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Solar Power Equipment Industry

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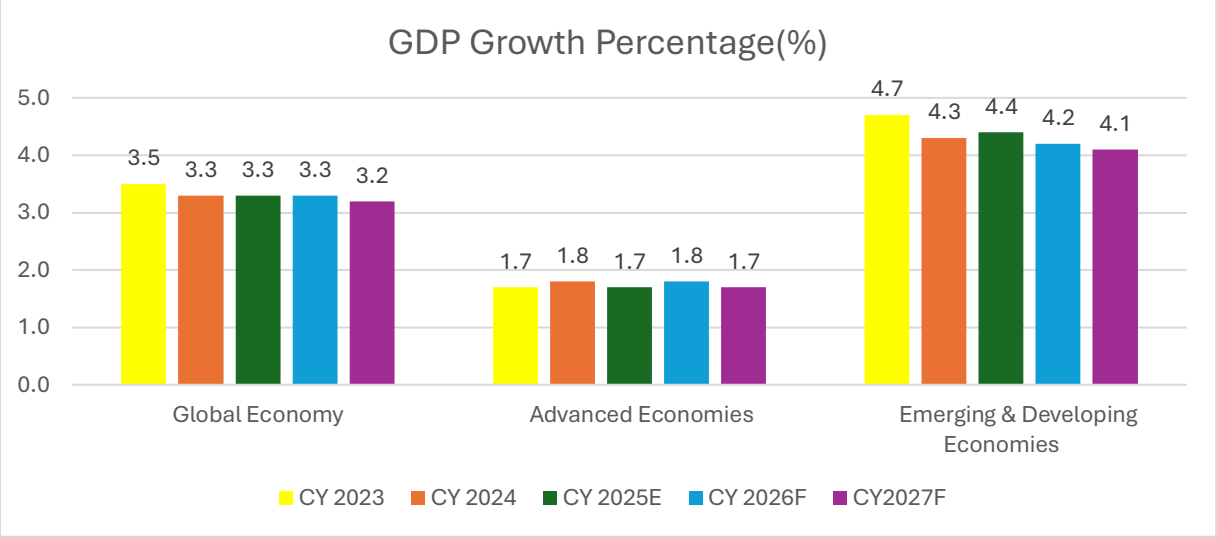
1. Global Economic Outlook

As per the IMF's World Economic Outlook (WEO) published in January 2026, global growth is projected to remain resilient at 3.3 percent in 2026 and at 3.2 percent in 2027.

Global headline inflation is expected to decline from an estimated 4.1 percent in 2025 to 3.8 percent in 2026 and further to 3.4 percent in 2027. The inflation projections are also broadly unchanged from those in October and envisage inflation returning to target more gradually in the United States than in other large economies.



F – Forecast, Source – IMF World Economic Outlook January 2026

Note: Advanced Economies and Emerging & Developing Economies are as per the classification of the World Economic Outlook (WEO). This classification is not based on strict criteria, economic or otherwise, and it has evolved over time. It comprises of 40 countries under the Advanced Economies including the G7 (the United States, Japan, Germany, France, Italy, the United Kingdom, and Canada) and selected countries from the Euro Zone (Germany, Italy, France etc.). The group of emerging market and developing economies (156) includes all those that are not classified as Advanced Economies (India, China, Brazil, Malaysia etc.)

Growth in advanced economies is projected to be 1.8 percent in 2026 and 1.7 percent in 2027. In the United States, the economy is projected to expand by 2.4 percent in 2026, supported by fiscal policy and a lower policy rate, while the impact of higher trade barriers also gradually wanes. This 0.3 percentage point upward revision from the October forecast reflects a stronger-than expected GDP outturn in the third quarter of 2025, a rebound in activity in the first quarter of 2026 compared with that in the fourth quarter of 2025 following the end of the federal government shutdown, and the associated carryover.

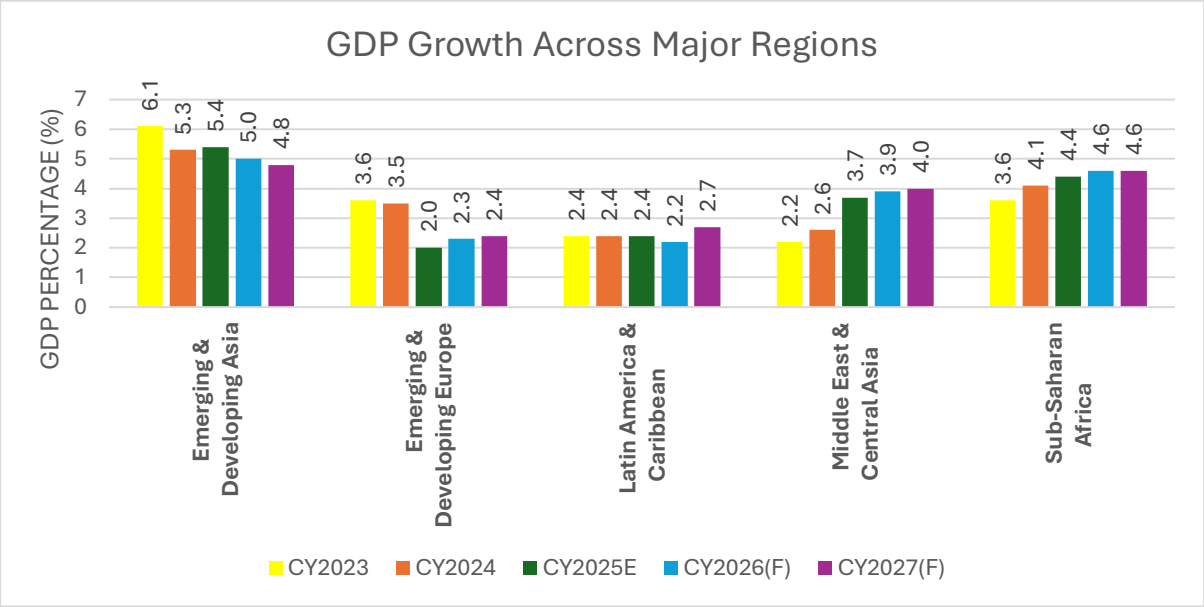
In emerging market and developing economies, growth is expected to continue to hover just above 4.0 percent in 2026 and 2027. Relative to the projection in October, growth in 2025 for China is revised upward by 0.2 percentage point to 5.0 percent. The revision reflects stimulus measures and additional policy bank lending for investment. Growth for 2026 is also revised upward by 0.3 percentage point to 4.5 percent, reflecting the lower US effective tariff rates on Chinese goods due to the yearlong trade truce agreed to in November and stimulus measures that are assumed to be implemented over two years. The economy's growth rate is expected to decelerate to 4.0 percent in 2027 as structural headwinds assert themselves.

In India, growth is revised upward by 0.7 percentage point to 7.3 percent for 2025, reflecting the better-than expected outturn in the third quarter of the year and strong momentum in the fourth quarter. Growth is projected to moderate to 6.4 percent in 2026 and 2027 as cyclical and temporary factors wane.

In the Middle East and Central Asia, growth is projected to accelerate from 3.7 percent in 2025 to 3.9 percent in 2026 and to 4.0 percent in 2027, supported by higher oil output, resilient local demand, and ongoing reforms. Growth is also expected to accelerate in sub-Saharan Africa, from 4.4 percent in 2025 to 4.6 percent in 2026 and 2027, supported by macroeconomic stabilization and reform efforts in key economies. In Latin America and the Caribbean, growth is projected to moderate to 2.2 percent in 2026 and bounce to 2.7 percent in 2027 as countries in the region approach potential from different cyclical positions. In emerging and developing Europe, a sharp slowdown in 2025 to a growth rate of 2.0 percent is expected to reverse, with economies in the region expanding at an average rate of 2.3 percent in 2026 and 2.4 percent in 2027. In most regions, the rebound also reflects the fading effect of shifting trade policies

1.1 GDP Growth across Major Regions

GDP growth across major global regions—including Europe, Latin America & the Caribbean, Middle East & Central Asia, and Sub-Saharan Africa—continues to display varied trajectories. The global outlook presents a mixed scenario, with emerging economies continuing to outperform advanced economies.



Source-IMF World Economic Outlook January 2026 update

In Emerging and Developing Asia, growth is projected to moderate from 5.4% in CY 2025 to 5.0% in CY 2026 and further projected at 4.8% during CY 2026. India's expected growth in 2025 has been uplifted at 7.3% in CY 2025, supported by resilient rural consumption and sustained infrastructure investments, up from 6.5% in CY2024. The growth estimate for 2026 and 2027 is kept at 6.4%. In contrast, China's growth is estimated at 5.0% in CY2025, and to further decelerate at 4.5% in 2026 and 4.0% in 2027.

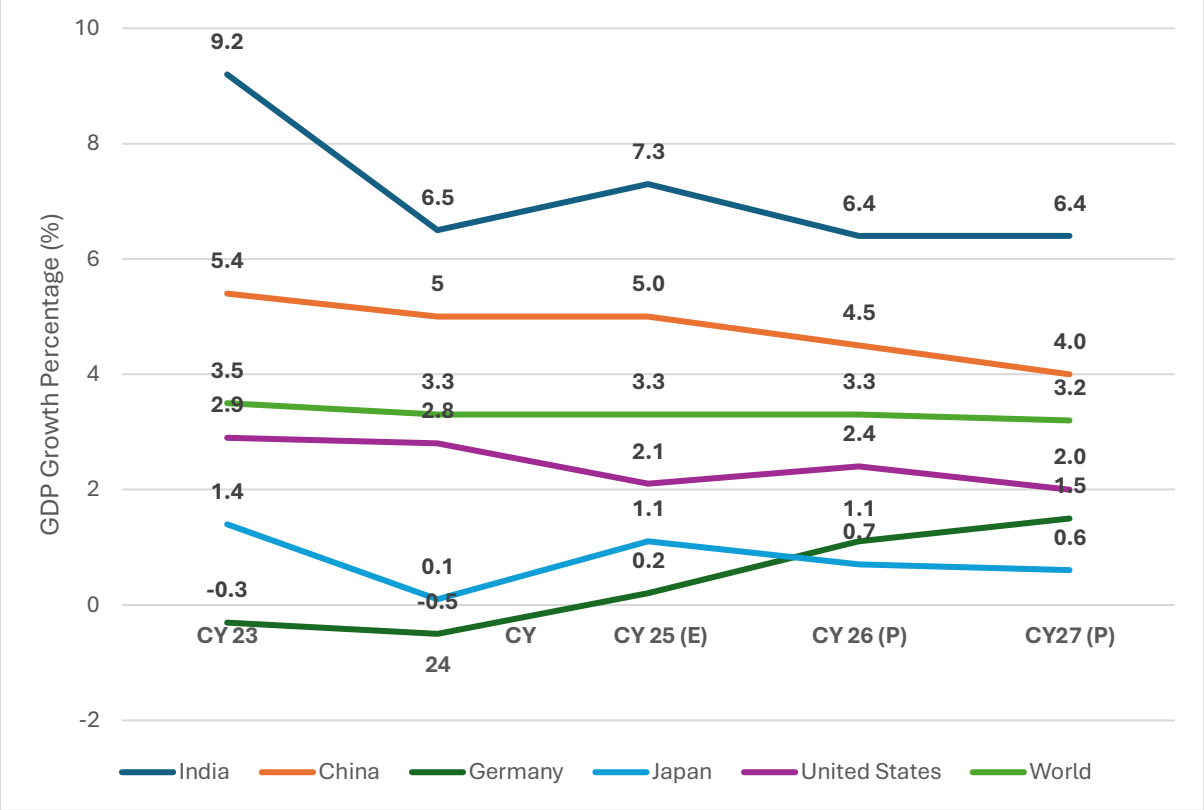
Sub-Saharan Africa is projected to grow at 4.4% in CY 2025, increased from 4.1% in CY 2024, with growth is expected to accelerate further at 4.6% in CY 2026. This gradual improvement is being supported by better weather conditions and more efficient supply chain operations.

In the Middle East and Central Asia, the economy is forecasted to expand from 3.7% in CY 2025 to 3.9% in CY 2026, and further at around 4.0% in CY 2027, driven by stabilization in oil production and ongoing economic reforms.

For Latin America and the Caribbean, the economy is expected to slow from 2.4% in CY 2025, to 2.2% in CY2026, but increase again at 2.7% in CY 2027 reflecting stable yet subdued economic momentum supported by stronger macroeconomic management across key economies.

Emerging and Developing Europe remains subdued, with growth estimated at 2.0% in CY 2025, down from 3.5% in CY 2024, expected to rise modestly to 2.3% in CY 2026 and further at 2.4% in 2027. However, the recent Greenland issue and tariff imposition by the US President has posed fresh challenges for the region. The region continues to face structural manufacturing challenges, particularly in major economies like Germany.

India and Top 4 Global Economies GDP Growth Forecast



Note: P = Projections, Source: IMF World Economic Outlook January 2026 update

Overall, while global growth is expected to remain steady at 3.3% in CY 2025~CY2026 and at 3.2% in CY2027, regional disparities persist, influenced by a combination of domestic challenges, external geopolitical tensions, and fluctuating commodity prices.

2. India's Macroeconomic Scenario

2.1 Gross Domestic Product (GDP)

Real GDP is estimated to grow by 7.4% in FY 2025–26, improving from a growth rate of 6.5% in FY 2024–25. This momentum is also evident on a quarterly basis, with real GDP recording a robust growth of 8.2% in Q2 of FY 2025–26 compared to the growth rate of 5.6% during Q2 of FY25, whereas nominal GDP has witnessed a growth rate of 8.7% in Q2 of FY 2025-26. *Source – MOSPI, Press release – First advance estimates of Gross domestic product posted on January 07th,2026.*

In its latest Economic Outlook, the OECD noted that India remains one of the fastest-growing major economies, supported by strong investment activity and resilient services. OECD highlighted that India's GDP is projected to grow by 6.7% in fiscal year 2025-26, 6.2% in 2026-27 and 6.4% in 2027-28. Despite some likely impact of the US tariff on Indian exports, private consumption will be supported by rising real incomes as inflation remains soft and low consumption/indirect taxes (GST). Going forward, investment will be sustained by declining borrowing costs and strong public capital expenditure. Current low headline inflation is projected to gradually converge towards the 4% target. Notably, India's Headline Inflation drops to 0.25 % in October 2025.

India's Economic Growth Momentum Remains Strong - Surpassed USD 4 Trillion.

In June 2025, India became the fourth-largest economy in the world and retained its position as the fastest-growing major economy. The country is projected to become the world's third largest economy by 2030, with an estimated GDP of USD 7.3 trillion.
Source: PIB, Press Release - India Becoming an Economic Powerhouse posted on June 16, 2025

India achieved a significant milestone by overtaking Japan to become the *third most powerful nation in the Asia-Pacific region*, as per the Asia Power Index 2024. India's overall score rose to 39.1, reflecting a 2.8-point increase from the previous year, driven by growing influence across economic, military, and diplomatic dimensions.
Source: PIB, Press Release - India becomes 3rd Most Powerful Nation in Asia, Surpasses Japan in Asia Power Index posted on September 24, 2024

Key factors behind India's rise include its strong economic performance, expanding and youthful workforce, and increasing strategic engagement across the region. India's Economic Capability improved significantly, supported by its position as the world's third-largest economy in terms of purchasing power parity (PPP). Additionally, a notable increase in its Future Resources score highlights the demographic advantage that is expected to sustain its growth trajectory in the coming years.

2.2 Gross Value Added (GVA)

According to the First Advance Estimate of GDP for 2025-26 by MOSPI, Govt. of India (GoI), Real GVA is estimated at ₹184.50 lakh crore in the FY 2025-26, against the Provisional Estimates (PE) for the FY 2024-25 of ₹171.87 lakh crore, registering a growth rate of 7.3%. Nominal GVA is estimated to attain a level of ₹323.48 lakh crore during FY 2025-26, against ₹300.22 lakh crore in FY 2024-25, showing a growth rate of 7.7%. (*MOSPI, Press Release, 7 January 2026*).

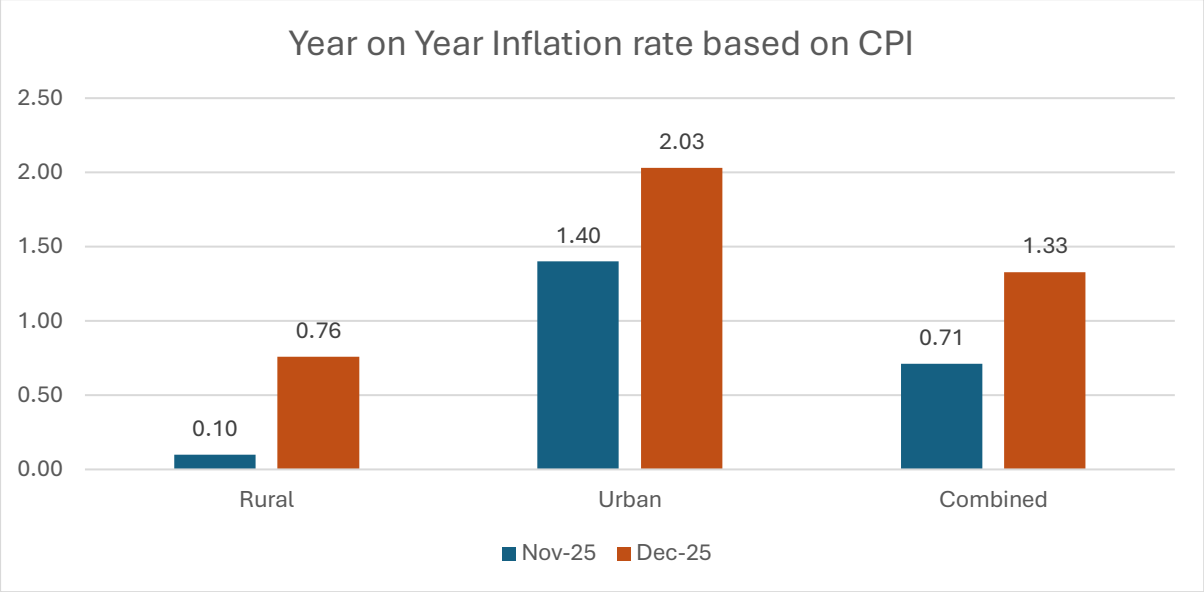
Major Highlights:

- Real GDP has been estimated to grow by 7.4% in FY 2025-26 against the growth rate of 6.5% during FY 2024-25.
- Nominal GDP is estimated to grow at 8.0% in FY 2025-26.
- Buoyant Growth in Services Sector has been found to be a major driver in the estimated Real GVA growth rate of 7.3% in FY 2025-26.
- Financial, Real Estate & Professional Services and Public Administration, Defence & Other Services in the Tertiary Sector have been estimated to attain a substantial growth rate of 9.9% at Constant Prices in FY 2025-26.
- Trade, Hotels, Transport, Communication & Services related to Broadcasting Sector has been estimated to grow by 7.5% at Constant Prices in FY 2025-26.
- Manufacturing and Construction in the Secondary Sector has been estimated to achieve a growth rate of 7.0% at Constant Prices in FY 2025-26.
- Agriculture & Allied Sector (3.1%) and Electricity, Gas, Water Supply & Other Utility Services Sector (2.1%) have seen moderate growth rate in GVA at Constant Prices during FY 2025-26.
- Real Private Final Consumption Expenditure (PFCE) has been estimated to attain a growth rate of 7.0% during FY 2025-26.

