group captive models offer sustained cost arbitrage versus grid power, with open-access solar tariffs structurally below industrial grid tariffs, providing long-term tariff certainty for corporates.
	Corporate ESG & Net-Zero Targets	Rising commitments under RE100, net-zero, and broader ESG frameworks are driving incremental demand, reinforced by increasing renewable sourcing mandates among large corporates.
Rooftop	PM Surya Ghar & Rooftop Phase-II	Capital subsidy support, direct incentives for residential systems, and benefits such as free electricity up to defined limits improve household payback and drive mass-market rooftop adoption. Allocation towards PM Surya Ghar has been increased by 29% y-o-y in FY27 budget to Rs 22,000 crores, strengthening policy support for the rollout of rooftop solar capacity.
	Net Metering & Digital Processes	Supportive net-metering policies for small systems, coupled with online approval portals and digital processes, reduce procedural friction and improve project IRRs.
	Urban Power Demand Growth	Rising urban electricity consumption driven by higher appliance ownership and cooling penetration supports rooftop solar adoption while helping DISCOMs manage peak load demand.
Cross-segment	National Solar Mission (JNNSM)	Long-term policy visibility under JNNSM supports scale-driven cost reduction and domestic capability building, with targets of 100 GW utility-scale capacity under Phase-III and 2 GW off-grid capacity.
	Manufacturing & Trade Policy	Policy support through PLI schemes, 20% BCD on cells and modules and 100% FDI allowance is accelerating import substitution, improving supply-chain resilience, and attracting manufacturing investments.

3.2.10 Key Risks Impacting Solar Capacity Additions

Rooftop solar growth is constrained by weak distribution network infrastructure, especially in dense urban areas where low-voltage feeders cannot handle reverse power flow. Many buildings have poor structural strength, complex roofs or shading issues that limit system design and generation. DISCOMs also face technical challenges in metering, grid synchronisation and managing intermittency at the local transformer level. Together, these issues slow approvals, limit feasible rooftop potential and increase project execution complexity.

Table 14: Key Risks Impacting Solar Capacity Additions

Key risk	Description	Mitigation Factor
Land availability and permitting risk (utility-scale)	Utility-scale solar typically requires ~4–5 acres per MW (order-of-magnitude benchmark), so land aggregation for a 1 GW park can be ~4,000–5,000 acres, making acquisition/clearances a critical schedule risk.	Solar Park / plug-and-play sites (land + common infrastructure + single-window facilitation) to reduce land aggregation risk
Transmission / evacuation risk	Delays in pooling substations/lines can push CODs and raise curtailment risk; where network constraints exist, projects may operate below intended offtake until bays/lines are available.	Choose sites in **solar parks/RE zones** with committed evacuation buildout

DISCOM financial health and off-taker risk	Payment delays remain a measurable risk. As per Ministry of Power's PRAAPTI portal, total DISCOM dues to generators were ~ Rs 38,862.21 crores as of Feb-26	Robust **payment security mechanism** and tighter receivable covenants
Increase in capital cost / cost inflation risk	Module/BoS volatility and interest rates directly impact tariffs/IRRs. Even a 100–150 bps increases in debt cost or a 5–10% EPC cost increase can make aggressively bid PPAs marginal where pass-through is absent.	Price-lock / framework supply contracts for modules/inverters and structured procurement
PPA / tender cancellation and renegotiation risk	India has recently experienced significant solar tender cancellations, with over 11.4 GW of renewable energy capacity, primarily solar, cancelled by agencies like SECI and MNRE between April 2023 and mid-2025.This risk increases when tariffs are bid at the edge of viability or when technology/cost assumptions change materially post-bid	Bid discipline: realistic tariffs with downside buffers for capex/interest/transmission delays

Source: CareEdge Research

4 Assessment of Solar Module Manufacturing in India and Globally

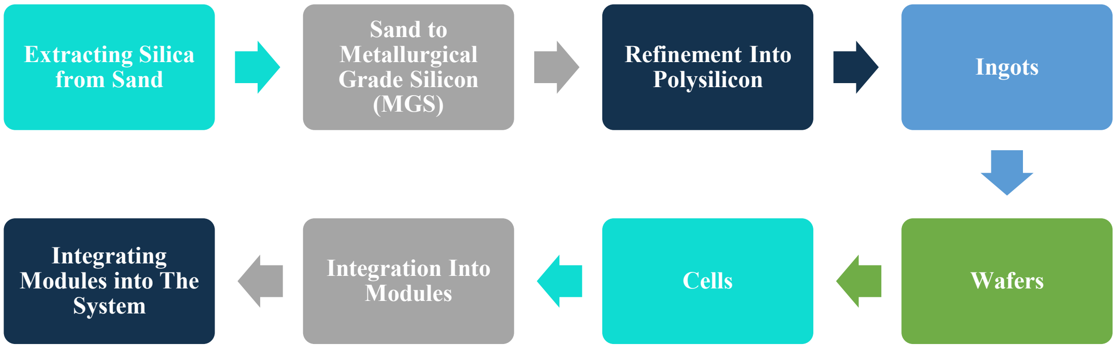
4.1 Solar PV Module Chain

The solar PV value chain is typically classified into upstream, midstream and downstream segments. The upstream segment comprises the production of core inputs, including polysilicon, ingot and wafer processing. The midstream segment primarily involves the Solar Cell Manufacturing while the downstream includes assembly of solar modules from manufactured cells. The downstream segment also encompasses engineering, procurement and construction (EPC) activities, balance-of-system (BoS) components, project installation and operations and maintenance (O&M) of solar assets. In addition, downstream activities also include project development and ownership, where developers or independent power producers (IPPs) undertake project development, financing and long-term operation of solar power plants.

Wafer-based technology forms the largest segment of the global PV market. Silicon wafer-based technology accounted for about 98% of total production in 2024.

The value chain for the PV technology has been briefly described.

Figure 1: Value Chain for PV Technology



1. Extracting Silica from Sand: Sand processing to extract raw silicon (silica) is at the heart of the value chain.

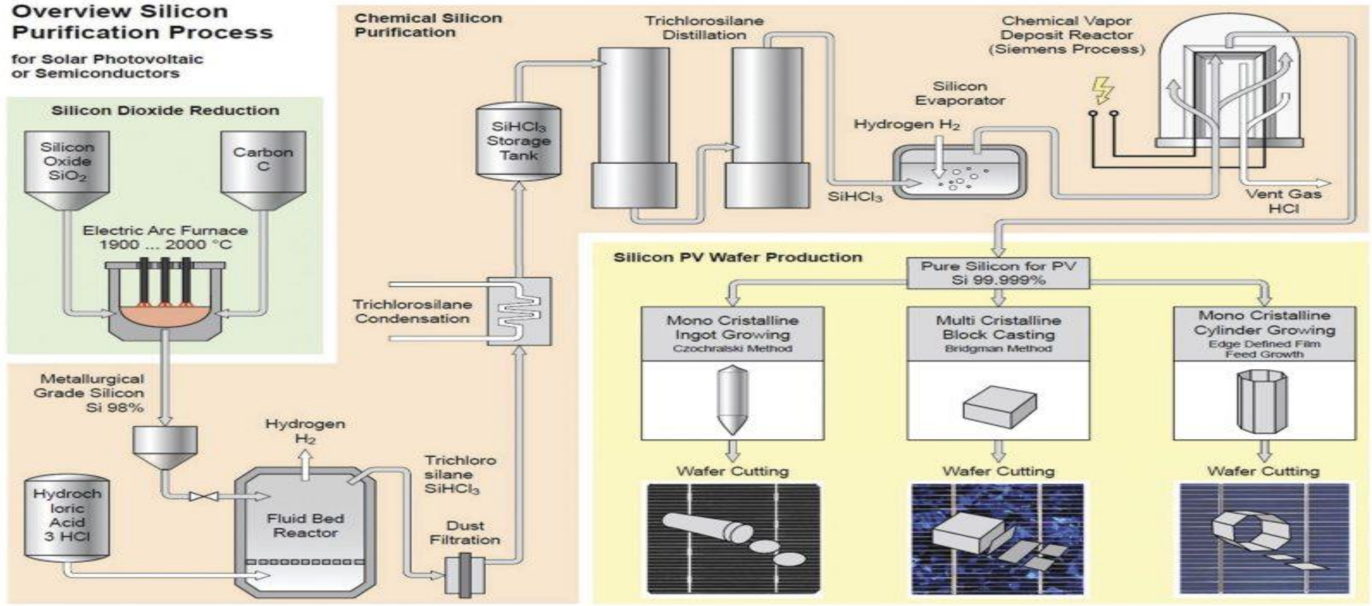
2. Sand to Metallurgical Grade Silicon (MGS): Silica is mined and reduced to Metallurgical Grade silicon (MGS) through the carbothermic reduction process.

3. Refinement Into Polysilicon: The MGS is refined to remove impurities and converted into high-purity solar grade polysilicon through Siemens process.

4. Ingots: Polysilicon is doped mainly with boron (p-type) or phosphorus (n-type) and crystallised into ingots, with monocrystalline silicon produced via the Czochralski process accounting for ~95–98% of global PV production due to superior efficiencies

5. Wafers: The Ingots are converted into bricks and sliced into wafers using a diamond wire, the base for solar cells.

Figure 2: Overview of Silicon Purification Process

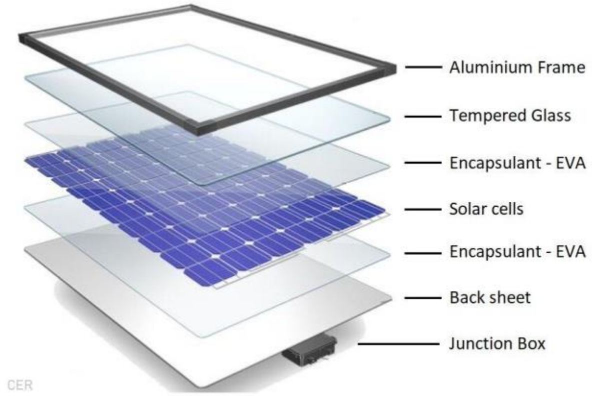


6. Cells: Wafer processing involves controlled doping to form a p–n junction, application of anti-reflective coatings, deposition of metal contacts for charge collection and electrical testing to classify cell efficiency, collectively determining solar cell performance.

7. Integration Into Modules: Cells connected in series are encapsulated between EVA sheets, laminated with tempered glass and a backsheet or rear glass, fitted with a junction box and framed with aluminium to form a solar module

8. Integrating Modules into The System: Multiple solar panels/modules are connected to form a bigger unit called an array. The entire setup is then integrated into a solar system that can generate power.

Figure 3: Solar Module Components



Solar Cells

Figure 4: Solar Cell Manufacturing Process

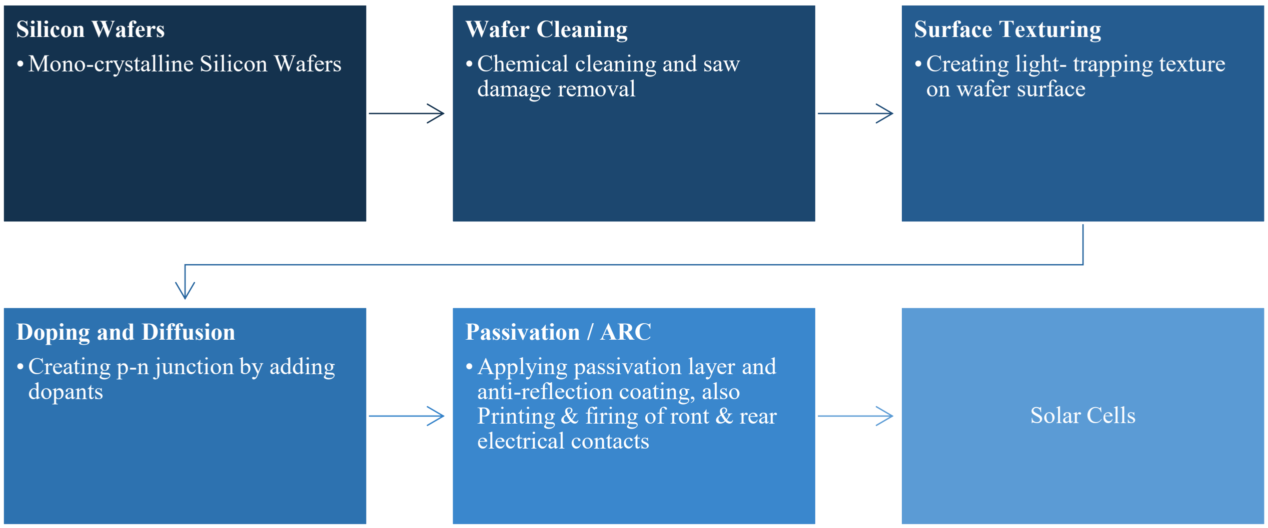


Table 15: Solar Cell Manufacturing Process

Process Stage	Description	Key Raw Materials
Silicon Wafers (Mono-crystalline)	High-purity monocrystalline silicon wafers form the base of solar cells. Their uniform crystal structure enables higher efficiency and lower electrical losses.	Mono-crystalline silicon wafer; Deionised water (DI water); Isopropyl alcohol (IPA)
Wafer Cleaning	Chemical cleaning removes saw damage, organic residues, and metallic impurities. This ensures a uniform surface for effective texturing and dopant diffusion.	Deionised water (DI water); Hydrofluoric acid (HF); Hydrochloric acid (HCl)
Surface Texturing	Chemical etching creates microscopic pyramid structures on the wafer surface. This reduces light reflection and improves photon absorption.	Potassium hydroxide (KOH); Isopropyl alcohol (IPA); Deionised water (DI water)
Doping and Diffusion	Dopants such as boron or phosphorus are diffused to form a p–n junction. This junction enables charge separation and electricity generation under sunlight.	Phosphorus oxychloride ($POCl_3$); Oxygen (O_2); Nitrogen (N_2)
Passivation / Anti-Reflective Coating (ARC)	A passivation layer with anti-reflective coating reduces recombination and reflection losses. Front and rear metal contacts are printed and fired for efficient current collection.	Silane (SiH_4); Ammonia (NH_3); Silver paste (Ag paste)
Solar Cells	Finished cells convert sunlight into direct current electricity. Cells are tested, efficiency-binned, and prepared for module assembly.	Electrical test probes/fixtures; Polymer trays/carriers; Barcode labels (pressure-sensitive labels)

Source: CareEdge Research, Note: The Raw Material set changes materially for different kinds of cells

To successfully manufacture cells, a facility must possess the following specialised capabilities:

Semiconductor-Grade Process Control

- Ability to precisely control wafer cleaning, surface texturing, dopant diffusion, and junction formation at micro-scale tolerances.

Advanced Thin-Film Deposition and Metallisation

- Capability to apply uniform passivation and anti-reflective coatings using processes such as PECVD, along with high-precision front and rear metallisation.

High-Purity Materials and Contamination Management

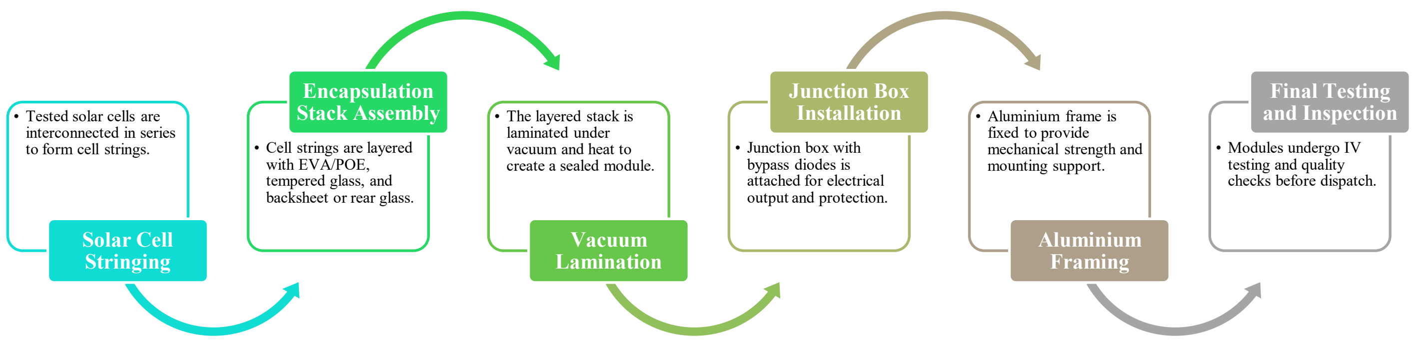
- Access to high-quality mono-crystalline wafers, ultra-pure gases, chemicals, and deionised water, supported by contamination-controll management directly affects electrical performance and long-term reliability manufacturing environments.

Inline Testing

- Strong testing infrastructure for electrical characterisation, efficiency binning, and defect detection at the cell level.

Solar Module

Figure 5: Solar Cell to Module Process



Cell line starts from a semiconductor substrate while module starts from already functional cells due to which the cell lines are more contamination-sensitive due to junction and thin films.

Table 16: Comparison showing cell manufacturing is more complex than module

Process	Cell	Module
Key steps	Cleaning → texturing → diffusion → passivation/ARC → metallisation → firing	Stringing/tabbing → lay-up → lamination → framing → junction box
Input Material	Silicon Wafers	Finished Cells, Glass, EVA, Frames
Cleanliness requirement	Higher (particle/metal contamination impacts efficiency/yield)	Moderate (clean assembly environment required, but less contamination sensitive
Capital Investment	High	Low as compared to Cell
Waste/Regulation	Chemical effluents, hazardous materials	Minimal, mainly packaging waste

Source: CareEdge Research

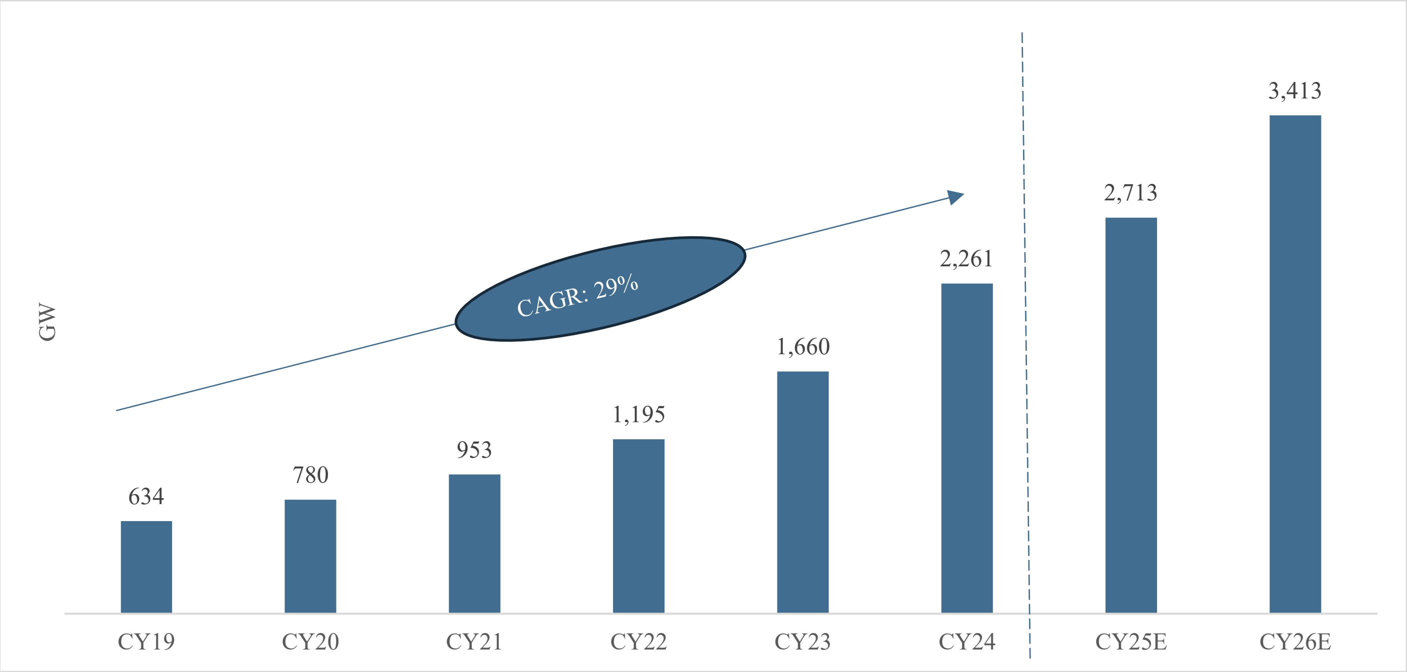
4.2 Global Solar Photovoltaic Market

4.2.1 Overview of Global PV Module and Cell Capacity

Global solar PV capacity is projected to add around 3,500 GW by CY30. This growth is expected to be supported by declining technology costs, improved project economics and faster permitting and execution timelines across major markets.

During the year CY24 China continues to dominate the global solar market, accounting for around 46% of cumulative installed capacity and contributing roughly 50% of global capacity additions during CY19–CY24.

Chart 35: Global Installed Solar Generation Capacity

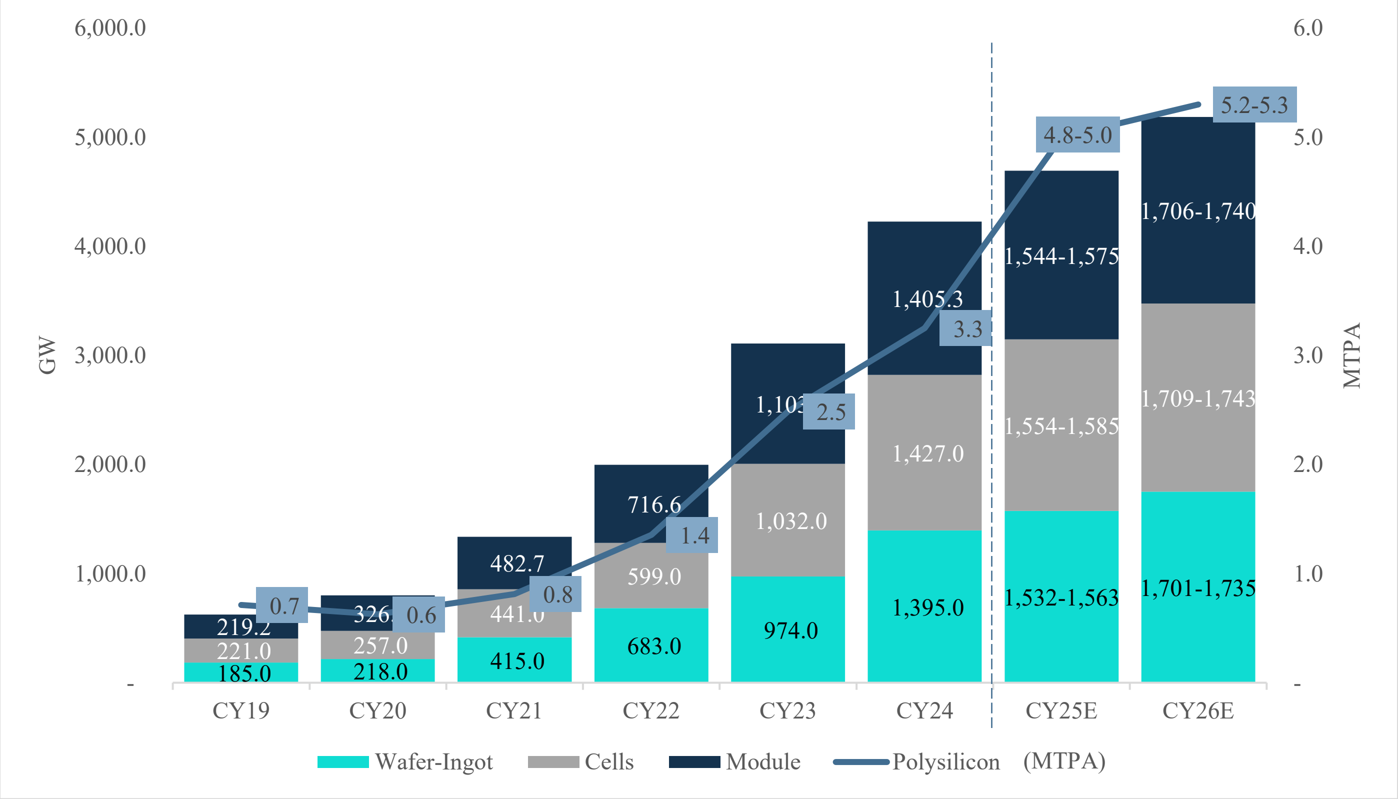


Source: International Energy Agency (IEA) PVPS, CareEdge Research

Global solar PV manufacturing capacity has expanded sharply across the value chain over CY19–CY24, led by accelerated additions in upstream and midstream segments. Ingot-wafer capacities increased more than seven times over this period, while cell and module capacities rose ~6 times, reflecting a concerted push to backward integration and reduce upstream bottlenecks. Capacity additions intensified from CY22 onwards, with CY23-CY24 marking a step-up phase as ingot, wafer, cell and module capacities crossed the 1,000 GW threshold.

Going forward global manufacturing capacity will continue expanding till CY26, with PV manufacturing capacity across the value chain expected to cross 1,700 GW. Despite the existing imbalance between supply and demand, global polysilicon manufacturing capacity is expected to continue expanding. If currently announced projects proceed as planned, polysilicon capacity could grow from 3.25 million tons per year in CY24 to ~5.0 million tons per year by CY25 and is estimated to reach 5.2-5.3 million tons by CY26.

Chart 36: Global Solar PV Manufacturing Capacity



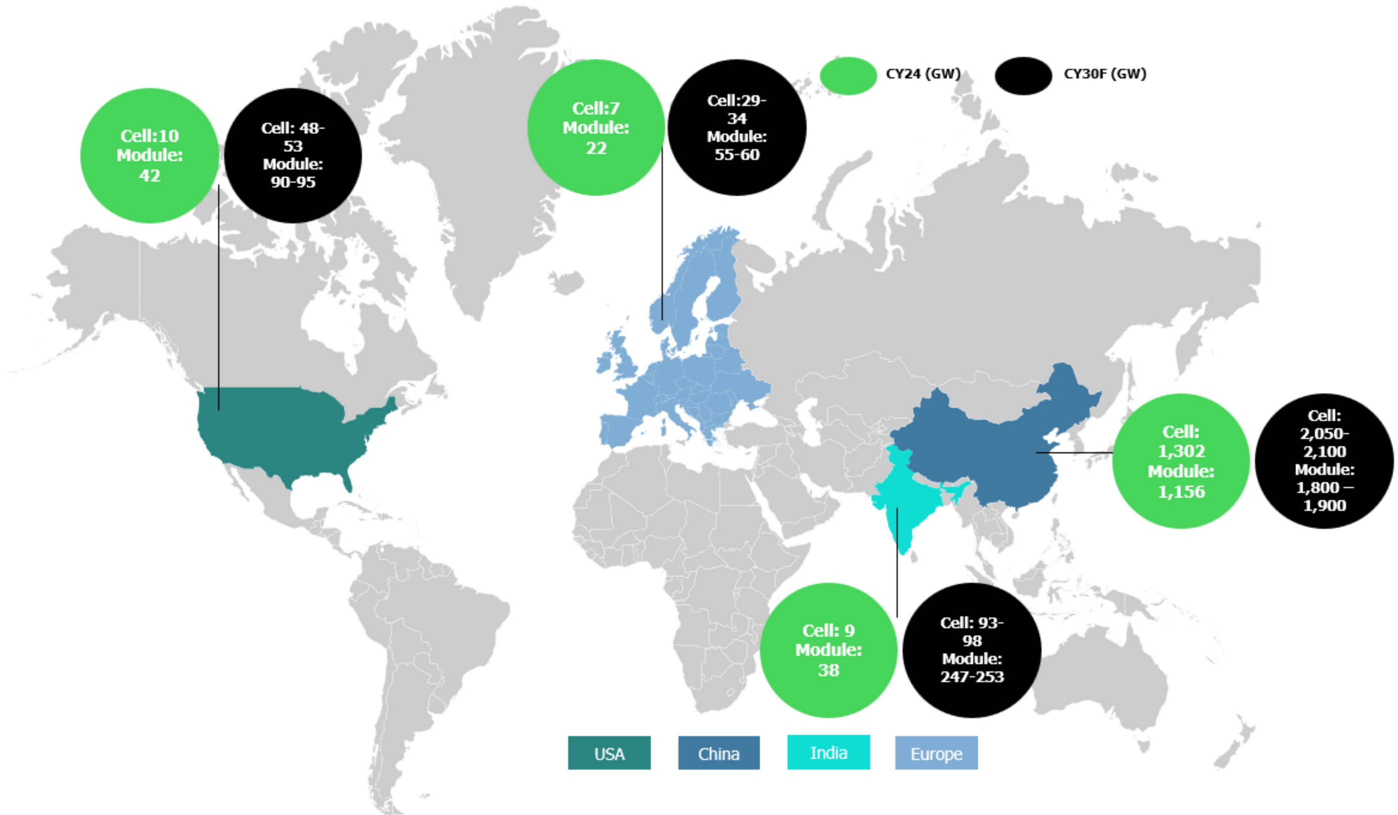
Source: IEA PVPS, CareEdge Research

While global PV manufacturing capacity continues to expand, its distribution remains highly concentrated and uneven as China dominates the market accounting more than 90% in last five years, driven by large-scale integrated facilities, low-cost polysilicon and sustained investments in high-efficiency technologies.

India is emerging as a fast-growing solar manufacturing hub and its rapid capacity additions are being propelled by policy support such as the Production-Linked Incentive (PLI) scheme, Basic Customs Duty (BCD), Approved List of Models and Manufacturers (ALMM) and state-level incentives, which are encouraging backward integration into wafers and cells.

However, despite diversification efforts, China continues to dominate the end-to-end solar PV value chain benefiting from scale, integrated supply ecosystems, and cost leadership.

Figure 6: Region-wise Global Cell and Module Capacity Manufacturing Capacity



Source: IEA PVPS, TechSci Research, CareEdge Research, Note: Data for India is in FY Basis. Eg: CY24 data is FY24.

Polysilicon: Prices remained elevated in CY22, as the imbalance between supply and demand persisted due to fire at East Hope's polysilicon facility in Xinjiang. From CY23, substantial capacity expansions in China resulted in structural oversupply, triggering a sharp correction in prices across the solar value chain. In response to the sustained downturn, leading Chinese producers such as Tongwei Group and Daqo announced production curtailments aimed at stabilising polysilicon prices, with cascading effects on wafer, cell and module pricing.

