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Industry Research Report on Power Sector

December 2024

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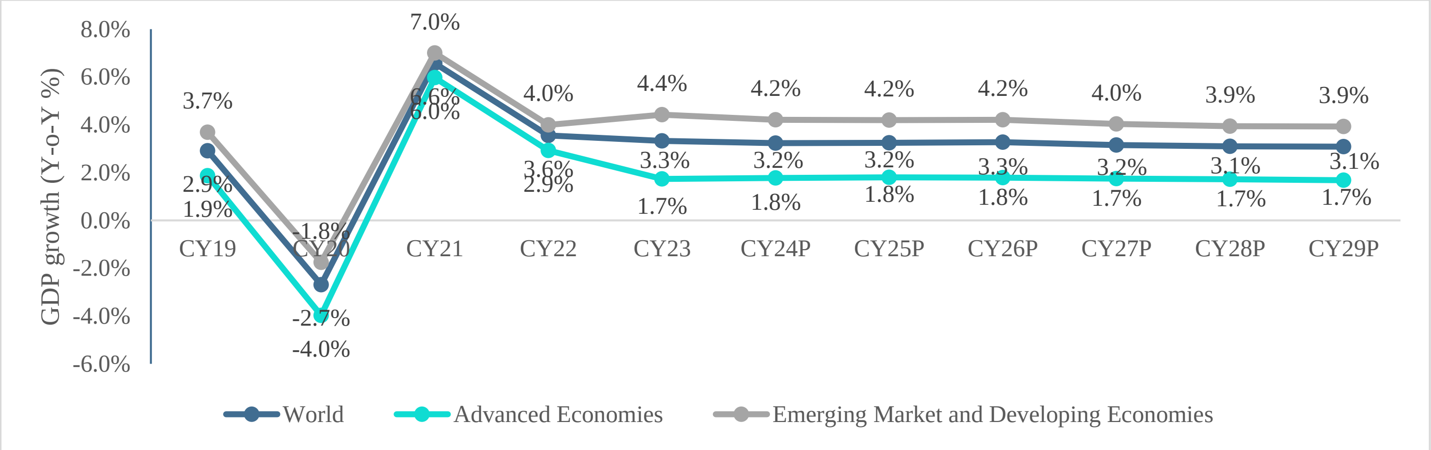
1 Economic Outlook

1.1 Global Economy

Global growth, which stood at 3.3% in CY23, is anticipated to fall and remain at 3.2% in both CY24 and CY25. The global real GDP growth outlook shows signs of improvement as cyclical imbalances ease, aligning economic activity with potential output in major economies. While global disinflation progresses, risks remain, particularly from financial market volatility and geopolitical tensions that could disrupt trade and increase commodity prices. Nonetheless, stronger public investment in advanced economies aimed at infrastructure and the green transition may stimulate private sector investment and bolster global demand. Additionally, accelerating structural reforms in both advanced and emerging markets could enhance productivity and support medium-term growth.

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



Source: IMF – World Economic Outlook, October 2024; P: Projection

Table 1: GDP growth trend comparison - India v/s Other Economies (Real GDP, Y-o-Y change in %)

	Real GDP (Y-o-Y change in %)									
	CY20	CY21	CY22	CY23	CY24P	CY25P	CY26P	CY27P	CY28P	CY29P
Emerging Economies										
India	-5.8	9.7	7.0	8.2	7.0	6.5	6.5	6.5	6.5	6.5
China	2.2	8.4	3.0	5.3	4.8	4.5	4.1	3.6	3.4	3.3
Indonesia	-2.1	3.7	5.3	5.0	5.0	5.1	5.1	5.1	5.1	5.1
Saudi Arabia	-3.6	5.1	7.5	-0.8	1.5	4.6	4.4	3.6	3.5	3.5
Brazil	-3.3	4.8	3.0	2.9	3.0	2.2	2.3	2.4	2.5	2.5
Sub Saharan Africa	-1.6	4.8	4.1	3.6	3.6	4.2	4.4	4.3	4.4	4.4
Advanced Economies										
Euro Area[1]	-6.1	6.2	3.3	0.4	0.8	1.2	1.5	1.4	1.3	1.2
United States	-2.2	6.1	2.5	2.9	2.8	2.2	2.0	2.1	2.1	2.1
Japan	-4.2	2.7	1.2	1.7	0.3	1.1	0.8	0.6	0.6	0.5