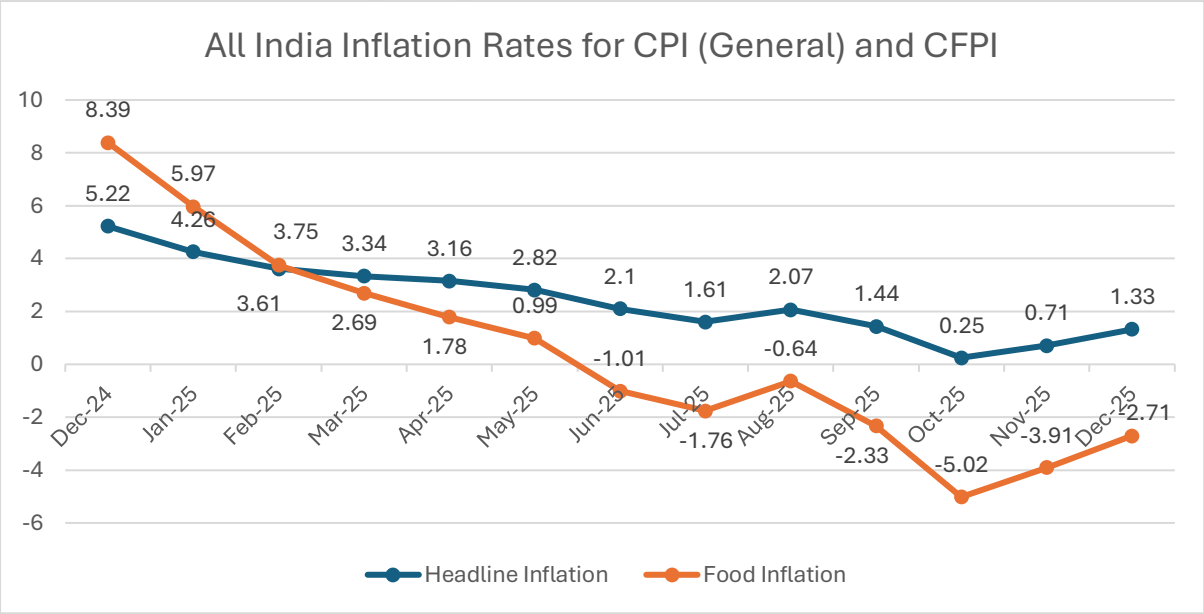
Source: *MOSPI, Press Release, 7 January 2026, Govt. of India (GoI).*

2.3 Consumer Price Index (CPI)

The year-on-year inflation rate, based on the All-India Consumer Price Index (CPI), stood at a 1.33% (Provisional) in December 2025, compared to December 2024. This represented an increase of 62 basis points in headline inflation of December 2025 in comparison to November 2025. In contrast, October 2025 over October 2024 is 0.25% (Provisional). There is decrease of 119 basis points in headline inflation of October 2025 in comparison to September 2025. It is the lowest year-on-year inflation of the current CPI series.



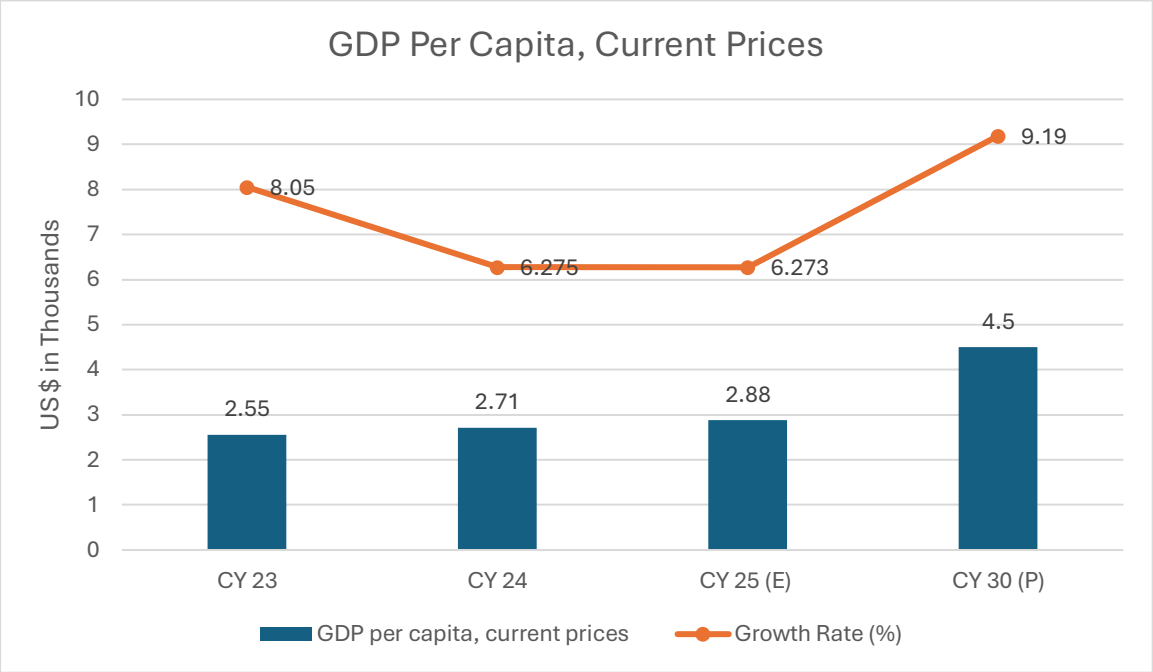
Source: MOSPI, GOI



Source: MOSPI, GOI

2.4 India Per Capita GDP Forecast

Per capita GDP growth for India is estimated at 9.19 % CAGR between CY2025-CY2030. Increased individual incomes are expected to create additional discretionary spending, which may be beneficial for the sector.



Note: E = Estimated, P = Projected

Source: IMF Data Mapper, World Economic Outlook April 2025, India, GDP Per Capita

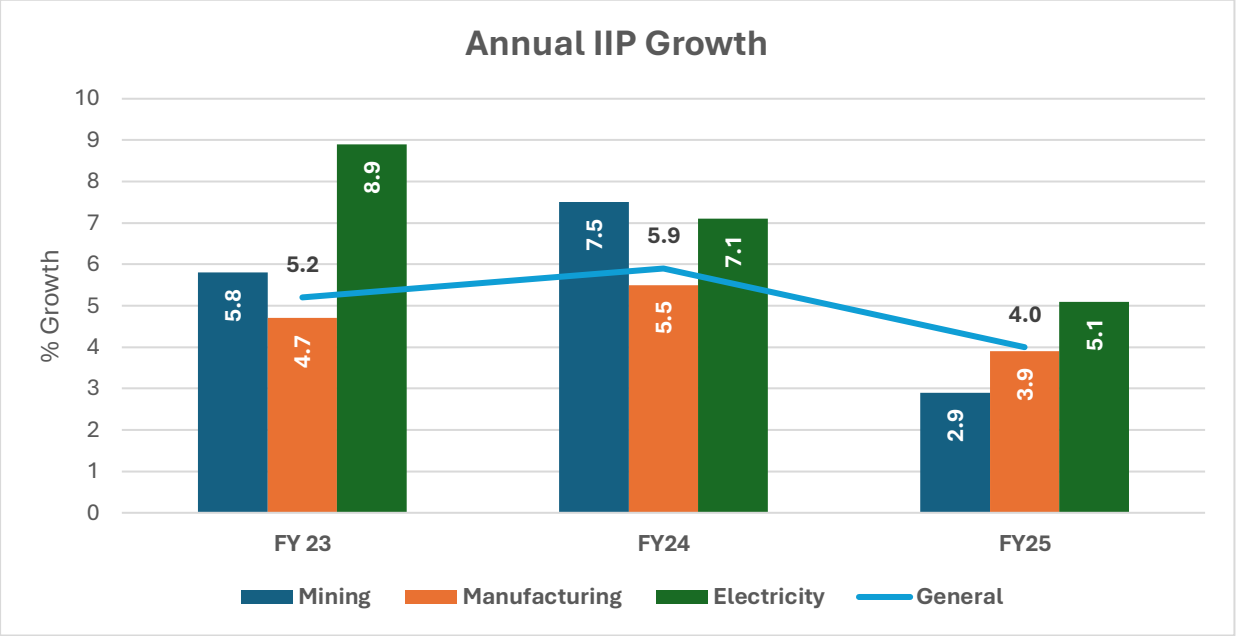
2.5 Index of Industrial Production (IIP) Growth Trends:

As per the Index of Industrial Production (IIP), the industrial sector grew by 4.0% in FY 2025, moderating from 5.9% in FY 2024 and 5.2% in FY 2023. This deceleration in overall IIP growth in FY 2025 reflects a softening of industrial momentum amidst global headwinds and tighter financial conditions.

Among key components:

- **Manufacturing** (which holds a 77.6% weight in IIP) registered a slower growth of 3.9% in FY 2025, compared to 5.5% in FY 2024 and 4.7% in FY 2023.
- **Mining** growth also moderated sharply to 2.9% in FY 2025 from 7.5% in FY 2024 and 5.8% in FY 2023.
- **Electricity** growth remained relatively stable at 5.1% in FY 2025, slightly down from 7.1% in FY 2024 and significantly lower than 8.9% in FY 2023.

This slowdown indicates tightening domestic demand and spillover effects from a weaker global industrial cycle.



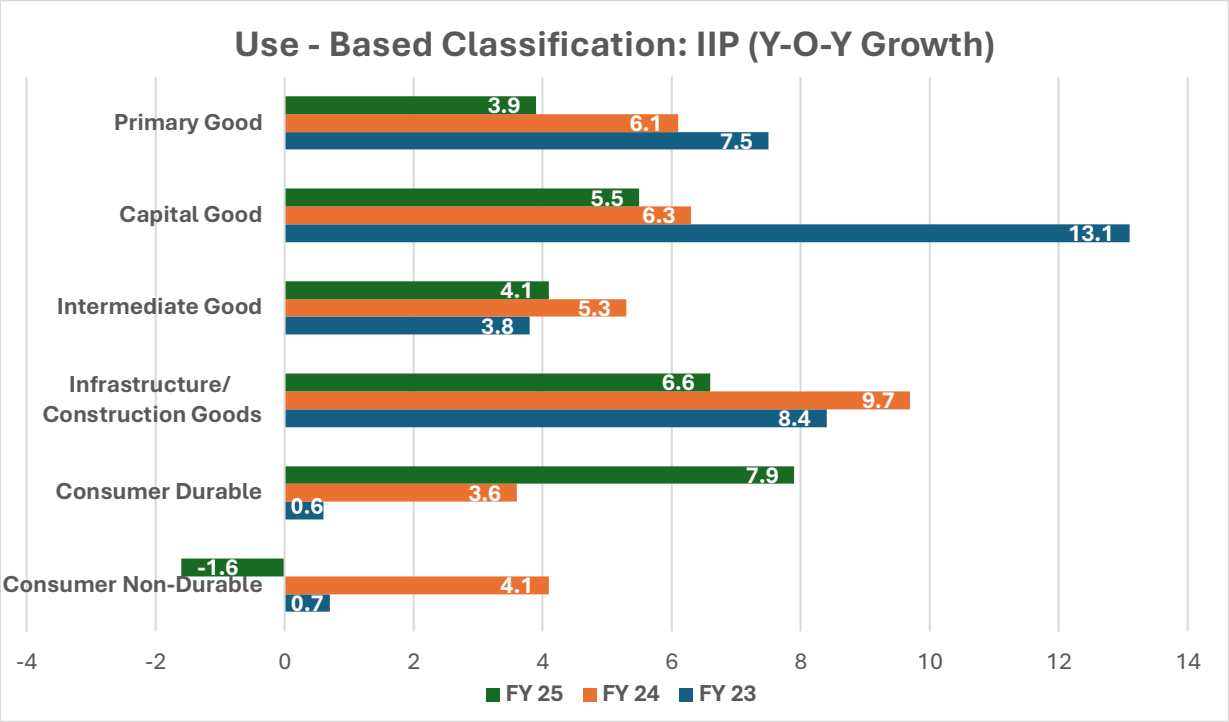
Source: Ministry of Statistics & Programme Implementation (MOSPI)

Latest IIP data in Oct'25 remains a tad low amid less activity during festival times

The Index of Industrial Production (IIP) slows a tad at 0.4% during Oct'25 due to less working days available amid festivals. The growth rates of the three sectors, Mining, Manufacturing and Electricity for the month of October 2025 are (-) 1.8 percent, 1.8 percent and (-) 6.9 percent respectively. Lower demand in October 2025 and subsequent decline in electricity generation was driven by extended rainfall season and comfortable ambient temperature across multiple States/UTs.

Source: Quick Estimate of Index of Industrial Production and Use-Based Index for the Month of October 2025, MOSPI, December 01, 2025 Release

Use-Based Classification Trends:



Source: Ministry of Statistics & Programme Implementation (MOSPI)

According to the use-based classification:

- Capital Goods segment growth slowed to 5.5% in FY 2025, down from a high of 13.1% in FY 2023 and 6.3% in FY 2024, indicating a reduction in investment momentum.
- Primary Goods also witnessed slower growth at 3.9%, compared to 6.1% in FY 2024 and 7.5% in FY 2023.
- Intermediate Goods rebounded modestly to 4.1% in FY 2025, up from 3.8% in FY 2023, although still lower than 5.3% in FY 2024.
- Infrastructure/Construction Goods slowed to 6.6% in FY 2025 from 9.7% in FY 2024 and 8.4% in FY 2023, pointing to softening construction and infrastructure activity.
- Consumer Durables grew significantly by 7.9%, rebounding from 3.6% in FY 2024 and 0.6% in FY 2023, indicating improved demand in consumer electronics and appliances.
- In contrast, Consumer Non-Durables contracted by 1.6% in FY 2025, reversing the 4.1% growth in FY 2024, likely reflecting subdued rural and essential goods demand.

  The divergence in growth across segments suggests an uneven industrial recovery in FY 2025. While certain consumer categories have rebounded, investment-related and primary sectors remain under pressure.

The latest growth rates of IIP as per Use-based classification in October 2025 over October 2024 are (-)0.6 percent in Primary goods, 2.4 percent in Capital goods, 0.9 percent in Intermediate goods, 7.1 percent in Infrastructure/ Construction Goods, (-) 0.5 percent in Consumer durables and (-)4.4 percent in Consumer non-durables. Based on use-based classification, top three positive contributors to the growth of IIP for the month of October 2025 are Infrastructure/ construction goods, Intermediate goods and Capital goods.

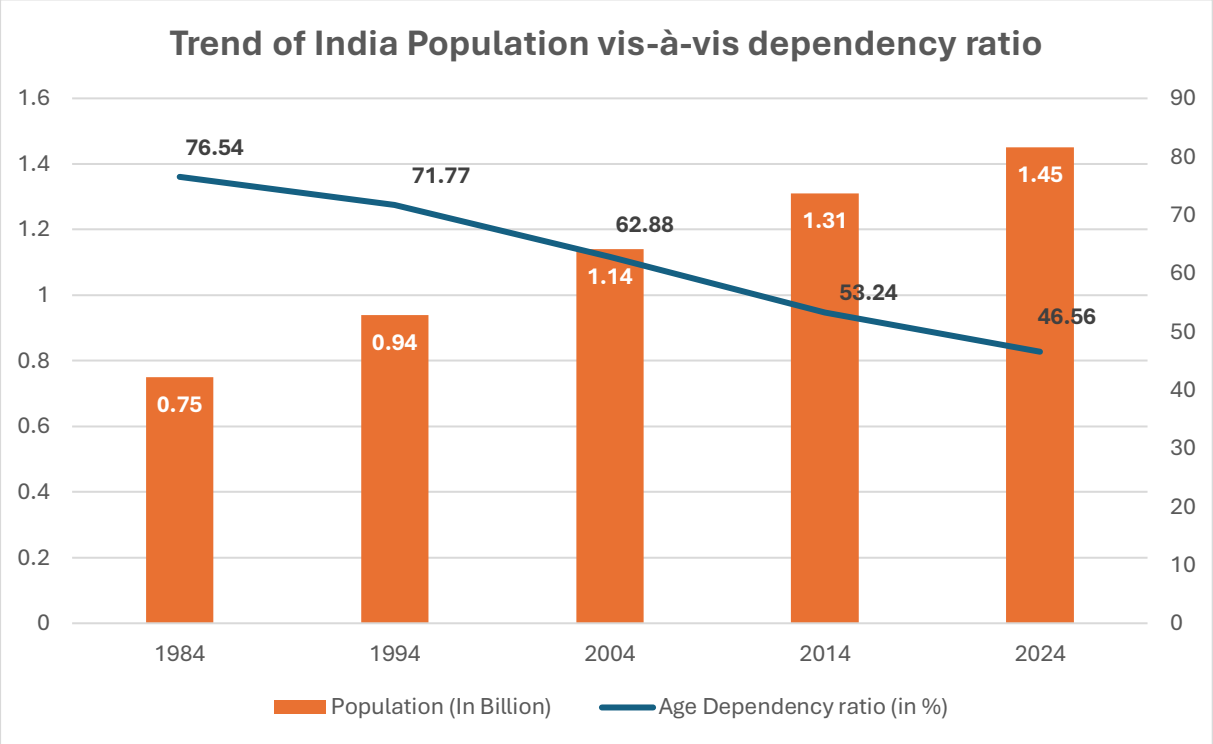
2.6 Overview on Key Demographic Parameters

2.6.1 Population growth and Urbanization

India's economic trajectory and consumption dynamics are closely tied to its demographic shifts. According to the World Bank, India's population expanded from approximately 0.75 billion in 1984 to 1.45 billion in 2024, consolidating its position as the world's most populous nation. This growth underlines the emergence of a vast labour force and consumer base, essential for driving sustained economic progress.

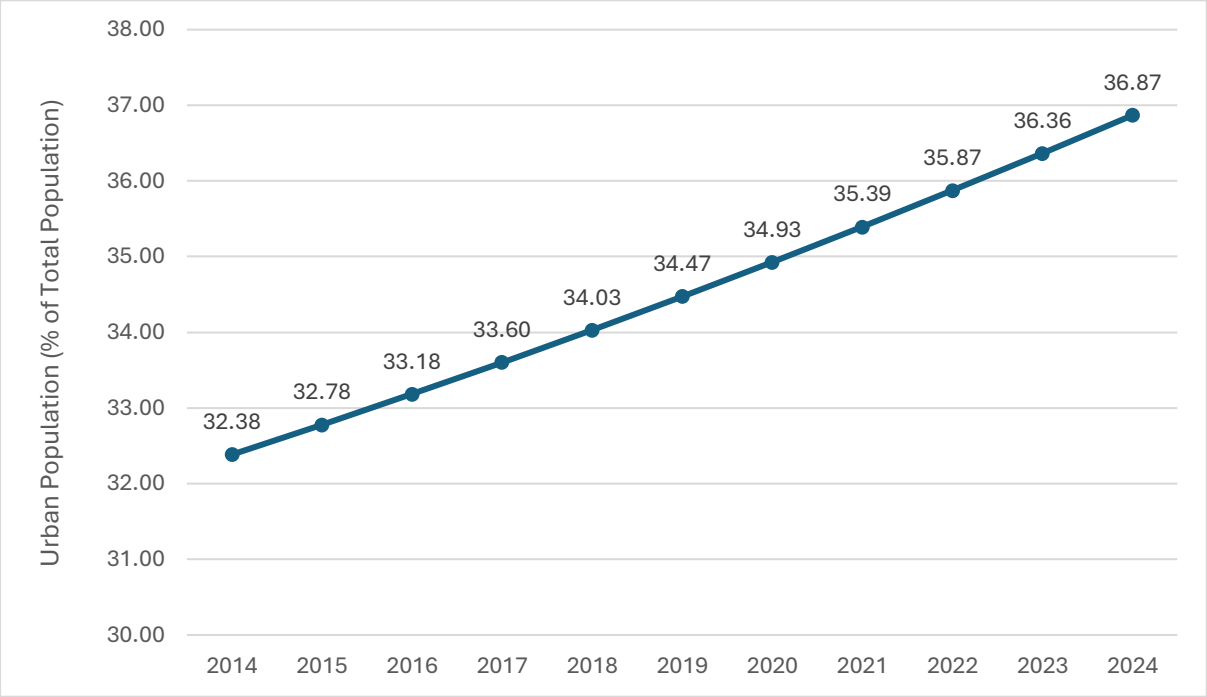
A key demographic indicator—the age dependency ratio—has witnessed a steady decline over the last four decades. From a high of 76.54% in 1984, it reduced to 71.77% in 1994, 62.88% in 2004, and 53.24% in 2014, before reaching a low of 46.56% in 2024. This downward trend signifies that for every 100 working-age individuals, there are now fewer than 47 dependents, compared to over 76 dependents in the mid-1980s. Such a shift reflects a growing share of the working-age population, unlocking India's demographic dividend—a critical driver of productivity, savings, and investment.