Wafer: Wafer-ingot prices corrected sharply from ~USD 0.13/Wdc in CY22 to ~USD 0.07/Wdc in CY23, reflecting the rapid pass-through of upstream cost easing and the surge in China-led capacity additions. With substantial new wafer lines commissioned through CY23, production volumes remained well above demand absorption in both CY23 and CY24, intensifying price-based competition.

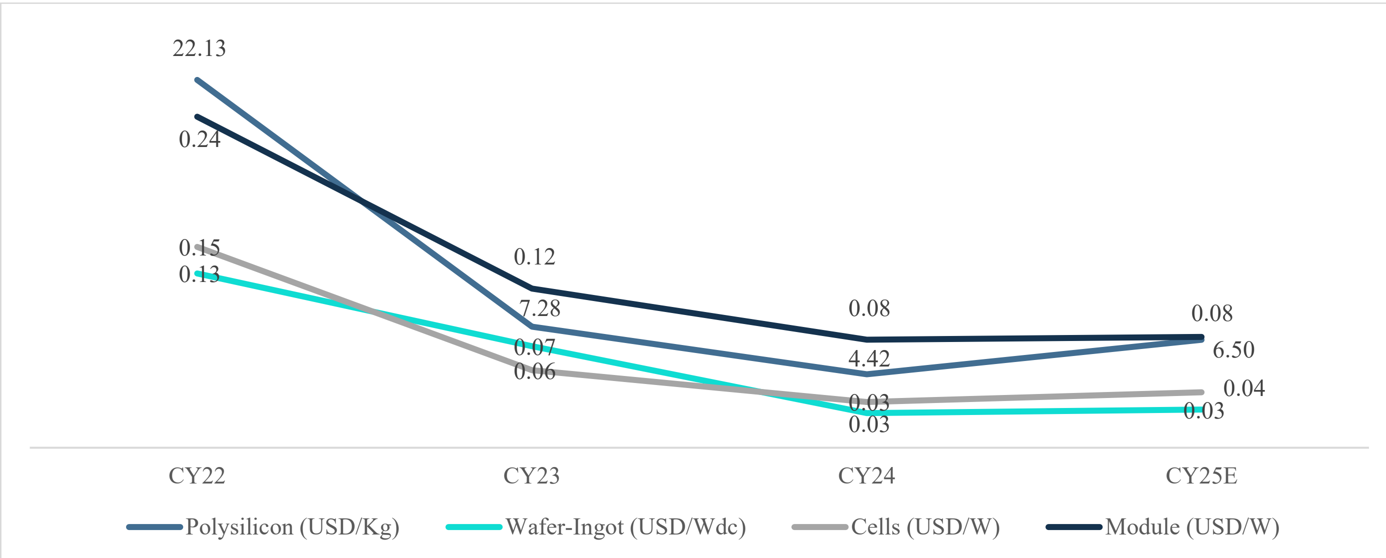
Cell: Cell prices saw a steeper reset, declining from ~USD 0.15/W in CY22 to ~USD 0.06/W in CY23 and further to ~USD 0.03/W in CY24 as excess capacity and weaker realisations intensified competition.

Module: Prices declined sharply from ~USD 0.24/W in CY22 to ~USD 0.12/W in CY23, tracking the rapid unwind in upstream costs as China's capacity additions pushed the value chain into oversupply. As a direct consequence of the large volumes of manufacturing that came online in CY23, production volumes were well above the market's capacity to absorb in 2023 as well as in 2024.

The adverse pricing environment extended into mid-CY25. As of July 2025, several large manufacturers were reevaluating their capital allocation frameworks and production strategies. Concurrently, select players have initiated strategic diversification into energy storage systems and integrated clean energy solutions to mitigate earnings volatility and enhance operational resilience.

However, prices are expected to rise in CY26 due increasing silver prices. Additionally, China has proposed policy changes especially the phasing out of export tax/VAT rebates and production cuts which will support higher benchmark pricing and reduce oversupply. Prices are expected to increase by ~8-9%.

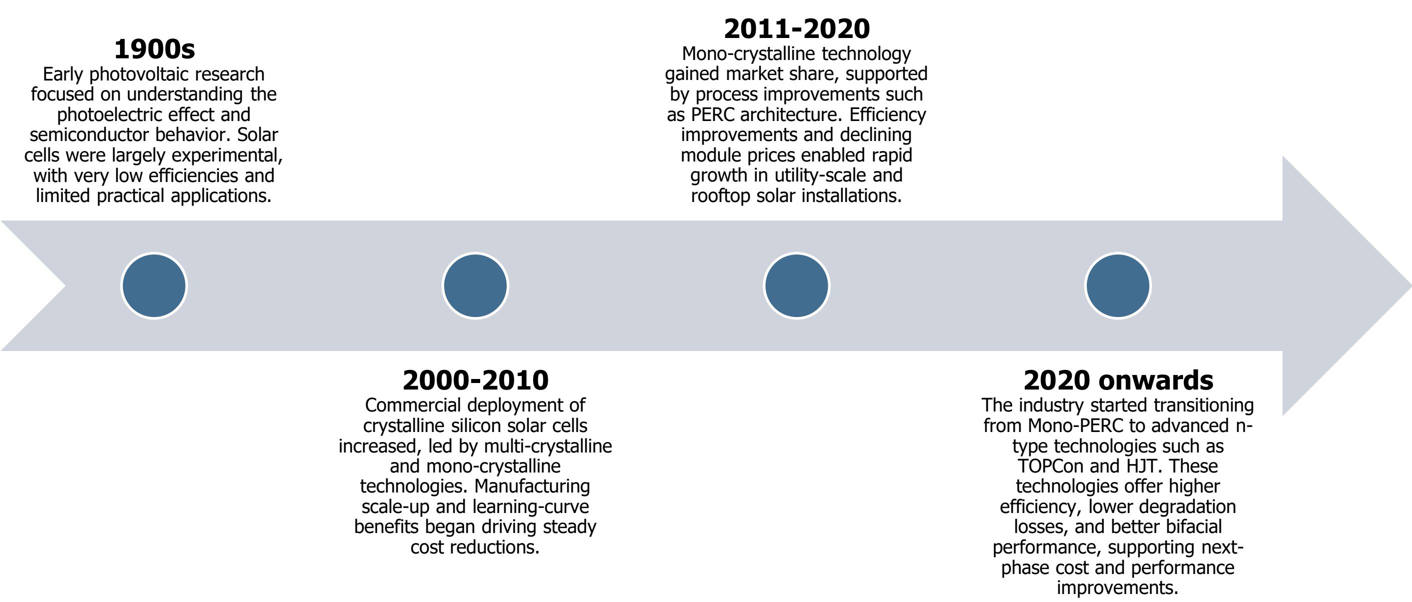
Chart 37: Global Solar PV Average Pricing Trends



Source: IEA PVPS, CareEdge Research

4.2.2 Global Cell Technologies

The evolution of solar cells reflects a progression shaped by scientific breakthroughs, technological innovation and competitive advancement.



Intensifying competition and rapid capacity expansion across the solar value chain have accelerated the shift toward higher-efficiency module technologies. The industry has progressively transitioned from multi-crystalline to mono-PERC modules and is now moving toward advanced n-type technologies such as TOPCon and heterojunction (HJT). Alongside this shift, rising module wattage has enabled higher power output per unit area, supporting land optimisation for the same generation capacity.

As the company expands into newer solar module technologies, its capex requirement is expected to remain comparatively lower than that of peers because it can leverage its existing module manufacturing lines. Most of the technology shift from PERC to next-generation formats such as TOPCon or beyond occurs at the cell level, while the module line largely continues to perform assembly, with only incremental upgrades needed in stringing, lamination, and testing. This allows the company to adopt advanced module technologies without undertaking a full greenfield investment. In contrast, fully integrated players or new entrants must invest heavily in specialised cell equipment, oxidation and deposition tools, and advanced metrology systems. As a result, the company benefits from a more efficient capex profile while still being able to participate in higher-efficiency module segments.

Table 17: Cell Comparison

Parameter	Mono-PERC	TOPCon (n-type)	HJT (Heterojunction)
Cell efficiency	~21–23%	~23–25%	~23.5–25%
Module efficiency	~20–22%	~22–23.5%	~22.5–24%
Manufacturing complexity	Low–Medium (mature process, high yields, widely deployed)	Medium (higher than PERC, lower than HJT)	High (tight process control, sensitive to materials and equipment)
Capex intensity	USD ~31–38 mn/GW	USD ~38–45 mn/GW	USD ~65–75 mn/GW
Bifaciality	~65–70%	~80–85%	~90–95%
LID / PID losses	Higher LID and PID susceptibility	Lower Compared to Mono Perc	Negligible LID and very low PID losses

Source: CareEdge Research

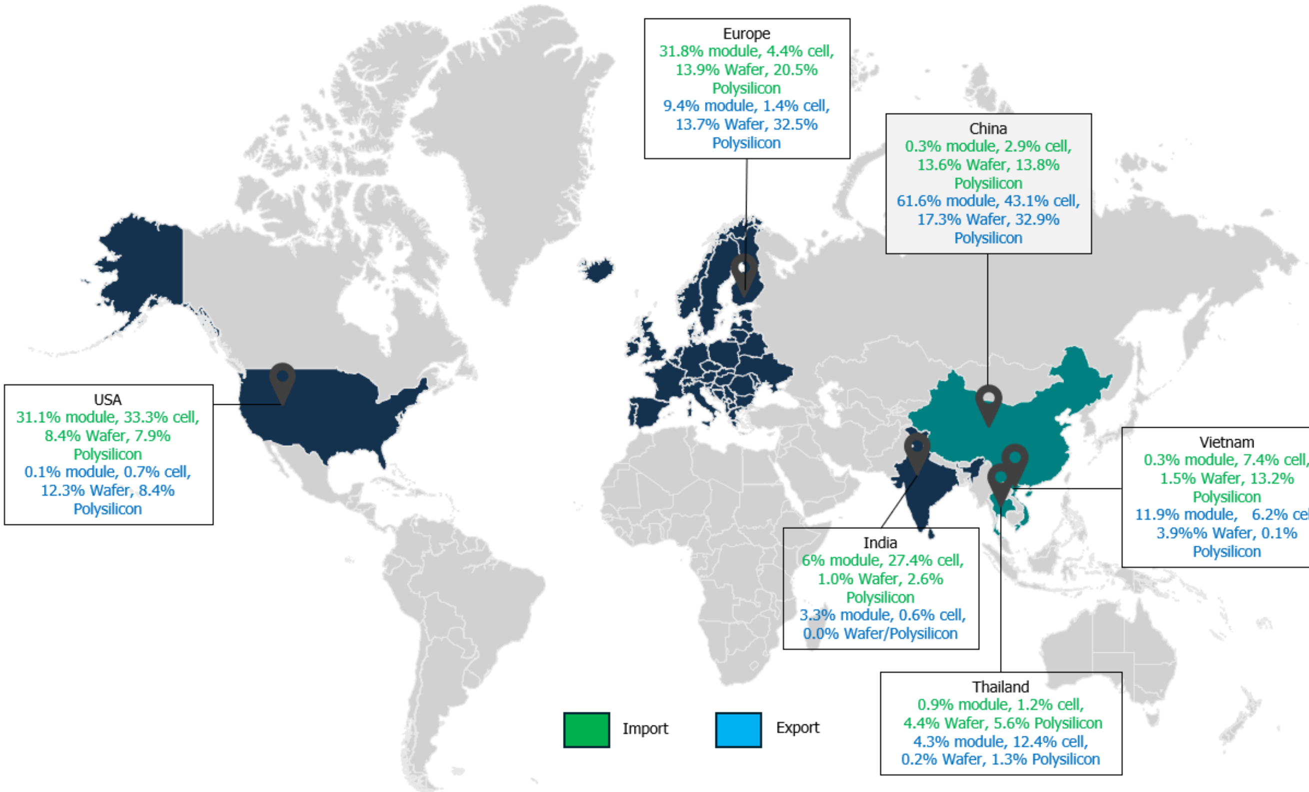
Several countries are actively encouraging domestic PV manufacturing to strengthen self-reliance and reduce exposure to global supply chain disruptions.

4.2.3 India's Presence in the Value Chain and Import Dependency Along with Major Import Countries

Global solar trade in CY24 demonstrates strong downstream demand concentration alongside upstream supply consolidation. Aggregate trade across the four key segments (Polysilicon, Wafer, Cell and Module) exceeded USD 150 billion, with modules alone accounting for ~60% of total trade value. The US remained the single largest demand centre, importing over 23% of total import, while China's total exports across the value chain remained 47%, underlining its structural dominance.

India's presence in global module exports has also improved, with its share rising to ~3% in CY24 from ~0.5% in CY19, supported by capacity additions driven by tariff and non-tariff measures such as BCD and ALMM.

Figure 7: Import Export in Solar PV Value Chain (CY24)



Source: ITC Trade Map, CareEdge Research

The global solar PV export landscape is characterised by significant concentration, particularly in downstream segments where China maintains a dominant position by exporting ~USD 35.9 billion in CY24.

India's export presence is presently limited to modules with negligible upstream participation. Future competitiveness may depend on backward integration into cells and wafers, export market diversification and policy support for domestic manufacturing. Based on ongoing Tariffs and CVD from USA, India can explore other destinations such as UAE and others to export their solar products.

4.2.4 Key Global Initiatives

Country/Region	Initiative Name	Description	Objective
India and France	**International Solar Alliance (ISA)**	A global, treaty-based organisation launched by India and France in 2015 (COP21) to Unlock USD 1 trillion in solar investments by 2030, provide energy access to 1 billion people and install 1,000 GW of solar capacity	To promote solar energy, unite solar-rich nations, and mobilise investments

USA	**Inflation Reduction Act (IRA) & Trade Policies**	Introduces production tax credits for PV modules, cells, wafers, polysilicon	To boost U.S. clean energy, manufacturing, and climate goals via massive incentives, while its trade policy aspects focus on domestic production (localisation), friend-shoring (partnering with allies for secure supply chains), and reducing reliance on foreign energy, often using tax credits tied to U.S. content, creating friction with allies but accelerating green tech domestically
USA	**The Uyghur Forced Labor Prevention Act**	The Uyghur Forced Labor Prevention Act (UFLPA) is a U.S. law. It established a rebuttable presumption that goods mined, produced, or manufactured wholly or in part in the Xinjiang Uyghur Autonomous Region (XUAR) of China or by an entity on the UFLPA Entity List are subject to import under Section 307 of the Tariff Act of 1930 (19 U.S.C. § 1307). The law was enacted on December 23, 2021, and enforcement began on June 21, 2022.	Prevent goods made with forced labour connected to the XUAR from entering the United States and to further promote accountability for entities responsible for forced labour
European Union	**International Solar Manufacturing Initiative (ISMI) – Solar Power Europe**	A coalition of EU solar manufacturing stakeholders (modules, inverters, trackers) launched in March 2025	Secure international offtake, align export and development policies, access financing via Global Gateway, DFIs, ECAs, and strengthen global PV supply resilience
Australia	**ARENA Solar Sunshot Programme**	USD 1 billion Australian government initiative, delivered by the Australian Renewable Energy Agency (ARENA) to establish domestic solar manufacturing. Offers grants and production credits through various rounds, with Round 2 focusing on inputs to solar modules and deployment systems, aiming to make Australia a leader in solar tech	Designed to boost Australia's solar PV manufacturing by funding innovation, scaling up production, and creating resilient domestic supply chains for solar components, from raw materials to module assembly, supporting Australia's renewable energy goals

India	**PM Surya Ghar**	Launched in February 2024 with an outlay of Rs 75,000 crores, the scheme targets 10 million households by CY27 implying ~30 GW of rooftop solar capacity. Installations reached ~3 GW in FY25, with ~10 GW additions expected in FY26E, taking cumulative capacity to ~7.34 GW as of December 2025	These regulatory interventions are expected to support import substitution and greater formalisation of the domestic inverter market. As a result, the domestic inverter segment is likely to see sustained growth, with integrated Indian players such as PEL well positioned to capture incremental demand

India has also launched various schemes such as Basic Custom Duty, ALMM, CPSU Scheme to promote PV manufacturing. Details for the same are given in schemes and incentives supporting solar manufacturing chapter below.

4.2.5 Key Global Companies in Solar Module and Cell Market (CY24)

The below companies together account for ~30% of total module manufacturing capacities worldwide

Table 18: Key Global Solar Module and Cell Companies

Parameter	LONGi Solar	Trina Solar	Jinko Solar	JA Solar	Canadian Solar
Production capacity	Module – 70.2 GW Cell – 60.8 GW Wafer – NA Polysilicon- NA	Module – 66GW, Cell – 59.4 GW, Wafer- NA Polysilicon- NA	Module – 130 GW Cell – 95 GW Wafer -120 GW Polysilicon- NA	Module – 100 GW Cell – NA Wafer-NA Polysilicon-NA	Module – 60 GW Cell – 48 GW Wafer – 31 GW Polysilicon- NA Ingot- 25GW
Product shipments	Module - 75.8 GW	Module – 70.5 GW	Module – 92.9	Module – 74.2 GW	Module – 31.1 GW
Key products and services	Solar PV modules, wafers, solutions for utility and rooftop	Solar PV modules, solar trackers, utility solutions, EPCM services	Solar PV modules, energy storage systems, C&I and rooftop solutions	Solar PV modules, energy storage systems for domestic and C&I use	Solar PV modules, energy storage systems, inverters, EPC service
Key technologies offered	TOPCon, Mono PERC, bifacial modules, half-cut cells	Bifacial PERC, TOPCon, HJT, half-cut cells	Half-cell, bifacial tiling ribbon technologies, PERC and TOPCon	TOPCon, Mono PERC, bifacial modules, half-cut cell	TOPCon bifacial & monofacial, HJT modules, dual-cell PERC

Source: Company websites, Annual reports, IEA PVPS & RTS Corporation

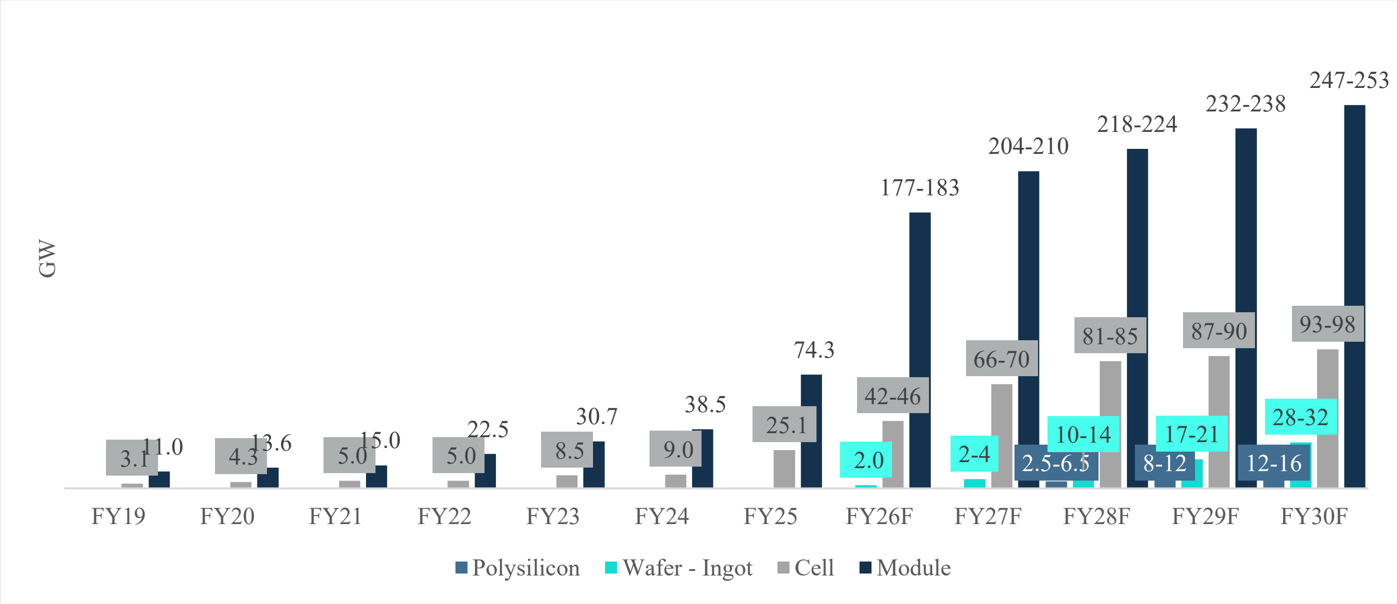
Note: Production volumes are manufacturers' own production, whereas shipment volumes include commissioned production and OEM procurement

4.3 Domestic Solar PV Manufacturing

4.3.1 Evolution of Cell Technology in India: Cell and Module Capacity

India's solar manufacturing ecosystem is undergoing rapid expansion, marked by a significant increase in domestic capacities across the value chain. Solar module manufacturing capacity rose sharply from 38 GW in FY24 to 74 GW in FY25, while solar PV cell capacity nearly tripled from 9 GW to 25 GW over the same period.

Chart 38: India PV Manufacturing Capacity (GW)



Source: PIB, CareEdge Research

India's solar module demand continues to rise across utility-scale tenders, C&I open-access projects, rooftop installations, and decentralised/agricultural schemes, with steady growth expected through FY30. Domestic sourcing remains preferred as ALMM compliance and DCR-linked schemes direct procurement toward Indian manufacturers. BCD has reduced the price advantage of imported modules, while PLI incentives are strengthening scale, supply depth, and overall bankability of domestic products. If low-priced imports re-enter the market, anti-dumping duties remain a possible safeguard to support local manufacturing. However, deeper backward integration into cells and wafers is essential, as cell capacity remains the critical bottleneck and continued dependence on imported wafers and cells exposes the sector to FX and supply-chain risks.

While module manufacturing capacity has expanded significantly, cell production capacity is also increasing at a rapid pace supported by ALMM, DCR requirements and import substitution under BCD.

FY25 represented an important structural milestone with the commissioning of India's first ingot–wafer manufacturing facility, with an initial capacity of 2 GW, signalling early progress toward greater vertical integration within the sector. The country is at the cusp of starting domestic polysilicon production, with major, fully integrated manufacturing plants aimed at reducing reliance on Chinese imports expected to come online between FY26-FY28.

Gujarat has emerged as the most preferred location for PV manufacturing, with around two-fifths of India's module capacity located in the state, supported by proximity to ports and a supportive policy regime. Under Gujarat's Electronics Policy 2022–28, eligible investors can receive incentives up to 20% of eligible capital expenditure, along with 100% waiver on stamp duty and registration charges for lease/sale/transfer of land. As of December 2024, Gujarat also accounts for over one-third of India's annual solar cell manufacturing capacity, the highest among states.

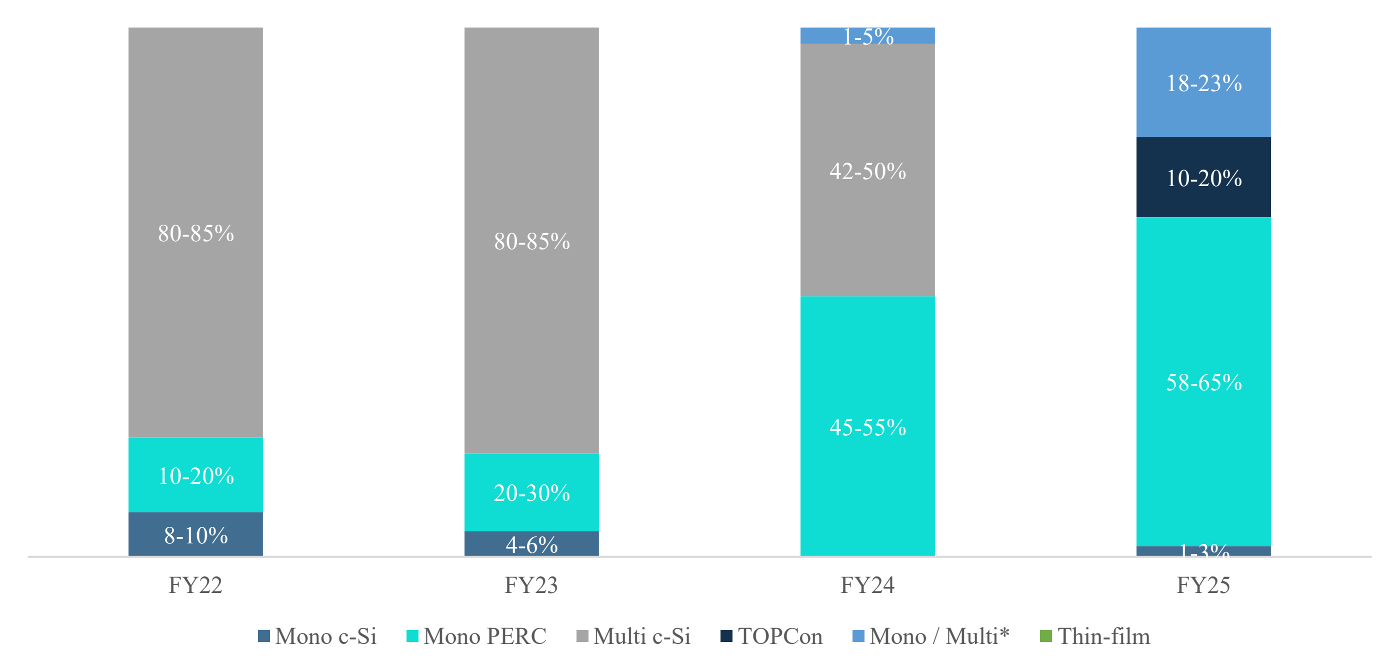
Madhya Pradesh is also positioning itself as an emerging green energy hub, with five major solar projects aggregating 2.75 GW as of FY25, alongside ongoing developments such as the 170 MW Neemuch solar project and the Morena hybrid generation and storage park. On the manufacturing enablement side, the Madhya Pradesh Industrial Promotion Policy (IPP) 2025 provides infrastructure support, including 50% assistance for developing utilities and connectivity (power, water, gas, roads, drainage and sewage) up to the factory gate, capped at Rs 5 crore for eligible units.

Looking ahead, India's solar manufacturing landscape is poised for substantial growth. According to CareEdge estimates, solar module capacity is projected to expand to approximately 247–253 GW by FY30. This scale-up is expected to be supported by significant upstream investments, including 93–98 GW of solar cell capacity and around 30 GW of wafer and ingot capacity. In addition, polysilicon manufacturing capacity is expected to commence from FY28, further strengthening backward integration and reducing reliance on imports for critical raw materials.

Cell Technology Types

TOPCon adoption has moved from early-stage penetration in FY22–FY24 to a clear scale-up phase in FY25 (~10–20%), as manufacturers upgrade Mono-PERC lines to n-type with relatively lower incremental capex and higher efficiency (~23–25%). Over FY26–FY30, the technology mix is expected to tilt decisively towards TOPCon, with most new greenfield expansions and brownfield upgrades being configured for n-type, given bankability, improving yields and narrowing cost premiums versus PERC. As a result, the majority of incremental crystalline silicon capacity additions by 2030 are expected to be TOPCon-led, while Mono-PERC increasingly becomes the legacy base and is likely to lose share as lines are converted or displaced by n-type architectures.

Chart 39: Cell Technology by Types



Source: CareEdge Research

4.3.2 Government Schemes to drive growth in the sector

The solar industry in India is heavily influenced by government policies and regulatory frameworks, including the Approved List of Models and Manufacturers ("**ALMM**") and the Pradhan Mantri Kisan Urja Suraksha Utthaan Mahabhiyan ("**PM-KUSUM**") schemes.

<u>Basic Customs Duty (BCD)</u>

To safeguard domestic cells and modules against the predatory pricing, the government imposed a BCD of 25% and 40% on imported cells and modules respectively, effective from 01 April 2022, which were later revised to 20% on each. This has increased the capital costs and narrowed the price gap with imports, driving demand for Indian-made modules.

Chart 40: Imported Modules with BCD (in Rs)

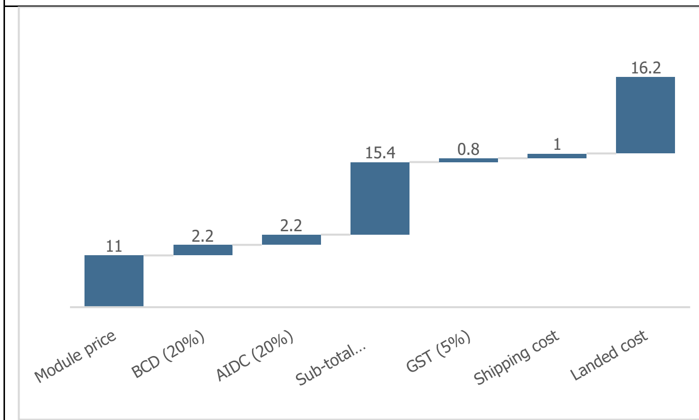
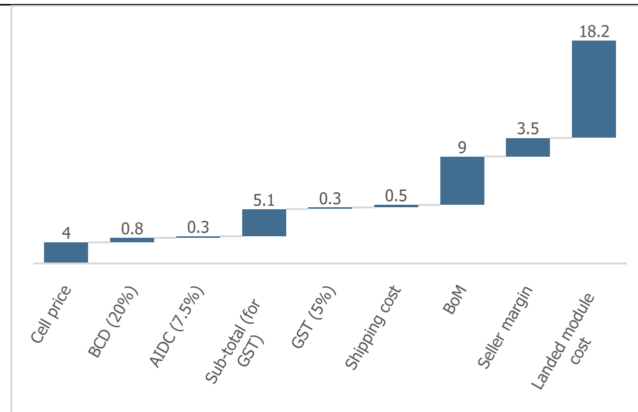


Chart 41: Domestic Modules Using Imported Cells with BCD (in Rs)



Source: MNRE, Industry Sources, CareEdge Research, Note: Cost assumptions based on wafer/cell/module prices; BoM refers to Balance of Materials. Shipping cost, BoM and seller margin are assumed.