[1] Euro Area includes the following states: Austria, Belgium, Croatia, Cyprus, Estonia, Finland, France, Germany, Greece, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, The Netherlands, Portugal, Slovak Republic, Slovenia, Spain

Germany	-4.1	3.7	1.4	-0.3	0.0	0.8	1.4	1.2	0.8	0.7

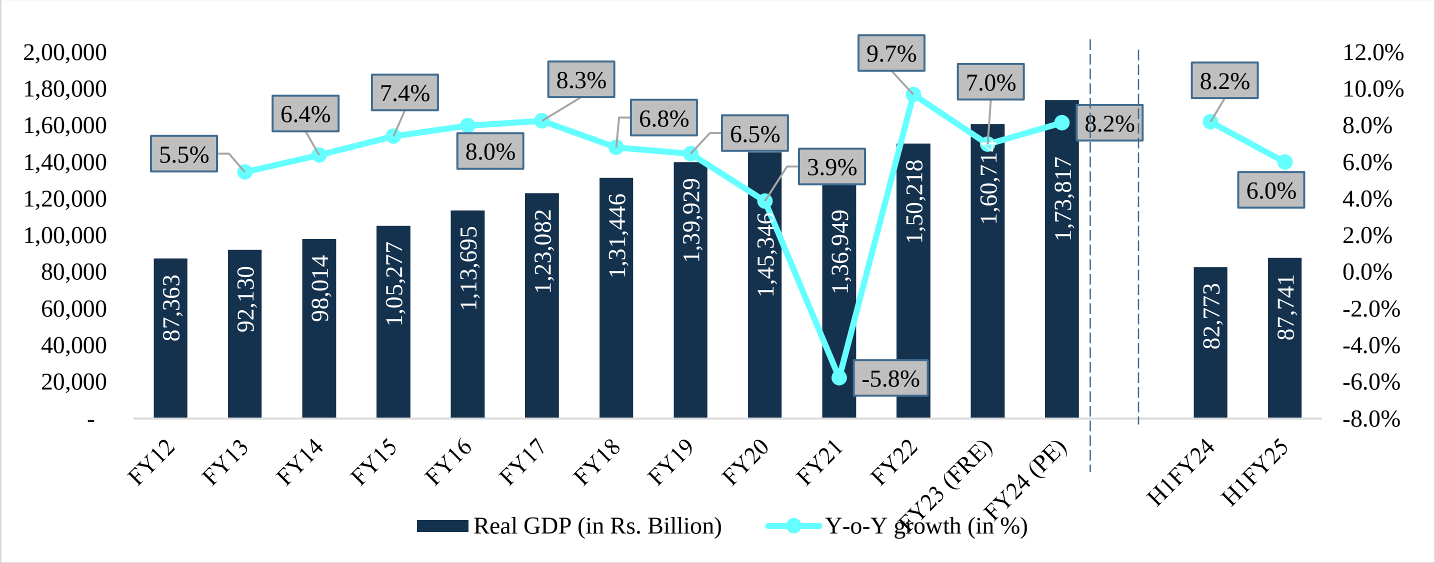
Source: IMF- World Economic Outlook Database (July 2024); P: Projections

1.2 Indian Economic Outlook

1.3 GDP Growth and Outlook

Resilience to External Shocks remains Critical for Near-Term Outlook

Chart 2: Trend in Real Indian GDP growth rate



Source: MOSPI; Note: FRE – First Revised Estimates, PE – Provisional Estimates

India's real GDP grew by 7.0% in FY23 (Rs. 161 trillion) and is estimated to grow 8.2% in FY24 (Rs. 173.82 trillion), driven by strong domestic demand, particularly investment. In H1FY25, GDP grew 6.0% YoY, with private consumption increasing by 6.7% and government spending contracting by 2.0%.