Together, the rising total population and declining dependency ratio provide a dual advantage: a larger workforce capable of supporting economic activity and a lower demographic burden, which allows for higher disposable incomes and consumption growth. These demographic fundamentals form a strong backbone for India's long-term economic and private consumption expansion.



Source: World Bank Database, Infomerics Analytics & Research

Urbanization Trend in India



Source: World Bank Database

Urbanization, too, is transforming India's socio-economic fabric. The urban population rose from 424.96 million in 2014 (32.38% of total population) to 522.93 million in 2023 (36.36%), and further to approximately 534.91 million in 2024 (36.87%), according to World Bank estimates. This rapid growth in urban areas underscores the need for sustainable urban planning, investment in infrastructure, and development of smart cities to accommodate and benefit from the shifting population dynamics.

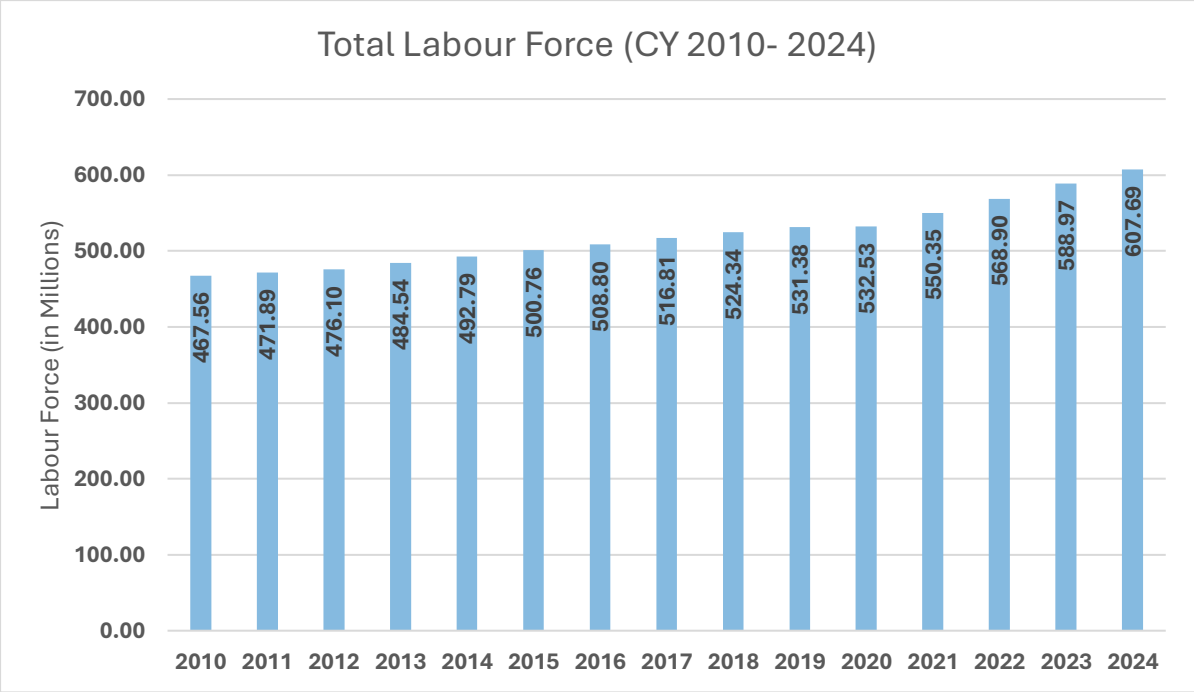
2.6.2 Labour Force in India

India's labour force has experienced significant growth over the past decade. In 2010, the total labour force was approximately 467.56 million. By 2024, this number had increased to 607.69 million, reflecting a Compound Annual Growth Rate (CAGR) of 1.89% over the 14-year period.

This upward trend underscores the expanding working-age population and the country's ongoing economic development. However, it also highlights the need for effective employment policies to ensure that the growing labour force is adequately absorbed into productive sectors.

The labour force participation rate (LFPR) has also seen fluctuations, influenced by various socio-economic factors. As of 2024, the LFPR stood at 45.1%, indicating the percentage of the working-age population that is either employed or actively seeking employment.

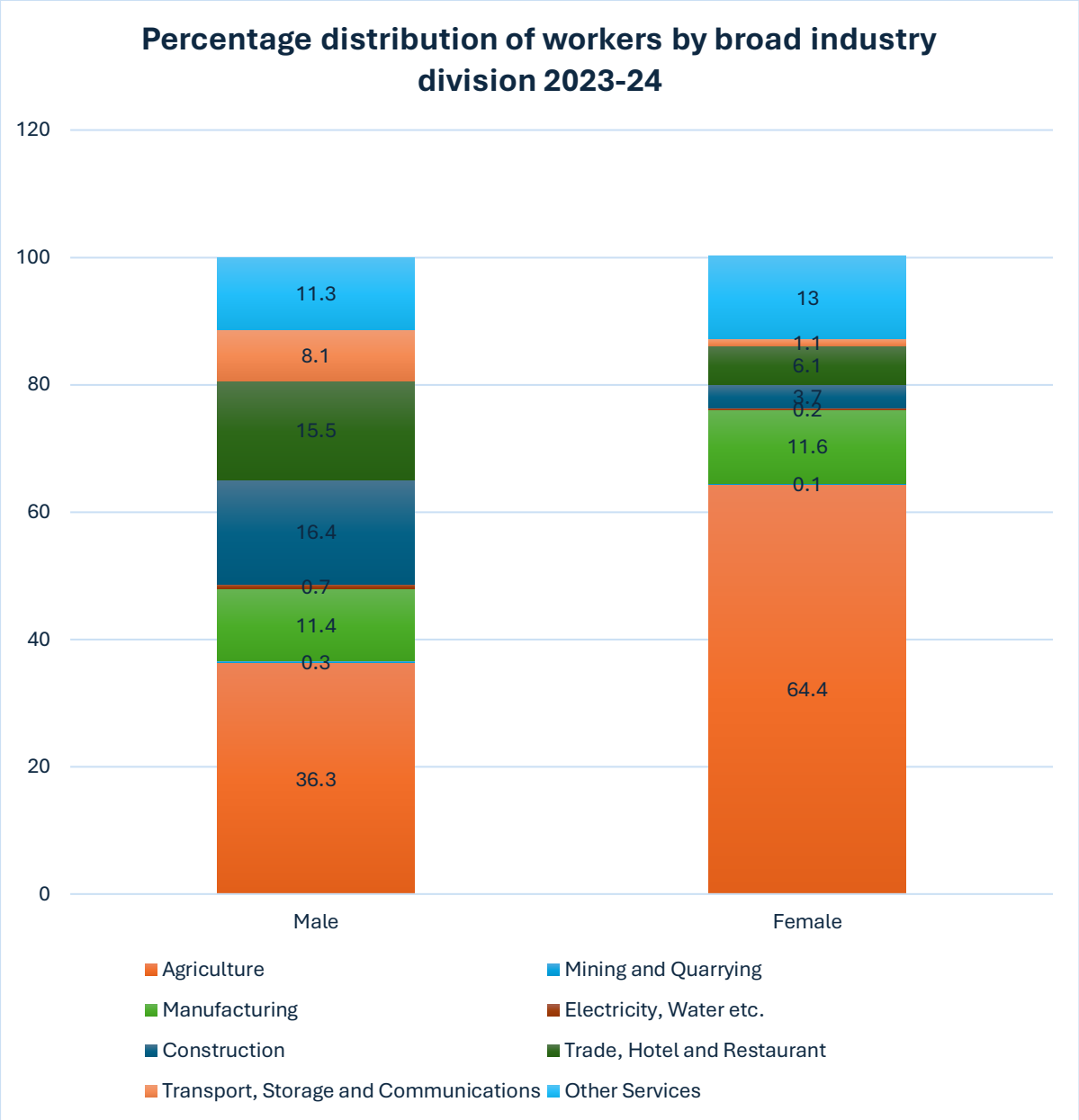
These statistics emphasize the importance of implementing strategies that not only create employment opportunities but also enhance the quality and inclusivity of jobs across different sectors of the economy.



Source: World Bank Database

2.6.3 Breakdown of Employment by Sector

According to the Periodic Labour Force Survey (PLFS) 2023–24, the employment distribution across various sectors exhibits distinct gender-based patterns. A significant portion of male workers are engaged in agriculture, followed by notable participation in construction, manufacturing, and trade-related activities. In contrast, female workers are predominantly employed in agriculture, with considerable involvement in manufacturing and other services sectors. While female representation in trade and construction is lower compared to males, Additionally, a substantial proportion of employed women are self-employed, often contributing as unpaid helpers in household enterprises or operating small businesses, indicating a reliance on informal employment avenues.

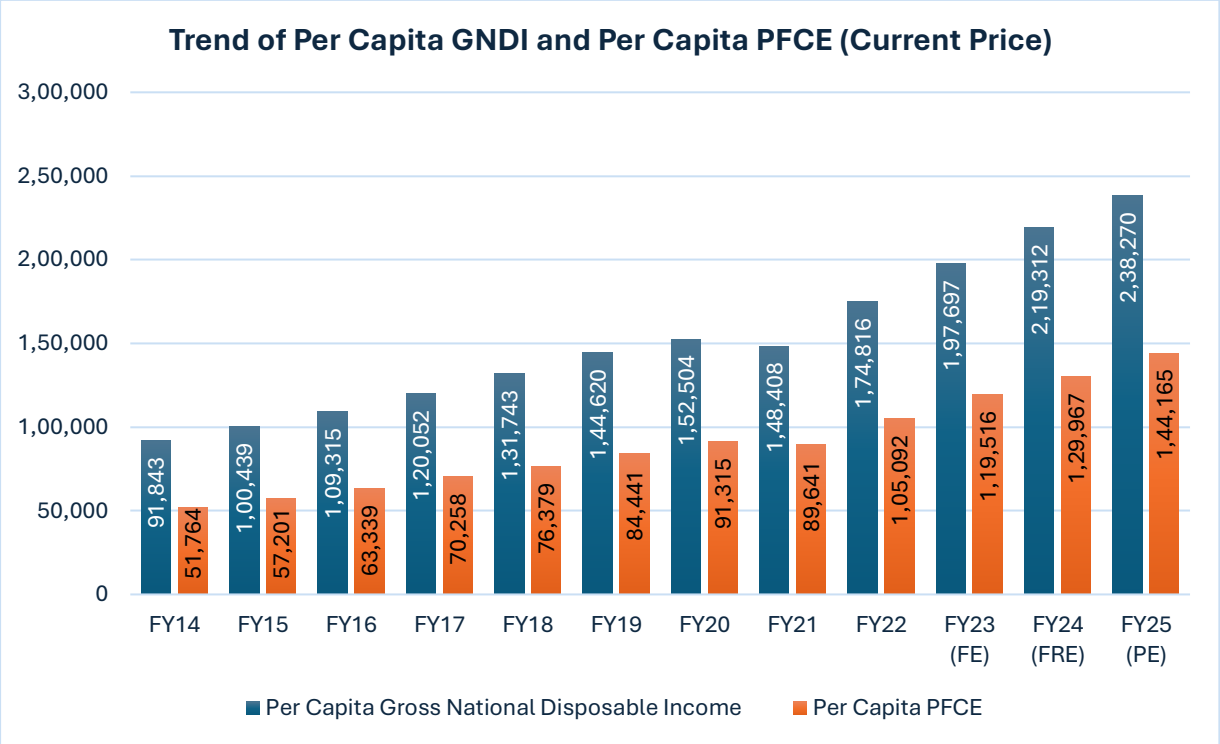


Source: Annual Report 2023-24, Periodic Labour Force Survey

2.6.4 Disposable Income and Consumer Spending

Gross National Disposable Income (GNDI) represents the total income available to a nation's residents for consumption and saving after accounting for income transfers with the rest of the world. In FY24, Per capita GNDI grew by 10.9%, followed by a moderate growth of 8.6% in FY25. This steady increase indicates that households and businesses had more income at their disposal, which is critical for supporting both consumption and savings—key components of economic resilience and expansion.

The rise in GNDI has translated into higher consumer spending, as reflected in the growth of Private Final Consumption Expenditure (PFCE), which measures the total value of goods and services consumed by households. Per Capita PFCE grew by 8.7% in FY24 and further accelerated to 10.9% in FY25, highlighting strong consumer confidence and robust domestic demand.



Note: Data mentioned is in INR, FE – Final Estimates, FRE – First Revised Estimates, PE – Provisional Estimate; Source: PIB, *Provisional estimates of GDP 2024-25 released on May 30th, 2025*

2.7 Union Budget FY26-27 Highlights

The Union Budget FY 2026–27, presented by Finance Minister Nirmala Sitharaman, introduces a comprehensive set of measures aimed at stimulating economic growth, enhancing infrastructure, and fostering inclusive development. With a focus on sectors such as agriculture, MSMEs, infrastructure, innovation, and exports, the budget seeks to create a conducive environment for sustained economic expansion.

- **Capital Expenditure and Infrastructure Development**
  In FY2026-27, the Union Budget has increased the public capex towards to ₹12.2 lakh crore from the previous ₹11.21 lakh crore (3.1% of GDP) which was earmarked in FY 2025–26. To strengthen the confidence of private developers regarding risks during infrastructure development and construction phase, the budget proposed to set up an Infrastructure Risk Guarantee Fund to provide prudently calibrated partial credit guarantees to lenders.
- **Support for MSMEs**
  Recognizing the pivotal role of Micro, Small, and Medium Enterprises (MSMEs) in India's economic landscape, the budget introduced a three-pronged approach to support the sector. The budget introduced a dedicated ₹10,000 crore SME Growth Fund as well as proposed to top up the Self-Reliant India Fund set up in 2021, with ₹2,000 crore to continue support to micro enterprises and maintain their access to risk capital. With TReDS, more than ₹7 lakh crore has been made available to MSMEs. To leverage its full potential, the budget further proposed four measures: (i) mandate TReDS as the transaction settlement platform for all purchases from MSMEs by CPSEs, serving as a benchmark for other corporates; (ii) introduce a credit guarantee support mechanism through CGTMSE for invoice discounting on TReDS platform; (iii) link GeM with TReDS for sharing information with financiers about government purchases from MSMEs, encouraging cheaper and quicker financing; (iv) introduce TReDS receivables as asset-backed securities, helping develop a secondary market, enhancing liquidity and settlement of transactions. Moreover, Government will facilitate Professional Institutions such as ICAI, ICSI, ICMAI to design short-term, modular courses and practical tools to develop a cadre of 'Corporate Mitras', especially in Tier-II and Tier-III towns, which will help MSMEs meet compliance requirements at affordable costs.
- **Establishment of dedicated Rare Earth Corridors**
  A Scheme for Rare Earth Permanent Magnets was launched in November 2025. In line with that, the budget proposed to support the mineral-rich States of Odisha, Kerala, Andhra Pradesh and Tamil Nadu to establish dedicated Rare Earth Corridors to promote mining, processing, research and manufacturing.

- **Integrated Programme for the Textile Sector**
  The following Schemes have been announced:
  (a) The National Fibre Scheme for self-reliance in natural fibres such as silk, wool and jute, man-made fibres, and new-age fibres.
  (b) Textile Expansion and Employment Scheme to modernise traditional clusters with capital support for machinery, technology upgradation and common testing and certification centres.
  (c) A National Handloom and Handicraft programme to integrate and strengthen existing schemes and ensure targeted support for weavers and artisans.
  (d) Tex-Eco Initiative to promote globally competitive and sustainable textiles and apparels.
  (e) Samarth 2.0 to modernize and upgrade the textile skilling ecosystem through collaboration with industry and academic institutions.

- **Carbon Capture Utilization and Storage (CCUS)**

Aligning with the roadmap launched in December 2025, CCUS technologies at scale will achieve higher readiness levels in end-use applications across five industrial sectors, including, power, steel, cement, refineries and chemicals. An outlay of ₹20,000 crore is proposed over the next 5 years.

- **Municipal Bonds**
  To encourage the issuance of municipal bonds of higher value by large cities, the budget proposed an incentive of ₹100 crore for a single bond issuance 10 of more than ₹1000 crore. The current scheme under AMRUT which incentivises issuances up to ₹200 crore, will also continue to support smaller and medium towns.

- **Ease of Doing Business**

Individual Persons Resident Outside India (PROI) will be permitted to invest in equity instruments of listed Indian companies through the Portfolio Investment Scheme. It is also proposed to increase the investment limit for an individual PROI under this scheme from 5% to 10%, with an overall investment limit for all individual PROIs to 24%, from the current 10%.

- **Hubs for Medical Value Tourism**
  To promote India as a hub for medical tourism services, the budget proposed to launch a Scheme to support States in establishing five Regional Medical Hubs, in partnership with the private sector. These Hubs will serve as integrated healthcare complexes that combine medical, educational and research facilities. They will have AYUSH Centres, Medical Value Tourism Facilitation Centres and infrastructure for diagnostics, post-care and rehabilitation. These Hubs will provide diverse job opportunities for health professionals including doctors and AHPs.

- **Agriculture Related Schemes**

  To diversify farm outputs, increase productivity, enhance farmers' incomes, and create new employment opportunities, the budget announced support schemes related to high value crops such as **coconut, sandalwood, cocoa and cashew** in coastal areas. Agar trees in Northeast and nuts such as, **almonds, walnuts and pine nuts** in hilly regions will also be supported. India is the world's largest producer of coconuts. About 30 million people, including nearly 10 million farmers, depend on coconuts for their livelihood. To further enhance competitiveness in coconut production, the Budget proposed a **Coconut Promotion Scheme** to increase production and enhance productivity through various interventions including replacing old and non-productive trees with new saplings/plants/varieties in major coconut growing States. A dedicated programme is proposed for Indian cashew and cocoa to make India self-reliant in **raw cashew and cocoa production and processing**, enhance export competitiveness and transform Indian Cashew and Indian Cocoa into premium global brands by 2030. Further, the Central Government will partner with State Governments to promote focused cultivation and post-harvest processing to restore the glory of the Indian Sandalwood ecosystem. To rejuvenate old, low-yielding orchards and expand high-density cultivation of walnuts, almonds and pine nuts, the budget announced to support a dedicated programme to enhance farmer incomes and in bringing value addition by engaging youth.

The Union Budget FY 2026–27 presents a balanced approach to economic growth by addressing immediate consumption needs and laying the foundation for long-term sustainability. Through targeted investments in infrastructure, support for MSMEs, and sector-specific initiatives, the budget aims to foster an inclusive and resilient economy. These measures are expected to create new opportunities for financial institutions, as the growing demand for investment products will provide avenues for expansion and innovation in the financial services sector.

3. Industry Overview – Solar Power Equipment Industry

3.1 Introduction

The global Solar Power Equipment Industry forms a core pillar of the world's transition toward clean, reliable, and low-carbon energy systems. This industry includes the full suite of technologies required to generate, convert, manage, and store solar energy, covering photovoltaic (PV) modules, solar inverters, hybrid inverters, power conversion systems (PCS), charge controllers, mounting structures, lithium-ion and lead-acid energy storage systems, battery management systems (BMS), and digital monitoring solutions. As solar energy emerges as one of the fastest-growing sources of new power capacity worldwide, the demand for efficient power electronics and dependable storage technologies has become increasingly critical.