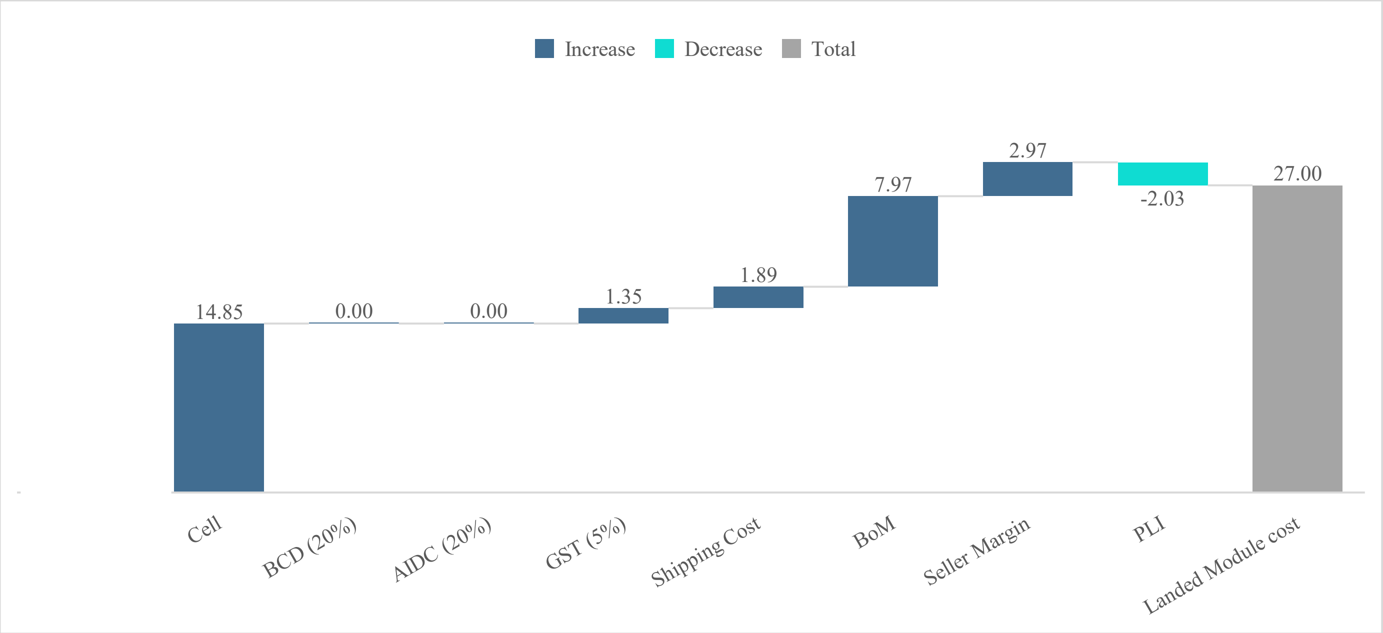
Domestic Content Requirement (DCR):

India's Domestic Content Requirement (DCR) mandates the use of domestically manufactured solar cells and modules in select government-supported programmes, including CPSU Phase-II, PM-KUSUM, and certain rooftop solar schemes. The policy is primarily applicable to public-sector and subsidy-backed installations and does not extend to private or fully commercial solar projects.

Under the CPSU Phase-II scheme, the Government of India has approved approximately Rs 8,600 crores in viability gap funding (VGF) to support the development of 12 GW of grid-connected solar projects by central public sector undertakings, of which around 8.2 GW has been sanctioned to date. These projects are required to procure DCR-compliant modules, thereby, ensuring assured demand for domestically manufactured solar equipment.

Although the DCR framework covers a limited portion of total annual solar capacity additions, it plays a meaningful role in strengthening India's solar manufacturing ecosystem by providing long-term demand visibility to domestic cell and module manufacturers. When implemented alongside complementary initiatives such as the Production-Linked Incentive (PLI) scheme, DCR supports capacity creation, encourages vertical integration and reduces reliance on imported solar components.

Chart 42: Module Cost (DCR) (in Rs)

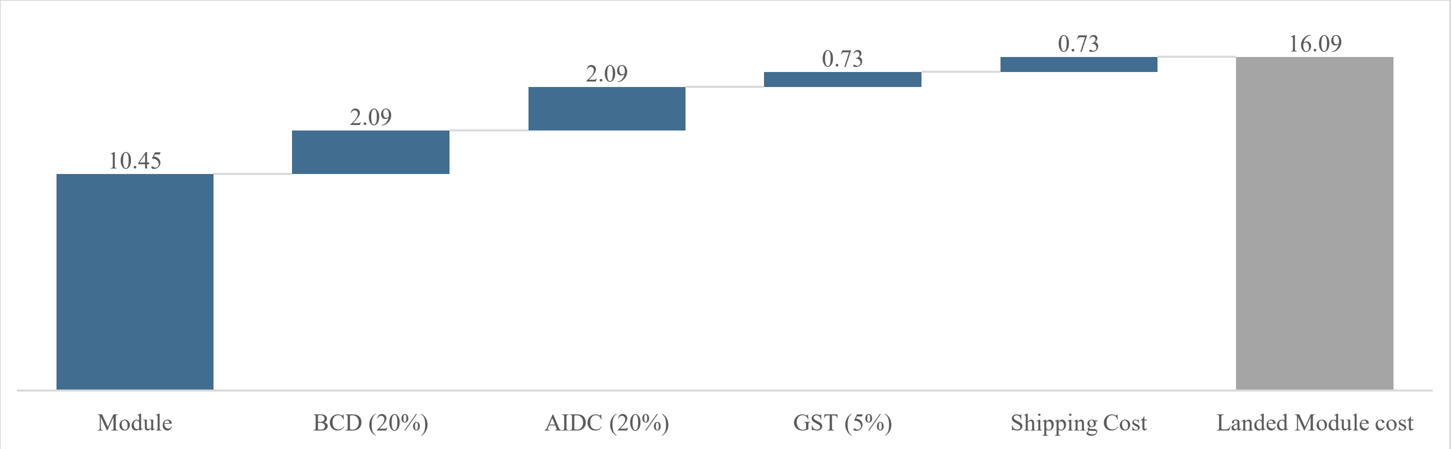


Source: CareEdge Research

The non-DCR cost structure heavily relies on imported components, which typically benefit from lower global manufacturing prices and economies of scale. The cost build-up includes various duties such as Basic Customs Duty (BCD) and the Agriculture Infrastructure and Development Cess (AIDC) imposed on these imported materials. The final cost for non-DCR modules tends to be lower upfront, making them an option for private or commercial projects not seeking government subsidies.

The use of fully domestically manufactured solar cells and modules, which is mandatory under certain government-supported schemes, is associated with higher costs compared to globally sourced alternatives. This cost primarily arises from the relatively higher production costs of domestic solar cells versus prevailing international market prices. However, government support mechanisms such as the Production Linked Incentive (PLI) scheme are designed to partially offset these higher costs. By providing financial incentives to domestic manufacturers, the PLI scheme improves the economic viability of domestically produced solar panels and supports the broader objective of strengthening self-reliance in the solar manufacturing ecosystem.

Chart 43: Module Cost (Non-DCR) (in Rs)



Source: CareEdge Research

Production Linked Incentive (PLI) Scheme:
The Production Linked Incentive (PLI) Scheme under the National Programme on High Efficiency Solar PV Modules aims to scale up domestic manufacturing and reduce import dependence through performance-linked incentives. Tranche-I, implemented by IREDA attracted bids for 54.8 GW from 18 applicants against a target of 10 GW, with Rs 4,455 crores allocated for 8.7 GW of fully integrated capacity to Shirdi Sai Electricals, Reliance New Energy and Adani Infrastructure.

Tranche-II, administered by SECI, was tendered in November 2022 with awards issued in February 2023. Under this tranche, Rs 13,937 crore was allocated to 11 manufacturers across technology-linked categories. Around 54% of the incentive outlay was directed towards polysilicon-to-module integration, covering 15.4 GW of capacity.

Table 19: Companies With PLI (GW)

Company Name	Manufacturing Capacity	PLI Eligible Allocated Capacity	PLI Eligible Allocated Amount (Rs Million)	Polysilicon	Ingots	Wafer	Cell	Module
Shirdi Sai Electricals Limited	4	2	18,750	4	4	4	4	4
Reliance New Energy Solar Limited	4	2	19,170	4	4	4	4	4
Adani Infrastructure Private Limited	0.74	0.37	6,630	0.74	0.74	0.74	0.74	0.74
Indosol Solar Private Limited	6	3	33,000	6		6	6	6
Reliance New Solar Energy Limited	6	3	30,980	6		6	6	6
FS India Solar Ventures Private Limited	3.4	1.7	11,776	3.4		3.4	3.4	3.4
Waaree Energies Limited	6	**3**	19,232			6	6	6
Avaada Ventures Private Limited	3	1.5	9,616			3	3	3
ReNew Solar (Shakti Four) Private Limited	4.8	2.4	15,386			4.8	4.8	4.8
JSW Renewable Technologies Limited	1	0.5	3,205			1	1	1
Grew Energy Private Limited	2	1	5,667			2	2	2
Vikram Solar Limited	2.4	1.2	5,285				2.4	2.4

AMPIN Solar One Private Limited	1	0.5	1,397				1	1
TP Solar Limited	4	2	3,830				4	4
Total				**24.14**	**8.74**	**40.94**	**48.34**	**48.34**

Source: MNRE, CareEdge Research

Approved List of Models and Manufacturers (ALMM):

The ALMM (Approved List of Models and Manufacturers) order in India, introduced by the Ministry of New and Renewable Energy (MNRE), mandates the use of approved solar PV modules and cells in government-supported schemes and specified projects, with the objective of promoting domestic manufacturing and ensuring quality.

The models of Solar PV Module Manufacturers will be enlisted under ALMM, which comply with the BIS Standards and are having the following minimum module efficiency:

Category	Application/ Use	Minimum Module Efficiency Requirement For Crystalline - Silicon Technology Based Solar PV Modules	Minimum Module Efficiency Requirement for Cadmium Telluride Thin Film Technology Based Solar PV Modules
Category I	Utility/ Grid Scale Power Plants	20%	19%
Category II	Rooftop and Solar Pumping	19.5%	18.5%
Category III	Solar Lighting	19%	18%

Note: As of March 28, 2025, the number of module manufacturers under ALMM is 95.

Introduction of ALMM List-II for Solar PV Cells

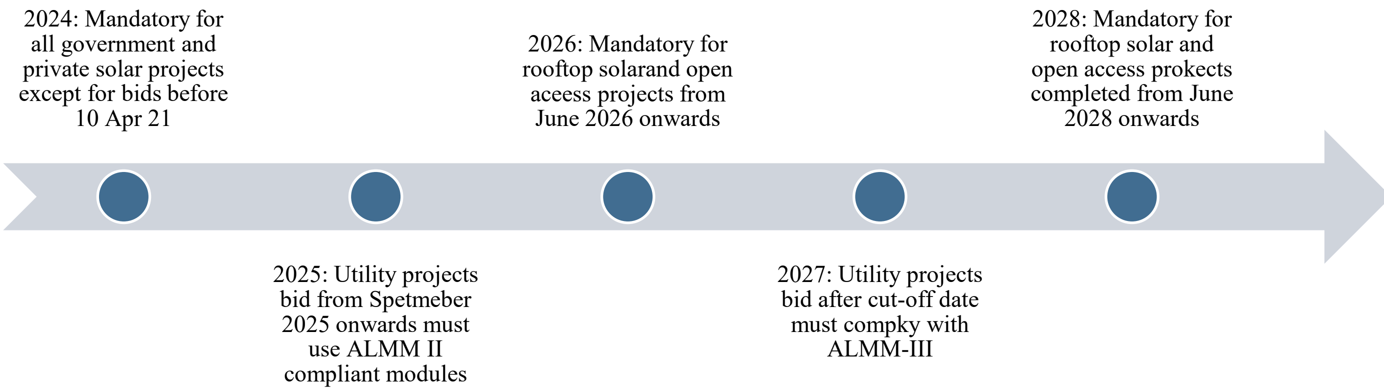
The introduction of List-II is a response to the country's rapidly growing solar manufacturing capabilities. Until now, the absence of List-II was due to a limited domestic supply of solar cells.

From 1st June 2026, all solar PV modules used in projects – including government supported schemes, net-metering projects and open access renewable energy initiatives – will be required to source their solar cells from ALMM List-II, ensuring quality and reliability in solar PV cells used in India's energy infrastructure.

Introduction of ALMM List-III

MNRE has released a draft order for the implementation of the Approved List of Models and Manufacturers (ALMM) for wafers and ingots (ALMM List – III), which shall be effective from 1st June 2028.

The draft implementation clearly indicates the government's commitment to advancing domestic PV upstream integration and bridging the capacity gap between modules, cells and wafers.



Source: Industry Sources, CareEdge Research

Table 20: Timeline for ALMM and DCR

Regulation	Scope	Timeline	Applicable Projects
DCR (Domestic Content Requirement)	Mandatory use of India-manufactured solar cells and modules	Adopted in 2010; continues for select MNRE schemes	CPSU Scheme Phase-II; PM-KUSUM (A & B; C subject to state/MNRE linkage); select MNRE rooftop programmes
ALMM List-I (Modules)	Approved List of solar PV module manufacturers	Notified Apr 2021; enforced from 1 Apr 2024	MNRE-supported projects; central & CPSU tenders; PM-KUSUM; government rooftop schemes
ALMM List-II (Cells)	Approved List of solar PV cell manufacturers	Notified 2023; enforcement from 1 Jun 2026 based on bid cut-off	Government-linked projects required to comply with ALMM (modules + cells)

Source: MNRE, CareEdge Research

The reinstated ALMM structure creates a clearly bounded window for non-ALMM-cell supply into utility solar projects. All bids with last-date-of-submission on or before 31 August 2025 remain exempt from ALMM-List-II cell requirements irrespective of commissioning date, forming the core of the FY27 addressable market. Given typical procurement cycles—where modules are sourced ~1.5 years after PPA—these pre-cut-off awards migrate into their procurement window through FY27, enabling delivery of ALMM-listed modules assembled using non-ALMM cells. Meanwhile, post-cut-off utility bids and OA/rooftop projects commissioning after June 2026 must fully comply with ALMM-II, structurally narrowing the eligible market.

Reduction in Goods and Services Tax (GST) Rates:

The GST Council announced a reduction in GST rates applicable on solar cells and modules from the existing 12% to 5% w.e.f. September 22, 2025, which would reduce the tax component on turnkey solar project contracts from 13.8% to 8.9%. As a result, developers are likely to reap savings of 4-5% on overall project costs due to a reduction in landed costs of non-DCR and DCR modules by 1.0-1.2 cents/Wp and 1.3-1.6 Cents/Wp respectively, potentially lowering plain vanilla solar tariffs by Rs 0.08-0.10 per unit.

Pradhan Mantri Kisan Urja Suraksha Evam Utthaan Mahabhiyaan (PM KUSUM)

The PM KUSUM scheme aims to add Solar capacity of 34,800 MW by FY26 with the total Central Financial support of Rs 34,422 crore, including service charges to the implementing agencies. The Scheme has the following three components:

- Component-A: Setting up of 10,000 MW of Decentralised Ground/ Stilt Mounted Grid-Connected Solar or other Renewable Energy based Power Plants.
- Component-B: Installation of 14 Lakh stand-alone Solar Agriculture Pumps.
- Component-C: Solarisation of 35 Lakh Grid Connected Agriculture Pumps including Feeder Level Solarisation

Table 21: PM-KUSUM Scheme – Component-wise Provisions

Component	Target Beneficiary / Installation Type	Financial Support (CFA / Subsidy / PBI)	Implementation Model / Key Provisions
Component A – Renewable Energy-based Power Plants (REPP)	500 kW to 2 MW solar plants set up by individual farmers / groups of farmers / cooperatives / panchayats / FPOs / WUAs (collectively termed Renewable Power Generators – RPGs)	DISCOM eligible for PBI @ Rs 0.40/unit purchased or Rs 6.6 lakh per MW installed (whichever is lower) for 5 years from COD	If beneficiaries cannot arrange equity, REPP can be developed through private developers or DISCOM (considered RPG). DISCOMs will publish sub-station-wise surplus capacity and invite applications. Power will be procured by DISCOM at SERC-determined FiT.
Component B – stand-alone Solar Pumps	Individual farmers for off-grid agriculture pumps (up to 7.5 HP)	- General states: 30% CFA + 30% State subsidy + max 40% by farmer (bank loan allowed → only 10% upfront by farmer) - NE States, Sikkim, J&K, HP, Uttarakhand, Lakshadweep & A&N Islands: 50% CFA + 30% State subsidy + max 20% by farmer	Support for installation of off-grid pumps in areas without grid supply. Central assistance available even where states cannot provide their share.
Component C – Individual Pump Solarisation (IPS)	Grid-connected agriculture pumps for individual farmers	- General states: 30% CFA + 30% State subsidy + max 40% by farmer (loan allowed → 10% upfront) - NE States, Sikkim, J&K, HP, Uttarakhand, Lakshadweep & A&N Islands: 50% CFA + 30% State subsidy + max 20% by farmer	Solar PV capacity up to 2× pump capacity allowed. Generated power can be used for irrigation and surplus power sold to DISCOM. Central CFA allowed even if state subsidy not available.
Component C – Feeder Level Solarisation (FLS)	Solarisation of agriculture feeders by states	CFA @ 30% of cost of solar plant (up to Rs 1.05 Cr/MW) NE States, Sikkim, J&K, HP, Uttarakhand, Lakshadweep & A&N Islands: 50% (up to Rs 1.75 Cr/MW)	Solar plants sized to meet feeder demand installed through CAPEX or RESCO model (25-year project period). For non-separated feeders, loans can be taken from NABARD/PFC/REC; support also available under RDSS. Farmers receive daytime reliable irrigation power free of cost or as per state tariff.

Source: MNRE, CareEdge Research

During the year 2024, the scheme PM KUSUM has seen tremendous growth in terms of installation. Under Feeder Level Solarisation, states have tendered all the allocated quantities and LOAs of more than 20 GW are issued. The gestation period of the scheme is 24 months from the date of sanction, therefore most of the quantities would be installed by March 2026. Till December 2024, 397 MW have been installed in Component A, 6.16 lakhs number of pumps have been installed in Component B & 1.12 lakhs pumps has been solarised under Component C of the scheme.

The allocation for the PM-KUSUM Yojana has been raised to Rs 5,000 crore in FY26 Budget, nearly double the earlier budget of Rs 2,600 crore.

Rebate Withdrawal in China

China's continued withdrawal or reduction of export rebates and fiscal incentives for PV products is expected to enhance the relative cost competitiveness of Indian manufacturers by narrowing the landed-price gap between China-origin modules, cells, and wafers and those produced domestically. As Chinese suppliers face higher net export costs and increasingly focus on domestic or strategic markets, the volume of low-priced exports to India is likely to ease. This should support better price realisation and higher utilisation levels for ALMM-listed Indian capacities. Combined with India's BCD, DCR, and PLI frameworks, these dynamics are expected to accelerate investment and scaling across module manufacturing as well as upstream segments such as cells and wafers, driving stronger domestic capacity additions over FY26–FY30

National Policy on Electronics

India's National Policy on Electronics is formulated by the Government of India to boost its electronics systems and design manufacturing industry and improve its global market share. The scheme provided financial incentive of 25% on capital expenditure for the identified list of electronic goods that comprise downstream value chain of electronic products, i.e., electronic components, semiconductor/ display fabrication units, ATMP units, specialised sub-assemblies and capital goods for manufacture of aforesaid goods, all of which involve high value-added manufacturing.

Table 22: State-wise Initiatives for Solar Module and Cell Manufacturing

State	Incentives
Gujarat	**Capital Subsidy:** 6%–12% of eligible fixed capital investment, based on location (taluka category), disbursed annually; Annual cap: Rs 40 crore per year. **Government Land Lease:** Long-term lease of government land for up to 50 years at 6% of market rate
Tamil Nadu	**Base Capital Subsidy:** 25% on eligible plant & machinery, capped at Rs 150 lakh. **Additional Subsidy (MSMEs):**10% subsidy on plant & machinery investment, capped at Rs 5 lakh.
Rajasthan	**SGST Reimbursement (Investment Subsidy):** 75% of State tax due and deposited for 7 years under Rajasthan Investment Promotion Scheme **Land Tax Exemption:** 100% exemption for 7 years for manufacturing enterprises. **Stamp Duty Exemption:** Up to 100% exemption on purchase/lease/sub-lease of land and construction for manufacturing units.
Karnataka	**Capital Subsidy:** 10%–25% on fixed assets based on zone (Zone 1–3). The state is divided into industrial development zones based on the level of development in the district, this is to promote balanced regional development Zone 1 – Most developed, Zone 2 – Moderately developed, Zone 3 – Least developed **Production-Linked Incentive (PLI):** Up to 2.5% of net sales turnover for large/mega/ultra-mega enterprises. **Stamp Duty Exemption:** 100% in Zone 1; 75% in Zone 2 and Nil in Zone 3.

Source: CareEdge Research

Policy Backed Demand Pipeline for Domestic Solar Manufacturing

Table 23: Domestic Content Linked Demand Pipeline

Scheme	Target
PM-KUSUM	Scheme aims to add Solar capacity of 34GW by March 2026
Commercial & Industrial (Open Access from 2026 onward)	15–18 GW should flow from C&I open-access projects once the June 1, 2026 cell requirement extends domestic-cell sourcing beyond subsidy-linked schemes.
PM Surya Ghar (Residential Rooftop)	The scheme is projected to add 30 GW of solar capacity through rooftop installations in the residential sector.
CPSU Scheme	12 GW will be contributed by the CPSU Phase-II programme, which is explicitly DCR-mandated

Source: CareEdge Research

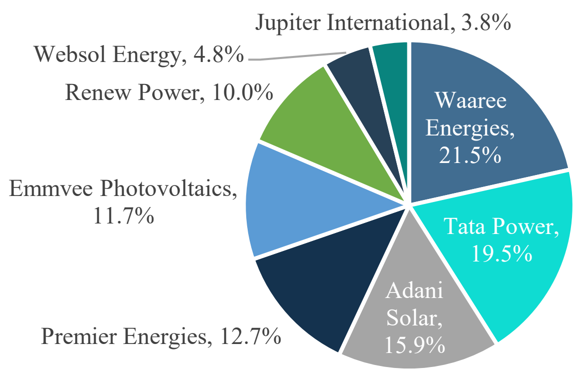
4.3.3 Backward Integration by Major Players

India's solar module manufacturing capacity has expanded rapidly, reaching approximately 144 GW in Dec-25, driven by strong policy support and rising domestic demand. Despite this progress, domestic solar cell manufacturing meets only about 25–30% of demand, creating a significant gap in the upstream value chain. As a result, India remains heavily dependent on imports particularly from China for solar cells, exposing the sector to supply-chain vulnerabilities and trade-related risks.

Chinese manufacturers have a significant advantage through deep vertical integration, which allows them to maintain lower cost structures. To tackle the situation Indian companies are making way for producing cells domestically with planned capex of ~ Rs 55,000 crore by FY28.

Backward integration is critical given India's high import dependence of Rs 316.3 billion on solar cells and modules, which exposes manufacturers to supply-chain risks and price volatility. Further, ALMM-II applicability mandates the use of domestically manufactured cells and modules, making integrated cell-to-module manufacturing essential for policy compliance, cost stability and participation in utility-scale and government-supported projects.

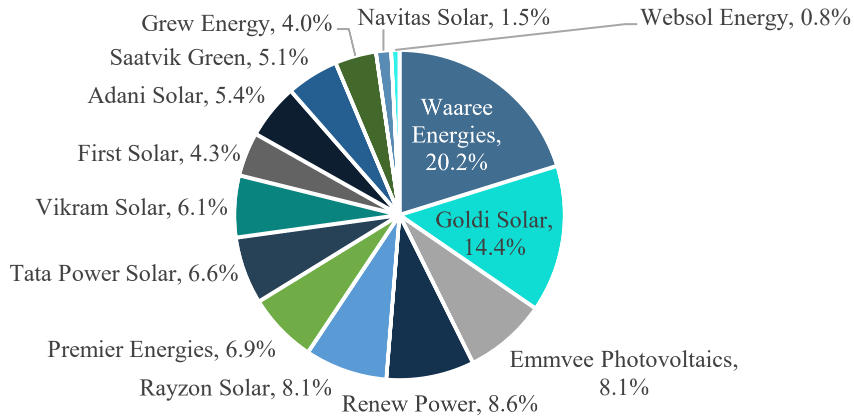
Chart 44: Market Share of Indian PV Cell Manufacturers (FY25) – Capacity: 25 GW



Source: Company Filings, CareEdge Research

A few players are involved in solar panel manufacturing presently, including Waaree Energies Limited, Goldi Solar Private Limited, Emmvee Photovoltaics Power Limited, Renew Power, Rayzon Solar, Premier Energies Limited, Vikram Solar Limited, etc.

Chart 45: Market Share of Indian PV Module Manufacturers (FY25) – Capacity: 74 GW



Source: Company Website, Note: Data doesn't include data private players such as SAEL, Cosmic PV Power Limited, Pahal solar, Bluebird Solar, Citizen solar etc

Looking ahead, India's solar module manufacturing capacity is expected to exceed 200 GW by FY29, alongside substantial additions in domestic solar cell manufacturing, which should help meaningfully reduce import dependence at the cell level. However, capacity expansion in upstream segments such as wafers and ingots is likely to remain insufficient, due to high capital intensity, technology barriers, and limited domestic capability. Consequently, continued reliance on imports for wafers and ingots is expected, even as India improves self-sufficiency in modules and cells.

Table 24: Overview of Major Domestic Players in the Market

Parameter	Vikram Solar Limited	Waaree Energies Limited	Adani Solar	Premier Energies Limited	RenewSys India Private Limited*	Tata Power Solar	Emmvee Photovoltaic Power Limited	Alpex Solar Limited*	Goldi Solar Private Limited*
Enlisted capacity as per ALMM list (Dec 2025)	4.3	22.21	4.21	3.65	2.95	5.71	8.20	0.42	15.57
Topcon module mfg	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Total module capacity (GW)	9.5	23	4	5.1	5.5	4.9	10.3	1.2	14.7
Module pipepline (GW)	6	6	NA	5.6	NA	NA	6	2.4	5
Total cell capacity (GW)	NA	5.4	4	3.2	4.5	NA	2.9	NA	NA
Cell pipepline (GW)	12	10	NA	7	NA	NA	6	2.2	16
Ingot/wafer	NA	10	2	10	NA	10	NA	NA	NA

pipeline (GW)									
Order book (Rs bn)	10.3 GW	600	NA	137	NA	NA	78.12	NA	NA
Export oriented	Yes	Yes	Yes	Yes	Yes	Yes	yes	Yes	Yes
Products and services	Integrated Solar energy solutions provider with a presence in solar PV modules, EPC services, and O&M services	Solar PV modules, inverters, batteries, EPC services, rooftop solutions, O&M services, solar home appliances, and solar water pumps	Solar PV cells and modules, EPC services, O&M services	Solar PV cells and modules , EPC services, O&M services, water pumps, power	Solar PV modules and cells, encapsulants, back sheets	Solar PV cells and modules, EPC services, O&M services, and water pumps	Solar PV cells and modules, EPC services, rooftop solutions, O&M services, and solar water heater solutions	Solar PV modules, EPC services, Solar Water Pumps	Solar modules, EPC services, Solar Water Pumps
Technology	mono PERC, bifacial & monofacial and smart and polycrystalline PV modules	Multicrystalline, Monocrystalline and TopCon technology, mono-PERC, bifacial, flexible modules, BIPV	Multi-crystalline, mono-PERC, and bifacial modules	Poly-crystalline and mono-crystalline Si cells, mono-PERC, poly-crystalline PV modules	Mono/multi- PERC, bifacial, half-cut and full cell modules	Mono-PERC cells, mono-PERC half-cut modules	Mono-PERC, poly-crystalline modules, bifacial modules, half-cut cell modules	Mono-crystalline, poly-crystalline PV modules, bifacial modules	Mono-crystalline, poly-crystalline PV modules

Source: Company websites, MNRE ALMM November 2025
Note: All data is as of Dec'25 apart from RenewSys India and Alpex Solar which as as of H1'FY25 and Goldi Solar which as of FY25
Note: *ALMM capacity can be higher than reported operational capacity. Including subsidiaries and joint ventures

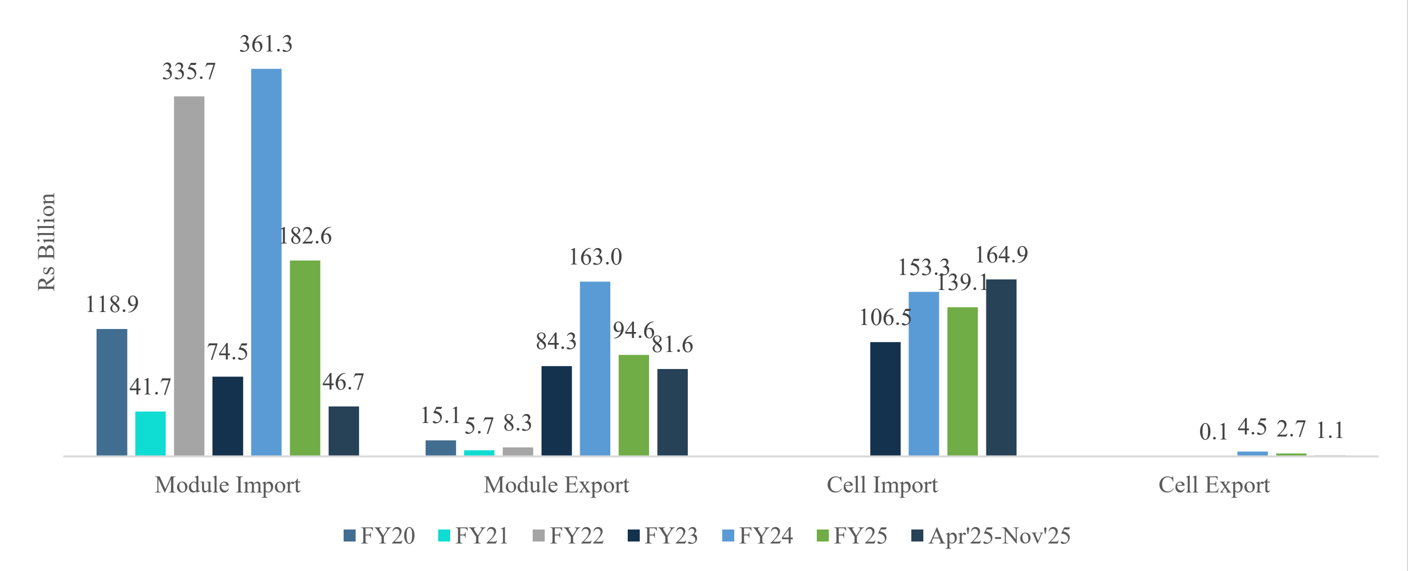
4.3.4 Import Export of Solar Modules and Cells

In value terms India has exported Rs 378.3 billion during FY20-FY25. India's solar module and cell Exports have grown sharply in last five years. The surge was also largely driven by U.S. developers diversifying away from China, through exports to markets outside the U.S. have remained relatively stable. The major factor of rise in export was implication of Uyghur Forced Labor Prevention Act (UFLPA) curtailed imports from China-linked supply chains making India an alternative supplier.

In FY25, exports declined primarily due to a sharp contraction in shipments to the United States that had accounted ~97% of India's module exports. Exports to USA declined by ~42% in FY25, primarily due to tighter U.S. trade actions and tariff escalation, alongside rapid ramp-up of domestic solar manufacturing capacity in the U.S. under the Inflation Reduction Act, which reduced import dependence.

India's solar import trajectory over FY20–FY25 reflects pandemic-related disruptions, a sharp spike in FY22 due to front-loaded procurement ahead of the April-2022 imposition of Basic Customs Duty, and a pronounced surge in FY24 driven by the temporary suspension of ALMM, steep global module price declines, and accelerated procurement to meet commissioning deadlines, followed by moderation in FY25 as ALMM was reinstated and domestic manufacturing capacity scaled up rapidly.

Chart 46: Import and Export Analysis of Solar Module and Cell in India



Source: Ministry of Commerce; CareEdge Research

Note: HS Codes for FY20-FY21: 85414011, FY22: 85414012, FY23-FY25: 85414300.

Subsequently, from FY 2022-23, the Solar PV Cells and Solar PV Modules (other than those exclusively used with ITA-1 items) are put under HS Codes 85414200 and 85414300 respectively.

Previously India's solar module demand was met through imports due to limited local manufacturing, competitive foreign pricing and preference towards advanced technologies. However, in recent years India's solar module import share has gradually diversified over the past few years, reducing the country's dependence on China as the dominant supplier. China's share in India's module imports declined from 92.6% in FY23 to 52.5% as of Nov'25, reflecting a shift in sourcing patterns. Suggesting a shift towards multiple geographies, due to supply chain risk, evolving trade policies and the need to reduce reliance on a single country for critical solar components. Going forward import dependency is expected to decline due to significant domestic capacity additions, policy interventions like DCR (domestic content requirement) and ALMM, and rising domestic demand.

Chart 47: Country-wise imports – Module

	FY23	FY24	FY25	Apr'25-Nov-25
Others	0.1%	0.5%	1.0%	3.5%
Singapore	2.5%	2.2%	0.5%	0.1%
Hong Kong	0.3%	4.8%	3.9%	3.3%
Malaysia	0.1%	5.5%	0.3%	14.6%
Vietnam	4.4%	21.4%	15.4%	26.2%
China	92.6%	65.5%	78.8%	52.5%

Source: Ministry of Commerce; CareEdge Research

Note: The Solar PV Cells and Solar PV Modules (other than those exclusively used with ITA-1 items) are put under HS Codes 85414200 and 85414300 respectively.

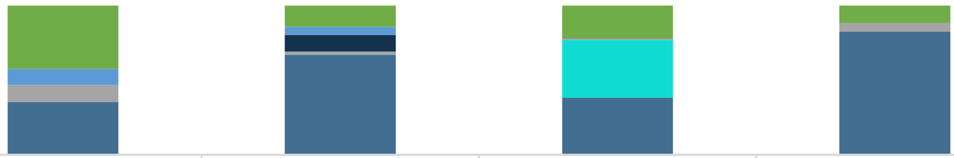
Chart 48: Country-wise imports - Cell

	FY23	FY24	FY25	Apr'25-Nov-25
Others	4.6%	8.9%	1.4%	11.1%
Indonesia	0.1%	0.1%	3.7%	6.4%
Vietnam	17.4%	4.9%	5.6%	3.5%
Malaysia	13.6%	16.8%	0.0%	0.0%
Thailand	20.0%	13.4%	6.5%	4.8%
China	44.3%	55.9%	82.8%	74.2%

Source: Ministry of Commerce; CareEdge Research

Note: The Solar PV Cells and Solar PV Modules (other than those exclusively used with ITA-1 items) are put under HS Codes 85414200 and 85414300 respectively.

Chart 49: Country-wise Exports - Module



	FY23	FY24	FY25	Apr'25-Nov-25
Others	1.9%	0.6%	1.0%	0.5%
South Africa	0.5%	0.2%	0.0%	0.0%
Somalia	0.0%	0.5%	0.0%	0.0%
U Arab Emts	0.5%	0.1%	0.0%	0.3%
Bangladesh	0.0%	0.0%	1.7%	0.0%
U S A	97.1%	98.5%	97.2%	99.2%

Source: Ministry of Commerce; CareEdge Research
Note: The Solar PV Cells and Solar PV Modules (other than those exclusively used with ITA-1 items) are put under HS Codes 85414200 and 85414300 respectively.

Chart 50: Country-wise Exports - Cell

	FY23	FY24	FY25	Apr'25-Nov-25
Others	88.4%	3.0%	0.1%	0.5%
Canada	0.0%	0.1%	5.5%	0.0%
Indonesia	0.0%	14.4%	0.0%	0.0%
U Arab Emts	0.0%	0.0%	0.0%	66.8%
Thailand	9.7%	22.6%	1.4%	0.0%
U S A	1.9%	59.9%	93.0%	32.6%

Source: Ministry of Commerce; CareEdge Research
Note: The Solar PV Cells and Solar PV Modules (other than those exclusively used with ITA-1 items) are put under HS Codes 85414200 and 85414300 respectively.

India's solar export demand has been driven primarily by the US (historically the largest destination for India's cell and module exports), supported by buyers preference for traceable, non-Xinjiang supply chains under the UFLPA regime, while the US has simultaneously tightened trade remedies on alternative supply bases, including final AD/CVD orders on solar cells (and modules assembled using those cells) from Cambodia, Malaysia, Thailand and Vietnam and the earlier duty-free "moratorium" window that expired on 6 June 2024.

The near-term US export outlook for Indian solar manufacturers has weakened after the US Department of Commerce issued a preliminary CVD of 125.87% on Indian imports (alongside Indonesia at 86–143% and Laos at ~81%), citing alleged subsidisation. The investigation began around six months ago, with a final ruling expected by Jul-26, and a separate anti-dumping probe is also underway to assess below-cost exports. The CVD on India alone increases landed cost by 2.26x versus the no-CVD case. However, the US CVD/AD pertains to sourcing of cell (country of production) and not module.

Given this disruption, Indian manufacturers are had started exports towards Middle East and Africa markets such as the UAE, Saudi Arabia, Oman and South Africa, where renewable capacity additions and localisation-linked procurement are rising, while the US trade actions on Southeast Asia and UFLPA-driven scrutiny still indirectly support demand for compliant non-China supply from alternative origins.

Further, the recent India-US trade agreement announced on 2nd February 2026 effectively reduced reciprocal tariffs on Indian goods, including solar modules and cells, from 50% to 18%, is expected to lower the landed cost of "Made-in-India" solar exports to the U.S. market and improve their competitiveness with other suppliers. This tariff reset has already prompted Indian manufacturers to re-open talks with U.S. buyers and revisit plans for exports and potential local manufacturing in US. In medium term, this development is expected to support a recovery in export volumes to US and position India as a cost-competitive alternative supplier.

Table 25: Indian Solar Module Demand-Supply Balance FY25-30E (in GW)

Module	FY25	FY26E	FY27E	FY28E	FY29E	FY30E
Consumption	33.36	57.89	56.00	53.20	47.60	43.40
Export	4.32	6.90	11.05	17.68	24.75	32.42
Demand	**37.68**	**64.79**	**67.05**	**70.88**	**72.35**	**75.82**
Production	34.04	57.60	62.10	67.55	70.43	75.01
Import	27.50	7.19	4.95	3.32	1.91	0.81
Total Supply	**61.54**	**64.79**	**67.05**	**70.88**	**72.35**	**75.82**

Source: CareEdge Research; E: Estimates, P: Projected.

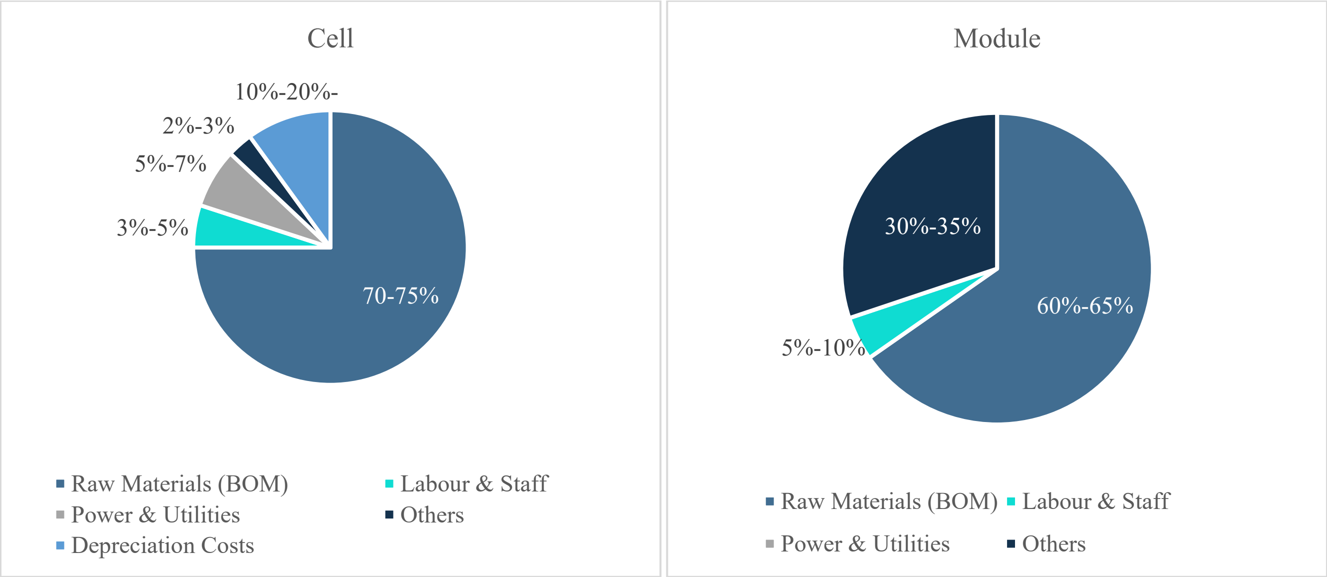
Due to domestic capacity building imports are expected to decline drastically in next five years and eventually will become negligible whereas Module Exports are expected to pick up with more than 45% CAGR during the same time frame as global installed solar generation capacity is likely to double by CY30. The growth in export is also attributable to the ability of manufacturers to export modules produced from non-ALMM compliant capacity, that may not be eligible for domestic projects. This implies a structural shift towards export-led growth, as domestic manufacturing capacity expands.

However, given the early stage of upstream integration, continued dependence on Chinese supply chains, uncertainty regarding export scalability, and slower progress in renewable capacity augmentation due to systemic constraints, these aspects remain key monitorable risks over the medium term.

4.3.5 Cost Break-up for Solar Modules and Cells

The estimated cost for establishing a 1 GW/yr solar cell and module manufacturing plant in India is based on a combination of imported and locally sourced raw materials. Financial assumptions consider a plant life of 15-16 years and capacity utilisation of 90%. O&M costs are projected at 1% of Capex, while electricity expenses are calculated at Rs 5.5/kWh. This cost structure reflects current market conditions and government policy support, which aim to promote domestic manufacturing capacity for solar cells and modules under schemes such as the PLI program.

Chart 51: Cost Break-up of Solar Cell and Module (CY25)



Source: TechSci Research, CareEdge Research
Note: 1) Module raw material break-up: Cells-42%-44%, Aluminium-4%-6%, Glass-3%-5%, EVA (encapsulant)-4%-6%, Junction-4% - 6%
2) Cell raw material break-up: Wafers-68%-70%, Screen-3%-6%
3) The above calculations are for reference purposes only. Actual calculations may vary depending on various factors

Raw material costs constitute a substantial portion (~70–75%) of operating expenses for Indian solar cell manufacturers, with wafers being the largest cost component. Since wafers are largely imported, manufacturers remain exposed to foreign exchange risk, which can adversely affect project profitability. This reliance on imports continues due to the limited domestic availability of upstream inputs such as polysilicon and ingots.

4.3.6 Insights on Price Trend of Solar PV Modules

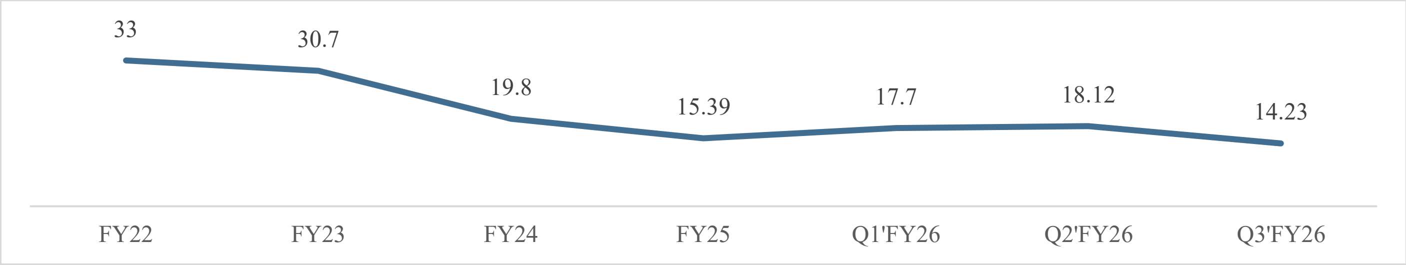
Solar tariffs in India have been falling steadily over the past few years. This drop is mainly because the cost of solar modules and cells have come down sharply, and financing has become cheaper.

Major reason for this price decline is global oversupply especially from China which has kept module and raw material prices under pressure. At the same time, lenders have become more comfortable with solar projects, offering longer-term loans at better rates, which has reduced the cost of capital.

Looking ahead, India is working on increasing backward integration in its solar manufacturing chain, particularly in cells and upstream components. This will reduce reliance on imports and foreign exchange risks, helping bring costs down further and keep tariffs competitive in the medium term.

At current pricing levels, even after an 18% tariff, Indian cell-based modules remain materially competitive versus US-made modules making a difference of approximately 8–10 US cents/W (The comparison does not consider the preliminary countervailing duties (CVD) of ~126% imposed by the United States, as these measures are not yet finalised)

Chart 52: India Solar Module Average Pricing Trends (Rs/Wp)



Source: CareEdge Research, Note: Prices are based Mono PERC pricing and are on last trading day of Fiscal Year

4.3.7 Key Differentiators for Companies Involved in Module Manufacturing

Key Differentiator	Description
Extent of Backward Integration	Presence across multiple stages of the value chain supports better control over input costs, improves supply security, and reduces vulnerability to import dependence.
Technology Profile and Product Mix	Ability to manufacture differentiated module types and adopt advanced cell technologies (e.g., TOPCon, HJT) enhances efficiency and supports premium positioning where higher energy yield improves lifecycle economics.
Scale of Operations and Cost Competitiveness	Larger capacities facilitate economies of scale and lower unit costs, enabling competitiveness in price-sensitive segments and improving resilience during industry down-cycles.

Location and Supply-chain Logistics	Proximity to key upstream suppliers and raw materials reduces logistics and procurement costs, supports faster turnaround times, and enhances supply reliability.
Policy Linkage and Incentive Support	Eligibility under government incentive schemes, including the PLI programme, ALMM and compliance with domestic content requirements, improves competitiveness and revenue visibility.

5 Wind Solar Hybrid

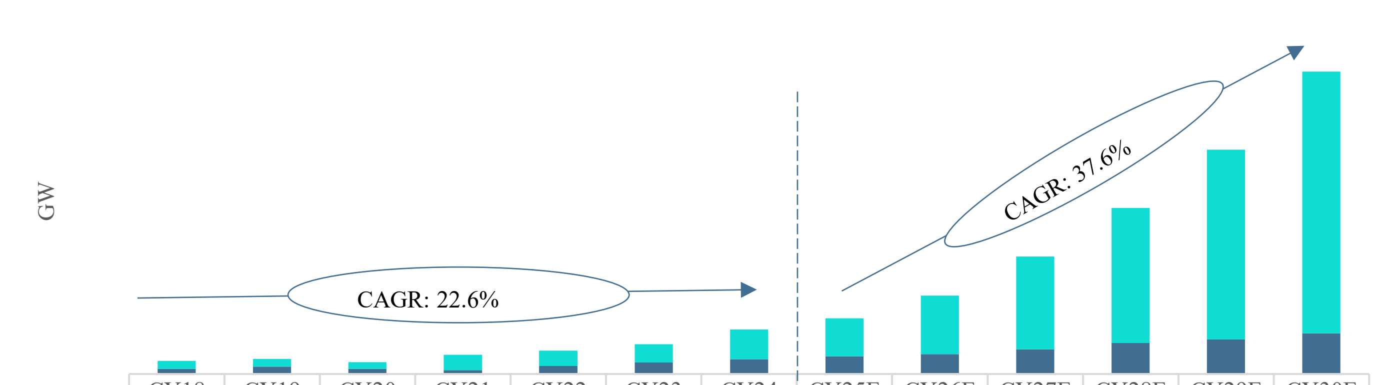
5.1 Overview of Wind Solar Hybrid Capacity Additions in India

India's renewable energy market is moving from standalone wind or solar projects to hybrid configurations that aim at improving reliability and grid stability. In addition to conventional hybrid projects, recent developments include RTC tenders with CUF commitments, peak-power supply structures, hybrids integrated with energy storage, and FDRE projects with firm dispatch obligations. This shift reflects a transition from standalone capacity addition to customised generation-and-dispatch solutions, supported by clearer policy direction and maturing procurement frameworks.

Cumulative wind solar hybrid capacity is expected to be 9-10% of total installed overall power capacity by 2030, led by declining module prices that have reduced capital costs in solar and large-scale projects such as Gujarat Hybrid Renewable Energy Park (Khavda) and hybrid projects by Adani Green Energy in Rajasthan. Continued ISTS-connected hybrid tenders by Solar Energy Corporation of India and NTPC are expected to sustain capacity additions in this segment.

In addition to SECI and many state governments continue to offer incentives to encourage the construction of WSH facilities. WSH is expected to reduce capital costs by 6%–7% compared to stand-alone wind and solar assets which improves project returns and enhance the attractiveness of the segment for new and existing developers.

Chart 53: Cumulative Wind Solar Hybrid Capacity



	CY18	CY19	CY20	CY21	CY22	CY23	CY24	CY25E	CY26E	CY27E	CY28E	CY29E	CY30E
Total	3.04	3.50	2.73	4.46	5.42	6.91	10.31	12.89	18.14	27.17	38.41	51.88	69.90
Solar	1.86	1.79	1.53	3.59	3.59	4.26	6.91	8.84	13.53	21.45	31.22	43.92	60.52
Wind	1.19	1.72	1.20	0.87	1.83	2.64	3.40	4.05	4.61	5.72	7.18	7.96	9.38

Source: MAIA, CareEdge Research

WSH systems often achieve ~35–45% CUF (vs. ~18–22% for standalone solar) as wind generation typically complements solar by contributing during evening/night hours, thereby improving utilisation of evacuation and land infrastructure. This complementary generation profile reduces intra-day variability and smoothens the aggregate output curve, lowering balancing requirements relative to standalone projects.

Within the WSH, solar continues to remain the dominant capacity contributor as 50-70% of total capacity comes from solar. With solar capacity is projected to add 51.5 GW from CY25-CY30, the growing push for wind–solar hybrid projects will only strengthen this momentum, creating steady long-term demand for better solar modules, inverters, trackers and other equipment.

Hybridisation also enhances overall plant efficiency through shared pooling substation, transmission bay, land, O&M and common control systems, improving asset sweat. In structured procurement (RTC/peak/FDRE), hybrids can be configured to deliver higher-value supply during peak windows (supported by storage and/or contractual shaping), while wind-rich night generation helps meet residual demand and reduces the incremental storage/firming requirement.

5.2 WSH tariffs in India

Wind–solar hybrid tariffs have largely settled in the range of Rs 2.9 –4.7/kWh, which is higher than standalone solar tariffs of about Rs 2.5–2.8/kWh but broadly comparable with recent wind tariffs of around Rs 3.7–4.0/kWh.

Table 26: Hybrid Projects in India

Tender Name	Issue Date	Central/State	Capacity (MW)	Average Tariff (kwh)	Winners	Capacity allocated (MW)
NHPC, 1200 MW, ISTS Connected WSH, Pan India, Dec 2024	Dec-24	Central	1,200	3.40	Adani Renewable Energy Holding Twelve (Adani Green Energy) Illuminate Hybren (Mahindra Susten) Sprng Vayu Vidyut Avaada Energy	1,200
Wind-Solar Hybrid Auction (Tranche VII)	Sep-24	Central	2,000	3.2	NTPC Renewable Juniper Green Energy Green Infra Wind Energy	900
NTPC, 1200 MW, Wind-Solar Hybrid,	Aug-24	Central	1,200	3.4	Jindal Renewables Adyant Enersol (Datta Infra) AMPIN Energy Adani Renewable Energy Holding	1,200
Wind-Solar Hybrid Auction (Tranche VI)	Jul-24	Central	1,000	3.4	Juniper green energy JSW Neo Energy TEQ Green Adyant Enersol Avaada Energy	1,000
SJVN, 1200 MW, ISTS Connected Wind Solar Hybrid	Jun-24	Central	1,200	3.2	Gentari Renewables Juniper Green Energy EG Energy Development (Enfinity Global) Sunsure Solarpark RJ One (Sunsure Energy Adyant Enersol (Datta Infra)	1,200
MSEDCL, 1150 MW, Wind Solar Hybrid (Phase IV)	Jun-24	State	1,150	3.6	JSW Neo Energy Tata Power Renewable Energy Juniper Green Energy Avaada Energy	1,162
NTPC – 1,000 MW ISTS-Connected Wind-Solar Hybrid (Tranche V	Feb-24	Central	1,000	3.4	Sprng Energy, AMPIN Energy Transition, Juniper Green Energy,	1,000
Torrent Power distribution, 300 MW, Wind Solar Hybrid,	Jan-24	NA	300	3.7	Torrent Power energy	300
SECI, 2000 MW, ISTS connected Wind Solar Hybrid	Oct-23	Central	2,000.00	3.2	NTPC Renewable Juniper Green Energy Green Infra Wind Energy	900

(Tranche VII), Pan India, Oct 2023						

Source: CareEdge Research

Table 27: Characteristics of Plain Hybrid WSH, Peak Power, RTC and FDRE

Parameter	Plain Hybrid	Peak Power	RTC	FDRE
Technologies	Wind + Solar	RE + Storage	RE + Storage + Hydro	Multi-RE + Large Storage
Storage	Minimal	Limited	Moderate–High	High
Supply Profile	Intermittent	Peak-specific	24×7	Firm & scheduled
Reliability	Low–Medium	Medium	High	Very High
Grid Support	Moderate	High (peak)	Very High	Maximum
Tariff Level	Lowest	Medium	High	Highest
Average Tariff Range (Rs/KWh)	2.99 - 4.70	4.64 - 6.70	4.7 - 5.1	4.30 - 5.07

Source: CareEdge Research

5.2.1 Government Initiatives in the Hybrid Technology

Tariff-based Competitive Bidding

Tariff-based competitive bidding has become the cornerstone for scaling wind–solar hybrid (WSH) projects in India, providing a transparent framework for price discovery through reverse auctions. The MNRE guidelines, introduced in 2020, standardised technical requirements such as minimum project size and mandated CUF thresholds, which helped reduce uncertainty for developers and off takers. Subsequent amendments enabled DISCOMs to procure hybrid power directly, improving cost efficiency and accelerating project contractualisation.

Parallel to this, SECI and MNRE have advanced firm and dispatchable renewable energy (FDRE) tenders that combine wind, solar and storage to supply round-the-clock or peak-hour power aligned with demand curves. These tenders encourage hybrid configurations that maximise complementary generation profiles and strengthen grid reliability. The national bidding trajectory of 50 GW annually through FY28 further signals long-term procurement visibility, including a dedicated quota for wind.

Firm and Dispatchable Renewable Energy (FDRE)

To accelerate the deployment of firm and dispatchable renewable power, the Ministry of Power (MoP) notified the "Guidelines for Tariff-Based Competitive Bidding Process for Procurement of Firm and Dispatchable Power from Grid-Connected Renewable Energy Power Projects with Energy Storage Systems" in June 2023.These guidelines establish a standardised framework for the procurement of renewable energy (including wind, solar, wind-solar hybrid and other RE sources) integrated with energy storage systems (ESS) and connected to the grid.

Under the regime, procurers are required to specify a demand-profile in the Request for Selection (RfS) such that the selected bidder must supply power both on a "round-the-clock" or peak-hour basis in alignment with the profile. The minimum bid size is set at 50 MW for such projects, reinforcing economic scale and enabling robust participation through reverse auctions. The guidelines also incorporate obligations on capacity utilisation, firm delivery and penalties: in cases of shortfall in supply against the profile, defined contractual consequences can apply (such as damages or contract default) as per the bidding documents.

This regulatory instrument is pivotal for transitioning India's power system towards a higher share of renewables by enabling sustained availability and grid-friendly dispatch of clean energy, thereby supporting reliability, decarbonisation and investment predictability.

National Wind and Solar Hybrid Policy

India's National Wind-Solar Hybrid policy, notified by the Ministry of New and Renewable Energy in 2018, provides a comprehensive framework to promote large, grid-connected hybrid power projects by combining solar PV and wind generation at a single site.

Table 28:Highlights of the Policy

Aspect	2018 National Wind–Solar Hybrid Policy
Objective	To promote **co-located wind + solar projects**
Key goal	Improve **grid stability** and **transmission utilisation**
Definition of hybrid	Wind & solar at same site
Minimum capacity rule	One source ≥ **25%** of the other
Technology scope	Wind + Solar
Storage inclusion	Allowed (battery, pumped hydro, etc. storage)
Scheduling & forecasting	Mandatory forecasting and scheduling
Tariff mechanism	Competitive bidding encouraged
Financial incentives	No direct subsidy in policy
Role of states	States encouraged to adopt

Source: CareEdge Research

In addition to this many states have come up with their own initiatives to promote WSH. Below are some of the exemptions and initiatives of key states in India.

State-wise WSH Initiatives

Parameters	Gujarat	Andhra Pradesh	Karnataka	Rajasthan
RPO obligation	RPO can be fulfilled separately for both solar and wind/non-solar	RPO can be fulfilled separately for solar and non-solar	RPO can be fulfilled separately for solar and non-Solar	Mandatory for Discom to purchase power equivalent to 5% of their RPO targets under this policy
Banking charges	Nil	Banking charges are adjusted in kind at 5% of the energy delivered at the point of drawl	2%	10%
Banking Settlement Period	Monthly	NA	Annual	Annual
Cross Subsidy Surcharge (CSS) & Additional Surcharge (AS)	50% concession for 3rd party sale	50% waived for third party sale projects set up within the state	75% exemption on AS	NA
Electricity Duty (ED)	Waived off for intra state consumption	50% exemption for intrastate consumption	Waived off for intra state consumption, applicable for third party	Waived off for intra-state consumption

Transmission / Wheeling Charges	50% concession for captive consumers on wheeling charges & losses. Waivers applicable only at 11KV voltage drawl. No waivers for Third party sale.	50% exemption in transmission and wheeling charges for new projects developed within the state	No additional connectivity/transmission capacity charges for existing plants; applicable only for additional transmission capacity.	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 project commissioning

Source: CareEdge Research

5.2.2 Key Issues

Key issues in WSH

- Hybrid projects are often commissioned ahead of adequate transmission infrastructure, particularly in high-RE regions leading to evacuation constraints that adversely impact power offtake and project revenues
- The availability of land with both high solar irradiance and strong wind regimes is limited, with such co-located resource potential largely concentrated in Gujarat and Rajasthan. This constrains the scalable development of wind–solar hybrid projects in other regions and increases site selection complexity
- Variations and periodic revisions in state-level banking and open access charges increase tariff uncertainty and complicate risk assessment for developers and off takers over the project lifecycle
- Large-scale hybrid projects require accurate scheduling and forecasting, and evolving deviation and penalty regulations continue to add to operational risk, particularly during high-generation periods.
- Wind–solar hybrid projects require sites with strong wind and solar resources and large land parcels, while land conversion and approvals often lead to execution delays

6 Overview of Indian Solar EPC Market

Solar EPC refers to the engineering, procurement and execution/commissioning services provided for setting up solar power installations. EPC services can be classified into various subcategories based on the scale and type of installations, i.e., Utility Scale Solar, rooftop solar and Distributed/Off-grid solar installations. Favourable government initiatives, such as MNRE's target of achieving 280 GW of solar energy capacity by fiscal year 2030, have led to a sharp rise in ground-mounted utility scale solar installations, accounting for the majority of India's solar capacity. Parallelly, increased demand for green energy and rooftop installations by corporate consumers have also boosted solar installations. However, the Solar EPC sector in India presents high entry barriers, as it demands a minimum level of technical expertise and experience to qualify for tenders, along with restrictions on joint ventures participating in bids.

Solar EPC projects are generally executed through separate supply and services contracts rather than a single EPC arrangement. High-value equipment such as modules, inverters, transformers and cables, which together account for about 70–75% of project cost, is usually sourced directly by developers. Execution-related activities, including civil works, installation and commissioning, form the balance 25–30% of costs and are assigned to specialised service contractors. In certain cases, solar module manufacturers also undertake full EPC responsibilities, covering both supply and project execution.

Solar EPC contracts vary based on assignment of roles and responsibilities and penalty. Based on these differences, various project delivery mechanisms have been devised. The size and nature of the project also influence the choice of the project delivery mechanism.

6.1 EPC Project: Turnkey vs Balance of Plant (BoP)

There are two types of modes for the EPC contract to be executed – the turnkey project structure and balance of plant structure.