Global momentum toward decarbonization—supported by the Paris Agreement, national net-zero targets, renewable energy policies, and rising sustainability investments—has significantly accelerated solar deployment across residential, commercial & industrial (C&I), and utility-scale segments. Continuous declines in PV module prices, advancements in inverter topologies, and rapid adoption of Battery Energy Storage Systems (BESS) have strengthened the integration of solar energy into mainstream power systems.

The industry is characterized by a broad set of interlinked product categories, including string inverters, hybrid/off-grid inverters, solar-plus-storage systems, lithium-ion batteries, lead-acid batteries, charge controllers, EMS (Energy Management Systems), and AI/IoT-based remote monitoring platforms. Ongoing technological innovation—such as higher MPPT efficiencies, transformer-less designs, wide-bandgap semiconductor technology (IGBTs/SiC), intelligent hybrid inverters, and high-voltage lithium storage—is redefining performance benchmarks, improving safety, and enhancing system reliability.

Rising adoption of rooftop solar, distributed energy resources, and C&I solar installations is driving substantial demand for advanced power conversion and energy storage equipment. Lithium-ion technologies, especially LFP ($LiFePO_4$), have become the preferred storage solutions due to superior energy density, long life cycles, and rapidly declining battery costs. The industry is also moving toward emerging innovations, including solid-state batteries, virtual power plants (VPPs), and bidirectional smart inverters capable of providing grid support and demand response services.

As solar energy continues its transition into a mainstream global energy source—particularly across Asia-Pacific, North America, and Europe—the Solar Power Equipment Industry is

positioned for sustained growth. Increasing electrification, rising grid instability, the need for energy independence, and the evolution of flexible, distributed power networks will drive large-scale adoption of hybrid inverters, residential and commercial battery systems, smart controllers, and integrated solar energy management technologies. The industry will continue advancing through technological innovation, cost optimization, digitalization, and the integration of next-generation energy storage solutions.

Market Segmentation

Segmentation Category	Sub-Segments
By Equipment's	• Solar Panels • Mounting Systems • Racking Systems • Tracking Systems (Single-Axis, Dual-Axis) • Storage Systems (Battery Energy Storage Systems) • Solar Inverters • Others (Charge Controllers, Wiring, Connectors, Junction Boxes, and Other Balance-of-System Components)
Applications Covered	• Residential • Non-Residential (Commercial & Industrial) • Utility (Utility-Scale Solar Plants)

4. Global Outlook

4.1 Global Solar Energy

The global power stack is rapidly shifting from thermal baseload generation toward variable renewables, with utility-scale solar emerging as the dominant driver of new capacity additions worldwide. Solar PV has become the centrepiece of modern power buildouts, supported by sustained policy incentives, declining module and balance-of-system costs, higher efficiencies, and improved digital O&M. Falling LCOE across mature and emerging markets continues to accelerate adoption, even as the sector navigates challenges such as grid congestion, interconnection delays, land-use constraints, and trade-related measures (tariffs, AD/CVD).

Storage attachment rates are rising sharply, enabling solar-plus-storage systems to enhance grid flexibility and value creation. Despite operational and regulatory bottlenecks, solar has transitioned from a niche growth segment to a core global asset class, attracting record investment and reinforcing its position as the leading technology in the global clean energy transition. Between CY2019 and CY2024, total global solar capacity expanded from 592.65 GW to 1,865.49 GW, reflecting a remarkable CAGR of 25.78**%**. This trajectory underscores the sector's pivotal role in driving the global energy transition toward net-zero pathways.

In GW	CY 2019	CY 2020	CY 2021	CY 2022	CY 2023	CY 2024	CAGR '19'24
World Solar	592.65	723.63	866.83	1060.52	1413.54	1865.49	25.78%
Solar PV On-Grid	586.29	717.23	860.46	1053.96	1406.68	1858.62	25.96%
Solar PV Off grid	3.02	3.52	3.81	4.41	4.71	6.29	15.82%
Others	3.34	2.88	2.56	2.15	2.15	0.58	- 29.54 %

Note: Others include concentrated solar power, solar power heating and cooling, Agro voltaic, Building integrated solar, solar fuels, other hybrid solar cells
*Source: IRENA 2025, Infomerics Analytics & Research * Based on the latest available data.*

Within the broader solar ecosystem, on-grid PV systems—which are directly connected to national and regional grids—account for approximately 99% of solar energy. On-grid PV capacity grew from 586.29 GW in CY2019 to 1,858.62 GW in CY2024, delivering a robust CAGR of 25.96%. These installations, spanning utility-scale plants and commercial/industrial rooftops, dominate the market by ensuring grid-level integration, large-scale power delivery, and reliable contribution to national energy security.

In contrast, Off-grid PV systems—comprising stand-alone home systems, lanterns, and rural mini-grids—remain a smaller but strategically significant segment. Global off-grid solar capacity increased from 3.02 GW in CY2019 to 6.29 GW in CY2024, achieving a CAGR of 15.82%. Although representing less than 2% of global solar capacity, off-grid systems are vital in bridging energy access gaps, particularly across Africa, South Asia, and rural Asia-Pacific, where electrification through centralized grids remains challenging.

The bifurcation between on-grid and off-grid PV reflects the dual imperatives of global solar growth: scaling utility-scale projects to anchor national power generation, while deploying decentralized solutions to deliver last-mile energy access. Together, these dynamics reinforce solar PV's status as the fastest growing and most transformative pillar of global renewable energy.

4.1.1 Global Solar Power Installed Capacity by Region (CY19–CY24) – On Grid

Solar PV On-Grid constitute about 41.78% of the Total Renewable Energy. It has delivered the largest increment among renewables since 2019, led overwhelmingly by China and the rest of Asia, with Europe and India rising fast since 2021.

In Gigawatts	CY2019	CY2020	CY2021	CY2022	CY2023	CY2024	CAGR '19'24	Share of global %
World	586.29	717.23	860.46	1,053.96	1406.68	1,858.62	25.96%	100%
Asia ex.India	295.59	372	438.34	537.65	767.97	1058.43	29.06%	56.9%
India	34.90	39.36	49.60	63.048	72.51	97.04	22.69%	5.22%
Europe	137.41	157.45	184.40	220.39	277.29	336.07	19.59%	18.0%
North America	70.06	86.21	108.08	127.65	154.50	194.07	22.60%	10.44 %
Africa	8.19	9.55	10.48	11.52	12.43	14.29	11.77%	0.77%
Middle East excl. Saudi	5.56	7.304	9.42	13.17	16.37	17.81	26.19%	0.96%
Saudi Arabia	0.05	0.35	0.389	0.39	2.53	4.29	135.68 %	0.23%
Others	34.48	44.98	59.72	80.11	103.06	136.61	31.70%	7.35%

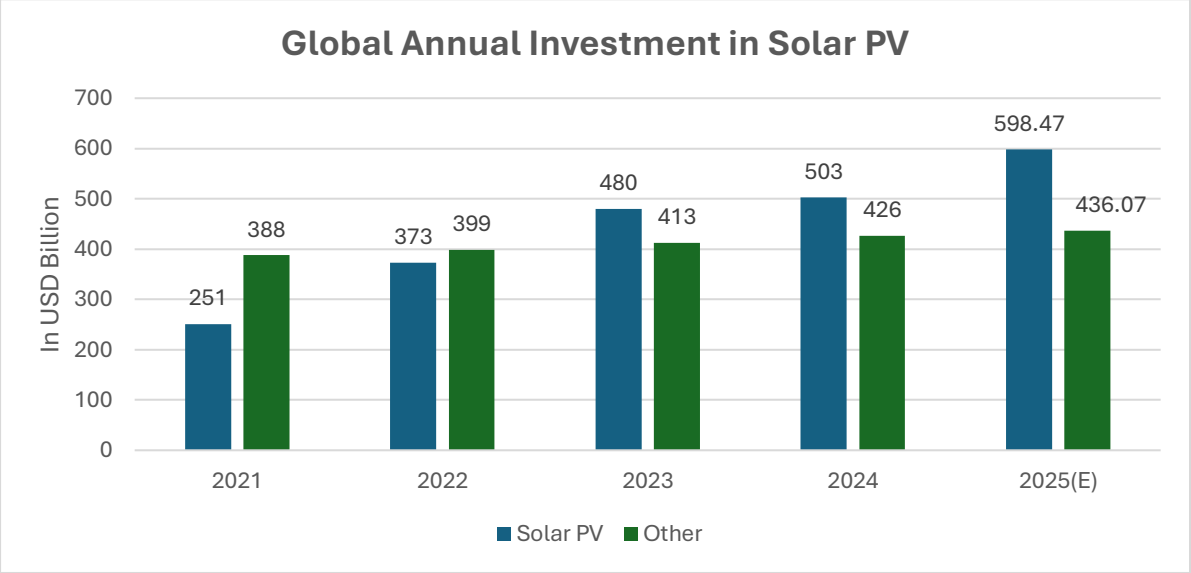
*Source: IRENA 2025, For India the figures are estimated. * Based on the latest available data.*

Asia (ex-India) emerged as the undisputed leader, with installed capacity surging from 295.59 GW in CY2019 to 1,058.43 GW in CY2024, reflecting a CAGR of 29.06% and capturing 56.95% of global share. China remains the overwhelming driver of this growth, leveraging economies of scale, state-backed manufacturing dominance, and rapid utility-scale deployment to cement its position as the world's largest solar market. Saudi Arabia, though a smaller player in absolute terms, posted exponential growth. Installed solar PV capacity expanded from just 0.05 GW in CY2019 to 4.29 GW in CY2024, translating into a world-leading CAGR of 135.68%. This surge reflects the early impact of Saudi Arabia's Vision 2030 diversification program and its accelerated pipeline of mega-projects across the Middle East.

Asia (China) and Europe dominate global solar buildout, enabled by both policy support and falling costs. The Middle East and Africa show the fastest proportional increases, but from smaller bases. India and Saudi Arabia are rapidly scaling utility PV via government-led tenders.

4.1.2 Global Annual Investment in Solar PV (CY21–CY25)

Annual investment in solar PV rose sharply from USD 251 billion in 2021 to USD 503 billion in 2024, delivering a robust 18.98% CAGR. This growth far outpaced other renewables, where capital inflows expanded only marginally.

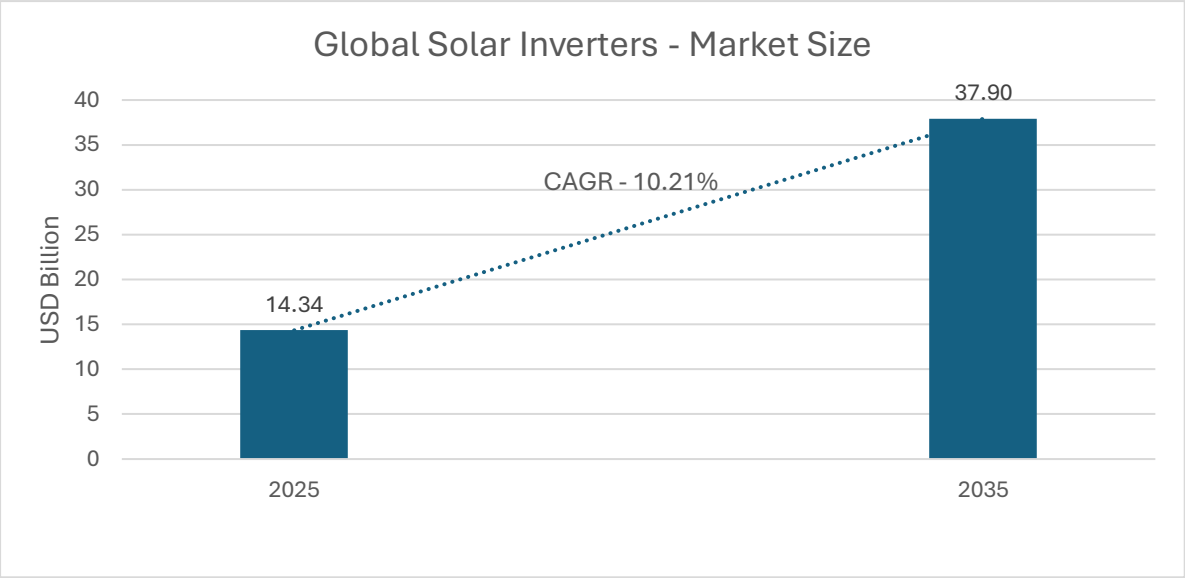


Source: IEA, Infomerics Analytics & Research

The investment surge reflects accelerating deployment pipelines, resilient policy frameworks (net-zero mandates, competitive auctions), expanding green finance pools, and strong corporate demand for decarbonization. Despite volatility in module pricing and supply chain costs, EPC-led deployment capital remained on an upward trajectory, underscoring solar PV's role as the anchor technology in the global energy transition.

4.2 Global Solar Inverters

The global Solar Inverter industry is estimated at USD 14.34 billion in 2025 and is projected to reach USD 37.90 billion by 2035, reflecting a CAGR of 10.21% over the period.



Source – Infomerics Analytics & Research

This strong expansion underscores the critical role of inverters in the solar value chain, as they enable efficient power conversion, grid compatibility, and system monitoring. Growth is supported by several structural drivers, including the rapid scaling of utility-scale solar farms, increasing adoption of residential and commercial rooftop systems, and the shift toward smarter, higher-efficiency inverter technologies such as string inverters, central inverters, and hybrid/solar-plus-storage solutions. Additionally, global decarbonisation targets, declining solar installation costs, and supportive regulatory frameworks continue to accelerate inverter demand across major markets in Asia-Pacific, Europe, and North America. Overall, the projections indicate a steadily expanding market with rising technological sophistication and broader integration of energy storage systems.

Lithium-ion batteries have become central to the manufacturing of modern hybrid and off-grid solar inverters because these systems are now designed to operate as integrated solar-plus-storage solutions rather than simple power-conversion devices. The shift toward lithium-based storage—especially LFP, which offers higher cycle life, faster charging, deeper discharge capability, and improved thermal stability—has pushed inverter manufacturers to redesign power electronics, battery management systems (BMS), and communication protocols for seamless integration. As battery prices fall and storage adoption rises, inverter manufacturers increasingly incorporate lithium-ion–compatible MPPT controllers, advanced BMS communication (CAN/RS485), and higher voltage battery inputs, enabling greater efficiency,

longer backup duration, and better system reliability. This makes lithium-ion technology a critical enabler of the next generation of smart, energy-efficient hybrid inverters widely used in homes, commercial facilities, and industrial energy storage systems.

Lithium-ion batteries—particularly LFP chemistry, which is ~30% cheaper per kWh—play a critical role in modern solar inverters and energy storage systems by providing fast-charging, high-cycle, and high-efficiency storage required for managing intermittent solar generation. As global battery prices fell 20% in 2024 and LFP penetration reached ~50%, hybrid and off-grid solar inverters increasingly integrate lithium-ion packs to enable load shifting, backup power, and peak shaving. In India, the rapid growth of the lithium-ion market (USD 1.79 billion in 2024, projected to USD 7.49 billion by 2034) is directly supporting the adoption of residential, commercial, and industrial solar-plus-storage systems, driven by rising demand for reliable power, policy incentives, and the shift from lead-acid to lithium-based solutions.

Supply Dynamics:

- **Cell Manufacturing:**
  - Global battery cell production capacity reached 3 TWh in 2024, nearly three times annual demand. China accounted for 85%, while Korea, Japan, and the US supplied the balance. By 2030, global capacity is projected to reach 6.5 TWh, with China's share moderating to ~66%.
  - Korean manufacturers remain the largest foreign investors, with overseas production potentially reaching 1.1 TWh by 2030. US and European capacity is expanding, supported by government incentives and cross-border investments. Tesla, LG Energy Solution, Samsung, and SKI are driving US capacity growth, while Europe sees increased Chinese investment, despite domestic production challenges.
- **Lithium Supply:**
  - In 2024, global lithium demand exceeded 200 kt Li (~1.1 Mt LCE), predominantly for EV batteries. Supply rose ~35%, stabilising prices at ~USD 12,000 per tonne LCE. Australia, China, and Argentina accounted for 77% of global lithium supply, with China refining ~70% of lithium chemicals.
  - Looking ahead, supply diversification is expected from Africa (notably Zimbabwe and Mali) and the Americas (Canada, Argentina, USA), although China will continue to dominate refining, especially for hard rock lithium (~95% of hard rock refining).

Market Trends

1. Rapid Expansion of Energy Storage Technologies - Energy storage—especially lithium-ion, LFP, and emerging sodium-ion batteries—is becoming the backbone of modern renewable energy systems. As solar and wind installations surge, grid operators require reliable storage solutions to manage intermittency, stabilize supply, and support peak demand. This has triggered massive investments in battery manufacturing, with many companies expanding gigafactory capacities and improving cycle life, safety, and energy density. Storage is also enabling hybrid systems, off-grid solutions, and backup power for households and industries, making battery energy storage one of the fastest-growing renewable equipment segments.

2. Increasing Adoption of Hybrid Renewable Systems - Hybrid systems that combine solar + energy storage, solar + wind, or solar + diesel replacement is gaining significant traction. These systems improve energy reliability, reduce lifecycle costs, and operate independently of grid disturbances. Due to declining inverter and battery prices, hybrid renewable systems are becoming mainstream in commercial & industrial (C&I) facilities, telecom towers, agricultural pumps, and residential applications. Equipment manufacturers are designing inverters and controllers that seamlessly integrate multiple energy sources, making hybrids a transformative trend in the sector.

3. Rise of Smart Inverters and Digital Energy Management - Smart inverters equipped with IoT, advanced monitoring, grid-forming capabilities, and AI-based optimization are becoming essential components of renewable installations. These inverters can communicate with utilities, provide reactive power support, ensure frequency stabilization, and perform remote diagnostics. Digital energy management platforms also allow users to track real-time energy consumption, performance ratios, and system health through mobile apps. As electricity networks modernize, smart inverters are evolving into key grid-interactive devices that strengthen overall system resilience.

4. Growth of Utility-Scale Solar and Wind Projects - The renewable energy equipment industry is experiencing a strong push from large utility-scale solar PV parks, offshore wind farms, and hybrid renewable plants. These large installations require high-capacity inverters, advanced switchgear, heavy-duty wind components, transformers, and utility-grade storage systems. Government auctions, long-term PPAs, and cost reductions have accelerated deployments. The scale of these projects drives higher demand for efficient, high-wattage modules, central inverters, multi-MVA transformers, and grid-balancing solutions, boosting the equipment manufacturing ecosystem globally.

5. Decentralized and Off-Grid Renewable Solutions on the Rise - Demand for decentralized energy—mini-grids, rooftop solar, home batteries, and off-grid solar systems—is expanding rapidly, especially in rural regions and emerging markets. These systems help overcome grid limitations, reduce dependency on diesel generators, and provide reliable power for

households, shops, telecom sites, agriculture, and small industries. Equipment manufacturers increasingly design rugged inverters, DC systems, and modular batteries suited for off-grid environments. This trend is widening access to clean energy while creating new market opportunities for distributed renewable technologies.

6. Sustainability and Circularity in Manufacturing - There is a rising emphasis on sustainable and circular manufacturing practices, driven by regulatory pressure and corporate goals. Renewable energy equipment manufacturers are adopting eco-friendly materials, improving recyclability of solar panels and batteries, reducing carbon footprints in production, and implementing take-back programs. Lithium battery recycling is becoming a major growth segment, with companies recovering lithium, nickel, cobalt, and graphite for reuse. Circularity is emerging as a strategic differentiator for global renewable energy brands.