Table 29:Turnkey vs Balance of Plant (BoP)

Feature	Turnkey EPC	Balance of Plant (BoP)
Scope	Complete project delivery (modules, inverters, BoP, commissioning)	Only construction & system integration (client procures modules/inverters)
Responsibility	EPC contractor responsible for design, procurement, construction, and commissioning	BoP contractor responsible only for installation, wiring, and commissioning
Risk Allocation	Contractor assumes most risks (delays, performance)	Developer bears risk for modules/inverters; contractor handles construction risk
Flexibility	Low – client has minimal input on components	High – client can choose modules, inverters, and suppliers
Cost	Usually higher (risk premium included)	Potentially lower if developer sources equipment competitively
Project Management	Minimal from client	Higher – client must manage procurement and integration

6.2 Key Criteria for Selection of EPC Contractor

The selection of an EPC contractor is based on its overall execution capability, financial strength, and past performance in delivering solar projects of similar scale and complexity. Key considerations also include the contractor's technical expertise, ability to provide end-to-end EPC and O&M services, and in-depth knowledge of equipment and project engineering. Adequate experience in securing statutory approvals and managing on-ground execution is also important to ensure timely project completion. In addition, a strong local presence and a proven track record across geographies provide comfort on execution quality and delivery timelines.

General Criteria

- The Bidder should be either a body incorporated in India under the Companies Act, 1956 or 2013 including any amendment thereto and engaged in the business of Solar Power.
- The EPC contractor should be able to provide end-to end solutions for a solar power plant implementation
- The Bidder (either individually or as a consortium or any of the participating members of the Consortium) shall not have been debarred by EMPLOYER/ Owner/ Ministry of MNRE or any other ministries and / or any other Government Department, Agencies or CPSUs from future bidding due to “poor performance” or “corrupt and fraudulent practices” or any other reason in the past.
- The Bidder should not be under any liquidation court receivership or similar proceedings on the due date of submission of bid.

Technical Criteria

- The bidder must have successfully installed and commissioned at least one grid-connected solar PV power project of a specified capacity. The project should have been commissioned prior to the Techno-Commercial Bid Opening date. The bidder is required to submit a list of such projects, indicating their grid-connected status, along with relevant supporting documentation, such as the commissioning certificate and work order/contract/agreement from the client or owner.

Financial Capacity

- The bidder must have an annual turnover of a specified amount per MW in any one of the last three financial years preceding the bid deadline, provided that the bidder has completed at least one full financial year of operation.OR
- The bidder must have a net worth equal to or greater than the value calculated at a specified rate per MW of the capacity offered in the bid.
- In case of more than one Price Bid submitted by the Bidder, the financial eligibility criteria must be fulfilled by such Bidder for the sum total of the capacities being offered by it in its Price Bid.

These eligibility requirements act as strong entry barriers in the solar EPC market, restricting participation to a limited set of qualified players. Financial thresholds are closely linked to tender size; for example, projects of 200 MW and 260 MW typically stipulate minimum average annual turnover requirements of about Rs 150 crore and Rs 224 crore respectively. In addition, bidders are required to maintain a positive net worth in the last financial year.

6.3 Key Covenants of an EPC Contract

CLIENT SCOPING	Single-Point Responsibility	Commercial Terms	Time & Performance Assurance	Risk & Liability Framework	Security & Payment Safeguards
Clearly specifies technical standards, performance criteria and deliverables.	EPC contractor assumes end-to-end responsibility for execution and issue resolution	Covers contract price structure, payment terms, variations and escalation provisions.	Includes guaranteed completion timelines and performance guarantees, backed by delay and performance liquidated damages.	Defines caps on liability, termination rights, suspension provisions and variation mechanisms.	Incorporates performance security and retention to protect the owner against non-performance

The EPC contract is established between the client (the owner) and the EPC contractor for a specific project or scope that the contractor is obligated to deliver

6.4 In-house vs. Outsourced EPC

In India, the solar power developers consist of both public and private sector entities. The public sector entities include NTPC Renewable Energy, NHPC, SJVN, Gujarat State Electricity Corporation (GSECL), etc. while the private sector entities include Adani Group, Renew, Acme Solar, Ayana, Enfinity, Radiance, Serentica, Bluepine, IMC etc. Most of the established private sector companies have mobilised in-house EPC teams which have the capability of executing large projects. Both public and private sector players engage EPC contractors for execution of the project.

In-House EPC	Outsource/Third Party EPC
Advantages • Full control over design, procurement and execution. • Easier to customise projects to meet specific technical and operational requirements • Direct coordination within the organisation often speeds up approvals and reduces delays. **Challenges** • Significant investment in equipment, skilled manpower and technology is required. • Difficult to ramp up quickly for large projects. • All execution risks borne by the company •	**Advantages** • Low capital investment as no need to build internal infrastructure or hire large teams • Access to experienced EPC contractors with proven capabilities • Greater flexibility and scalability for multiple projects **Challenges** • Reduced control over timelines and quality. • Coordination gaps can lead to delays. • Margin pressure from competitive bidding may impact quality

6.5 Average EPC Realisation Per MW

The average EPC realisation per megawatt in India's solar sector typically falls in the range of Rs 3.5 – Rs 4.5 crore per MW, depending on project scale, technology choices and site conditions. For large utility-scale projects, economies of scale often drive realisations toward the lower end of the range, as bulk procurement and standardised designs reduce per-MW costs.

Regional variations also play an important role as projects in states with favourable solar policies, land availability and grid infrastructure often achieve lower EPC realisations compared to those in urban or land-scarce regions. Additionally, compliance requirements such as ALMM certification and quality audits add to EPC costs, particularly when procurement options are limited. From a financial perspective, these realisation levels translate into returns of 11–15% for utility-scale and industrial projects, with payback periods ranging between 3–7 years, depending on tariff structures and subsidies. Residential rooftop projects, though costlier per MW, often achieve faster payback due to government incentives and net-metering benefits.

Table 30:Solar EPC Cost

Sector	EPC Cost
Residential EPC	Rs 35,000-Rs 55,000 per kW
Commercial/ Industrial EPC	Rs 35,000-Rs 50,000 per kW
Utility-Scale EPC	Rs 30,000-Rs 45,000 per kW

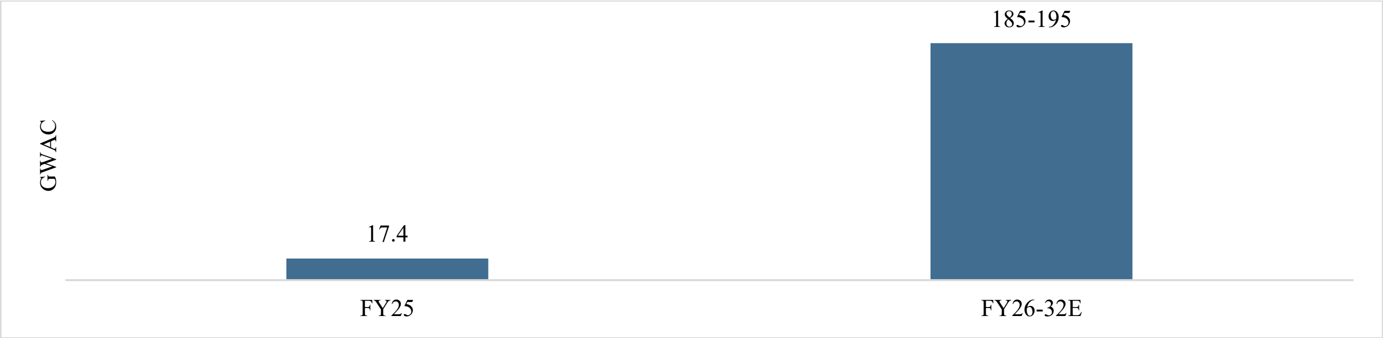
Source: Industry Source, CareEdge Research
* Indian solar EPC companies operate at 5–12% gross margins

6.6 Outlook for Solar EPC Market

India's installed solar capacity is rising rapidly, supported by MNRE's plan to invite ~50 GW of renewable bids annually from FY24–FY28 to achieve 500 GW by 2030. EPC players are critical in delivering generation and evacuation infrastructure through design optimisation, equipment sourcing and grid connectivity. Investment in EPC enhances execution capacity, shortens timelines and ensures grid readiness for faster capacity addition. Domestic solar module production is set to grow under initiatives like the PLI scheme, reducing import dependence and lowering project costs.

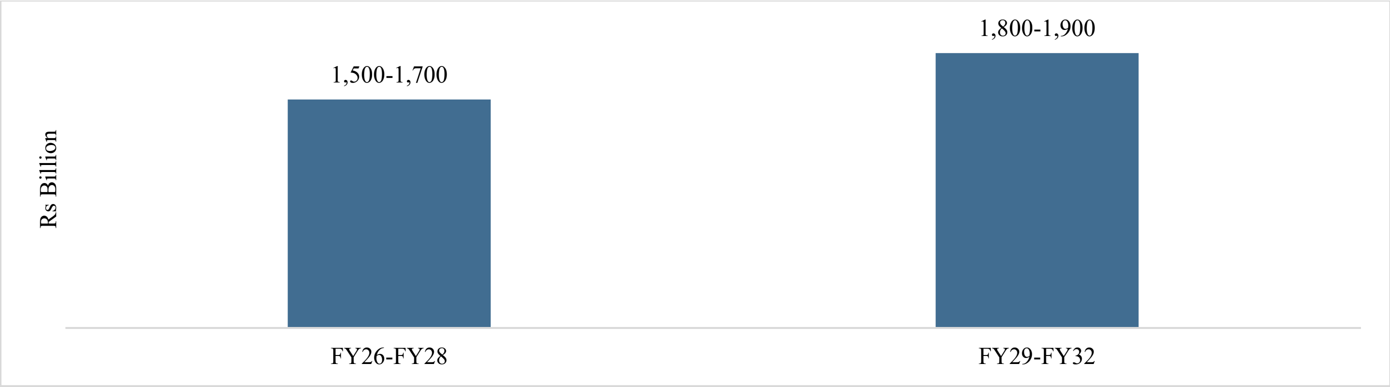
The solar EPC market is expected to add 185-195 GW_{Ac} during FY26-FY32E.

Chart 54: India Solar EPC Additions



Source: CareEdge Research, *GW_{AC} refers to Gigawatts Alternating Current i.e. actually delivered power output to the electrical grid

Chart 55: Investments in Solar EPC



Source: NEP Vol -I, CareEdge Research

6.7 Key Drivers

Rising Power Demand and Grid Augmentation

Rapid urbanisation, industrial growth and higher electricity consumption are driving investments across generation, transmission and distribution, creating sustained EPC execution opportunities.

Policy-driven Renewable Capacity Addition

Government targets 500GW non-fossil capacity by FY30 and is supported by schemes such as PM-KUSUM, RDSS and the Green Energy Corridor are ensuring a strong and visible project pipeline across solar, wind, hybrid and storage segments.

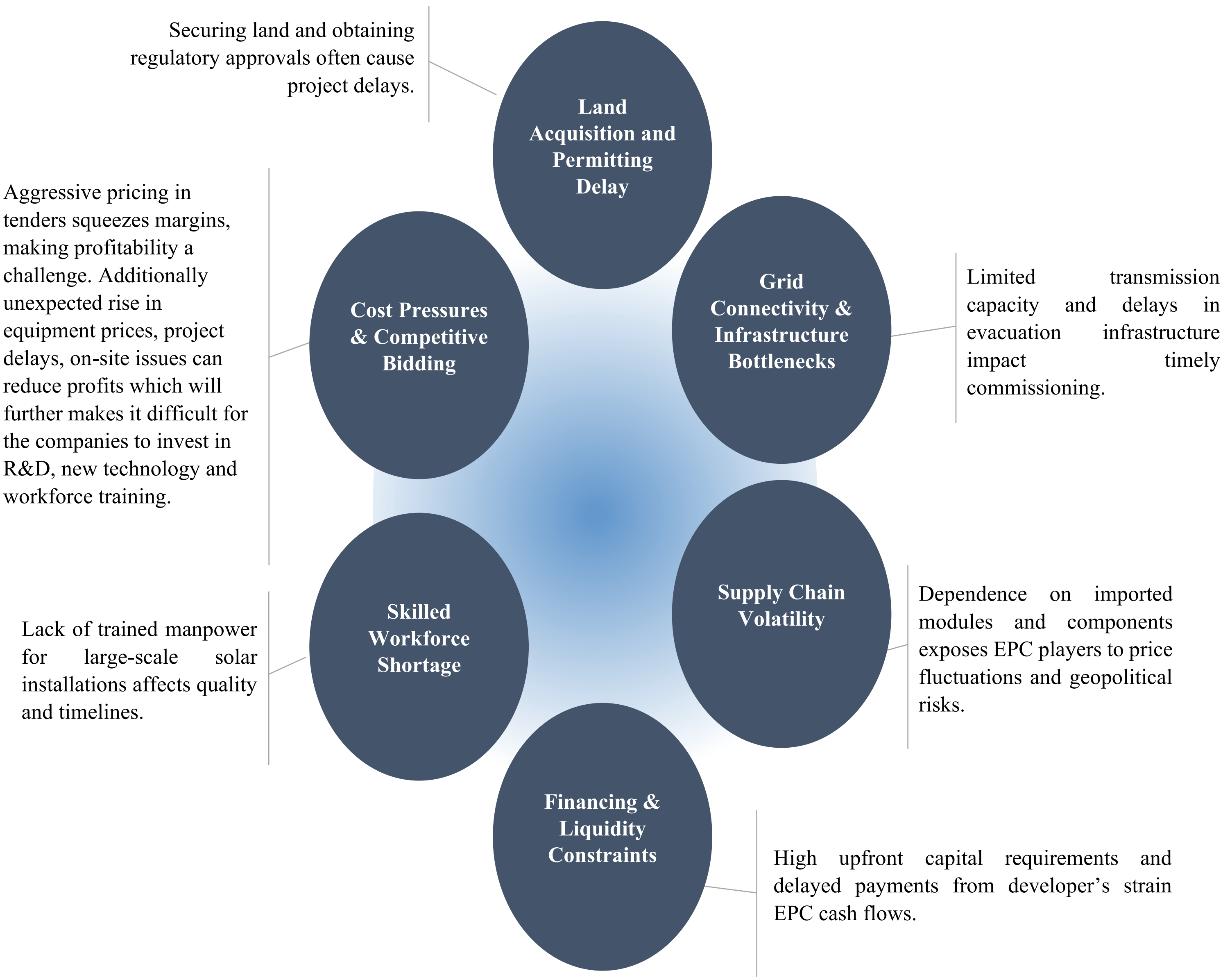
Traction in C&I Segment

The C&I segment is increasingly looking at procuring solar power for their operations either through rooftop solar projects or through open access.

Technological Advancements

Rising adoption of complex solar configurations such as floating solar and solar-plus-BESS has increased engineering and grid-integration requirements. This is driving faster adoption of advanced power electronics and energy management technologies to ensure stable and efficient operations.

6.8 Key Challenges



The ALMM mandate has increased execution complexity for solar EPC players by restricting module sourcing, leading to design changes, longer procurement cycles and higher working-capital requirements. While EPCs have adopted mitigation measures such as multi-vendor sourcing and flexible designs, project execution has become more compliance-driven and time-consuming. These issues are further compounded by frequent policy changes and divergent state-level regulations, which create cost uncertainty and delay projects. Site-specific challenges, particularly terrain levelling in difficult geographies, add to civil costs and extend execution timelines.

6.9 Competitive Mapping of Solar EPC Players

Parameters	Waaree RTL	Sterling & Wilson	Oriana Power	Solar World	KPI Green	Tata Power Solar	Mahindra Susten
Commissioned Capacity	3.95 GWp	21.7 GWp	400 MWp	1.1 GWp	1.56 GWp	12.5 GWp	5.85 GWp
Order Book	25 GWp	12.8 GWp	550+ MWp	994 MWp	5.49 GWp	NA	NA
Services Offered	Solar EPC solutions, Rooftop solutions, CAPEX and RESCO models	Solar EPC solutions and O&M	Carport Solar, Floating Solar, Solar EPC Solutions and O&M, Solar Parks	Solar EPC solutions, Rooftop solutions, CAPEX and RESCO models	Solar CPP and IPP	Solar EPC solutions, Rooftop solutions, solar water pump	Solar PV system design, Solar EPC solution, Solar Inverters
Revenue from EPC (Rs Million)	15,593.1	60,640.3	9,666.1	4,779.3	15,180.6	NA	NA
Market Presence	India, Vietnam	India, Middle East, Latin America, Africa, Southeast Asia, Australia, USA	India	India	India	India	India

Source: Company Filings, CareEdge Research

7 Overview of Battery Energy Storage Systems (BESS)

7.1 Overview of Energy Storage Technologies

Energy storage systems (ESS) capture energy from renewable sources or the grid and store it for later use, especially when demand increases or supply falls. They help match supply with demand, support grid stability and enable higher integration of variable renewable generation. Depending on the technology, energy can be stored in chemical form (batteries), mechanical form (pumped hydro and compressed air), or thermal form (molten salts and hot water).

Figure 8: Classification of Energy Storage Technologies

Mechanical

- Pumped Hydro Energy Storage (PHES)
- Compressed Air Energy Storage
- Flywheel Energy Storage

Electrochemical

- Lead Acid Batteries, Advanced Lead Acid (Lead Carbon, Bipolar Lead Acid)
- Lithium Batteries (LCO, LMO, LFP, NMC, LTO, NCA)
- Flow Batteries (ZnBr, Vn Redox)
- Sodium Batteries (NaS, NaNiCl2)
- Zinc Batteries- Zn Air, ZnMnO2

Thermal

- Sensible-Molten Salt, Chilled Water
- Latent- ice Storage, Phase Change materials
- Thermochemical Storage

Electrical

- Superconducting Magnetic Energy Storage (SMES)
- Super Capacitors

Chemical (Hydrogen) electrochemical

- Power-to -Power (Fuel Cells, etc)
- Power-to-Gas

Source: Energy Storage System: Roadmap for India: 2019-2032, MNRE

Lithium-ion batteries are preferred for short- to medium-duration grid and C&I applications due to their high round-trip efficiency, rapid response capability (wide C-rate range), compact footprint, and relatively low operating costs.

On the other hand, pumped hydro storage (PHS) and compressed air energy storage (CAES) are better suited for long-duration storage, given their lower levelised cost per kWh and extended cycle life. However, PHS require higher capex due to complex infrastructure, large land requirements, and longer development timelines. Emerging technologies such as flow batteries and NaS offer longer discharge durations and higher cycle life than Li-ion, though their higher costs and lower maturity currently limit large-scale adoption.

Table 31: Performance Characteristics of Energy Storage Technologies

Energy Storage System Attributes	Lead Acid	Li-Ion	NaS	Flow Batteries	Flywheel	CAES	PHS
Description	Electrochemical storage using lead dioxide and sponge lead electrodes in sulphuric acid electrolyte	Electrochemical storage based on lithium-ion intercalation between cathode and anode	High-temperature electrochemical storage using molten sodium and sulphur	Electrochemical storage where energy is stored in liquid electrolytes circulated through a cell stack	Mechanical storage using rotational kinetic energy in a high-speed rotor	Mechanical storage using compressed air stored in underground caverns	Mechanical storage using gravitational potential energy of water between upper and lower reservoirs
Round Trip Energy Efficiency (DC-DC)	70–85%	85–95%	70–80%	60–75%	60–80%	50–65%	70–80%
Range of Discharge Duration	2–6 hours	0.25–4+ hours	6–8 hours	4–12 hours	0.25–4 hours	4–10 hours	6–20 hours
C Rate	C/6 to C/2	C/6 to 4C	C/8 to C/6	C/12 to C/4	C/4 to 4C	N.A.	N.A.
Cost Range Per Energy Available in Each Full Discharge (USD/kWh)	100–300	250–800	400–600	400–1000	1000–4000	>150	50–150
Development & Construction Period	6 months – 1 year	6 months – 1 year	6 months – 1.5 year	6 months – 1.5 year	1–2 years	3–10 years	5–15 years
Operating Cost	High	Low	Moderate	Moderate	Low	High	Low
Estimated Space Required	Large	Small	Moderate	Moderate	Small	Moderate	Large
Cycle life: # of Discharges of Stored Energy	500–2000	2000–10,000+	3000–5000	5000–8000+	100,000	10,000+	10,000+

Maturity of Technology	Mature	Commercial	Commercial	Early to moderate	Early to moderate	Moderate	Mature

Source: Energy Storage System: Roadmap for India: 2019-2032, MNRE

Table 32:Type of materials for Battery Systems and its availability across India

Stage	Description	India's Status
Raw Materials	Lithium, cobalt, graphite, nickel	Mostly imported; Major supplying countries are DR Congo, Zambia, Australia, Chile, Argentina, China and Indonesia China accounts for approximately 70–80 per cent of global lithium-ion battery cell manufacturing capacity and output.
Active Materials	Cathodes, anodes, separators	Largely absent
Recycling	Recovery of lithium, cobalt	At early stage; EPR framework under discussion. EPR collection targets are prescribed as a percentage of batteries introduced in the market, ramping up annually (for most battery categories, 60% initially, rising to 70% and then 80%+ over subsequent years, as notified by CPCB). • Minimum recycling efficiency thresholds are specified by battery chemistry (for example, ~90% material recovery for lead-acid batteries and ~70–90% for lithium-ion batteries, depending on the material). • Mandatory use of recycled content is introduced on a phased basis, with minimum recycled material percentages in new batteries to be notified and progressively increased.

Source: CareEdge Research

7.2 Key Companies in Energy Storage Systems

Table 33: List of Major Suppliers of Raw Materials and Components in India

Battery Energy Storage Systems	Lithium-Ion Cell	BoS Hardware	BoS-inverter
Advait Energy Transitions Limited (AETL)	Waaree Energies (Waaree ESS)	Vertiv India	Hitachi Energy India
EnerCube	Exide Industries	Delta Electronics India	Nidec Conversion (India ops)
Waaree Technologies Limited	Amara Raja Energy & Mobility	Sahyadri Industries	Lineage Power
Exide Industries Limited	SunGarner Energies Limited.	nVent (SCHROFF)	FIMER India
	Semco Infratech	Pyrotech Electronics	Fuji Electric India
	Cummins India		TMEIC India
	Avaada Group		Newen Systems
	Reliance Industries (Reliance New Energy Battery)		
	JSW Energy (JSW Neo Energy)		

Source: TechSci Research, CareEdge Research

7.3 Battery Energy Storage Systems

Battery Energy Storage Systems (BESS) have emerged as a key storage technology in recent years, offering higher energy density than Pumped Storage Plants (PSP) and enabling ancillary services. It is easy to install, requires minimal setup time, and supports diverse grid functions such as energy shifting, distribution deferral, and arbitrage. However, the technology is still evolving, involves high capital costs and associated risks, and batteries typically need replacement or disposal after 10–12 years of use.

7.4 Comparison of PSP vs BESS

Parameter	BESS (Battery Energy Storage System)	PSP (Pumped Storage Project)
Description	Electrochemical storage solution where batteries charge during surplus generation and discharge when required. Mainly used for short to medium duration balancing, grid support and renewable integration.	Mechanical storage solution that pumps water to an elevated reservoir during surplus generation and releases it to produce electricity when needed. Mainly used for long-duration supply, peak demand support and load shifting.
Storage Principle	Stores energy in battery cells through electrochemical reactions.	Stores energy by moving water between upper and lower reservoirs using reversible hydro units.
Land Requirement	Comparatively low; systems can be installed within industrial premises, renewable project sites, or substations.	High; requires suitable terrain, reservoir area, and civil infrastructure along with environmental clearances.
Lifespan	Battery modules degrade over time and need periodic replacement; overall system life depends on chemistry and cycling frequency.	Long operating life with gradual efficiency reduction; turbines and civil structures remain functional over decades with maintenance.
Tariff	Solar + BESS: 2 hr dispatch tariff at Rs 3.09/kWh and 4 hours at Rs 3.34/kWh	Rs 7.87– Rs 8.15/kWh
Efficiency	85–90%	75–80%
Ideal Storage Duration	2–8 hours (Li-ion)	6–12 hours
Capex (Rs crore/MW)	6-7 (4-hour) 9-10 (6-hour)	5-6
Gestation Period	Shorter 1-2 years	Longer 5-7 years
Operation Cycle	1-2	1-2
Operational Capacity (Dec-25)	0.76 GWh	7.2 GW
Under Construction Capacity (Dec-25)	3.1 GWh	39.45 GWh
PPA Period	8-12 years	15-40 years
VGF Support	Yes	No

Source: CEA, NEP Vol I, IESA, CareEdge Research, *Using BESS

PSP has traditionally dominated the storage landscape due to its large-scale and long-duration storage capabilities. However, the surge in renewable energy adoption has driven a rapid shift towards BESS. As India moves toward its 2030 storage targets, the evolving tender framework underscores the complementary nature of both technologies in ensuring grid reliability and supporting the clean energy transition. Overall, while PSP remains critical for long-duration storage, its higher costs and longer execution timelines make it less competitive than BESS in the near term.

7.5 Problem with Lithium battery

Lithium-ion batteries (LIBs) are the dominant energy storage technology for Battery Energy Storage Systems (BESS) owing to their high energy density, fast response capability, high round-trip efficiency and operational maturity across grid-scale and behind-the-meter applications. However, despite enabling renewable integration and grid flexibility, battery manufacturing remains carbon-intensive and constitutes a significant share of lifecycle emissions for BESS. The environmental footprint is further exacerbated by the resource-intensive extraction of lithium, cobalt and nickel, raising concerns related to environmental degradation, water consumption and ethical sourcing practices. Moreover, the limited global availability and geographically concentrated reserves of these critical minerals create structural supply-chain vulnerabilities. In addition, battery cell manufacturing is highly energy-intensive, and where production is powered by fossil-fuel-based electricity, it results in elevated embedded carbon emissions, partially offsetting the decarbonisation benefits delivered during BESS operation.

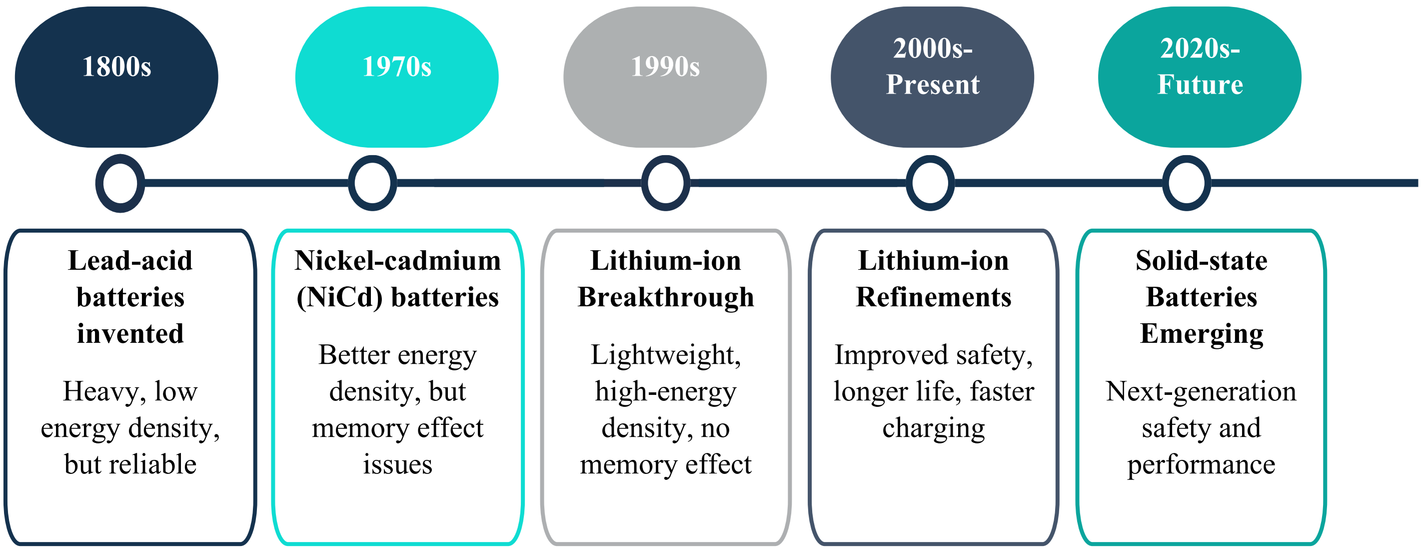
Recycling of lithium-ion batteries remains limited due to high costs, technological challenges in material recovery and inadequate collection and reverse-logistics infrastructure, restricting the development of a circular battery economy. Safety risks also persist, as lithium-ion batteries are susceptible to thermal runaway, increasing fire and explosion risks, particularly in large-scale EV and grid-scale BESS deployments. In India, these challenges are compounded by heavy import dependence, with the current ~15 GWh battery demand almost entirely met through imports. With demand projected to rise sharply to ~54 GWh by FY27 and ~127 GWh by FY30, this dependence significantly heightens exposure to supply-chain disruptions, price volatility and geopolitical risks.

7.6 Conventional Liquid State vs Solid State Advantages

The core difference between a conventional lithium-ion battery and a solid-state battery lies in the electrolyte. A traditional battery uses a liquid or gel polymer electrolyte to move ions between the anode and cathode. A solid-state battery, as the name suggests, replaces this liquid with a solid material, often a ceramic, polymer or sulphide compound.

The push towards solid-state technology stems from the inherent limitations of liquid electrolytes. These liquids are often flammable, can be sensitive to extreme temperatures, and contribute to battery degradation over time. As the demand for more powerful and safer energy storage grows, leading developers are investing heavily in solid-state designs to overcome these hurdles.

Figure 9:Battery Technology Timeline



Source: Energy Storage System: Roadmap for India: 2019-2032, MNRE

Liquid-state lithium-ion batteries are currently dominant in grid and industrial storage, supported by mature manufacturing, standardised deployment and predictable performance. Solid-state batteries are being developed as the next stage of evolution and aim to improve energy density, safety and cycle life by replacing the liquid electrolyte with a solid medium. However, commercial adoption depends on future progress in manufacturing scale, material optimisation and cost reduction relative to existing chemistries.

7.7 BESS Value Chain

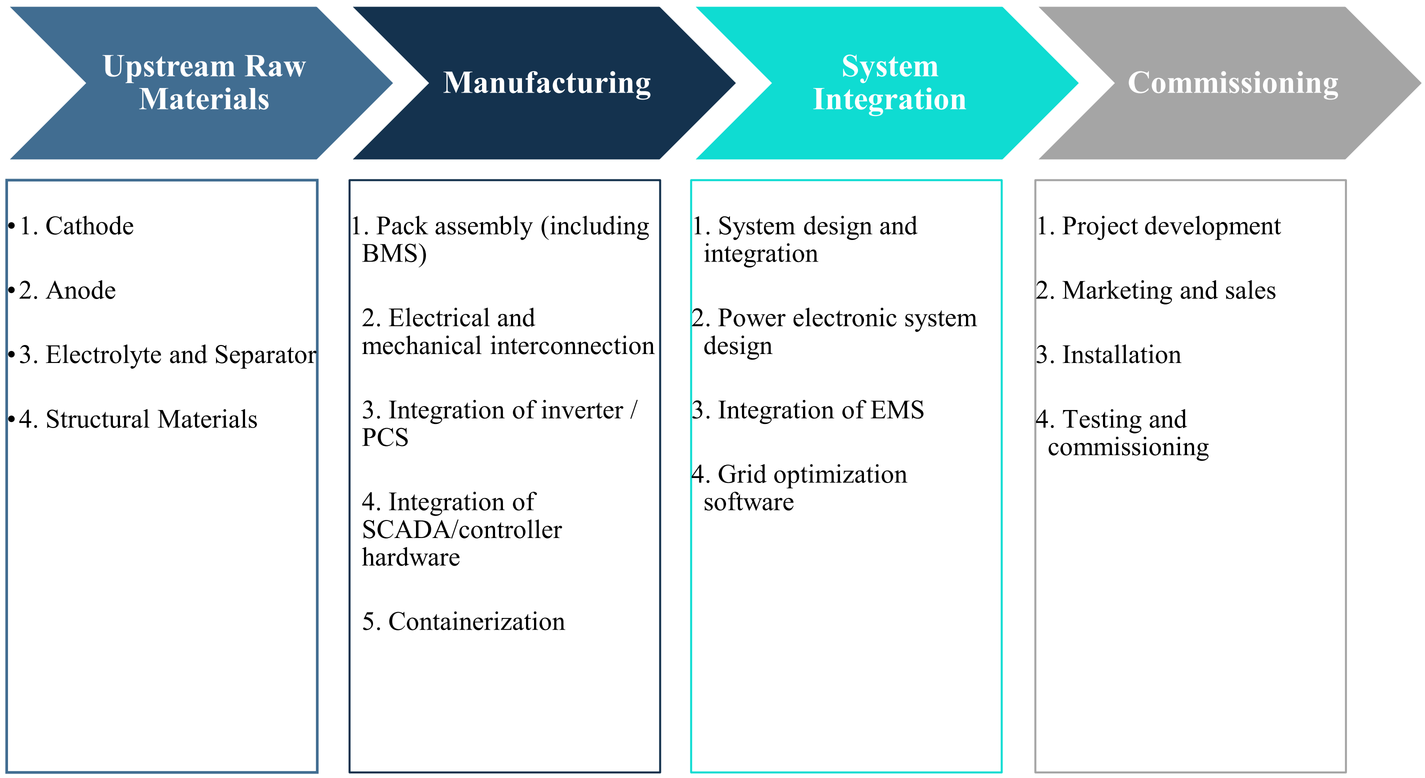
The BESS value chain comprises upstream raw materials, manufacturing, system integration, and customer acquisition and commissioning. The manufacturing segment includes production and assembly of battery system components such as battery cells, packs (including BMS), inverters or power conversion systems, interconnection hardware, SCADA and control hardware, and containerised enclosures. BESS assemblers operate across the manufacturing and early integration stages of the value chain. BESS assemblers convert discrete components into a deployable battery system that is ready for system-level integration and site deployment.

The system integration segment covers activities related to overall system design and configuration, power electronic system design, integration of energy management systems, and deployment of grid optimisation software. These activities enable coordination between the battery system, power conversion equipment and grid requirements.

BESS deployers operate in the downstream part of the value chain, focusing on project development and execution. The downstream segment includes commissioning activities such as project development, marketing and sales, installation, testing, and commissioning of BESS projects. BESS deployers coordinate with assemblers and system integrators to deliver projects at the site level and manage regulatory approvals, grid connectivity, and handover to end users.

Battery cell manufacturing is fundamentally more complex than module assembly because it is a chemical process requiring precise, atomic-level and nano-level engineering to create energy storage, whereas module assembly is primarily a mechanical assembly process. Cell manufacturing involves handling hazardous materials, requires ultra-low humidity environments (dry rooms), and operates at the intersection of material science and, for solar, semiconductor physics.

Chart 56: BESS Value Chain



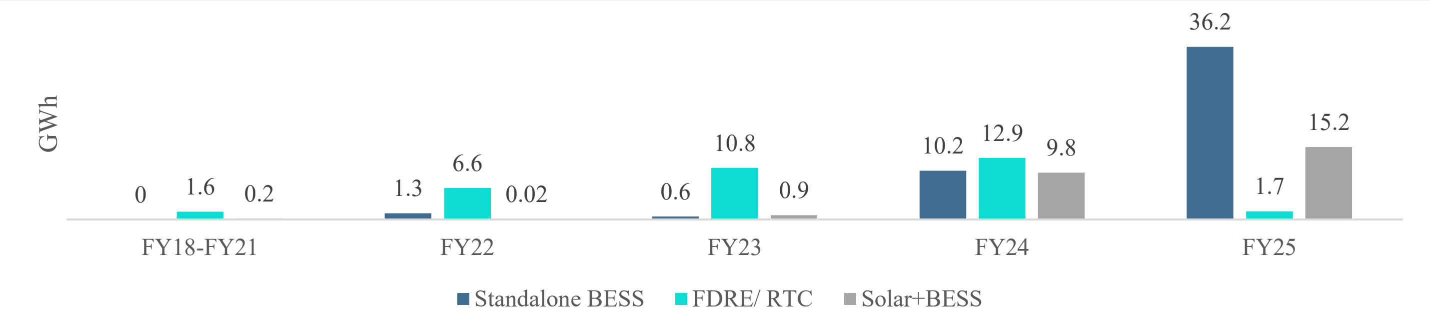
The BESS manufacturing ecosystem in India is currently centred on battery pack assembly and system integration, with domestic firms importing lithium-ion cells and assembling them into modules and containerised storage systems for grid-scale and renewable energy applications.

7.8 Tender Trends and Prices

FDRE and RTC bids have discovered higher tariffs of around Rs 4.3–5.1/kWh, with peak and storage-heavy tenders reaching up to Rs 8.5/kWh, reflecting the cost of storage and round-the-clock supply obligations. Overall, while these tariffs carry a premium, they indicate growing acceptance by procurers for reliable, dispatchable renewable power.

The rising share of FDRE and RTC tenders is expected to significantly support BESS capacity expansion in India, as these procurement frameworks inherently require integrated energy storage solutions. Unlike conventional renewable or hybrid tenders, FDRE and RTC projects necessitate storage to address intermittency, maintain minimum supply commitments, and avoid deviation-related penalties. The sharp increase in FDRE/RTC tender volumes from about 0.02 GWh in FY22 to nearly 12.9 GWh in FY24 has consequently accelerated BESS deployment, given the embedded storage requirement. However, in FY25 there has been a noticeable decrease in the issuance of demand profile following FDRE tenders due to their stringent power delivery, availability conditions and solution complexity. Instead, FDRE tenders are shifting their focus to ensuring power availability for energy offtakes during peak hours.

Chart 57: Category-wise Annual Trend of Tenders



Source: IESA, CareEdge Research

Table 34: FDRE Projects in India

Tender Month	Tendering Authority	FDRE Capacity (MW)	FDRE Awarded Capacity (MW)	RE (MW)	ESS (MWh)	FDRE Category	Current Status	Winner	Winning Bid (INR)
Jun-23	SJVN	1,500	1,180	2,368	664	Assured Peak	Under Execution	O2, Blupine, ACME, HFE, TPREL, Juniper, ReNew	4.38–4.39/kWh
Sep-23	NHPC	1,500	1,400	NA	NA	Assured Peak	Under Execution	Brightnight, HFE, Blupine, Juniper, ReNew, ACME	4.55–4.63/kWh
Oct-23	NTPC	3,000	1,530	3,499	415	Assured Peak	Under Execution	Axis, ReNew, TPREL, Juniper, Serentica, Brightnight, HFE	4.64–4.73/kWh
Jan-24	NHPC	1,200	1,200	NA	NA	Assured Peak	Under Execution	Essar, Juniper, Serentica, Hexa Climate, Avaada	4.37–4.38/kWh
Jun-24	NTPC	1,200	760	NA	NA	Assured Peak	Tender Awarded	Hexa Climate, ACME, Avaada	4.69–4.70/kWh
Jun-24	NHPC	1,200	2,350	NA	NA	Assured Peak	Under Execution	Rays Power, Avaada, ACME, Juniper	4.48–4.56/kWh

Sep-24	SECI	2,000	200	200	800	Peak Only	Tender Awarded	O2 Power	8.50/kWh
Dec-24	SJVN	1,500	1,500	NA	NA	Peak Only	Tender Awarded	ACME, Blupine, Sembcorp, Reliance NU	6.74/kWh
Apr-25	TATA Power	250	250	NA	NA	Assured Peak	Tender Awarded	TPRIL, ACME, Juniper, Navayuga	4.76–4.77/kWh

Source: IESA, CareEdge Research, Note: Data updated as on 29 November 2025

Table 35: RTC Projects in India

Tender Month	Tendering Authority	FDRE Capacity (MW)	FDRE Awarded Capacity (MW)	RE (MW)	ESS (MWh)	FDRE Category	Current Status	Winner	Winning Bid (INR)
Mar-24	SJVN	1,200	2,400	4,855	1,959	RTC	Under Execution	Hero, Zelestra, Juniper, ReNew, Avaada	4.25/kWh
Sep-24	SJVN	1,200	448	NA	NA	RTC	Tender Awarded	ReNew, EG Energy, Dinesh Chandra, Serentica, TPREL	4.82–4.91/kWh
Oct-24	SECI	1,200	420	1,272	1,283	RTC	Under Execution	HFE, Jindal, Sembcorp, Hexa	5.06–5.07/kWh

Source: IESA, CareEdge Research, Note: Data updated as on 29 November 2025

Table 36: Stand-alone BESS Tenders

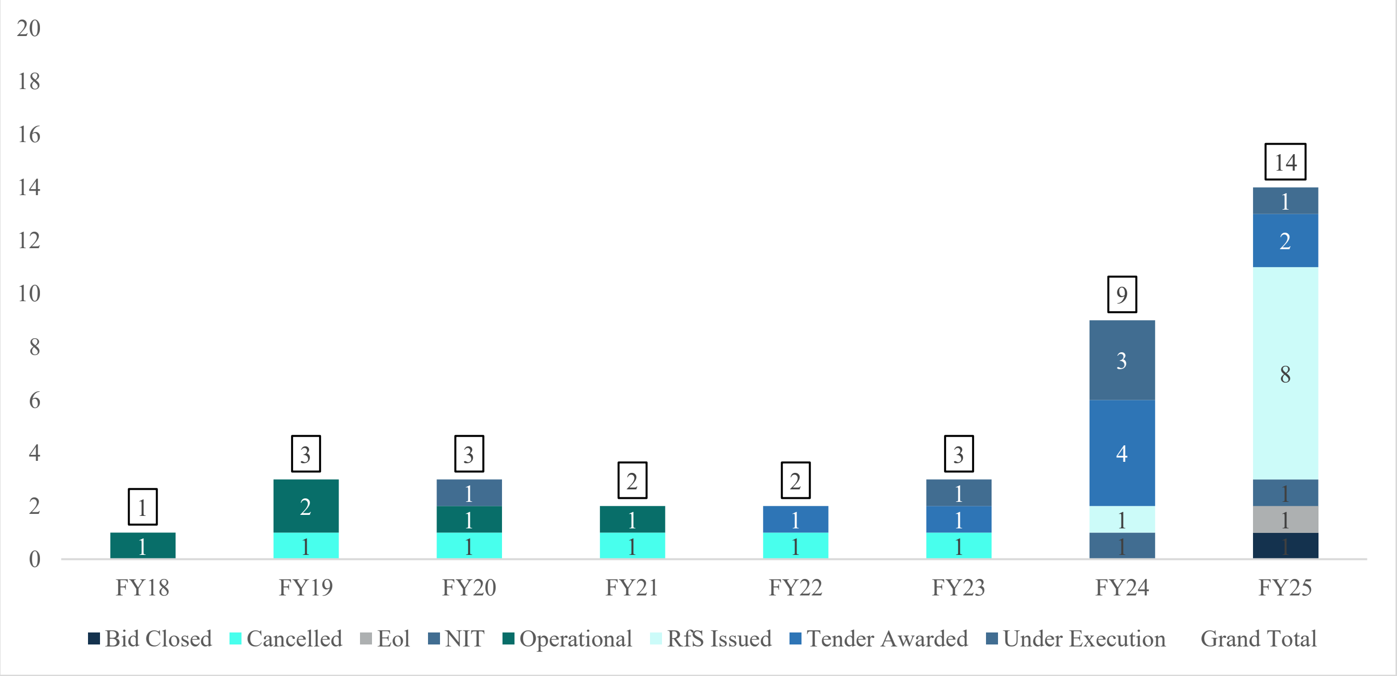
Tender Month	Tendering Authority	Power Capacity (MW)	Winners	Winning Quote (Rs lacs/MW/month)
Apr-22	KSEB	10	Hero Future	11.25
Oct-22	UPPCL	50	ACME, JSW, Continental Milkose	10.66
Nov-23	GUVNL	250	Indigrid, Gensol	4.49
Mar-24	GUVNL	500	Gensol	3.72
Jun-24	NTPC	500	Indigrid, HS Infra, Kintech Synergy	2.37
Jun-24	SECI	1000	JSW, Reliance ADA	3.81
Aug-24	GUVNL	500	Kintech, HG Infra, Bhilwara, Adwait	2.26
Nov-24	RVUNL	500	Oriana, JSW, Rays Power, Solarworld	2.21
Dec-24	SECI (Kerala)	125	JSW Energy	4.41
Jan-25	GUVNL	500	Solarworld, HG Infra	2.8
Jan-25	NHPC (Kerala)	125	NTPC, Opera Energy	4.34
Jan-25	TGGNCO	250	Bondada Engg, Oriana Power, Pace Digitek	2.4
Feb-25	KPTCL	500	Sarala, Oriana, Pace Digitek	2.49

Feb-25	BSPGCL	125	Barbrik, Saatvik Green, Kundan Green, Prostram, Hindustan Thermal, Suryam International	4.4
Feb-25	NHPC (AP)	500	Patel Infra, ACME	2.08
Feb-25	SJVN (UP)	375	Patel Infra, Energrid	3.59
Feb-25	NTPC (UP)	250	Sunsure, Indigrid	6.64/kWh
Feb-25	NVVN (RJ)	500	Solar 91, Rays Power, experts, Stockwell Solar, Oriana	2.16
Feb-25	TNGECL	500	Bondada Engg, Oriana, NLC	2.46
Jun-25	RVUNL	1000	Stockwell, OIL, Micromax, Patanjali, RCRS, Viviana, Galaxy, Manda, Mineralia, Onward, ST Elect	1.775
Jun-25	KPTCL	150	KP Group, Engg, MEC Power, Samavit, Stockwell, Solar 91	2.54
Jul-25	GUVNL	2000	Viviana, Rashi Power, Ultimate Flexipack	1.85
Jul-25	MSEDCL	2000	Patanjali, Bhilwara, Diwakar, Armee Infotech, Mahati Industries	1.65
Aug-25	RVUNL	500	Ultravitant, Rama Reflection, Patanjali, Mecpower, Bhagwati, Diwakar Solar	2.85
Aug-25	APTRANSCO	1000	Ecoren, Bondada	1.47

Source: India Energy Storage Alliance (IESA), CareEdge Research, Note: Data updated as on 29 November 2025

Falling battery prices are clearly reflected in the sharp decline in BESS tariff discovery across successive tenders. Winning quotes have fallen from Rs 11.25 lakh per MW per month in April 2022 to Rs 1.47–1.85 lakh per MW per month by July–August 2025, implying a reduction of nearly 85–90% over three years. This steep decline mirrors the drop in lithium-ion battery prices, improvement in system integration efficiencies, and lower financing costs as the risk perception around BESS reduces.

Chart 58: Solar with BESS Tender overview



Source: India Energy Storage (IESA), CareEdge Research, Note: Data updated as on 29 November 2025

There has been an increasing trend for the number of integrated tenders issued over the last few years. In FY25 the highest number of requests for selection (RfS) were issued for Solar with BESS tenders, in the same year no cancellation of tenders were seen for this category.

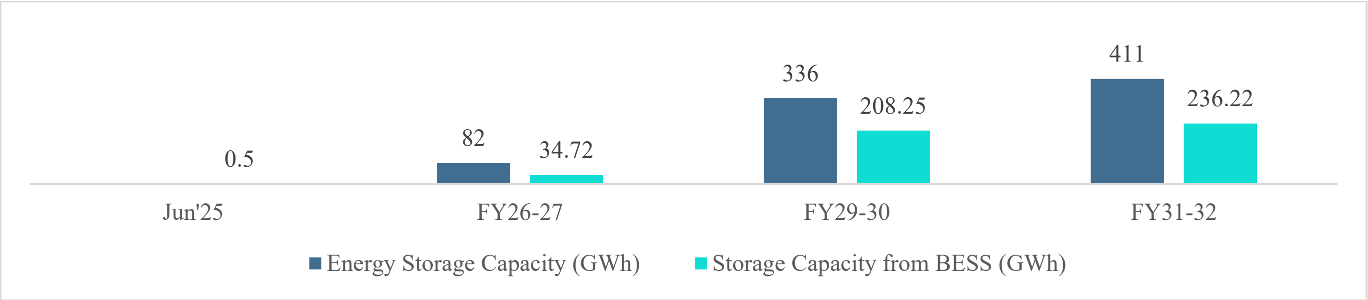
7.9 Review of BESS Capacity Addition in India

While the current installed base of grid-scale BESS in India remains at an early stage (predominantly pilot deployments, initial utility procurements and C&I backup and power quality applications), the forward demand outlook is being shaped by national power system planning projections and an expanding pipeline of competitive bids for stand-alone and renewable-plus-storage projects.

As per National Electric Plan (NEP) 2023 the battery energy storage capacity requirement is projected to add ~201 GWh from FY27-FY32. To develop this storage capacity during the estimated fund requirement for BESS would be ~Rs 2,926 billion during FY27-FY32.

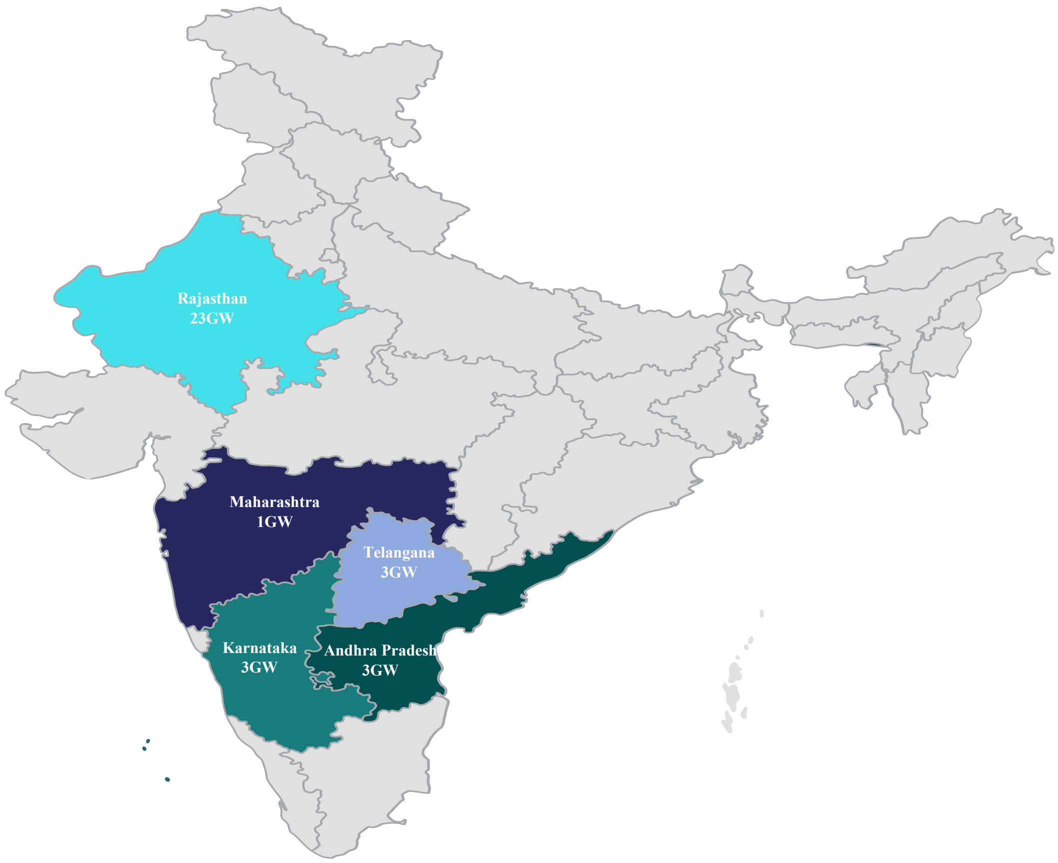
However, between 2022 and early 2025, India auctioned approximately 12.8 GWh of battery energy storage system (BESS) capacity for both hybrid and standalone applications out of which only about 219 MWh of BESS capacity is reported to be operational, leaving a large pipeline of projects under construction.

Chart 59: BESS Energy Capacity Storage (GWh)



Source: CEA, IESA, CareEdge Research

Figure 10: State-wise BESS Addition by 2030

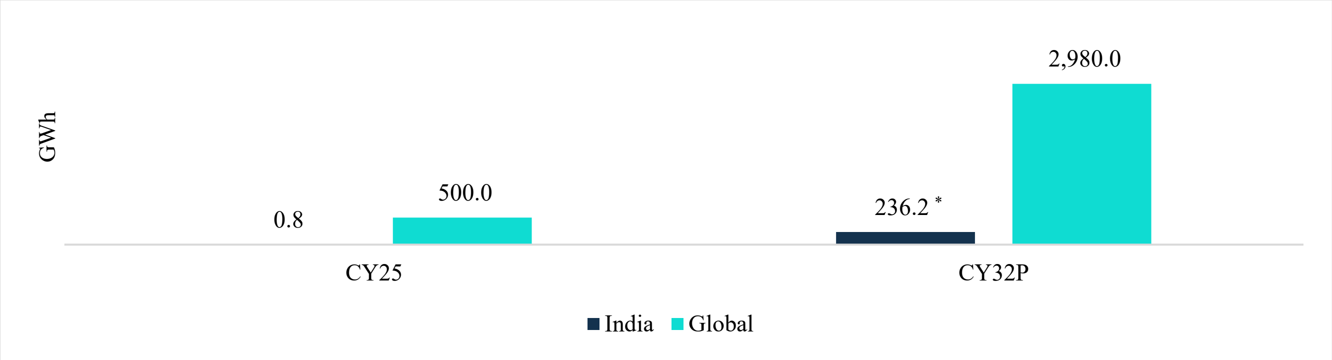


7.10 India’s Position in Global BESS Market

India’s current position in the global BESS market remains nascent in terms of commissioned capacity. In 2025, India’s operational BESS capacity was 0.76 GWh against global operational capacity of 500 GWh, indicating a negligeable share of global deployments and a lower installed base than leading markets such as China and the United States, where storage has scaled on the back of earlier adoption of grid flexibility solutions and faster conversion from procurement to commissioning.

Looking ahead, India’s projected BESS capacity by 2032 remains meaningful but still smaller than the global capacity. In 2032, India’s BESS capacity is expected to reach 236.2 GWh against a global capacity of 2,980 GWh, indicating that India’s global relevance will depend on the pace of execution and commissioning. This growth trajectory is supported by improving project economics and procurement frameworks, with declining battery costs lowering delivered storage costs and enabling BESS viability across applications such as renewable firming, peak shifting and grid support. In addition, policy measures are expected to strengthen project bankability by improving revenue visibility and reducing execution risk, including the viability gap funding framework for BESS and ISTS waivers for eligible storage projects, alongside planning guidance that encourages bundling storage with solar. Tendering momentum is expected to remain a key leading indicator of future commissioning, supported by improved economics and policy support, with BESS tendered volumes already increasing from 4 GWh in CY23 to 60 GWh in CY25.

Chart 60: India vs Global BESS Capacity



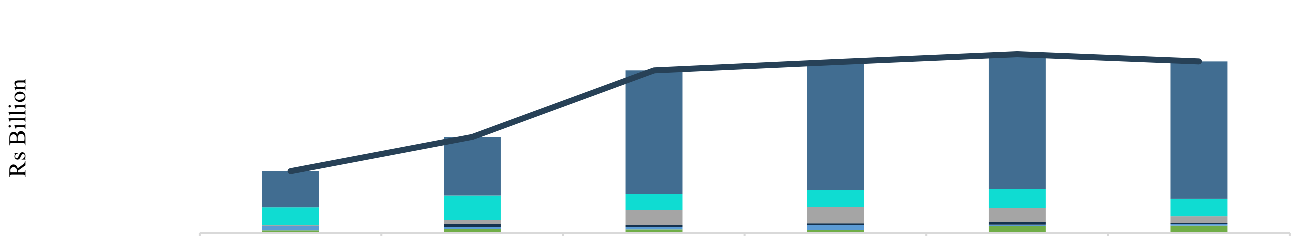
Source: CEA, IESA, CareEdge Research, *Note: For India year 2032 is on FY Basis

7.11 Import Dependency in BESS

In BESS value chain, battery and PCS accounts for the largest share in total system cost, which makes cell sourcing a key driver of economic feasibility of these projects. India’s current manufacturing remains concentrated in downstream integration, where cells are imported and assembled into modules and packs, or in some cases packs are imported directly. As a result, availability of battery hardware continues to depend on imports, while domestic value addition is limited to pack assembly, integration and testing.

India majorly imports lithium batteries, inverters and other power electronics from China, South Korea, Hong Kong, and Singapore. China accounts for an average of about 71 percent of India’s lithium battery imports and about 56 percent of inverter imports, making India highly dependent on China for two cost critical components. This dependence increases exposure to foreign exchange movements, and susceptible to policy or geopolitical disruption risk, pricing cycles, and global market instability.

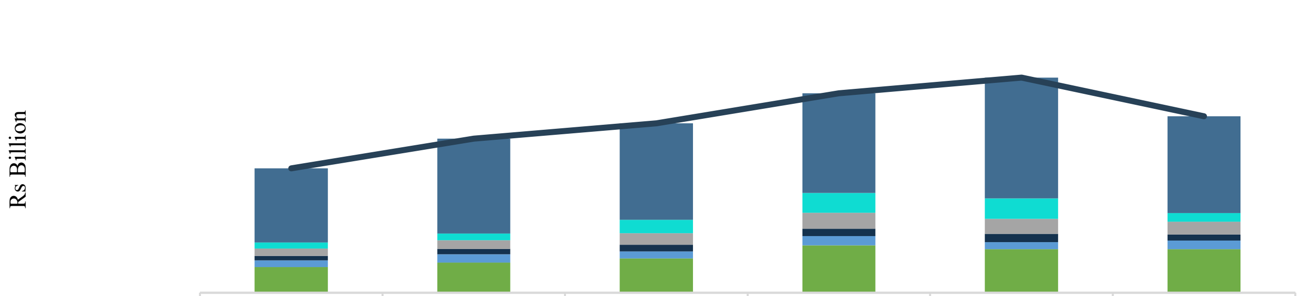
Chart 61: Trend in Import of Lithium Battery



	FY21	FY22	FY23	FY24	FY25	FY26*
China	51.7	83.5	176.4	182.5	191.5	195.7
Hong Kong	25.5	34.8	22.2	24.2	27.4	24.7
Korea	0.7	5.5	21.6	23.0	20.3	9.7
Singapore	0.8	4.5	3.1	2.4	3.6	1.3
Vietnam	5.7	2.4	3.2	6.6	1.8	2.4
Others	3.8	6.1	5.0	4.7	9.9	10.6
Total	88.1	136.7	231.5	243.5	254.6	244.3

Source: Ministry of Commerce, CareEdge Research Note: HSN Code: 85076000, * denotes data as of November 2025

Chart 62: Trend in Import of Inverters



	FY21	FY22	FY23	FY24	FY25	FY26*
China	55.3	70.9	72.0	74.5	90.4	72.5
Singapore	4.6	5.0	10.1	14.8	15.1	6.4
Germany	5.5	6.5	8.6	11.8	11.3	9.5
USA	3.4	3.9	4.9	5.6	6.3	4.6
Hong Kong	5.0	6.2	5.4	6.8	5.2	6.4
Others	19.2	22.6	25.5	35.5	32.6	32.6
Total	93.0	115.1	126.6	149.0	160.9	132.0

Source: Ministry of Commerce, CareEdge Research Note: HSN Code: 850440, * denotes data as of November 2025

To enhance domestic manufacturing and reduce reliance on imports, the Indian government has introduced several key policies. Under the PLI Scheme for Advanced Chemistry Cell (ACC) Battery Storage programme, the targeted 50 GWh of cell manufacturing capacity has seen 40 GWh awarded to beneficiary companies. Besides the PLI ACC scheme applicants, more than 10 companies have announced a cumulative capacity of about 178 GWh in the country over the next five years. Along with The National Critical Mineral Mission, rare earth corridor for critical minerals is planned for development across states like Odisha, Kerala, Andhra Pradesh and Tamil Nadu to support exploration, processing, recycling and capability building for critical minerals, which are critical for long term battery supply chain. In addition, increment of VGF from Rs 100 crore to Rs 1,000 crore for BESS projects and extension of BCD exemption to capital goods used in BESS manufacturing can further improve bid viability and lower manufacturing set-up costs, which should support tendering momentum. Beyond policy support, private sector's investments in R&D, material localisation, and recycling infrastructure can also help reduce cost and dependence on import. These initiatives will help increase the BESS value chain indigenisation from 20-25% in 2025 to 45-50% by 2030.