7. Technological Advancements in Solar and Wind Equipment - Solar equipment is witnessing rapid innovation—including high-efficiency n-type TOPCon and HJT modules, bifacial panels, larger wafer formats, and tracker-integrated systems. Wind energy equipment is evolving with larger rotor diameters, taller towers, and more efficient direct-drive turbines. These advancements reduce the levelized cost of energy (LCOE), increase capacity factors, and expand deployment in lower-wind-speed regions. Manufacturers are investing heavily in R&D to deliver high-performance systems that maximize power generation per unit area.

5. Indian Outlook – Solar Power Equipment Industry

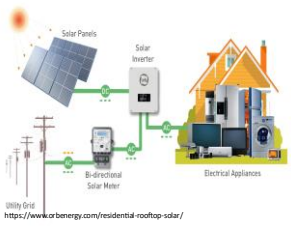
5.1 Overview of the Solar Power Equipment Industry in India

The solar power equipment industry in India is a key driver of the country's clean energy transition, supplying the technologies essential for generating, converting, and storing solar electricity. Supported by rising power demand, grid challenges, and India's target of 500 GW non-fossil capacity by 2030, the sector has grown rapidly from heavy import dependence to stronger domestic manufacturing capabilities. It plays a central role across residential rooftop systems, commercial and industrial (C&I) installations, and large utility-scale solar projects. The industry includes solar PV modules, string and hybrid inverters, battery energy storage systems (primarily LFP-based lithium batteries), mounting and racking structures, tracking systems, and balance-of-system (BOS) components such as cables, connectors, junction boxes, charge controllers, and monitoring devices. Solar inverters remain one of the most critical components, with increasing adoption of hybrid, grid-interactive, and smart digital inverters. Energy storage solutions are gaining momentum as customers demand higher reliability, backup power, and integration with rooftop and C&I solar systems. Overall, the solar power equipment industry in India is expanding quickly, driven by improvements in module efficiency (TOPCon, HJT), smart inverter technologies, digital monitoring, and solar-plus-storage solutions. With growing rooftop penetration, rising C&I adoption, and increasing investments in large-scale solar and hybrid renewable projects, the industry remains dynamic, competitive, and central to India's long-term clean energy goals.

India – 3rd largest solar power producer

India has become the world's third-largest solar power producer, generating 1,08,494 GWh of solar energy in FY 2024–25, surpassing Japan's 96,459 GWh. As of July 2025, India's cumulative solar power capacity stood at 119.02 GW, comprising:

Ground-mounted solar plants



Grid-connected rooftop solar systems

Hybrid projects

Off-grid installations

- **90.99 GW** – Ground-mounted solar plants
- **19.88 GW** – Grid-connected rooftop solar systems
- **3.06 GW** – Hybrid projects
- **5.09 GW** – Off-grid installations

India's solar progress is central to its renewable energy growth, with renewables making up 50.07% of the country's total installed power capacity (484.82 GW) – a COP26 commitment achieved five years ahead of schedule.

The total solar sector potential of the Indian subcontinent is 748 GW. High potential states include Rajasthan, Gujarat, Karnataka, Tamil Nadu, Andhra Pradesh, Maharashtra, Madhya Pradesh, Chhattisgarh, and Odisha. Notably, Palli village (Jammu & Kashmir) has become India's first carbon-neutral panchayat, fully powered by solar energy.

Domestic Manufacturing Growth

India's solar manufacturing ecosystem has witnessed unprecedented expansion in the last two years, positioning the country as a self-reliant and globally competitive player across the solar value chain.

1. **Solar Module Manufacturing**

- Capacity nearly doubled within a year, rising from 38 GW in March 2024 to 74 GW in March 2025.
- This rapid expansion has been enabled by large-scale investments, government-led tendering, and Production Linked Incentive (PLI) schemes.
- The higher domestic module capacity reduces dependence on imported products, especially from China, and strengthens India's export competitiveness.

2. **Solar PV Cell Manufacturing**

- Capacity increased almost three-fold, from 9 GW in FY 2023–24 to 25 GW in FY 2024–25.
- This scaling up addresses one of the critical gaps in India's solar supply chain, where domestic PV cell production earlier lagged module assembly.
- Increased cell production ensures greater backward integration and lowers import reliance, particularly for projects supported under government-linked programs.

3. **Ingot-Wafer Manufacturing**

- A major milestone was achieved with the commissioning of India's first ingot-wafer manufacturing facility (2 GW capacity).

- Ingot-wafer production is a critical upstream process that provides the base material for solar cells. Until now, India depended almost entirely on imports for this stage of the value chain.
- Establishing this facility marks the beginning of India's transition towards a fully integrated solar manufacturing ecosystem, reducing vulnerabilities to global supply chain disruptions.

Policies such as Basic Customs Duty (BCD) on imported modules/cells and mandatory domestic sourcing under government schemes have supported this expansion.

India has emerged as a global leader in advancing solar energy cooperation through multilateral platforms. The International Solar Alliance (ISA), co-founded by India and France in 2015, now brings together over 100 member countries with the objective of mobilising USD 1 trillion in solar investments by 2030, reducing technology costs, and promoting affordable solar deployment, particularly in Least Developed Countries (LDCs) and Small Island Developing States (SIDS). Complementing this, the One Sun, One World, One Grid (OSOWOG) initiative, launched by India in 2018, envisions the creation of a transnational solar grid to enable cross-border electricity trade under the principle that "the sun never sets." By linking solar-rich regions across South Asia, Africa, and Europe, OSOWOG aims to ensure reliable, sustainable, and cost-effective energy access, reinforcing India's leadership in shaping the global clean energy transition.

Comparative Advantages of Solar Products over Conventional Products

Category	Solar Products	Conventional Products (Fossil Fuel-Based)
Energy Source & Sustainability	Renewable, inexhaustible sunlight; supports decarbonization and long-term energy sustainability	Non-renewable fossil fuels; finite resources with long-term sustainability challenges
Upfront Cost	Higher initial investment for panels, inverters, and installation	Lower initial connection or setup fees
Running / Operating Cost	Minimal; sunlight is free; low maintenance	Continuous and recurring electricity/fuel expenses; maintenance-intensive
Payback Period	3–7 years depending on system size and usage	Not applicable; ongoing expenses with no return

Long-Term Savings / ROI	Significant savings over 25–30-year lifespan; system pays for itself and generates free power thereafter	No financial return: bills continue indefinitely, exposed to rising tariffs
Cost Control / Energy Independence	Greater control over energy costs; reduces dependence on grid and imported fuels; ensures energy security	Limited control; fully dependent on utility companies and market fluctuations
Carbon Emissions	Zero emissions during operation; environmentally clean	High CO_2 emissions; major contributor to global warming
Air & Water Pollution	No pollutants and less water consumption as compared with conventional products.	Releases SOx, NOx, particulates; large water usage for cooling, causing ecological and health impacts
Monthly Bills	Can significantly reduce or eliminate electricity bills	Full exposure to grid tariffs; costs rise over time
Government Incentives	Eligible for subsidies, tax credits, rebates, and net metering	Typically, no financial incentives
Power Reliability	Reliable, especially with battery storage; can provide backup during outages	Subject to grid failures and fuel supply disruptions
Operational Characteristics	Silent operation; low maintenance; smart monitoring and optimization; modular and scalable	Noise from generators; higher maintenance; expansion requires infrastructure upgrades; limited energy management
Grid Interaction / Revenue Potential	Can export surplus electricity for credits/revenue via net metering	Cannot monetize excess production; strictly a consumer
Long-Term Strategic Benefits	Creates productive long-term asset; predictable	No asset creation; exposes users to environmental and

	energy costs; supports ESG and sustainability goals	financial risks; limited strategic value
Technology Integration	Smart inverters, energy management, storage compatibility	Limited technological advancement; traditional mechanical systems

Overall Growth of the Solar Industry

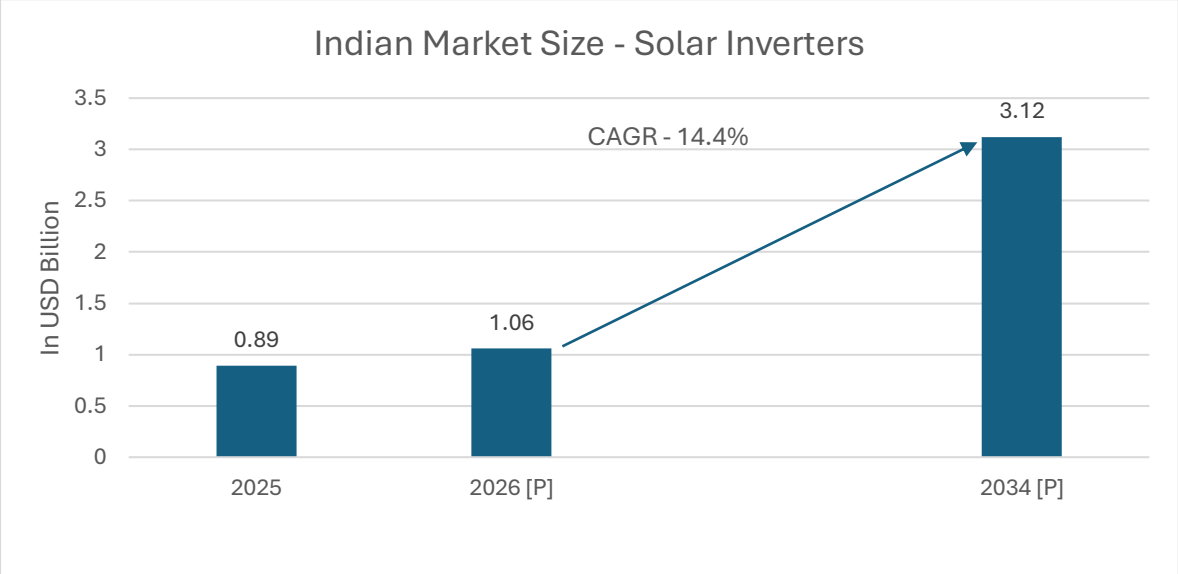
- **Milestone Achieved:** India has surpassed 100 GW of installed solar power capacity, marking a major milestone in its renewable energy journey and reinforcing its position as a global leader in solar energy.
- **Government Commitment and Vision:** This achievement reflects India's commitment to a cleaner, greener future and is a step toward the ambitious target of 500 GW of non-fossil fuel-based energy capacity by 2030.
- **Union Minister's Statement:** Shri Pralhad Joshi, Union Minister of New and Renewable Energy, highlighted that initiatives like solar parks, rooftop solar projects, and government schemes have revolutionized the energy sector. He emphasized that India is becoming self-reliant in green energy, providing a global model for clean power adoption.
- **Rooftop Solar Expansion:** The PM Surya Ghar: Muft Bijli Yojana has been a game-changer, making rooftop solar accessible to households. As of 2025, nearly 9 lakh rooftop solar installations have been implemented, empowering citizens with clean, decentralized energy.
- **Unprecedented Growth Over the Decade:** India's solar capacity has increased by 3,450% over the past decade, rising from 2.82 GW in 2014 to 100 GW in 2025. This rapid growth underscores the accelerated adoption of solar technologies nationwide. Total solar + hybrid capacity pipeline: 296.59 GW
- **Dominance in Renewable Energy Mix:** Solar energy accounts for 47% of India's total installed renewable energy capacity, remaining the primary contributor to the country's green energy growth.
- **Annual Capacity Additions:**
    - 2024: 24.5 GW of new solar capacity added — more than double the 2023 installations.
    - Utility-scale solar: 18.5 GW installed in 2024, a 2.8-fold increase compared to 2023.

- Top-performing states: Rajasthan, Gujarat, Tamil Nadu, Maharashtra, and Madhya Pradesh contributed significantly to utility-scale solar growth.
- Rooftop solar in 2024: 4.59 GW added, reflecting a 53% increase over 2023, driven largely by the PM Surya Ghar initiative.

- **Growth in Solar Manufacturing:**
  - Solar module production increased from 2 GW in 2014 to 60 GW in 2024, positioning India as a global leader in solar manufacturing.
  - With continued policy support, India aims to reach 100 GW of solar module production capacity by 2030.

5.1.1 India Solar Inverters market

According to Ministry of Power, the market projections for the Indian Solar Inverters segment up to 2026, and building on these official estimates, we have extended the forecast horizon to 2034. Based on this, the Indian Solar Inverters market is valued at USD 0.89 billion in 2025 and is projected to reach USD 1.06 billion by 2026. Extending this growth trajectory further, the market is expected to achieve USD 3.12 billion by 2034, corresponding to a CAGR of 14.4% over the projection period.



Source – Ministry of Power, Infomerics Analytics & Research

This accelerated growth is driven by rising rooftop solar adoption in the residential and C&I segments, strong government push through schemes like PM-KUSUM and net metering reforms and increasing demand for hybrid and grid-interactive inverters. The market's expansion also reflects the broader surge in solar PV installations under India's 500 GW renewable energy target, coupled with a shift toward higher-efficiency, smart, and communication-enabled inverter technologies. India's solar ecosystem has rapidly advanced from basic inverter systems supporting only lights and fans to modern transformer-less technologies capable of powering wider household and commercial loads.

Overall, the growth trajectory underscores the critical role of inverters as a core enabling technology within India's evolving solar ecosystem.

Demand for Solar Inverters & Batteries in India

- **Residential and Small Commercial Demand** – The residential sector remains a key contributor to inverter demand, with increasing rooftop solar adoption driven by rising grid tariffs, power reliability concerns, and government subsidy schemes. Demand is particularly strong for small-capacity string and hybrid inverters (1–10 kW). There is also a parallel rise in battery demand, as households increasingly adopt lithium-ion and LiFePO4 battery systems for backup power and energy optimization, leading to higher demand for hybrid inverters integrated with storage.
- **Industrial and Commercial Segment Demand** – The industrial and C&I (Commercial & Industrial) segment is a major and fast-growing demand driver. Manufacturing units, warehouses, data centres, educational institutions, hospitals, and commercial buildings are adopting rooftop and captive solar systems to reduce power costs and ensure energy security. These installations typically require higher-capacity string inverters, central inverters, and hybrid systems, along with large-scale battery storage solutions for peak load management, demand charge reduction, and backup power. As industries seek uninterrupted operations and energy cost optimization, demand for both inverters and industrial-grade battery systems continues to expand.
- **Demand Linked to Installed Solar Capacity** – India's rapidly expanding solar base directly drives inverter and battery demand. Every megawatt (MW) of new solar capacity requires corresponding inverter capacity, while increasing grid instability and peak load challenges are accelerating the addition of battery energy storage systems (BESS) alongside solar installations. The large installed base of existing solar plants also generates recurring demand for inverter replacements, retrofits, and battery upgrades.
- **Demand by Inverter Type (String, Central & Hybrid)** – String inverters hold a strong share due to growth in rooftop and C&I installations, where modularity and ease of expansion are key. Central inverters remain essential for utility-scale solar parks. Meanwhile, hybrid inverters are witnessing rising demand across residential and industrial users due to their ability to manage solar, grid, and battery storage simultaneously, linking inverter demand closely with storage adoption.
- **Technology-Driven Demand Growth** – Market demand is increasingly shifting toward advanced inverter technologies with smart monitoring, multiple MPPTs, remote diagnostics, and battery compatibility. Growth in energy storage adoption is expanding demand for bidirectional inverters and integrated energy management solutions, increasing both inverter and battery market value.
- **Policy and Incentive-Driven Demand** – Government rooftop subsidy programs, net metering, renewable energy targets, and policies promoting energy storage integration are sustaining demand. These initiatives make solar-plus-storage systems financially attractive, encouraging adoption across residential and industrial users.

- **Supplier Activity Reflecting Strong Market Demand** – High shipment volumes from domestic and global suppliers across utility, industrial, and rooftop segments reflect structurally strong demand. Increasing orders for solar inverters and battery storage systems from EPC contractors and developers indicate a stable and expanding market.

Overall, demand for solar inverters in India is strong and broad-based, increasingly linked with battery energy storage demand. Growth is driven not only by rooftop and utility solar expansion but also by rising adoption in the industrial and commercial segment, where energy cost savings, reliability, and storage integration are key priorities. This positions the inverter and battery market as a critical enabler of India's renewable energy transition.

6. Market Dynamics

6.1 Key Growth Drivers

India's solar equipment industry is expanding rapidly, supported by rising electricity demand, strong government targets (500 GW RE by 2030), falling equipment costs, and increasing adoption across residential, commercial, industrial, and utility-scale segments. The shift toward domestic manufacturing—spurred by PLI schemes, ALMM regulations, and import diversification—has strengthened supply chains and boosted competitiveness. Technological advancements in inverters, batteries, trackers, and high-efficiency modules (TOPCon, HJT), along with digitalised monitoring systems, are further accelerating industry growth and improving system reliability.

Market Drivers and Impact Assessment

(All values represent directional impact based on industry estimates and qualitative analysis)

Drivers	Impact		
	1-2 Years	3-4 Years	5-7 Years
1. Shift to Advanced Inverter Technologies (Transformer-less, Hybrid, High-Efficiency MPPT)	High	High	High
2. Transition from Lead-Acid to Lithium (LFP) Batteries & Storage Growth	High	High	High
3. Growth in Rooftop Solar & Behind-the-Meter Storage	High	High	High
4. Increasing Demand for Smart, Communication-Enabled Inverters (WiFi/GPRS/IoT)	Medium	High	High
5. Declining Costs of Solar Modules & Balance of System Components	High	High	High
6. Domestic Manufacturing Push (PLI, ALMM, DCR, China+1 Strategy)	Medium	High	High
7. Utility-Scale Solar, Hybrid, RTC & Storage-Linked Projects	High	High	High
8. ESG Commitments & Corporate Net-Zero Targets	Medium	High	High

9. Financing Support & Green Investments (Green Bonds, Infra Funds)	Medium	Medium	High
10. Improvements in Grid Infrastructure & Need for Grid Stability Through Smart Inverters	Low	Medium	High

Source – Infomerics Analytics & Research

Detailed Overview

1. Shift to Advanced Inverter Technologies (Transformer-less, Hybrid, High-Efficiency MPPT) - The industry is moving from basic inverters to advanced transformer-less and hybrid systems that offer higher efficiency, lower heat loss, and better integration with batteries and the grid. Features such as improved MPPT algorithms and grid-forming capabilities enhance system reliability and energy yield, making these advanced technologies critical for residential, C&I, and utility-scale applications.

2. Transition from Lead-Acid to Lithium (LFP) Batteries & Storage Growth - The shift toward lithium (LFP) batteries is accelerating because of their superior cycle life, safety, depth of discharge, and lower maintenance requirements. As lithium costs continue to decline, adoption of solar-plus-storage solutions is rising, driving demand for hybrid inverters that seamlessly integrate with modern BMS-based storage systems for both backup and peak-shaving applications.

3. Growth in Rooftop Solar & Behind-the-Meter Storage - Rooftop solar adoption is accelerating due to rising electricity costs, government incentives, and higher consumer awareness. This growth directly drives demand for compact, efficient string and hybrid inverters. At the same time, behind-the-meter battery storage is expanding as users seek backup power and greater energy independence, strengthening demand for hybrid solutions.

4. Smart & Connected Inverters, Digitalisation, and Remote Monitoring - Smart inverters equipped with WiFi/GPRS connectivity, IoT integration, and advanced monitoring platforms are becoming mainstream. Remote fault detection, predictive maintenance, and energy analytics enable better asset management and improve overall system uptime. Digitalisation also supports seamless integration with BMS, EMS, and SCADA for data-driven solar operations.

5. Declining Costs of Solar Modules & BOS Components - Falling prices of solar modules and BOS components are reducing overall system costs, improving payback periods and making solar installations more financially attractive. This cost drop encourages capacity expansion across all segments and increases demand for high-efficiency inverters capable of supporting oversizing and high DC-to-AC ratios.

6. Domestic Manufacturing Push: PLI, ALMM, DCR, China+1 - Government initiatives such as PLI, ALMM mandates, and DCR requirements are strengthening domestic production and reducing dependence on imports. As supply chains localize, inverter manufacturers benefit from improved availability of components, reduced lead times, and enhanced competitiveness. The broader China+1 diversification strategy is also boosting investment in local inverter assembly and R&D.