7.12 Key Cell Manufacturers, Pack/Assemblers and BESS Deployers

Table 37: Key Cell Manufacturers in India

Company	Commissioned capacity	Expected Cell capacity	Capex Plan	Application
Ola Cell Technologies	1.4 GWh	Expansion to 5 GWh by Q1FY27	NA	EV cells
Agratas (Tata Group)	Under Development	20 GWh	Total initial capex outlay of Rs 130 billion.	EV + storage
Amara Raja Energy & Mobility	Phase I FY27-end commissioning target	Phase I - 2 GWh and plans to expand to 16 GWh	Total capex outlay of Rs 95 billion till FY31 in cell gigafactory and a battery pack assembly unit	Automotive and stationary energy storage systems
ACC Energy Storage Pvt Limited (Rajesh Exports Limited)	Under Development	5 GWh under PLI	NA	EV + ESS
Reliance New Energy	Under Development	40 GWh, expected to be completed in 2026	NA	EV + stationary
Jindal India Renewable Energy	Under Development	5 GWh cell capacity target by 2027	NA	Energy storage ecosystem
Exide Industries	Phase I FY26-end commissioning target	Phase I - 6 GWh and plans to expand to 12 GWh.	Total capex outlay of Rs 52 billion for Phase I, out of which Rs 39.5 billion invested till date.	Nickel-Cobalt-Manganese battery production line for 2Ws and company plans a prismatic LFP line aimed at stationary energy-storage applications
Waaree Group	Under Development	4 GWh	NA	EV + ESS
Vikram Solar	Under Development	1 GWh and plans to expand upto 5 GWh	NA	EV + ESS
Nsure Reliable Power Solutions	Under Development	1 GWh (expandable to 5 GWh)	NA	EV + ESS
Log9 Materials	50 MWh	NA	NA	EV

Source: Industry Sources, Company Filings, CareEdge Research

Table 38: Key Pack Assemblers and BESS Manufacturers

Sr. no	Company	Commissioned Capacity	Expected Capacity	Capex Plan	Type of Facility
1	Invergy India Pvt. Limited	500 MWh	2.5 GWh by Q4 FY26 and 5 GWh by FY28	NA	BESS Manufacturing Facility
2	Waaree Energies Limited	Under Development	5 GWh with Phase I (3.5 GWh) expected to start commercial production in FY27	The company has announced an overall capex plan of Rs 25,000 crore, which includes Rs 8,175 crore approved for battery energy storage systems (BESS). The BESS capacity will expand from 3.5 GWh to 20 GWh.	Pack and Container Facility

3	JSW Energy	To be commissioned in FY26	5 GWh expected to be commissioned in FY26	NA	Battery Assembly
4	Nash Energy	2GWh	NA	NA	Prismatic Battery pack manufacturing line
5	GoodEnough Energy	7GWh	Plans to expand capacity to 25 GWh within 3 years	NA	BESS Manufacturing Gigafactory
6	Godawari New Energy	Under Development	20 GWh in Phase I expected to be commissioned by FY27, 20 GWh in Phase 2 expected to be commissioned by FY29	Capex of Rs 16.3 billion for BESS plant which will be commissioned in 2 phases	BESS Manufacturing Facility
7	DDev Plastiks Industries	Under Development	5GWh	Capital Expenditure of Rs 1.5-2 billion and plant is expected to be commissioned in FY27	BESS Manufacturing Facility
8	Pastiche Energy Solutions	Under Development	1.5GWh, expected to be commissioned in FY26 and plans to expand capacity to 5 GWh	The company has announced capex of Rs 10 million for Phase 1 alongwith plans for backward integration to manufacture cells at the same facility	BESS Manufacturing Facility
9	Prostarm Info Systems	Under Development	1.2GWh, expected to be operational by end of FY26	The company has announced capex of Rs 250 million for the plant.	BESS Manufacturing Facility
10	Cygni Energy	4.8 GWh	10.8 GWh, expected to be comissioned by CY27	The company has announced capex of Rs 1.5 billion for expanding the capacity to 10.8 GWh.	BESS Manufacturing Facility
11	Vikram Solar Limited	Under Development	5GWh	The company has announced Rs 4.37 billion for Phase 1 of BESS manufacturing plant	BESS Manufacturing Facility
12	Amara Raja Energy and Mobility Limited	1 GWh for Stationery Application and 1.5 GWH for Mobility Application	Capacity Expansion to 5 GWh	Investment of Rs 9.5 billion for Gigacorridor	Pack Assembly
13	Exide Industries Limited	1.5 GWh	NA	NA	Pack Assembly
14	SPML Infra Limited	Under Development	The plant will be developed in two phases: 2.5 GW by Q1 FY27 and 5 GW by FY28	Capital expenditure of Rs 1.75 billion funded through preferential allotment and internal accruals.	BESS Manufacturing Facility
15	Luminous Power	500 MWh	NA	NA	Pack Assembly

Source: Industry Sources, Company Filings, CareEdge Research

Table 39: Key BESS Deployers

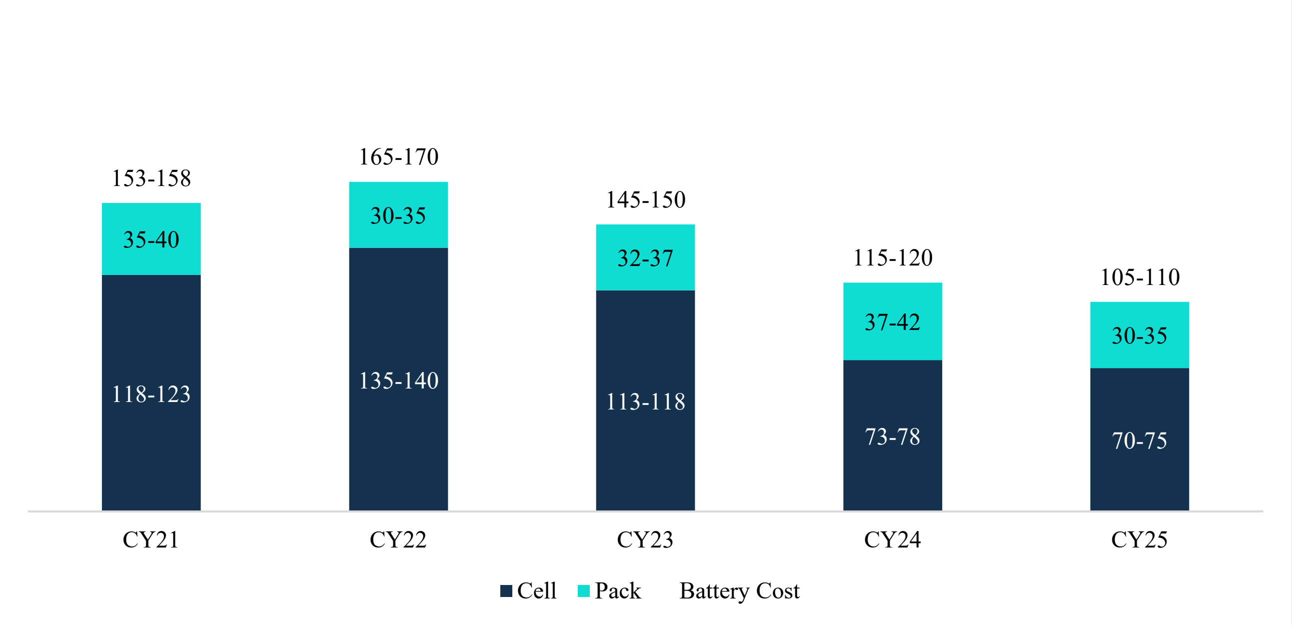
FDRE	Solar + BESS	Standalone BESS
O2 Power Private Limited	Larsen & Toubro	JSW Energy
BluPine Energy	Mahindra Susten	Hero Future Energies
ACME Solar	SunSource Energy	ACME Solar
BrightNight India	Tata Power	Reliance Infrastructure
Tata Power Renewable Energy	Nsure Energy	IndiGrid
Axis Energy Ventures India	Reliance Infrastructure	NTPC Green Energy
Juniper Green Energy	JBM Group	Rays Power Infra
Essar Renewables	Sunsure Energy	Pace Digitek
Hexa Climate Solutions	BluPine Energy	Opera Energy
Avaada Energy	ACME Solar	N G Infra Engineering
Rays Power Infra	Pace Digitek	Bhilwara Group
Serentica Renewables	SAEL	TrueRE
ReNew Private Limited	Hero Future Energies	Bondada Group
JSW Energy	NTPC	Patel Infrastructure Limited
Hero Future Energies	Jindal India Renewable Energy	ProSTARM
Vena Energy	Hindustan Power	Hindustan Power
	Onix Renewable	Kundan Green Energy
	Adani Group	Advait Infratech
	Sembcorp	Barbrik Projects
	Prozeal Green Energy	Sarala Project Works
		Solar 91 Cleantech
		Rays Power Experts
		Stockwell Solar
		NLC India
		Sunsure Energy
		Kintech Synergy

Source: IESA, CareEdge Research

7.13 Average Pricing of Cell, Pack and Battery

Over the five years the battery prices have declined significantly, with battery prices declining by ~47% between CY21 and CY25, primarily driven by a sharp reduction in cell-level pricing. The temporary increase in prices in CY22 was attributable to supply chain disruptions following the COVID-19 pandemic, which led to shortages of critical raw materials and elevated input costs across the lithium-ion battery ecosystem. From CY23 onwards, prices declined at an accelerated pace, supported by scaling up of production capacities, rising demand from electric vehicles and stationary energy storage applications, and continued improvements in battery manufacturing processes. In addition, innovations in battery chemistries such as the development of solid-state batteries and other next-generation technologies, advancement in recycling technologies, and the establishment of large-scale gigafactories enabled economies of scale and structural cost efficiencies, contributing to sustained reduction in prices across the battery value chain.

Chart 63: Average Prices of Battery (USD/KWh)



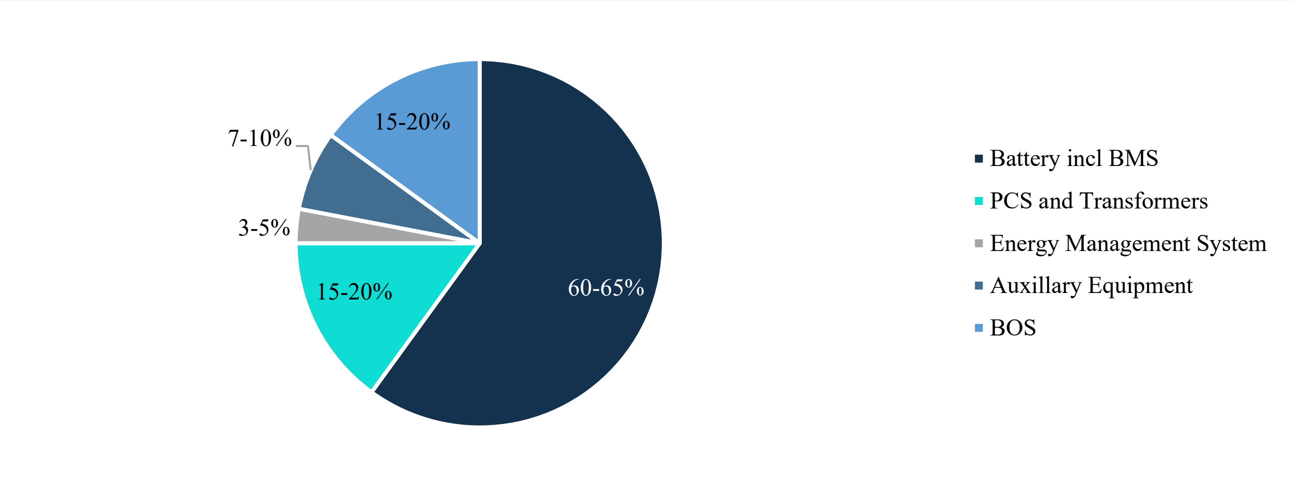
Source: CareEdge Research

7.14 Percentage Share of BESS Components

The cost break-up of a BESS consists of battery subsystem, power conversion and grid interface equipment, control systems, auxiliary systems, and balance-of-system (BOS). The battery including BMS constitutes the largest share, accounting for 60% to 65% of total system cost, as it covers the cells and packs along with the Battery Management System required for monitoring state-of-charge, voltage, temperature and safety parameters. This cost is significant because the battery subsystem is the core energy-storing asset and largely determines usable energy capacity, round-trip efficiency, degradation profile, warranty terms and replacement risk over the project life. Further, battery costs are highly sensitive to active material prices and cell supply-demand balance and embed safety and compliance requirements (BMS hardware, sensing, controls) that are critical for grid-scale deployment.

The PCS and transformers contribute at around 15% to 20%, as this equipment enables DC–AC conversion, synchronisation with the grid, and electrical stepping as per interconnection requirements. The Energy Management System (EMS) typically contributes 3% to 5%, given its role in operational scheduling, dispatch optimisation, performance analytics, and integration with SCADA or grid operator signals. The remaining share is attributed to Auxiliary Equipment and BOS, which includes thermal management systems and related safety infrastructure, enclosures or containers, cabling, switchgear, protection systems, structural works, and other site-level electrical and civil components required to commission the system. Overall, the BESS cost structure is primarily driven by the battery subsystem, while project-level engineering requirements and grid integration specifications influence the cost share of PCS, BOS, and auxiliary systems.

Chart 64: Cost Break-up of BESS Plant



Source: CareEdge Research

7.15 EPC Cost of BESS

Table 40: Total Project Cost Breakdown for Setting up BESS Plant in India

Particulars	Amount (Rs Cr/MWh)
Battery	0.72
Inverter/ PCS	0.14
Balance of System	0.06
EMS and others	0.02
Bay Construction Cost	0.09
IDT Transformers	0.02
Capex for Auxiliary Power	0.08
Civil Works	0.01
Total Plant and Machinery	**1.13**
Installation and Commissioning Cost	0.05
Contingency	0.01
Pre-operative Expenses	0.05
Interest During Construction	0.07
DSRA (Debt Service Reserve Account)	0.03
Total Soft Cost	**0.2**
Total Project Cost	**1.33**

Source: CareEdge Research

Note: The data is provided for indicative purposes only.

7.16 Key Battery Manufacturers Globally

The global battery manufacturing is dominated by companies based in China, South Korea, and Japan, with CATL, BYD, and LG Energy Solution leading in production. These top companies collectively hold a vast majority of the market share, driven by rising demand for lithium-ion and solid-state batteries.

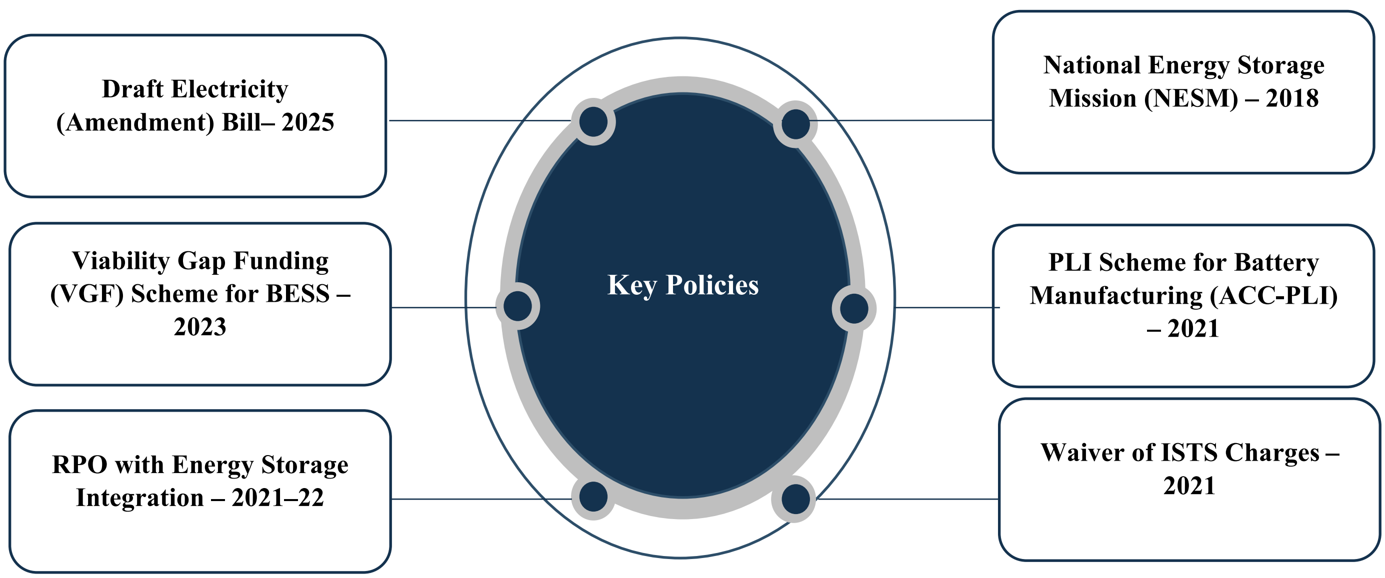
Table 41: Key Global Battery Manufacturers

Manufacturers	Country	Capacity (GWh)
CATL	China	676
Tesla	USA	80
LG Energy Solution	South Korea	310+
Samsung SDI	South Korea	29.6
BYD	China	134.5
SK On	South Korea	40
Panasonic Energy Solution	Japan	41

Source: Industry Sources, CareEdge Research

7.17 Policy Support and Framework for Promoting Energy Storage Systems

India's push towards a renewable energy-driven future is heavily dependent on the integration of Battery Energy Storage Systems (BESS). To support this, the government has established several policies and frameworks to foster the development and deployment of energy storage. Here are key aspects of the policy support and framework:



- **National Energy Storage Mission (NESM):** The NESM is a comprehensive policy roadmap to develop a strong energy storage ecosystem in India. It focuses on creating an enabling environment for BESS deployment across multiple sectors, from grid-scale to commercial and industrial (C&I) applications. The mission outlines roadmap for large-scale storage adoption and aims to reduce storage costs, foster domestic manufacturing, and integrate energy storage with renewable projects. It also focuses on research and development (R&D) in advanced storage technologies to encourage innovation.

- **PLI Scheme for Battery Manufacturing – (ACC PLI):** The government has launched the Production Linked Incentive (PLI) scheme with an outlay of Rs 18,100 crore and aims to build 50 GWh of domestic manufacturing capacity for batteries and support domestic battery manufacturing, particularly for advanced chemistry cells storage (ACC). This initiative is expected to boost the domestic manufacturing capacity of battery cells, enabling cost reduction and ensuring a steady supply of BESS solutions for various energy sectors in India.

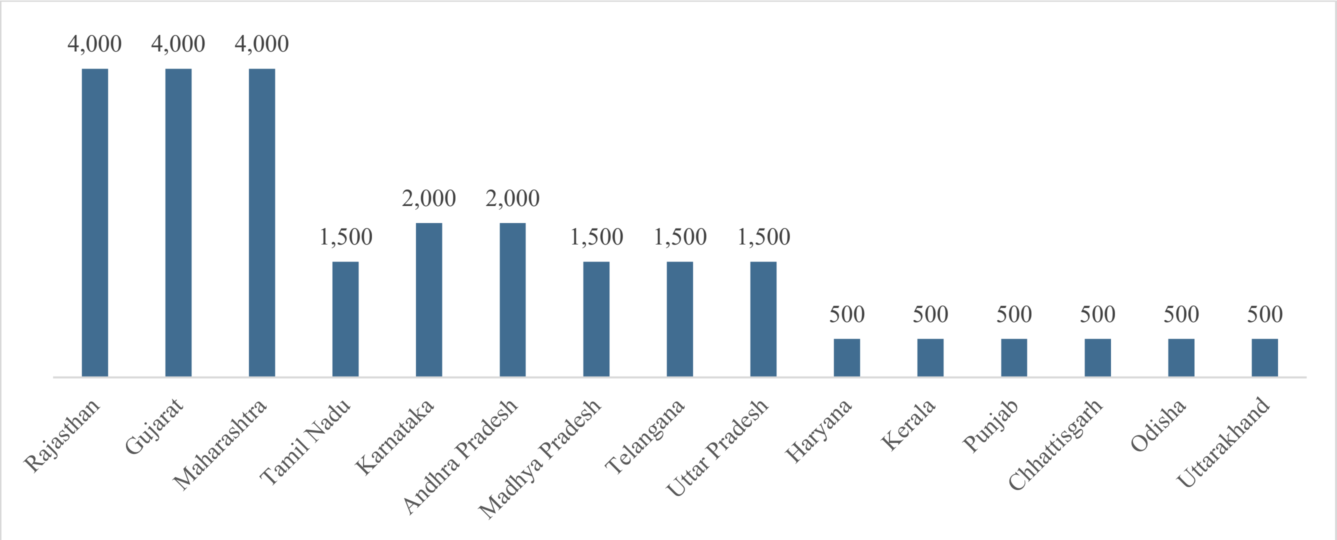
- **Waiver of ISTS Charges:** Waiver of Inter-State Transmission System (ISTS) charges has been provided for co-located BESS projects commissioned and PSPs awarded up to June 2028, to improve project viability.

- **Renewable Purchase Obligation (RPO) with Energy Storage Integration:** The Renewable Purchase Obligation (RPO) mandates state distribution companies (Discoms) to procure a certain percentage of their power from renewable sources. This obligation is now being expanded to include storage, that mandates by FY30, 4% energy consumed shall be solar/wind energy along, with/ through storage. This pushes Discoms to integrate BESS for more effective renewable energy usage and ensures that renewable energy can be stored and dispatched as needed, enhancing grid stability, managing peak loads, and reducing wastage of renewable energy.

- **Viability Gap Funding (VGF) Scheme for BESS (Tranche II):** With the budgetary allocation of Rs 5,400 Crore the scheme aims to provide VGF of Rs 18 lakh per MWh supporting a development of BESS capacity of 30 GWh.
  Out of 30 GWh, 25 GWh has been allocated across 15 Indian states, while 5 GWh is designated for NTPC. The scheme is projected to attract investments worth approximately Rs 33,000 crore, supporting India's near-term BESS targets through 2028. Among the states, the highest allocations were received by Rajasthan, Gujarat and Maharashtra, together accounting for nearly half of the total. This builds upon the previous 2023 scheme (Tranche I) that had supported 13.2 GWh with approved budgetary allocation of Rs 3,760 Crore.

In Addition to the above the Ministry of Power (MoP) has issued formal guidelines requiring future solar power procurement to incorporate Energy Storage Systems (ESS) so that solar generation can be made firm, flexible and dispatchable as part of grid planning. These guidelines were introduced with the National Framework for Promoting Energy Storage Systems, first issued in November 2021 and subsequently updated, which directs that all new solar and wind tenders include storage/firming mechanisms such as BESS or pumped hydro to improve grid integration, reduce curtailment, and provide ancillary services.

Chart 65: State-wise BESS Capacity Allocation (MWh) (2025)



Source: Digital Sansad, CareEdge Research

- **Draft Electricity (Amendment) Bill 2025:** The bill aims to transform the existing market structure by rationalising cross-subsidy, promoting cost-reflective tariffs and enabling direct procurement of power by industrial users. It seeks to dismantle longstanding barriers to India's manufacturing competitiveness, making industrial power more affordable, reliable, and responsive to market demands, and at the same time protecting the subsidised tariff for farmers and other eligible consumers

7.17.1 Selection of BESS Developers

Bidding Process

The Scheme's earmarked capacity will be offered in multiple tranches through a competitive bidding process. Any shortfall in the annual awarded capacity compared to the planned annual capacity will be carried forward to the subsequent year.

Project Developer Capacity Limits

To ensure wider participation, a single project developer shall be awarded a maximum of 50% of the total capacity offered in a particular tranche. Additionally, a project developer shall not be awarded a cumulative capacity exceeding 1,000 MWh across all the tranches. Only projects with a minimum capacity of 100 MWh shall be eligible for award. The projects shall be on a stand-alone basis

Project Developer Eligibility

It shall be ensured that both public and private sectors participate in the bid and that there is at least one bid from a private sector participant in every tranche, failing which the bid shall be cancelled, and tender will be floated afresh.

Contract Period

The project contract period, ranging from 10 to 12 years, shall be pre-specified in the RfS document. The contract shall be awarded on Build Own Operate (BOO) basis.

Developer Selection

Projects shall be awarded using the Tariff-Based Competitive Bidding (TBCB) process conducted by the BIAs in accordance with the RfS document.

Contract

The BIA initiates the bidding process and signs a Battery Energy Storage Purchase Agreement (BESPA) with the successful bidder for the specified contract period.

7.18 Key driving factors for adoption of BESS in India

Benefit	Benefit
Improved utilisation of renewable energy	BESS stores surplus electricity generated from solar or wind during periods of high production and supplies it later when output is low. This reduces renewable energy curtailment and helps align generation with consumption patterns. As a result, clean energy can be used more consistently throughout the day rather than only when generation conditions are favourable. Further, declining battery prices and falling storage tariffs have significantly improved the commercial viability of BESS
Backup power and energy reliability	BESS provides a dependable power source during grid interruptions, ensuring continuity for households, businesses and critical facilities. It reduces exposure to weather-related disruptions and unexpected outages. BESS is also deployed across data centres, telecom towers and industrial consumers to provide reliable backup power, power quality management and peak shaving to reduce demand charges.
Lower dependence on the grid	With on-site storage, consumers can use more of the energy they generate themselves and rely less on imported electricity from the grid. This supports greater energy autonomy and reduces sensitivity to grid disturbances and peak-time supply limitations. It also becomes relevant as climate-driven events increase stress on distribution infrastructure.
Reduced carbon footprint	By enabling higher consumption of renewable power and lowering reliance on fossil-fuel-based backup sources, BESS supports emission reduction goals. Storage minimises renewable energy wastage and increases clean energy utilisation, contributing to long-term sustainability commitments for both households and businesses.
Long-term cost savings	While installation requires initial investment, BESS can reduce electricity costs through peak-shaving, self-consumption of on-site energy, and lower demand charges. Over time, reduced energy bills and improved energy efficiency offset upfront expenditure. In commercial settings, storage can also help avoid operational losses caused by power disruptions.

Declining BESS costs, along with improved system integration and lower financing costs, has resulted in reduced levelised cost of storage, improving project viability making BESS becomes more competitive with conventional peaking power sources and supports greater adoption for renewable integration, peak-load management and grid balancing. For every Rs 1,000/kWh reduction in BESS cost may lower the blended LCOE by about Rs 0.08–0.12/kWh, depending on the cycling assumption/ system utilisation.

7.19 Key Risks in BESS Sector

Supply Chain and Import Exposure

- BESS project costs remain sensitive to global prices and availability of lithium-ion cells and upstream inputs.
- India has limited domestic availability of several key minerals used in batteries and also has gaps in battery-grade processing and refining, which keeps the supply chain exposed to external disruptions, shipping lead times and supplier concentration risk.

Policy and Regulatory Uncertainty

- Demand visibility and bankability can be affected by changes in incentive structures, eligibility conditions and timelines for support schemes.
- Any lack of consistency across central and state measures can impact project IRRs, contracting behaviour and manufacturing investment decisions.

Financial and Economic Risks

- High initial capital costs and high financing costs make projects expensive.
- Underbidding in auctions poses long-term viability risks, while battery degradation requires costly replacements.

Availability of Land and Project Approvals

- Fluctuations in input power costs may impact overall project viability.
- Projects are subject to multiple statutory and regulatory approvals, which may vary across states.
- Delays in land acquisition and approvals can impact project timelines and cost estimates.
- Such factors may affect the timely execution and commissioning of BESS projects.

Safety, Performance Warranty and Compliance

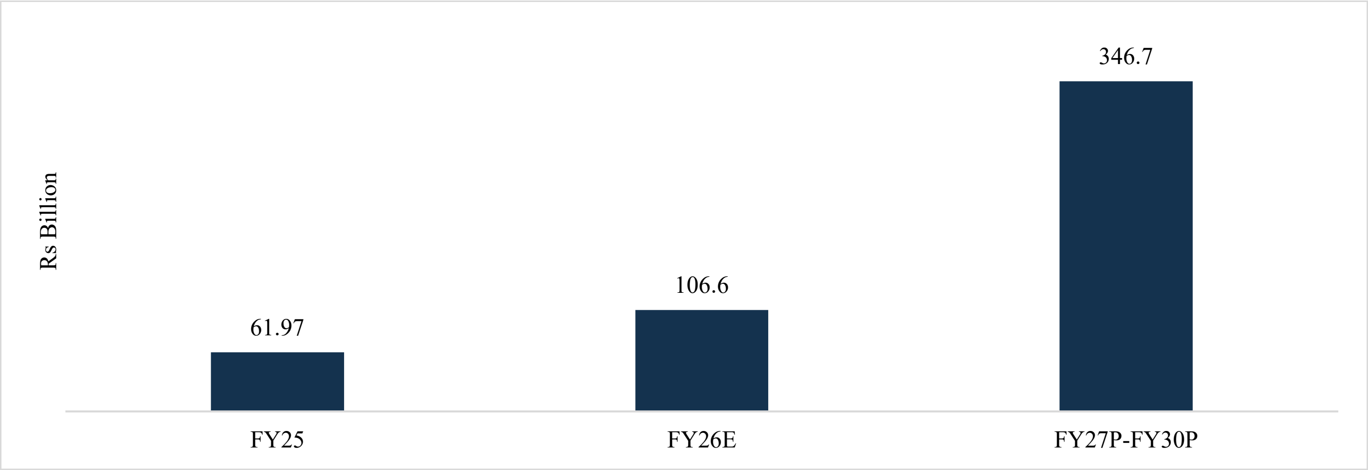
- Lithium-ion systems carry thermal and fire safety risks that require robust design, monitoring and emergency response protocols.
- Performance risk arises from degradation and availability guarantees, where outcomes depend on operating conditions and compliance with technical standards.

8 Overview of Solar frame market in India

8.1 Solar Frame Market Size in India

India's solar frame market reached Rs 61.97 billion in FY25 and is expected to reach Rs 106.6 billion by FY26. For cumulative period of FY27P-FY30P, the market size is estimated at Rs 346.7 billion. This growth is expected to be driven by sustained solar capacity additions and expansion in domestic module manufacturing, which keeps frame demand closely linked to module output volumes. In addition, the rising share of utility-scale installations and continued scale-up in rooftop solar should support broader growth in solar balance-of-materials, including mounting structures and related hardware, which typically moves in tandem with module deployments and project commissioning activity.