7. Utility-Scale Solar, Hybrid, RTC & Storage-Linked Projects - Large utility-scale solar, solar-wind hybrid, and energy-storage-linked RTC projects are becoming major growth engines for the sector. These projects require high-capacity central or string inverters with advanced grid-support features. With major tendering activity and long-term renewable procurement commitments, the utility segment remains a stable and high-volume driver of inverter demand.

8. Corporate ESG, Sustainability, and Net-Zero Commitments - Corporates are increasingly adopting solar to meet ESG commitments, reduce carbon footprints, and comply with net-zero targets. This shift is driving strong demand for high-quality, communication-enabled inverters that support detailed performance monitoring and sustainability reporting. C&I solar adoption is expected to accelerate under corporate decarbonisation mandates.

9. Financing Support: Green Bonds, Infra Funds & ESG Capital - Access to green financing is improving through instruments such as green bonds, renewable energy funds, and ESG-aligned capital. Lower cost of funds accelerates rooftop and utility-scale project execution, boosting overall inverter demand. Financing innovations are expected to play a major role in scaling solar capacity additions in the medium to long term.

10. Improvements in Grid Infrastructure & Need for Grid Stability Through Smart Inverters - As renewable penetration rises, the grid requires smarter inverters capable of providing reactive power support, frequency regulation, voltage stabilization, and anti-islanding functions. These advanced grid-support capabilities are increasingly becoming regulatory requirements. Over time, mandatory smart inverter standards will drive adoption of more sophisticated inverter technologies.

6.2 Challenges

Despite rapid capacity expansion and strong government policy support, the Solar Power Equipment Industry in India faces a series of structural, operational, and market-linked constraints that affect scalability, competitiveness, and long-term value creation. Domestic manufacturers continue to operate in a price-sensitive environment shaped by global module oversupply, fluctuating raw material costs, and elevated interest rates for capital-intensive manufacturing.

Challenges and Threats	Impact		
	1-2 Years	3-4 Years	5-7 Years
1. High Capital Intensity & Technology Upgradation Costs	High	Medium	Low
2. Dependence on Imported Cells, Wafers, Power Electronics & Battery Materials + Trade Policy & Tariff Uncertainty	High	High	Medium
3. Raw Material Price Volatility (Polysilicon, Glass, Aluminium, Silver, Copper)	High	High	Medium
4.Rapid Technology Obsolescence & Inventory/Compatibility Risks	Medium	High	High
5. Grid Integration Constraints & Interconnection Delays	High	High	Medium
6. Limited Availability of Skilled Technical Workforce	Medium	High	High
7. Price Competition & Margin Pressure from Global Oversupply	High	High	Medium
8. Compliance Burden: ALMM, DCR, Certification Delays	Medium	High	High
9. High Financing Costs & Interest Rate Sensitivity	High	Medium	Medium
10. Strong Presence of Low-Cost Chinese Products with Advanced Technology	High	High	Medium

Source – Infomerics Analytics & Research

Detailed Overview

1. High Capital Intensity & Technology Upgradation Costs - The solar equipment industry requires significant upfront capital for manufacturing lines, R&D, testing infrastructure, and continual technology upgrades. As global standards rapidly shift toward TOPCon, HJT, high-efficiency modules, advanced inverters, and BESS integration, manufacturers must frequently reinvest to stay competitive. This high capital intensity increases entry barriers and pressures cash flows, especially for mid-sized players.

2. Dependence on Imported Cells, Wafers, Power Electronics & Battery Materials + Trade Policy & Tariff Uncertainty- Despite progress in domestic manufacturing, India remains heavily import-dependent for critical components such as wafers, cells, MOSFETs, IGBTs, lithium cells, and rare materials. Any change in global supply, tariff structures, or geopolitical relations can disrupt costs and availability. This dependence remains a major risk over the next 3–4 years, though domestic capacity expansion may gradually reduce exposure.

3. Raw Material Price Volatility (Polysilicon, Glass, Aluminium, Silver, Copper) - Volatility in raw material prices directly impacts module, inverter, and BOS equipment costs. Polysilicon and silver prices, in particular, are highly sensitive to global demand cycles, geopolitical tensions, and mining supply constraints. Sudden spikes raise manufacturing costs, compress margins, and disrupt project-level financial planning, especially in utility-scale tenders with fixed tariffs.

4. Rapid Technology Obsolescence & Stranded Inventory Risk - Solar technology is evolving rapidly—from poly to mono, PERC to TOPCon/HJT, and from string inverters to hybrid and grid-forming inverters. Fast transitions make older technologies obsolete sooner, creating stranded or slow-moving inventory for manufacturers and distributors. This shortens product lifecycles, increases working capital risk, and complicates demand forecasting.

5. Grid Integration Constraints & Interconnection Delays - Utility-scale solar projects often face delays due to limited substation capacity, congested transmission corridors, and slow power evacuation approvals. Weak distribution networks also hinder rooftop and C&I adoption. These bottlenecks increase project timelines, raise integration costs, and impact equipment utilisation rates—directly affecting manufacturers dependent on predictable installation pipelines.

6. Limited Availability of Skilled Technical Workforce - The industry requires skilled technicians for module assembly, inverter servicing, BESS commissioning, SCADA integration, and quality assurance. A shortage of trained manpower prolongs installation cycles, increases error rates, and limits the industry's ability to scale rapidly. This challenge becomes more pronounced as technologies become more advanced and digitalised**.**

7. Price Competition & Margin Pressure from Global Oversupply - Global manufacturing overcapacity—especially from China—continues to create downward pressure on module and inverter prices. Indian manufacturers face stiff competition from low-cost imports, which reduces margins and limits the ability to recover R&D or capacity-expansion investments. Intense price wars also force companies to operate on thinner cost structures.

8. Compliance Burden: ALMM, DCR, Certification Delays - Mandatory certifications such as ALMM listing, BIS compliance, safety testing, and periodic audits create additional time and cost burdens for manufacturers. Delays in approval cycles impact market entry, restrict supply availability, and slow down project execution. Smaller companies especially face challenges in meeting stringent documentation and quality requirements.

9. High Financing Costs & Interest Rate Sensitivity - Solar equipment manufacturing and installation rely heavily on debt financing. Higher interest rates increase the cost of capital for both manufacturers and developers, making projects less viable. Financing challenges are acute for rooftop and C&I markets, where payback periods are sensitive to borrowing costs. Expensive financing slows adoption and reduces equipment offtake.

10. Strong Presence of Low-Cost Chinese Products with Advanced Technology - Indian solar manufacturers face significant competitive pressure from Chinese suppliers offering inverters, modules, and battery components at lower prices due to large-scale production, integrated supply chains, and technological maturity. These products are widely accepted in price-sensitive segments, leading to downward pressure on market prices and margin compression for domestic players. As a result, Indian companies must continuously invest in cost optimization and technology upgrades to remain competitive, making this a key short- to medium-term industry risk.

7. PESTEL Analysis of the Industry

Factor	Key Insights and Implications
Political	• Government strongly promotes domestic solar manufacturing through PLI Scheme, make in India, and Atmanirbhar Bharat, accelerating India's transition from import dependence to local value chain integration. • Updated ALMM (2024–2025) mandates procurement from approved domestic manufacturers for government projects, boosting demand for Indian-made modules, inverters, and BoS equipment. • Domestic Content Requirement (DCR) tightened cells made from imported diffused wafers are not considered domestic, encouraging deeper manufacturing (wafers, ingots). • State and central solar policies (Gujarat, Rajasthan, Karnataka, MNRE) continue to expand rooftop and utility-scale installations.
Economic	• India added 44.2 GW of solar module and 7.5 GW of solar cell manufacturing capacity in the first half of 2025, indicating rapid scale-up and strong production growth. • Demand is driven by falling solar tariffs, strong RPO mandates, and rising industrial/commercial power needs. • Persistent dependence on certain imports—over 352.57 in lakhs solar PV modules imported from China in FY25—creates exposure to global price volatility. • Fluctuating prices of key materials such as polysilicon, aluminium, copper, and silver affect equipment costs and margins. • Financing challenges arise due to high interest rates and long project cycles, impacting procurement of solar inverters, modules, and storage systems.
Social	• Rising awareness toward sustainability, energy independence, and lower electricity bills strengthens adoption across residential and C&I segments. • Government-backed rooftop programs like PM–Surya Ghar Yojana boost household demand for panels, inverters, and batteries. • Stronger consumer trust in domestic manufacturers due to better branding, certification, and quality monitoring. • Growing acceptance of hybrid inverters and solar storage solutions as reliable alternatives to diesel generators. • Increasing urbanization and electrification in rural/semi-urban regions expand the market base.

Technological	• Rapid adoption of TOPCon, HJT, and high-efficiency mono-PERC technologies with modules now exceeding 700+ Wp output. • Updated ALMM for solar cells pushes manufacturers toward deeper production (ingots → wafers → cells → modules). • Growing integration of IoT-enabled and smart inverters, remote monitoring, and AI-based performance analytics for power optimization. • Manufacturers increasingly use automation—robotic handling, AI-driven QC systems, and advanced testing—to meet PLI-linked efficiency benchmarks. • Fast-moving innovation risks obsolescence of older plants and increases capex needs for technology upgrades.
Environmental	• Solar manufacturing aligns with India's 500 GW non-fossil capacity by 2030 and broader decarbonization goals. • New environmental compliance norms require waste management systems, effluent treatment, and emission control from module and cell manufacturing units. • Emphasis on solar module recycling is increasing; draft recycling guidelines are being prepared to reduce landfill waste and recover critical materials. • Use of renewable energy in manufacturing is encouraged, improving the lifecycle sustainability of domestic products. • Climate-focused policies and green procurement norms create higher expectations for ESG-aligned manufacturing.
Legal	• Mandatory BIS certification for solar modules, inverters, and most BoS components ensures standardized quality across the industry. • Updated ALMM Order (2024–2025) introduces strict traceability and higher domestic value-add norms, ensuring modules and cells meet tighter Indian made component norms. • PLI beneficiaries must comply with rigorous efficiency, testing, and backward-integration requirements; compliance deadlines were extended by two years. • EPCs and manufacturers must meet safety and performance standards set by MNRE, CEA, and state regulators. • Increasing focus on contract enforcement, warranty obligations, and performance guarantees in large solar projects.

8. Government Initiatives and Policy Support

India's solar power equipment industry is strongly shaped by a wide range of government policies aimed at accelerating domestic manufacturing, reducing import dependency, promoting renewable adoption, and ensuring long-term investment stability. These initiatives—spanning fiscal incentives, tariff protections, quality standards, supply-chain localization, and public procurement—form the backbone of India's fast-growing solar manufacturing ecosystem. Below are a detailed assessment of key government policies and their implications for manufacturers of modules, cells, inverters, batteries, and balance-of-system (BOS) components.

1. Increase in MNRE Budget: The Ministry of New and Renewable Energy (MNRE) budget allocation for FY 2026-27 has been increased to approximately INR 32,914.7 crore, marking a significant rise aimed at accelerating renewable energy deployment including solar.

2. Production Linked Incentive (PLI) Scheme for High-Efficiency Solar PV Modules - The MNRE's PLI Scheme (Tranche I & II) with a total outlay of ₹24,000 crore is designed to develop a fully integrated domestic manufacturing ecosystem—from polysilicon to modules. It supports gigawatt-scale capacity creation and has already allocated incentives to manufacturers for setting up end-to-end production lines. The scheme directly boosts domestic supply of modules, cells, wafers, and ancillary equipment, reducing dependency on Chinese imports and ensuring long-term supply-chain stability.

3. Introduction of ALMM List-II for Solar PV Cells - On 31 July 2025, MNRE released the ALMM List-II, containing the first set of approved solar cell manufacturers in India. This strengthens the upstream manufacturing segment by ensuring that government projects procure domestically produced, traceable, and quality-certified solar cells. It also complements the PLI scheme by increasing demand for local cell production, reducing import reliance in the midstream component of the value chain. (Source – PIB)

4. Rooftop Solar Programme (Phase II) – 40 GW Target - MNRE's Grid-Connected Rooftop Solar Programme Phase-II targets 40,000 MW (40 GW) rooftop installations by 31 March 2026. Central financial assistance (CFA) for residential consumers has driven large-scale adoption of modules, inverters, hybrid inverters, and storage systems. This programme creates a steady domestic offtake market for small and medium-capacity solar equipment manufacturers, especially those producing inverters, batteries, and mounting structures**.**

5. Solar Goods Order Extension for Large SPV Inverters (>200 kW) - In August 2025, MNRE extended the implementation of the Solar Systems, Devices & Components Goods Order, 2025 for inverters above 200 kW until 30 June 2026. This directive provides manufacturers with regulatory clarity and a compliance window to meet local certification norms. It specifically

benefits utility-scale inverter manufacturers, encouraging investments in large central and string inverters aligned with future grid-integration needs.

6. Physical Progress: Solar & Hybrid Capacity Deployment - As per MNRE's October 2025 progress report, India has installed 129.92 GW of solar capacity, supplemented by 3.33 GW of solar-wind hybrid projects. The growing share of hybrid installations indicates rising demand for advanced hybrid inverters, grid-supporting electronics, smart controllers, and battery management systems. This deployment data highlights the expanding market base for technologically advanced solar power equipment.

7. BEE Standards & Labelling (S&L) Program for Solar Inverters - The Bureau of Energy Efficiency (BEE) launched a Standards & Labelling (S&L) program for grid-connected solar inverters starting in March 2024. This program sets Minimum Energy Performance Standards (MEPS) for inverters up to 100 kW, requiring a minimum efficiency of 92% for very small units up to 98% for larger ones. Only BIS-certified inverters (IS 16221-2:2015) can participate, helping consumers choose higher-quality, more efficient inverters.

8. GST Reduction in Solar Devices - The Government of India reduced the GST rate on solar devices and renewable energy equipment to 5%, from the earlier 12%, to promote clean energy adoption and reduce project costs. The concessional rate applies uniformly to solar cells, modules, photovoltaic panels, and solar power–based devices, whether supplied individually or as part of an integrated system. This reduction lowers upfront capital expenditure, improves project viability, and enhances affordability for residential, commercial, and utility-scale users, while supporting government initiatives such as energy transition, Make in India, and net-zero targets.

9. Net Metering - Under India's renewable energy policies, net metering is the principal mechanism that enables the sale or crediting of surplus solar electricity. Net metering requires a bidirectional meter that tracks both electricity drawn from the grid and electricity exported to it. When a solar system feeds excess power into the grid, the consumer earns credits against future grid electricity consumption. The net electricity billed is the difference between energy consumed from the grid and energy exported to the grid.

Impact on Solar Adoption and Financial Viability

The ability to sell or credit surplus solar generation has a direct positive impact on the financial attractiveness of grid-connected solar systems:

- It lowers net electricity costs by offsetting grid consumption with exported solar energy.
- It shortens payback periods by enabling value capture from excess generation beyond self-consumption.

- It encourages larger system installations since excess production yields economic benefit.

This mechanism has become a core demand driver for rooftop and distributed solar installations across India.

10. Customs Duty Support - In Energy sector, the basic customs duty exemption given to capital goods used for manufacturing Lithium-Ion Cells for batteries will be extended and the basic customs duty on import of sodium antimonate for use in manufacture of solar glass will be exempted.

11. Semi-conductors 2.0 - The Government of India's Semicon India Programme (Semiconductor Mission 2.0) aims to develop a domestic semiconductor and electronics manufacturing ecosystem by providing incentives for semiconductor fabrication, ATMP/OSAT units, and compound semiconductor and power electronics manufacturing. This initiative supports localization of key components such as power semiconductors, microcontrollers, control chips, and integrated circuits used in solar inverters, battery management systems (BMS), energy storage systems, and other solar power electronics. By reducing import dependence and strengthening the domestic supply chain for critical electronic components, the program enhances cost competitiveness, supply stability, and technological capability for manufacturers of solar products, thereby indirectly supporting the growth and indigenization of the solar energy industry.

9. Technology and Digital Transformation

The solar power equipment industry in India is being reshaped by a rapid wave of technological innovation and digital transformation. From advanced cell and module architectures to smart inverters, automated manufacturing lines, and IoT-enabled asset management, the sector is evolving to address the needs of a dynamic energy market. These developments are not only improving system efficiency and reliability but are also enabling the widespread integration of storage-backed (hybrid) solar solutions, paving the way for greater energy independence, grid resilience, and digital-first operations.

1. Rapid Advancement in PV Cell & Module Technologies - India's solar equipment industry is undergoing a major technology shift as manufacturers transition from polycrystalline modules to high-efficiency technologies like TOPCon, HJT, and bifacial modules. As per Mercom & MNRE's 2025 manufacturing update, India added 44.2 GW of new module capacity and 7.5 GW of solar cell capacity in the first half of 2025, with TOPCon alone contributing 39.9 GW of the new additions. This rapid adoption of advanced cell architectures is helping Indian manufacturers achieve higher module efficiencies (22–24%), reduce LCOE for utility-scale plants, and align with global competitive benchmarks. Innovation in materials—such as high-transparency glass, light-weight composite back sheets, and metallization pastes with lower silver content—is further driving technology-led cost reduction and performance gains.

2. Transformation in Solar Inverter Technologies (String, Hybrid & Grid-Forming) - Solar inverters are experiencing a major technological leap driven by digital control electronics, AI-enabled energy management, and hybrid storage integration. Manufacturers in India are rapidly shifting from older PWM-based designs to transformer less, high-frequency MPPT, and grid-forming inverters, enabling better system efficiency (>98%), flexible grid support, and seamless mode switching. Hybrid inverter technology has been a key focus area—boosted by policy momentum on rooftop & residential storage—leading to the widespread adoption of hybrid inverters with integrated Li-ion BMS, remote monitoring apps, and cloud diagnosis tools. Advanced DSP controllers, Wi-Fi/GPRS-based smart dashboards, and export-limit controls are becoming standard features, enabling smart grid readiness and better demand-response coordination.

3. Digitization & Automation of Manufacturing Ecosystems - Automation has become central to India's solar equipment manufacturing expansion. India's module manufacturing capacity increased from 38 GW in March 2024 to 74 GW by March 2025, driven largely by investments in automated line technologies such as multi-busbar (MBB) stringers, AI-assisted EL testing, automated bussing stations, and precision laser cutting for cells. Several upcoming PLI-backed factories are integrating Industry

4.0 systems—including automated material handling, robotics for lamination and cutting, digital quality control, and inline performance diagnostics. For inverter companies, digitalized PCB assembly (SMT lines), AI-based thermal modelling, and automated firmware testing environments are significantly improving design reliability and reducing failure rates.

4. Smart Monitoring, IoT, and Cloud-Based Asset Management - Digital transformation is reshaping operations and field performance of solar assets. IoT-enabled hardware and cloud platforms now allow real-time monitoring of string voltages, MPPT performance, inverter temperatures, and degradation patterns across utility and rooftop systems. Modern inverters come with built-in Wi-Fi, RS485, 4G SIM communication, and cloud dashboards that offer predictive maintenance alerts, fault analytics, and remote firmware upgrades. Asset management platforms used by DISCOMs and EPCs increasingly integrate SCADA, digital twins, and machine learning to optimize generation forecasts, scheduling, and inverter operational windows. The rise of hybrid rooftop systems is accelerating adoption of mobile app-based monitoring, empowering consumers with consumption analytics and battery performance insights.

5. R&D Acceleration and Domestic Innovation in Solar Components - India's solar R&D ecosystem is strengthening as manufacturers pursue backward integration and high-end product innovation. MNRE-supported testing facilities and R&D centres—such as NISE (Gurugram)—are working on next-generation PV cell architectures, grid-supportive inverter functions, and heat-resilient module technologies suitable for India's high irradiance and temperature profile. In FY 2025, India commissioned its first 2 GW ingot-wafer manufacturing line, marking a critical step toward achieving the full PV value chain domestically. Inverters are witnessing significant innovation in firmware reliability, adaptive MPPT algorithms, AI-based reactive power control, and cybersecurity layers, enabling them to operate more intelligently within modernized grid environments.

6. Digital Transformation Across Sales, Distribution & After-Sales - Digital commerce and analytics-driven customer engagement are playing an increasingly important role in the solar equipment industry. Manufacturers and distributors now rely on digital B2B platforms, online configurators, QR-coded warranty systems, and app-based service support for installers. For rooftop and hybrid inverter markets, digital comparison engines, remote commissioning tools, and integrated mobile apps have become standard, reducing installer time and improving system configuration accuracy. AI-enabled sales forecasting, CRM automation, and digital lead funnels are enhancing efficiency, especially for hybrid inverter and residential segments where consumer interaction is high.

7. Technology for Sustainability & Resource Optimization - Sustainability is being embedded into solar manufacturing through resource-efficient and low-carbon technologies. Large module factories are installing rooftop solar plants, energy-efficient curing ovens, and water-

recycling systems in EVA lamination and cleaning lines. Digital tools are being used to track energy consumption per MW of module output, enabling compliance with global sustainability reporting standards (ESG). Inverter makers are transitioning to more recyclable enclosures, RoHS compliance for components, and energy-optimized thermal management architectures. For the broader system, high-efficiency modules and hybrid inverters are improving the integration of renewable energy with storage—supporting grid stability, reducing fossil-fuel ramping, and enabling peak-shaving operations.

10. Competitive Landscape

The Indian solar equipment industry operates in a highly competitive and fast-evolving ecosystem characterised by a mix of large domestic manufacturers, global technology players, low-cost Chinese suppliers, specialised inverter and storage companies, and emerging MSME component makers. This diversity reflects the sector's transition from a price-driven market to one defined by technology advancement, localisation mandates, and performance reliability. Companies are continually repositioning themselves through efficiency upgrades, backward integration, digitalisation, and portfolio expansion into hybrid inverters and energy-storage-integrated systems to capture long-term growth opportunities.

10.1 Key Factors Shaping Competition

1. Technology-Led Differentiation & Efficiency Leadership - Competition is increasingly defined by advancements in module and inverter technology — including TOPCon, HJT, bifacial modules, transformer-less inverters, and hybrid inverter–battery integrated systems. Manufacturers with superior efficiency, lower degradation rates, longer warranties, and AI-enabled monitoring platforms gain a clear advantage, especially in utility-scale tenders and distributed rooftop markets where lifetime performance matters more than upfront cost.

2. Vertical Integration & Domestic Value Addition - Players that integrate cell–module manufacturing, in-house BMS design, inverter R&D, and batteries gain cost control and greater ALMM/PMP compliance. India's push for backward integration is shifting the competitive edge to firms with captive cell manufacturing, PCB assembly lines, and EMS setups for inverter production. Integrated players can offer bundled hybrid solutions, creating higher entry barriers.

3. Price Competition & Chinese Supplier Dominance - Despite increasing domestic capacity, Chinese firms continue to shape pricing for modules, inverters, and battery packs due to scale advantages and global supply-chain control. Indian firms compete by offering ALMM-compliant products, shorter delivery cycles, and after-sales strength. The competitive landscape is highly price-sensitive, especially in the residential and C&I inverter segments.

4. Digitalisation, Smart Inverters & Remote Monitoring Capabilities - Smart energy management systems, IoT-based inverter platforms, Wi-Fi-enabled hybrid inverters, and AI-driven predictive maintenance are becoming key differentiators. Companies that provide seamless app-based monitoring, grid-interactive features, and real-time analytics hold a competitive edge, especially among rooftop installers and commercial users who demand transparency and uptime assurance.

5. Quality, Reliability & Warranty Performance - Long-term reliability — including degradation warranties for modules, MTBF for inverters, battery cycle life, and temperature management — plays a crucial role in winning EPC and distributor trust. Firms offering 10–25 year warranties, robust service networks, and guaranteed after-sales responsiveness are preferred over low-cost suppliers, driving a shift from price-only competition to value-led competition.

6. Policy Alignment & Compliance with ALMM, BIS, and PMP Norms - The competitive landscape is heavily influenced by regulatory requirements such as the Approved List of Models & Manufacturers (ALMM), BIS certification, and Production Linked Incentive (PLI) norms. Companies that proactively align with domestic manufacturing rules, traceability mandates, and localisation standards gain procurement preference in government, utility, and DISCOM-led projects.

7. Supply Chain Resilience & Component Security - Given India's high dependence on imported cells, wafers, PCBs, MOSFETs, and lithium-ion cells, firms with diversified sourcing, localisation strategies, or captive manufacturing enjoy better stability. Supply chain disruptions (China, freight, raw materials) directly impact pricing and delivery schedules, making resilience a competitive differentiator.

8. Expansion into Hybrid & Storage-Integrated Solutions - Competition is shifting toward hybrid solar inverters, energy storage systems (ESS), and integrated solar-plus-battery packages as demand rises in residential, C&I, telecom, and rural markets. Companies offering advanced hybrid inverters with seamless switching, higher charging efficiency, and intelligent load management are capturing faster market share.

9. Distribution Network Strength & Installer Loyalty - In the rooftop and C&I inverter market, channel strength — including dealer networks, installer partnerships, training programs, and service centres — strongly shapes market competitiveness. Brands with pan-India distributor coverage and faster on-site service resolution outperform technically comparable competitors.

10. Global Partnerships, JVs & Technological Collaborations - Indian manufacturers increasingly partner with global technology leaders for advanced cell tech, inverter design expertise, BMS systems, and ESS platforms. Joint ventures, licensing arrangements, and OEM–ODM relationships help companies reduce development time and match global quality standards, intensifying competitive pressure within the domestic market.

10.2 Competitive Strategies

India's solar power equipment industry is undergoing rapid technological advancement, accelerated domestic manufacturing expansion, and intensifying price competition. Leading players are deploying multi-layered strategies to enhance efficiency, deepen backward integration, strengthen domestic value addition, and differentiate through digitalized and storage-integrated solutions. These strategies reflect both the market's shift toward higher-performance solar assets and the industry's response to policy incentives, import risks, and evolving consumer demand. The following competitive levers define the current competitive landscape:

1. Technology Upgradation & High-Efficiency Product Portfolios - Manufacturers are aggressively transitioning from conventional polycrystalline modules and basic string inverters to advanced technologies such as TOPCon and HJT modules, bifacial architectures, transformer-less inverters, and hybrid inverters with integrated MPPT and energy management systems. Firms investing in R&D, higher module efficiencies (22%+), superior inverter conversion efficiency (98%+), and smart grid-ready features are capturing premium market share across utility and C&I segments.

2. Vertical Integration & Localization of Critical Components - To reduce import dependence and meet ALMM/BIS/PMP compliance, firms are expanding into backward integration—cell lines, wafer slicing, BMS design, lithium battery pack assembly, PCB manufacturing, and EMS for inverter electronics. Fully integrated producers gain cost advantages, supply-chain resilience, and eligibility for government-linked contracts while enabling bundled inverter–battery–module solutions for hybrid systems.

3. Hybrid Inverter & Storage-Led Market Positioning - With rising rooftop and C&I demand for backup power, players are repositioning themselves as "solar-plus-storage solution providers" rather than standalone equipment suppliers. Firms offering hybrid inverters with seamless switching, higher charge/discharge efficiencies, intelligent load prioritization, and app-based monitoring are gaining strategic differentiation. This shift supports premium pricing and long-term AMC-driven recurring revenue.

4. Digitalization, Smart Monitoring & IoT-Enabled Inverter - Companies are embedding IoT-enabled monitoring, remote diagnostics, predictive maintenance, Wi-Fi/GPRS communication, and AI-driven energy optimization into inverters and energy management systems. Digital platforms that provide real-time performance analytics, fault alerts, and grid-interactive controls improve customer retention, reduce service costs, and strengthen distributor and installer loyalty.

5. Quality, Warranty Strength & Premium Reliability Positioning - As customers demand 25-year module performance guarantees and 8–12-year inverter warranties, firms are strengthening quality assurance, thermal stability, and long-term reliability metrics. Brands with robust on-ground service networks, faster replacement turnaround times, and bankable warranties are winning EPC and tender-driven opportunities where risk mitigation is a key procurement factor.

6. Cost Optimization & Scale-Based Manufacturing - With price competition driven heavily by Chinese imports, leading Indian firms are expanding manufacturing capacity, optimizing sourcing, automating production lines, and leveraging economies of scale to compete effectively. Cost competitiveness—especially in modules, inverters, and battery packs—is critical for defending market share in highly price-sensitive rooftop and C&I segments.

7. Strategic Distribution Network Expansion & Installer Engagement - A strong footprint of distributors, dealers, and certified installers has emerged as a key competitive differentiator. Firms are investing in channel programs, installer training, co-branded marketing, and regional service hubs to enhance product visibility and improve last-mile delivery. This strategy is particularly important for residential solar, hybrid inverters, and small C&I markets.

8. Policy Alignment, Certification Readiness & Tender Compliance - Companies are proactively aligning with government norms—ALMM compliance, BIS certification, traceability rules, domestic value-add requirements, and PLI eligibility. Early policy alignment ensures access to utility-scale tenders, rooftop schemes, and government procurement, creating a competitive moat for compliant manufacturers over low-cost non-compliant imports.

9. Global Partnerships, Technology Licensing & OEM/ODM Models - To shorten innovation cycles, Indian manufacturers are forming joint ventures, licensing next-generation cell technologies, partnering with battery and inverter specialists, and leveraging OEM/ODM manufacturing. These collaborations enhance product performance, accelerate time-to-market, and enable companies to compete with global leaders in efficiency and reliability benchmarks.

10.3 Barriers to Entry

Despite strong policy support and rising demand for renewable energy, the Indian solar power equipment industry presents significant structural and capability-driven barriers that make it difficult for new firms to enter and scale. These barriers arise from high capital requirements, technology complexity, stringent compliance norms, and the dominance of established domestic and global players. Key barriers include:

1. High Capital Intensity and Advanced Manufacturing Requirements

- Setting up a competitive solar equipment facility—whether for modules, cells, inverters, or lithium battery packs—requires substantial upfront investment in automated production lines, clean-room environments, precision testing equipment, and quality assurance systems.
- Entry is especially challenging in high-value segments such as cell lines, wafering, TOPCon/HJT manufacturing, and hybrid inverter design, where technology acquisition, R&D, and certification costs are prohibitively high for new entrants.

2. Technology Complexity, Efficiency Requirements & Continuous R&D

- Competing in today's market requires deep expertise in high-efficiency cell technologies (TOPCon, HJT, bifacial), MPPT algorithms, grid-interactive controls, IoT-enabled monitoring platforms, and lithium battery safety systems.
- Without strong R&D capabilities, thermal engineering expertise, and power electronics talent, new firms struggle to meet efficiency benchmarks or reliability expectations—especially for hybrid inverters and storage-integrated systems.

3. Compliance with ALMM, BIS Certification & Traceability Norms

- Mandatory government standards—such as ALMM approval, BIS certification, inverter safety testing, battery standards (IS 16270/IS 16893), and traceability norms—pose significant regulatory hurdles for new firms.
- Achieving compliance requires extensive documentation, testing cycles, and audit readiness; failure to obtain timely approvals prevents access to rooftop schemes, government tenders, DISCOM programs, and utility-scale EPC markets.

4. Supply Chain Dependence & Raw Material Constraints

- Critical components such as wafers, high-efficiency cells, semiconductor chips, power MOSFETs, PCBs, BMS components, and lithium cells remain heavily import-dependent.

- New entrants face long lead times, limited supplier relationships, volatile pricing, and minimum order quantity constraints—factors that established players mitigate through bulk contracts, global partnerships, and deeper backward integration.

5. Brand Trust, Bankability & Service Network Expectations

- Solar equipment purchases—especially inverters and storage—are long-term, risk-sensitive decisions, with customers and EPCs preferring brands with strong performance track records, fast service response, and bankable warranties.
- New entrants struggle to win trust without long-term field data, reliability certifications, established service hubs, and a nationwide installer/dealer network—areas dominated by incumbent global and Indian brands.

6. Economies of Scale & Price Competition with Global Players

- Market pricing for modules and inverters is strongly influenced by large-scale Chinese, Southeast Asian, and established Indian manufacturers with massive capacity, optimized procurement, and lower per-unit production costs.
- Small or new manufacturers cannot match these price levels without scale, automation, or integrated supply chains, making cost competitiveness a major entry barrier.

7. Distribution, Installer Ecosystem & After-Sales Infrastructure

- Solar sales are heavily channel-driven, requiring extensive dealer networks, certified installer programs, regional warehouses, and service centres for rapid maintenance and inverter replacements.
- New firms without existing channel partnerships or on-ground service capabilities face significant delays in customer adoption and EPC onboarding.

8. Tender Participation Criteria & Financial Strength Requirements

- Utility-scale and government-backed EPC projects require strict financial eligibility, performance guarantees, multi-year service contracts, and bank guarantees—requirements difficult for smaller or new firms to meet.
- Established firms with stronger balance sheets, insurance backing, and prior tender experience hold a structural advantage, further limiting new entrant access to large-volume demand.

10.4 Consolidation Trends

India's solar power equipment industry is undergoing rapid consolidation as domestic manufacturers scale capacity, global players strengthen their India presence, and supply chains become more integrated across modules, inverters, and energy storage. Policy incentives, technology shifts, and rising demand for high-efficiency products are accelerating M&A, joint ventures, and ecosystem partnerships. The following trends reflect how consolidation is reshaping competitiveness and manufacturing depth across the sector:

1. Strategic M&A for Capacity Expansion and Technology Upgradation

- Leading Indian manufacturers are acquiring smaller module and cell producers to expand capacities, especially in high-efficiency TOPCon and HJT lines.
- M&A is increasingly focused on gaining access to advanced cell technology, wafer expertise, and power electronics capabilities for next-generation string and hybrid inverters.
- Acquisitions also support entry into high-growth segments such as lithium battery packs, BMS design, and integrated solar-plus-storage solutions.

2. Global Solar Majors Deepening India Manufacturing Presence

- International module and inverter companies are consolidating their Indian operations through local JV partnerships, manufacturing tie-ups, and technology licensing with domestic firms.
- Global inverter brands are integrating India operations into their APAC supply chains, streamlining R&D, certification, and after-sales support under unified regional leadership.
- This consolidation is bringing advanced engineering practices, high-efficiency inverter platforms, and grid-interactive hybrid technologies into Indian manufacturing ecosystems.

3. Private Equity Interest & Platform Roll-Ups in Renewables Manufacturing

- Strong policy stability and long-term demand visibility for solar equipment have attracted private equity funding into module, cell, and inverter manufacturers.
- PE-backed platform roll-ups are emerging, where multiple mid-sized solar equipment units—such as inverter assemblers, battery pack makers, and BOS suppliers—are merged into integrated clean-energy manufacturing platforms.
- This capital infusion accelerates automation, backward integration, and entry into export markets.

4. Vertical Integration Across the Solar Value Chain

- Large Indian players are aggressively integrating backward and forward—covering polysilicon, ingots, wafers, cells, modules, inverters, mounting structures, and storage systems under one umbrella.
- Inverters and hybrid energy management systems are being vertically aligned with module manufacturing to deliver bundled solutions for rooftop and C&I customers.
- Such integration reduces supply chain volatility, improves cost competitiveness, and enhances control over quality and technology.

5. Rise of Platform-Centric Energy Solutions Models

- Manufacturers are consolidating energy tech capabilities to build integrated platforms combining modules, inverters, batteries, smart meters, and IoT monitoring tools.
- These unified platforms enable seamless solar-plus-storage management, remote fleet monitoring, advanced MPPT analytics, and grid-synchronization features for hybrid inverters.
- Consolidation around digital IP—such as EMS software, AI-based predictive maintenance, or BMS firmware—is becoming a key driver of M&A.

6. Regional Consolidation and Expansion into Tier-II Manufacturing Clusters

- Domestic players are acquiring regional manufacturers in Gujarat, Tamil Nadu, Telangana, and Rajasthan to build multi-location manufacturing clusters and reduce logistics costs.
- Companies are consolidating assembly and testing facilities for inverters and battery packs in Tier-II industrial zones to access lower-cost labor and state incentives.
- This regional clustering supports resilient supply chains and faster market access across India.

7. Quality Compliance, ALMM Norms & Tender Eligibility Driving Consolidation

- Firms lacking BIS certification, ALMM approval, or inverter safety compliance are being acquired by larger manufacturers that require compliant facilities to meet tender requirements.
- Consolidation is particularly strong in hybrid inverter and battery storage segments, where safety certifications, traceability norms, and test requirements are stringent. As government and DISCOM procurement tighten quality standards, non-compliant or subscale firms increasingly merge into structured entities capable of meeting regulatory and technical benchmarks.

10.5 Key Industry Players

India's solar equipment market is witnessing strong participation from both established manufacturers and emerging high-tech players who are scaling rapidly across residential, commercial, and small industrial segments. While larger companies compete on distribution networks, production capacity, and nationwide after-sales support, agile brands such as Smarten and iNVERGY are carving out niche leadership through innovative hybrid inverters, smart energy-storage systems, and IoT-enabled monitoring platforms.

- **Smarten Power Systems Limited**

Smarten Power Systems Ltd. is a leading India-based manufacturer of solar and power-backup products, incorporated in 2014. The company offers a diversified product portfolio that includes solar hybrid inverters, off-grid and on-grid solar PCUs, MPPT charge controllers, UPS systems, and solar management units (SMUs). Smarten has developed over 350+ SKUs and distributes across 23 states and 2 union territories through an established dealer and distributor network. The company differentiates itself by offering high-efficiency MPPT technology, robust energy-backup solutions, and scalable inverter systems suitable for households, shops, small commercial units, and rural electrification. With a focus on indigenous design and expanding manufacturing capabilities, Smarten continues to strengthen its presence in the fast-growing solar-power equipment market by integrating reliability, cost-efficiency, and customer-centric product innovation.

- **iNVERGY (Invergy Power Supply India)**

iNVERGY is a fast-growing smart solar inverter and energy-storage solutions provider headquartered in India, operating under GP Eco Solutions. The company specializes in advanced new-energy technologies and offers a wide product range including hybrid solar inverters (1 kW to 50 kW), on-grid inverters, off-grid inverters, energy-storage systems (LFP batteries), battery management systems (BMS), EV charging equipment, and intelligent Energy Management Systems (EMS) with real-time monitoring. iNVERGY has established itself as a technology-driven player through features such as UPS-grade switching (as low as 10 ms), 110% overload capability, WiFi/GPRS connectivity, mobile-app integration, and compatibility with both lithium and lead-acid battery technologies. Through its partnerships with global innovators such as Solinteg, the company delivers high-performance hybrid inverters and smart BESS units tailored to Indian grid conditions. With a focus on digitalization, safety, and low-carbon energy solutions, iNVERGY is emerging as a preferred choice for residential and commercial customers seeking modern solar-plus-storage solutions.

10.6 Company Positioning

Cellcronic Technologies Limited is a fast-growing power-electronics and solar-storage solutions provider, uniquely positioned at the intersection of advanced inverter engineering, energy-storage innovation, and digital intelligence. The company offers a comprehensive, end-to-end solar-plus-storage portfolio: hybrid solar inverters, $LiFePO_4$ battery packs, and associated accessories such as battery wiring harnesses and protection boxes — delivering complete, plug-and-play solar systems for homes, SMEs, commercial establishments, and emerging C&I applications.

Cellcronic's inverters are built with advanced UPS-grade switching technology, and the Company's new-generation inverters deliver a switching time of less than 5 milliseconds, ensuring near-instant power transition during grid failures. This ultra-fast response provides seamless backup support for sensitive loads such as computers, networking equipment, medical devices, and critical business systems, enhancing reliability and user confidence.