Chart 66: Solar Frame Market Size



Source: CareEdge Research

8.2 Benefits of Backward Integration in Frame Manufacturing

Supply Security For a Critical Input

- Frames are a high-volume, line-critical item. In-house cutting and punching reduces dependence on third-party fabricators and lowers the risk of production disruptions

Lower Lead Times and Better Production Planning

- Captive fabrication enables tighter alignment between frame availability and module line schedules, reducing uncertainty in daily dispatch planning.

Improved Module Line Uptime

- Reduced risk of line stoppages arising from delayed deliveries, wrong specifications or inconsistent quality from external vendors.

Quality and Dimensional Consistency

- Better control over cut-length tolerances and punching accuracy improves fitment, reduces rework and supports consistent output quality across batches.

Cost Efficiency in Conversion

- Internalisation eliminates job-work margins and reduces logistics, packaging and handling costs associated with sending profiles to external fabricators and receiving finished frames.

Higher Yield and Lower Scrap

- Process control over cutting and punching reduces material wastage from mis-cuts, mis-punching and burr-related rejections, improving aluminium utilisation

9 Risk and Challenges for Solar Module and Cell Manufacturing Industry in India

1. Supply Chain and Raw Materials

- **Dependence on Imports (especially China):** India currently imports key inputs like polysilicon, solar cells, wafers, and certain EVA/backsheet materials, exposing manufacturers to price volatility, supply interruptions, and geopolitical disruptions.
- **Polysilicon Supply Constraints:** Domestic polysilicon capacity is limited; ramping local supply requires high capex and technical expertise, creating bottlenecks in scaling production.

2. Financial and Cost Pressures

- **High Capital Intensity:** Setting up integrated manufacturing (polysilicon → ingot → wafer → cell → module) needs significant upfront investment, driving high financing costs.
- **Thin Margins / Price Competition:** Intense competition and global module price declines compress margins, especially if tariffs or incentives change.

3. Policy and Regulatory Risks

- **Incentive Uncertainty:** Reliance on schemes (Basic customs duty, production-linked incentives) exposes companies to policy shifts, delayed disbursals and regulatory ambiguity.
- **Trade Policy Fluctuations:** Import duty changes or anti-dumping actions can affect competitiveness but may also trigger retaliation or supply shocks if alternatives aren't ready.

4. Technology and Manufacturing Challenges

- **Rapid Tech Evolution:** Transition to newer technologies (e.g., PERC → TOPCon → HJT) requires ongoing R&D and retooling, risking technological obsolescence.
- **Scale & Yield Optimisation:** Achieving high cell efficiency and consistent quality at scale is technically demanding and requires skilled workforce.

5. Market and Demand Challenges

- **Competition from Global Players:** Chinese and Southeast Asian producers with low-cost structures dominate global module supply, making it difficult for Indian makers to compete without sustained incentives.
- **Project Payment Risks:** Delays in payments from developers, utilities, or government agencies reduce liquidity buffers.

6. External and Environmental Risks

- **Currency and Commodity Volatility:** Fluctuations in RS -USD and polysilicon/steel/glass prices affect landed cost of key inputs and profitability.
- **Climate Vulnerabilities:** Extreme weather events (heatwaves, floods) can disrupt operations and logistics.

7. Talent and Operational Risks

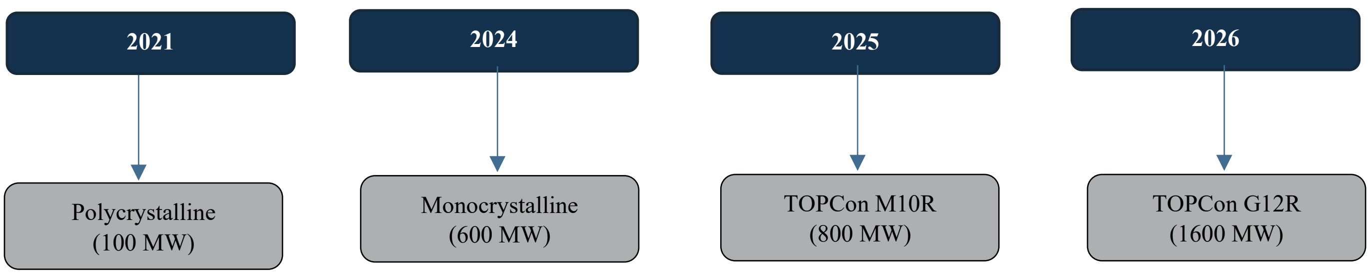
- **Skilled Workforce Scarcity:** High-tech manufacturing demands specialised engineers and technicians; shortage raises training cost and operational risk.
- **Quality Control and Warranty Exposure:** Long-term module warranties mean manufacturing defects can have multi-year financial and reputation costs.

10 Company Profile

Cosmic PV Power Limited is a manufacturer of solar photovoltaic (PV) modules serving utility-scale, commercial, industrial and residential solar markets. The company is certified by the Bureau of Indian Standards (BIS) and is listed under the Approved List of Models and Manufacturers (ALMM). It operates two automated manufacturing facilities in Surat, Gujarat, with a combined annual production capacity of about 3 GW and continues to expand its presence in the domestic PV manufacturing space.

Its product portfolio includes standard, customised, and advanced module technologies such as N-Type TOPCon (Tunnel Oxide Passivated Contact), Mono-PERC, and bifacial modules. TOPCon technology contributes to module efficiency and overall performance, with efficiency metrics that exceed those of Mono-PERC modules while offering potential cost benefits. The company also offers a 12-year product warranty and a 30-year limited power warranty on its solar PV modules, in line with prevailing industry standards.

Timeline of Technology adoption



The increasing deployment scale from 100 MW using polycrystalline modules in 2021 to 1,600 MW using G12R modules by 2026, reflecting a transition toward next-generation, higher-wattage module technologies. This shift enhances module efficiency from approximately 15–18% to 22–24%, enabling better land utilisation and supporting the development of larger-capacity solar projects.

The companies has vertically integrated operations across multiple segments of the solar value chain, with capabilities in module manufacturing as well as engineering, procurement and construction (EPC), and aluminium frame manufacturing. This integrated presence enables it to cater to a broad range of customer requirements, from module supply to project execution and system-level integration.

The company manufactures modules ranging from 40 WP to 680 WP, designed to meet the needs of different customer segments. The latest Solar PV Modules development has wattages between 420WP to 750WP in line with the products available in market with similar technology. The efficiencies for the same have been mentioned below:

Year	Peak Wattage	Technology	Efficiency
2021	335	Poly	17.26%
2024	550	Mono PERC	21.30%
2025	600	Topcon M10R	23.22%
2026	630	Topcon G12R	23.33%

The production is supported by automated systems, and modern manufacturing processes intended to maintain consistency and reliability. They also offer a comprehensive portfolio of modules designed with technologies that aim to reduce energy losses and support better system-level output. The transition from a predominantly OEM-based module business model to a mix of other EPC and BESS is expected to broaden their customer base and project engagement opportunities. The company is planning to enter as a BESS assembler where they will import cells and create packs.

Under aluminium frame manufacturing arm, the company focuses on cutting & punching of aluminium frames and their manufacturing capacity stands at 7+ lakh sets per annum.

Solar module manufacturing represents the company's primary revenue stream, contributing majority of its earnings. It supplies modules for residential rooftops, commercial and industrial projects, ground-mounted utility installations, and floating solar systems. The company's revenue from operations between FY23 to FY25 grew at a CAGR of 125.8%, showing highest revenue growth rate among the peers considered. And their EBITDA growth stood at 208.2% for the same period.

Cosmic PV Power Limited has also expanded its customer base from OEMs and mid-sized EPC partners to larger utility-scale and Independent Power Producer (IPP) segments. A major development was securing a Rs 600 crore solar module supply order from Zetwerk Manufacturing Businesses, making it one of the large-volume utility and IPP-focused contracts. Their operations align with national goals related to emissions reduction, renewable energy expansion, and the Make in India programme. India's target of achieving 500 GW of installed renewable capacity by 2030 guides the company's long-term plans. To support future growth and move toward greater vertical integration, the company is developing in-house capabilities in solar cell manufacturing and energy storage. This proposed cell manufacturing expansion will enable Cosmic PV to access the Domestic Content Requirement (DCR) market, and achieve compliance under ALMM List-II norms, and thereby broaden its addressable market across utility-scale, open access, and rooftop solar projects, supporting the backward integration and improved value capture across the solar value chain.

It has secured 24.66 HA land in Narmadapuram, Madhya Pradesh for a planned 1.10 GW solar cell manufacturing facility, the location is suitable for the proposed solar PV cell manufacturing facility as it falls within the Manufacturing Zone for Power and Renewable Energy Equipment. The location is aligned with the State's broader policy focus on promoting renewable energy equipment manufacturing and developing dedicated industrial infrastructure for such industries. This provides a supportive ecosystem for the proposed project and improves the suitability of the site for a specialised manufacturing facility such as N-type TOPCon solar PV cells. The location also benefits from the State's emphasis on industrial facilitation and investment promotion. Madhya Pradesh has taken measures to promote manufacturing investments through industrial policy support, land allotment mechanisms and approval facilitation systems.

The company, through its subsidiary Cosmic GEC Private Limited, also plans to enter the Battery Energy Storage Systems (BESS) segment and has signed an MoU with Indygreen Technologies Private Limited to establish a 2.0 GWh lithium-ion battery production line in Surat, Gujarat. This initiative is expected to strengthen the company's presence across the broader clean energy value chain.

With their expanding capacity, diversified capabilities, and increased participation in both utility-scale and storage-linked projects, the company is well placed to address increasing demand both domestic and international in the renewable infrastructure space.

Offerings:

Current		Upcoming	
Solar PV Module Manufacturing	**Engineering, Procurement & Construction (EPC)**	**Solar Cell Manufacturing**	**BESS Manufacturing**
• N-Type TOPCon • Mono-PERC • Bifacial	• Rooftop EPC services • End-to-end EPC for C&I customers • System design, procurement, installation, commissioning	• Upcoming - 1.1 GW solar cell manufacturing facility in Madhya Pradesh	• Upcoming - 2.0 GWh bettery cell-to-pack manufacturing facility in Surat, Gujarat

11 Peer Comparison

Vikram Solar Limited, Waaree Energies Limited, Solex Energy Limited, Premier Energies Limited and Emmvee Photovoltaic Power Limited are considered as the peer group for the analysis of Cosmic PV Power Limited based on similarity in business model and product offerings, these companies are considered direct competitors to the subject company.

11.1 Operational Parameters (H1'FY26)

Parameter	Vikram Solar Limited	Waaree Energies Limited	Solex Energy Limited	Premier Energy Limited	Emmvee Photovoltaic Power Limited	Cosmic PV Power Limited
Year of Incorporation	2005	1990	2014	1995	2007	2020
Cell (MW)						
Installed capacity	-	5,400	-	3,200	2,943	-
Under construction capacity	12,000	-	-	7,000	6,000	-
Module (MW)						
Installed Capacity	4,500	18,700	4,000	5,100	7,803	1,400
Under construction capacity	11,000	-	2,500	5,600	8,500	1,600
BESS						
BESS integration	✕	✔	✕	✔	✕	✕
BESS capacity (planned)	✔	✔	✕	✔	✔	✔
Closing Order Book (in MW)	11,150	24,000	-	9,114	5,071	1,580
Order Book (Rs crore)	-	47,000	4,000	13249.6	-	1,251.51
Geography Breakup: export oriented or not?	✔	✔	✔	–	✔	✕
Export-Import split	Export: 1% Import: 99%	-	-	Export 1%, Domestic 99%	Export: 0.86% Domestic (India): 99.14%	-
Module technology: Mono-PERC, Top-Con, (G12. M10 etc)	Bifacial N-Type TOPCon Module P-Type Monocrystal line Mono PERC modules	N-type HJT Modules, N-type TOPCon Modules Mono PERC	P Type Mono-PERC, N Type TopCON	N Type Module Topcon, G12, M10 P Type Monofacial, Bifacial Module	N-type, Mono PERC, Polycrystalline Modules, Bifacialmodule	Mono PERC ,TopCon ,M10 TopCon ,G12
Ability to manufacture Top-con module as per ALMM list	✔	✔	✔	✔	✔	✔
Backward integration in Aluminium Frame Mfg.	✕	✕	✕	✔	✕	✔

Source: Company Annual report, Investor Presentations, Transcript as on H1 FY26

Note: Export-Import Split for Vikram Solar and Emmvee PV Power Limited is as on FY25

11.2 Financial Parameter

Table 42: Revenue from Operations

Particulars (in Rs million)	FY23	FY24	FY25	H1'FY26
Waaree Energies Limited	67,508.73	113,976.10	144,445.00	104,914.70
Premier Energy Limited	14,285.34	31,437.93	65,187.45	36,576.07
Vikram Solar Limited	20,732.30	25,109.90	34,234.53	22,434.83
Emmvee Photovoltaic Power Limited	6,181.26	9,519.35	23,356.13	21,588.19
Solex Energy Limited	NA	NA	6,622.23	4,146.29
Cosmic PV Power Limited	480.97	999.46	2,451.61	1,816.93

Source: Company Annual report, Restated Financial Information – as applicable, Investor Presentations, DRHP Filings, Financial results H1 FY26

Table 43: Operating EBITDA

Particulars (in Rs million)	FY23	FY24	FY25	H1'FY26
Waaree Energies Limited	8,140.63	19,157.70	27,176.20	24,037.20
Premier Energy Limited	794.22	4,791.23	17,815.91	11,093.67
Vikram Solar Limited	1,861.78	3,869.35	4,920.11	4,772.08
Emmvee Photovoltaic Power Limited	562.72	1,204.39	7,219.38	7,498.86
Solex Energy Limited	NA	NA	759.86	598.57
Cosmic PV Power Limited	41.11	113.98	390.43	277.03

Source: Company Annual report, Restated Financial Information – as applicable, Investor Presentations, DRHP Filings, Financial results H1 FY26

Table 44: Operating EBITDA Margin

Particulars (in %)	FY23	FY24	FY25	H1'FY26
Waaree Energies Limited	12.06%	16.81%	18.81%	22.91%
Premier Energy Limited	5.56%	15.24%	27.33%	30.33%
Vikram Solar Limited	8.98%	15.41%	14.37%	21.27%
Emmvee Photovoltaic Power Limited	9.10%	12.65%	30.91%	34.74%
Solex Energy Limited	NA	NA	11.47%	14.44%
Cosmic PV Power Limited	8.55%	11.40%	15.93%	15.25%

Source: Company Annual report, Restated Financial Information – as applicable, Investor Presentations, DRHP Filings, Financial results H1 FY26

Table 45: Profit After Tax (PAT)

Particulars (in Rs million)	FY23	FY24	FY25	H1'FY26
Waaree Energies Limited	5,002.77	12,743.80	19,281.30	16,511.00
Premier Energy Limited	-133.36	2,313.60	9,371.32	6,612.32
Vikram Solar Limited	144.91	797.18	1,398.31	2,618.52
Emmvee Photovoltaic Power Limited	89.71	288.99	3,690.14	4,255.34
Solex Energy Limited	NA	NA	422.26	304.92
Cosmic PV Power Limited	18.35	65.75	244.39	128.16

Source: Company Annual report, Restated Financial Information – as applicable, Investor Presentations, DRHP Filings, Financial results H1 FY26

Table 46: PAT Margin

Particulars (in %)	FY23	FY24	FY25	H1'FY26
Waaree Energies Limited	7.41%	11.18%	13.35%	15.74%
Premier Energy Limited	-0.93%	7.36%	14.38%	18.08%
Vikram Solar Limited	0.70%	3.17%	4.08%	11.67%
Emmvee Photovoltaic Power Limited	1.45%	3.04%	15.80%	19.71%
Solex Energy Limited	NA	NA	6.38%	7.35%
Cosmic PV Power Limited	3.81%	6.58%	9.97%	7.05%

Source: Company Annual report, Restated Financial Information – as applicable, Investor Presentations, DRHP Filings, Financial results H1 FY26

Table 47: Total Debt

Particulars (in Rs million)	FY23	FY24	FY25	H1'FY26
Waaree Energies Limited	2,734.80	3,173.30	9,394.60	23,904.20
Premier Energy Limited	7,635.42	13,922.40	18,934.88	15,267.62
Vikram Solar Limited	7,377.87	8,083.33	2,306.67	801.59
Emmvee Photovoltaic Power Limited	5,196.21	14,413.02	19,496.86	18,630.91
Solex Energy Limited	NA	NA	1,474.99	2,674.41
Cosmic PV Power Limited	141.40	343.33	559.28	1,353.42

Source: Company Annual report, Restated Financial Information – as applicable, Investor Presentations, DRHP Filings, Financial results H1 FY26

Table 48: Total Equity

Particulars (in Rs million)	FY23	FY24	FY25	H1'FY26
Waaree Energies Limited	18,384.10	40,878.10	94,792.00	114,854.00
Premier Energy Limited	4,112.15	6,468.51	28,221.06	34,540.61
Vikram Solar Limited	3,651.95	4,454.17	12,419.89	29,496.56
Emmvee Photovoltaic Power Limited	1,404.95	1,687.61	5,367.97	9,567.02
Solex Energy Limited	NA	NA	1,575.47	1,863.01
Cosmic PV Power Limited	36.68	123.73	703.57	1,105.20

Source: Company Annual report, Restated Financial Information – as applicable, Investor Presentations, DRHP Filings, Financial results H1 FY26

Table 49: Debt- Equity Ratio

Particulars (in times)	FY23	FY24	FY25	H1'FY26
Waaree Energies Limited	0.15	0.08	0.10	0.20
Premier Energy Limited	1.80	2.11	0.67	0.44
Vikram Solar Limited	2.02	1.81	0.19	0.03
Emmvee Photovoltaic Power Limited	3.70	8.54	3.63	1.95
Solex Energy Limited	NA	NA	0.93	1.42
Cosmic PV Power Limited	3.85	2.76	0.79	1.21

Source: Company Annual report, Restated Financial Information – as applicable, Investor Presentations, DRHP Filings, Financial results H1 FY26

Table 50: Return on Equity

Particulars (in %)	FY23	FY24	FY25	H1'FY26
Waaree Energies Limited	42.61%	41.75%	27.53%	15.15%
Premier Energy Limited	-3.18%	43.73%	54.03%	21.07%
Vikram Solar Limited	4.05%	19.67%	16.57%	12.49%
Emmvee Photovoltaic Power Limited	NA	18.69%	104.60%	56.98%
Solex Energy Limited	NA	NA	NA	17.09%
Cosmic PV Power Limited	66.72%	80.99%	57.73%	13.93%

Source: Company Annual report, Restated Financial Information – as applicable, Investor Presentations, DRHP Filings, Financial results H1 FY26

Table 51: Return on Capital Employed

Particulars	FY23	FY24	FY25	H1'26
Waaree Energies Limited	54.01%	46.44%	36.28%	18.79%
Premier Energy Limited	5.83%	25.26%	41.87%	19.37%
Vikram Solar Limited	13.06%	23.21%	27.29%	19.05%
Emmvee Photovoltaic Power Limited	NA	7.15%	28.84%	24.13%
Solex Energy Limited	NA	NA	NA	13.71%
Cosmic PV Power Limited	20.88%	31.18%	39.22%	10.84%

Source: Company Annual report, Restated Financial Information – as applicable, Investor Presentations, DRHP Filings, Financial results H1 FY26

Table 52: Gross Fixed Asset Turnover Ratio

Particulars (in times)	FY23	FY24	FY25	H1'FY26
Waaree Energies Limited	6.34	6.76	4.15	NA
Premier Energy Limited	2.31	3.00	4.34	NA
Vikram Solar Limited	2.65	2.93	3.59	NA
Emmvee Photovoltaic Power Limited	NA	2.89	1.80	NA
Solex Energy Limited	NA	NA	NA	NA
Cosmic PV Power Limited	6.46	5.05	4.81	1.85

Source: Company Annual report, Restated Financial Information – as applicable, Investor Presentations, DRHP Filings, Financial results H1 FY26

Table 53: Debtor Days

Particulars (number of days)	FY23	FY24	FY25	H1'FY26
Waaree Energies Limited	11	21	27	22
Premier Energy Limited	26	39	39	44
Vikram Solar Limited	165	156	129	99
Emmvee Photovoltaic Power Limited	NA	32	22	20
Solex Energy Limited	NA	NA	NA	45
Cosmic PV Power Limited	36	28	34	46

Source: Company Annual report, Restated Financial Information – as applicable, Investor Presentations, DRHP Filings, Financial results H1 FY26

Table 54: Creditor Days

Particulars (number of days)	FY23	FY24	FY25	H1'FY26
Waaree Energies Limited	68	59	65	68
Premier Energy Limited	102	105	87	80
Vikram Solar Limited	135	119	105	105
Emmvee Photovoltaic Power Limited	NA	55	66	54
Solex Energy Limited	NA	NA	NA	75
Cosmic PV Power Limited	41	57	64	86

Source: Company Annual report, Restated Financial Information – as applicable, Investor Presentations, DRHP Filings, Financial results H1 FY26

Table 55: Inventory Days

Particulars (number of days)	FY23	FY24	FY25	H1'FY26
Waaree Energies Limited	111	107	92	97
Premier Energy Limited	129	125	104	123
Vikram Solar Limited	72	83	59	56
Emmvee Photovoltaic Power Limited	NA	108	139	147
Solex Energy Limited	NA	NA	NA	153
Cosmic PV Power Limited	44	65	72	102

Source: Company Annual report, Restated Financial Information – as applicable, Investor Presentations, DRHP Filings, Financial results H1 FY26

Table 56: Working Capital Cycle

Particulars (number of days)	FY23	FY24	FY25	H1'FY26
Waaree Energies Limited	-30	-34	-44	-30
Premier Energy Limited	-3	25	51	71
Vikram Solar Limited	116	140	95	53
Emmvee Photovoltaic Power Limited	NA	25	24	40
Solex Energy Limited	NA	NA	NA	76
Cosmic PV Power Limited	67	50	33	56

Source: Company Annual report, Restated Financial Information – as applicable, Investor Presentations, DRHP Filings, Financial results H1 FY26

11.3 Operational Parameters

Table 57: Order Book

Particulars (MW)	FY23	FY24	FY25	H1'FY26
Waaree Energies Limited	18,060.00	19,928.12	25,000.00	24,000.00
Premier Energy Limited	NA	NA	5,303.00	9,114.00
Vikram Solar Limited	2,787.00	4,376.00	10,341.00	11,150.00
Emmvee Photovoltaic Power Limited	538.71	1,100.25	4,891.64	5,071.00
Solex Energy Limited	NA	NA	NA	NA
Cosmic PV Power Limited	12.39	12.69	992.77	1,577.47

Source: Company Annual report, Restated Financial Information – as applicable, Investor Presentations, DRHP Filings, Financial results H1 FY26.
Note: Peer companies have been sourced directly from the publicly available information. No additional procedures have been carried out with respect to this data

Table 58: Order Book

Particulars (In Rs Million)	FY23	FY24	FY25	H1'FY26
Waaree Energies Limited	431,129.00	NA	490,000.00	470,000.00
Premier Energy Limited	9,860.46	54,332.37	84,456.00	132,496.00
Vikram Solar Limited	NA	NA	NA	NA
Emmvee Photovoltaic Power Limited	12,943.92	23,301.00	77,789.00	NA
Solex Energy Limited	NA	NA	1,750.00	40,000.00
Cosmic PV Power Limited	46.87	123.65	3,878.65	12,515.10

Source: Company Annual report, Restated Financial Information – as applicable, Investor Presentations, DRHP Filings, Financial results H1 FY26.
Note: Peer companies have been sourced directly from the publicly available information. No additional procedures have been carried out with respect to this data

Table 59: Annual Installed Capacity

Particulars (MW)	FY23	FY24	FY25	H1'FY26
Waaree Energies Limited	9,000.00	12,000.00	16,700.00	18,700.00
Premier Energy Limited	1,370.00	3,360.00	5,100.00	5,100.00
Vikram Solar Limited	2,500.00	3,500.00	4,500.00	4,500.00
Emmvee Photovoltaic Power Limited	1,585.13	1,585.13	6,015.57	7,803.00
Solex Energy Limited	NA	NA	1,500.00	4,000.00
Cosmic PV Power Limited	100.00	200.00	600.00	1,400.00

Source: Company Annual report, Restated Financial Information – as applicable, Investor Presentations, DRHP Filings, Financial results H1 FY26.
Note: Peer companies have been sourced directly from the publicly available information. No additional procedures have been carried out with respect to this data

Table 60: Effective Installed Capacity

Particulars (MW)	FY23	FY24	FY25	H1'FY26
Waaree Energies Limited	6,500.00	11,010.00	NA	NA
Premier Energy Limited	1,140.00	1,670.00	NA	NA
Vikram Solar Limited	1,079.00	1,779.50	1,646.29	NA
Emmvee Photovoltaic Power Limited	1,004.78	1,227.20	2,749.47	1,594.00
Solex Energy Limited	NA	NA	NA	NA
Cosmic PV Power Limited	57.26	57.26	238.58	362.65

Source: Company Annual report, Restated Financial Information – as applicable, Investor Presentations, DRHP Filings, Financial results H1 FY26.
Note: Peer companies have been sourced directly from the publicly available information. No additional procedures have been carried out with respect to this data

Table 61: Actual Production

Particulars (MW)	FY23	FY24	FY25	H1'FY26
Waaree Energies Limited	2,630.00	4,780.00	NA	NA
Premier Energy Limited	490.00	1,010.00	NA	NA
Vikram Solar Limited	426.30	855.70	1,286.10	NA
Emmvee Photovoltaic Power Limited	218.57	475.62	1,482.31	682.00
Solex Energy Limited	NA	NA	NA	NA
Cosmic PV Power Limited	31.78	51.21	138.44	241.46

Source: Company Annual report, Restated Financial Information – as applicable, Investor Presentations, DRHP Filings, Financial results H1 FY26.
Note: Peer companies have been sourced directly from the publicly available information. No additional procedures have been carried out with respect to this data

Table 62: Capacity Utilization

Particulars (%)	FY23	FY24	FY25	H1'FY26
Waaree Energies Limited	40.46%	43.37%	NA	NA
Premier Energy Limited	42.81%	60.29%	75.00%	79.00%
Vikram Solar Limited	39.51%	48.09%	78.12%	84.00%
Emmvee Photovoltaic Power Limited	21.75%	38.76%	53.91%	43.00%
Solex Energy Limited	NA	NA	NA	NA
Cosmic PV Power Limited	55.50%	89.43%	58.02%	66.58%

Source: Company Annual report, Restated Financial Information – as applicable, Investor Presentations, DRHP Filings, Financial results H1 FY26.
Note: Peer companies have been sourced directly from the publicly available information. No additional procedures have been carried out with respect to this data

Formula definitions

1. Revenue from operations means the Revenue from operations for the period/year as stated in Restated Financial Information, Annual Reports, and Financials Results, as applicable
2. Operating EBITDA is calculated as profit before exceptional items and tax plus depreciation and amortisation expense and finance costs, as reduced by other income as per the Restated Financial Information, Annual Reports, and Financials Results, as applicable
3. Operating EBITDA Margin is calculated as Operating EBITDA divided by Revenue from operations.
4. Profit for the period means Profit after tax for the period/year as stated in Restated Financial Information, Annual Reports, and Financials Results, as applicable
5. PAT Margin is calculated as profit/ (loss) for the period/year divided by Revenue from operations.
6. Total equity is calculated as Total equity (excluding non-controlling interest) as stated in Restated Financial Information, Annual Reports, and Financials Results, as applicable.
7. Total Debt is calculated as Non-Current Borrowings plus Current Borrowings.
8. Debt to equity is calculated as Total Debt divided by Total Equity (including non-controlling interest).
9. Return on Equity is calculated as profit/ (loss) for the period/year attributable to owners of the company divided by average of opening & closing total equity (excluding non-controlling interest).
10. Return on Capital Employed is calculated as EBIT divided by average of opening & closing capital employed. Capital employed is calculated as total equity (including non-controlling interest) plus total debt and EBIT is calculated as EBITDA less depreciation and amortization add other income.
11. Gross Fixed Assets Turnover Ratio is calculated as Revenue from operations for the period/year divided by average of opening & closing cost of property, plant and equipment and right-of-use assets.
12. Debtor days are calculated as average of opening & closing trade receivables divided by revenue from operations multiplied by 365 (year)/183 (half year).
13. Creditor days are calculated as average of opening & closing trade payables divided by Cost of Goods Sold multiplied by 365 (year)/183 (half year). Cost of Goods Sold is calculated as cost of raw materials consumed plus purchase of stock-in-trade (traded goods) plus (increase)/decrease in inventories of finished goods. contract execution expense and other manufacturing expenses as well as engineering, procurement, and construction (EPC) project expenses are included in calculation of COGS for Premier Energy Limited and Waaree Energies Limited
14. Inventory days are calculated as average of opening & closing inventories divided by Cost of Goods Sold multiplied by 365 (year)/183 (half year). Cost of Goods Sold is calculated as cost of raw materials consumed plus purchase of stock-in-trade (traded goods) plus (increase)/decrease in inventories of finished goods. contract execution expense and other manufacturing expenses as well as engineering, procurement, and construction (EPC) project expenses are included in calculation of COGS for Premier Energy Limited and Waaree Energies Limited
15. Working Capital Cycle is calculated as average of opening & closing working capital divided by revenue from operations multiplied by 365 (year)/183 (half year). Working Capital is calculated as total current assets minus total current liabilities excluding cash and cash equivalents, other bank balances, current investments and current borrowings.
16. Order book (MW) represents contracts which have been partly executed or yet to be executed and for which a purchase order/ letter of intent has been received, same is represented in megawatt (MW).
17. Order book (in Rs million) represents contracts which have been partly executed or yet to be executed and for which a purchase order/ letter of intent has been received, same is represented in millions.
18. Annual installed capacity refers to the annual installed capacity of a manufacturing plant, i.e. the maximum amount of production that a company can achieve in a year, assuming that all machines are running at full speed.
19. Effective installed capacity is the actual amount of production that a company can achieve in a period basis machine installation time during the period, assuming all machines are running at full speed.
20. Actual production refers to the actual production achieved during the relevant period.
21. Capacity utilization is calculated as actual production divided by effective installed capacity.

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About:

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