The company operates through a robust dealer-installer distribution model, supported by regional service centres to ensure rapid installation, after-sales service, and technical support. Compared to competitors, Cellcronic distinguishes itself by offering an integrated smart energy ecosystem in which inverters, batteries, wiring, protection hardware, and monitoring platforms work seamlessly together — backed by rugged design, digital intelligence, and user-centric convenience. By supplying inverters, batteries, and critical wiring and protection components, Cellcronic simplifies procurement and installation for customers and installers.

This full-spectrum offering reinforces its positioning as a reliability-focused, performance-driven, and convenience-oriented brand — well placed to capitalise on India's accelerating shift toward decentralized solar energy, hybrid storage solutions, and clean-energy adoption across residential, commercial, and industrial user segments.

The Company is set to introduce a new benchmark in product durability with the launch of IP54-rated hybrid solar inverters — currently unmatched by any other hybrid inverter manufacturer in India. These inverters deliver a strong balance of protection and affordability, offering dust-tight construction and resistance to water splashes, making them ideal for India's dusty, humid, and semi-outdoor installation environments.

The Company's focus on solar inverters, hybrid power solutions, lithium battery systems, and power-backup products aligns with national programmes such as the National Solar Mission, PM-KUSUM, Rooftop Solar Programme, and broader renewable energy capacity expansion targets. These initiatives promote increased adoption of solar and hybrid energy systems across residential, commercial, and institutional users, thereby supporting sustained demand for power electronics and energy management solutions.

Industries & Customer Segments Served

Cellcronic's solutions serve:

- Residential households requiring solar backup and hybrid systems.
- SMEs such as clinics, offices, and shops that need reliable power continuity.
- Solar installers & EPCs seeking quality inverters and batteries for projects.
- Dealers & distributors operating in the solar retail ecosystem.
- Rural & off-grid users dependent on solar-based electrification.

These initiatives reinforce Cellcronic's positioning as an innovation-led power electronics company enabling India's transition toward reliable and affordable clean energy.

Cellcronic offers a diverse range of energy storage and solar inverter solutions designed for residential, commercial, and heavy-duty industrial applications. Below are the detailed specifications and descriptions of their product portfolio:

1. Battery Storage Solutions - Cellcronic specializes in Lithium Iron Phosphate (LiFePO4) technology, designed for high safety and extreme longevity.

Product	Category	Description & Applications
Powerwall 2.0 (4.8kWh & 5.12kWh)	**LiFePO4 Energy Storage**	Engineered for residential and commercial use, featuring 6000+ cycles at 80% Depth of Discharge. It includes a smart 100A Battery Management System, supports up to 32 units in parallel, and is designed for an extraordinary lifespan of up to 45 years.
Powerwall 2.0 Plus (5.12kWh)	**Enhanced Energy Storage**	A premium version of the Powerwall offering a 10-year warranty and an estimated lifespan of up to 60 years. It maintains the same high-cycle life and smart BMS features for reliable long-term energy independence.
STACK 3.0 Battery System	**High-Voltage Scalable Storage**	A stackable, child- and pet-friendly home energy solution and 6000 life cycle with 80% Depth of Discharge. It is highly scalable, with configurations ranging from 20.48kWh to 61.44kWh, making it ideal for large residential energy needs.

2. Hybrid Solar Inverters - Cellcronic's inverters range from entry-level residential units to heavy-duty "Galaxy" series capable of powering entire homes and industrial equipment.

Product	Category	Description & Applications
InfiniSolar VIII (Eco Pro)	**3kW-24V Hybrid Inverter**	A single-phase inverter for residential use with a built-in grid feed-in function and anti-dust kit. It features dual outputs for normal and smart loads and supports a max DC input of 6000W.
Neo Pro Series (3k & 5k)	**IP54 Residential Inverter**	Designed for residential performance, these IP54-rated inverters support up to 150% usable PV power and 140A charge/discharge current. The 5k model allows up to 12 units to be paralleled.
Galaxy Pro Plus (5K, 8K, 12K-3P)	**Heavy-Duty Hybrid Inverter**	Built for demanding "Heavy Duty" applications with IP65 protection. These inverters can run multiple air conditioners (up to 8 on the 12kW model) alongside standard home loads and feature a fast <5ms switching time.
Galaxy-3K/5K-HY (Upcoming Pro Series)	**Next-Gen Hybrid Inverter**	New launches featuring high PV input (up to 27A on the 5k model) and AC coupling capabilities to retrofit existing solar systems. They support 20 units in parallel and include colourful touch LCD screens.

Key Technical Features New IP54 Neo Pro Series

1. **High Performance & Efficiency**

- Usable PV Power: Supports up to 150% usable PV power (6,000W for 3k and 10,000W for 5k).
- PV Input Current: Accommodates high-power PV panels with an 18A PV input current (up to 36A per MPPT).
- Efficiency: Achieves up to 95% efficiency from PV to AC and 93% from Battery to AC.
- Charge/Discharge: Features a high maximum battery charge and discharge current of 140A.

2. **Flexibility & Scalability**

- Battery Compatibility: Supports both Lithium-ion and Lead-acid batteries (24V for 3k; 48V for 5k) within a 40-60V range (21-30V for 3k).

- System Integration: Offers seamless integration with generators.
- Parallel Capability: The Neo Pro-5k model supports paralleling up to 12 units for increased capacity.
- Smart Load Control: Includes support for "Smart Load" to intelligently manage critical and non-critical loads.

3. Safety & Durability

- Ingress Protection: Features an IP54-rated design for safety and reliability.
- Comprehensive Protection: Includes built-in protections for over-voltage, overload, short circuits, and over-temperature.
- Surge Protection: Equipped with Type III surge protection for both DC and AC.
- Warranty: Comes with a 5-year standard warranty.

4. Intelligent Maintenance & Communication

- Remote Management: Supports intelligent management, remote monitoring, and firmware upgrades.
- Interface: Features a combined LED and LCD display for real-time status updates.
- Communication Ports: Includes USB (OTG), RJ45 for BMS (CAN/RS485), dry contacts, and optional Wi-Fi/LAN connectivity.
- Fast Switching: Provides rapid transfer times for backup power, typically 10ms for UPS mode and 20ms for home appliances.

10.7 Financial Performance Analysis

The financial performance analysis of Cellcronic Technologies Limited presents an overview of its operational and profitability trends over FY 2023 to FY 2025. The assessment highlights key indicators such as revenue from operations, total income, EBITDA, and profitability margins, reflecting the company's operational efficiency and financial stability.

*Figures are in INR lakhs (*Except for ratios and percentages*)*

Key Indicators (in INR Lakhs)	Cellcronic Technologies Limited		
	FY 2023	FY 2024	FY 2025
Total Operating Income	924.05	1711.52	2591.96
Total Income	924.05	1711.52	2599.40
EBITDA	17.30	233.44	547.39
EBITDA Margin (%)	1.87%	13.64%	21.12%
PAT	2.41	145.88	359.71
PAT Margin (%)	0.26%	8.52%	13.84%
Current Ratio (in times)	1.55	1.72	1.56
Tangible Net worth	14.42	160.30	520.01
Total Debt	355.77	289.26	299.60
Debt Equity Ratio (in times)	24.67	1.80	0.58
ROCE (%)	7.99%	55.77%	85.41%
Return on Net Worth (%)	33.43%	166.99%	105.75%

Source – Restated Financials as provided by the Company

Formula Used:

- EBITDA (Earnings Before Interest, Taxes, Depreciation and Amortisation): Total Operating Income - Operating Expenses (excluding Depreciation & Amortisation, Interest, and Taxes)
- EBITDA Margin: (EBITDA/ Total Operating Income) *100
- PAT Margin: (Profit after Tax/Total Income) *100
- Current Ratio: Current Assets /Current Liabilities
- Tangible Net Worth: Share Capital + Reserve & Surplus – Intangible Assets -Deferred Tax Assets – Misc Expenditure not written off – Revaluation Reserves
- Return on Net Worth (RONW): (Profit After Tax /Average Tangible Net Worth) *100
- Total Capital Employed: Fixed Assets + Long term fixed assets +Net Working Capital

- Return on Capital Employed (ROCE): (Earnings before Interest & Taxes/Average Capital Employed) *100

The Company has demonstrated significant improvement in its financial performance and balance sheet strength over the period. Revenue from operations increased sharply from INR 924.05 lakh in FY 2023 to INR 1,711.52 lakh in FY 2024 and further to INR 2,591.96 lakh in FY 2025, driven by wider domestic market penetration for inverters and batteries.

Operating profitability improved materially over the review period, with EBITDA increasing from INR 17.30 lakh in FY 2023 to INR 547.39 lakh in FY 2025. Correspondingly, EBITDA margin improved from 1.87% in FY 2023 further to 21.12% in FY 2025. Profit after tax rose from INR 2.41 lakh in FY 2023 to INR 359.71 lakh in FY 2025, with PAT margin increasing from 0.26% in FY 2023 further to 13.84% in FY 2025. The increase in PAT margin in FY25 is primarily attributable to strong growth in operations, which enabled economies of scale, better absorption of fixed costs, and operating leverage benefits, thereby improving overall operational efficiency. Cost of Goods Sold (COGS) increased from INR 1,360.49 lakhs in FY24 to INR 1,882.26 lakhs in FY25; however, the increase was lower relative to sales growth, resulting in a decline in COGS as a percentage of revenue and improvement in gross margins, reflecting enhanced cost efficiency, procurement management, and scale-driven advantages. Trade receivables increased in line with higher business volumes, supporting revenue expansion through credit-led sales while remaining aligned with operational growth. Additionally, finance costs declined due to reduced reliance on long-term borrowings, further supporting improvement in net profitability. Strengthening of internal accruals also enhanced the Company's financial position, as reflected in the substantial increase in tangible net worth from INR 14.42 lakh as of March 31, 2023, to INR 520.01 lakh as of March 31, 2025.

Total debt remained broadly stable, leading to a sharp decline in the debt–equity ratio from 24.67 times in FY 2023 to 0.58 times in FY 2025, reflecting a significantly strengthened capital structure and enhanced financial flexibility. Improved operating performance and efficient utilization of capital were also reflected in return indicators, with Return on Capital Employed (ROCE) increasing from 7.99% in FY 2023 to 85.41% in FY 2025 and Return on Net Worth remaining strong at 105.75% in FY 2025, notwithstanding the enlarged equity base.

Overall, the Company's performance over the review period reflects a phase of rapid revenue growth supported by improving profitability, strong retained earnings, and strategic strengthening of its tangible asset base to support ongoing and future expansion.

10.8 Peer Benchmarking Analysis

The peer benchmarking analysis assesses the financial performance of Cellcronic technologies Limited in comparison with relevant players in the Solar equipment industry. For this analysis, Cellcronic Technologies Limited has been benchmarked against Smarten Power Systems Limited and Invergy.

*Figures are in INR lakhs (*Except for ratios and percentages*)*

Key Indicators	Cellcronic Technologies Limited			Invergy India Limited			Smarten Power Systems Limited		
	FY 2023	FY 2024	FY 2025	FY 2023	FY 2024	FY 2025	FY 2023	FY 2024	FY 2025
Total Operating Income	924.05	1711.52	2591.96	2016.93	2081.35	4269.36	17993.50	19519.56	20174.85
Total Income	924.05	1711.52	2599.40	2017.73	2081.74	4273.11	18606.29	19873.21	20319.67
EBITDA	17.30	233.44	547.39	-107.93	36.44	58.26	187.70	1347.99	1691.96
EBITDA Margin	1.87%	13.64%	21.12%	-5.35%	1.75%	1.36%	1.04%	6.91%	8.39%
PAT	2.41	145.88	359.71	-81.36	30.09	41.19	517.25	1122.56	1277.03
PAT Margin	0.26%	8.52%	13.84%	-4.03%	1.45%	0.96%	2.78%	5.65%	6.28%
Current Ratio	1.55	1.72	1.56	0.58	0.90	1.56	1.17	1.42	1.55
Tangible Net worth	14.42	160.30	520.01	-115.42	-79.26	736.42	1440.74	2576.73	3828.69
Total Debt	355.77	289.26	299.60	2.00	2.00	60.20	413.06	667.76	1658.91
Debt Equity Ratio	24.67	1.80	0.58	-0.02	-0.03	0.08	0.29	0.26	0.43
ROCE (%)	7.99%	55.77%	85.41%	191.15%	-37.52%	13.47%	15.42%	78.22%	58.74%
Return on Net Worth (%)	33.43%	166.99%	105.75%	140.98%	-30.91%	11.19%	71.80%	87.13%	66.71%

Source - Financials for peer comparison are based on restated figures for Cellcronic Technologies (as provided by the company), Smarten Power Systems Limited (as filed on NSE) & Invergy India private limited (as on MCA).

Cellcronic Technologies Limited has demonstrated strong growth and superior financial performance over FY23–FY25, significantly outperforming its peers, Invergy India Limited and Smarten Power Systems Limited. Its total operating income increased from INR 924.05 lakh in

FY23 to INR 1,711.52 lakh in FY24 and further to INR 2,591.96 lakh in FY25, representing a cumulative growth of nearly 2.8 times, compared to Invergy's growth from INR 2,016.93 lakh to INR 4,269.36 lakh over the same period (just over 2 times) and Smarten's slower growth from INR 17,993.50 lakh to INR 20,174.85 lakh. Cellcronic's EBITDA rose sharply from INR 17.30 lakh (1.87% margin) in FY23 to INR 547.39 lakh (21.12% margin) in FY25, reflecting strong operational efficiency, while Invergy posted marginal EBITDA of INR 58.26 lakh (1.36%) in FY25 and Smarten reported INR 1,691.96 lakh (8.39%), highlighting Cellcronic's superior margin expansion. PAT performance further underscores this outperformance, increasing from INR 2.41 lakh (0.26%) in FY23 to INR 359.71 lakh (13.84%) in FY25, compared to Invergy's INR 41.19 lakh (0.96%) and Smarten's INR 1,277.03 lakh (6.28%) in FY25.

From a financial stability perspective, Cellcronic maintains healthy liquidity, with a current ratio around 1.56x in FY25, compared to Invergy's 1.56x and Smarten's 1.55x, while tangible net worth grew from INR 14.42 lakh in FY23 to INR 520.01 lakh in FY25, significantly improving shareholder equity, whereas Invergy had a negative net worth in FY23 and Smarten's net worth, though higher in absolute terms, grew more gradually. The company's debt is moderate at INR 299.60 lakh in FY25, resulting in a conservative debt-to-equity ratio of 0.58, compared to Invergy's 0.08 and Smarten's higher ratio of 0.43, reflecting prudent leverage management.

Cellcronic also excels in returns, with ROCE increasing from 7.99% in FY23 to 85.41% in FY25 and return on net worth rising from 33.43% to 105.75%, substantially higher than Invergy (ROCE 13.47%, RoNW 11.19% in FY25) and Smarten (ROCE 58.74%, RoNW 66.71%), highlighting its efficient capital utilization and high value creation for shareholders.

Overall, compared to peers, Cellcronic Technologies Limited demonstrates superior growth, profitability, operational efficiency, and returns, establishing it as a high-growth, high-return company in the energy and technology sector.

10.9 SWOT Analysis

Strengths (Internal / Competitive Advantages)	Weaknesses (Internal / Limitations)
✔ **Robust Revenue & Profit Growth**: Strong YoY expansion with Total Operating Income rising from ₹924 lakh (FY23) to ₹2,592 lakh (FY25) and EBITDA margin improving from 2.59% to 21.12%, reflecting operational efficiency and rising brand acceptance. ✔ **High ROCE & Profitability Momentum**: Exceptional improvement in ROCE from 11.28% (FY23) to 84.74% (FY25), demonstrating superior capital productivity and efficient utilization of assets. ✔ **Strong Market Position in Solar & Hybrid Inverters**: Focus on fast-growing segments like hybrid solar inverters, lithium battery systems, and power-backup solutions positions the company in high-demand renewable categories. ✔ **Lean, Scalable Business Model**: Asset-light structure and reliance on technology-led product development support rapid scaling, faster product launches, and flexibility in expanding into new solar categories.	✘ **Declining Liquidity Position:** Current Ratio dropped sharply from 36.32 (FY23) to 1.85 (FY25), indicating rising working-capital pressure and lower short-term liquidity cushion. ✘ **High Dependency on Imported Components:** Heavy reliance on foreign suppliers for PCBs, MOSFETs, BMS units, lithium cells, and electronic components exposes the company to supply-chain delays and price volatility. ✘ **Limited Manufacturing Integration:** Low backward integration increases dependence on third-party assemblers and EMS vendors, which may affect cost control and margins.

Opportunities (External / Market Realities)	Threats (External / Sector Challenges)
Rapid Growth in Hybrid Solar & Battery Storage: Rising rooftop solar adoption, load-shedding challenges, and MNRE-backed schemes create strong demand for hybrid inverters and Li-ion storage systems. **Import Substitution Push by Government:** Policies such as ALMM, BESS initiatives, and increased domestic cell manufacturing provide opportunities for local brands to replace Chinese imports. **Expansion into Smart Energy Solutions:** Opportunities to launch IoT-enabled monitoring systems, smart meters, energy management software, and integrated solar-plus-storage packages. **Growing Residential & C&I Solar Markets:** India's rooftop solar target of 40 GW and growing backup-power demand in Tier 2/3 cities provide strong avenues for scaling distribution and channel partnerships.	**Intense Competition from Chinese & Domestic Brands:** Aggressive pricing by established global inverter suppliers and domestic EMS-based brands can impact margins and market share. **Supply Chain Vulnerability:** Dependence on imported electronics and lithium cells exposes the business to geopolitical risks, freight cost spikes, and technology obsolescence cycles. **Regulatory & Policy Shifts:** Changes in BIS standards, ALMM requirements, or import duties on batteries/inverters can increase compliance costs and affect pricing. **Technology Disruption Risk:** Fast-evolving inverter technologies (Wi-Fi-enabled systems, AI-based energy management, advanced MPPT algorithms) require continuous R&D investment to remain competitive.

11. Future Outlook

The solar power equipment industry is entering a decade of accelerated expansion, driven by global decarbonization commitments, rising electricity consumption, and rapid advancements in photovoltaic and power electronics technologies. In India, the sector's long-term outlook remains exceptionally strong due to the government's push toward achieving 500 GW of renewable energy capacity by 2030, growing grid instability, rising power tariffs, and increasing adoption of distributed energy systems such as rooftop solar, hybrid inverters, and residential battery storage. Demand for solar inverters—especially hybrid, three-phase, and high-voltage variants—is expected to surge as consumers shift from basic grid-tie systems to solar-plus-storage solutions that support larger household loads and offer resilience during outages. The introduction of smart, IoT-enabled inverters with remote monitoring, higher-efficiency MPPT circuits, and safer lithium battery chemistries (LFP and NMC) will significantly enhance system reliability and performance, driving adoption in both urban and rural markets. Utility-scale solar parks, green hydrogen production using solar power, and the expansion of solar-wind hybrid projects will create new demand for high-capacity central inverters, string inverters, and grid-forming technologies that enhance grid stability.

On the manufacturing side, India's emphasis on domestic production through PLI schemes, BCD tariffs, Approved List of Models and Manufacturers (ALMM) and state incentives will reduce import dependence on components such as modules, cells, PCBs, MOSFETs, and BMS units, gradually shifting the industry toward localized value chains. However, short-term challenges such as raw material price volatility, lithium supply constraints, and reliance on Chinese electronics ecosystems may create cost pressures. Overall, the next 5–10 years will see solar power equipment becoming more efficient, modular, and affordable, with increasing integration into smart homes, microgrids, and electric mobility infrastructure—positioning India as a competitive global hub for renewable energy equipment manufacturing.

Yours Faithfully,

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