GDP Growth Outlook

- Driven by strong government capital expenditure, recovery in industrial activity, improved rural demand, and robust export performance, the economy continues to expand. The provisional estimates (PE) placed real GDP growth at 6.6% for FY24.
- Industrial activity in Q2FY25 slowed due to sector-specific issues and monsoon disruptions but is expected to recover in H2, driven by seasonal corrections, government spending, and the normalization of key sectors like cement, steel, mining, and electricity.
- Economic activity is recovering, with strong festive and rural demand. Agricultural growth is supported by good kharif crop, high reservoir levels, and improved rabi sowing. Industrial activity is normalizing, aided by government spending and sectoral growth. Services continue to expand (PMI 58.4), and exports (merchandise + services) are robust, with October merchandise exports up 17.2%.
- Investment activity is expected to pick up which will be driven by higher government capital expenditure and a recovery in industrial sectors like cement, iron, and steel. Strong export growth in both merchandise and services is also likely to support investment.

Persistent geopolitical tensions, volatility in international financial markets and geo-economic fragmentation do pose risk to this outlook. Based on these considerations, the RBI, in its December 2024 monetary policy, has projected real GDP growth at 6.6% y-o-y for FY25.

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

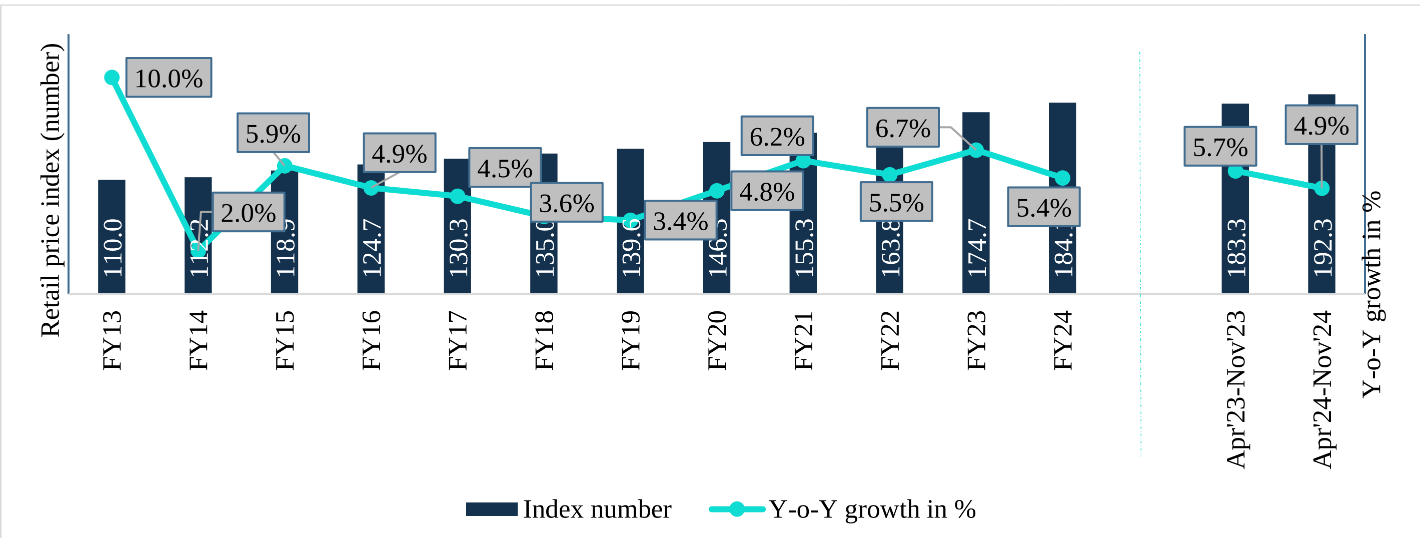
FY25P (complete year)	Q3FY25P	Q4FY25P	Q1FY26P	Q2FY26P
6.6%	6.8%	7.2%	6.9%	7.3%

Source: Reserve Bank of India; P: Projected

1.4 Consumer Price Index

CPI moderation was driven by improved south-west monsoon, better kharif sowing, and declines in food prices (vegetables, pulses, sugar, milk, fruits) and non-food sectors (transport, personal care, spices). These factors helped reduce inflationary pressures, despite occasional food price volatility.

Chart 3: Retail Price Inflation in terms of index and Y-o-Y Growth in % (Base: 2011-12=100)

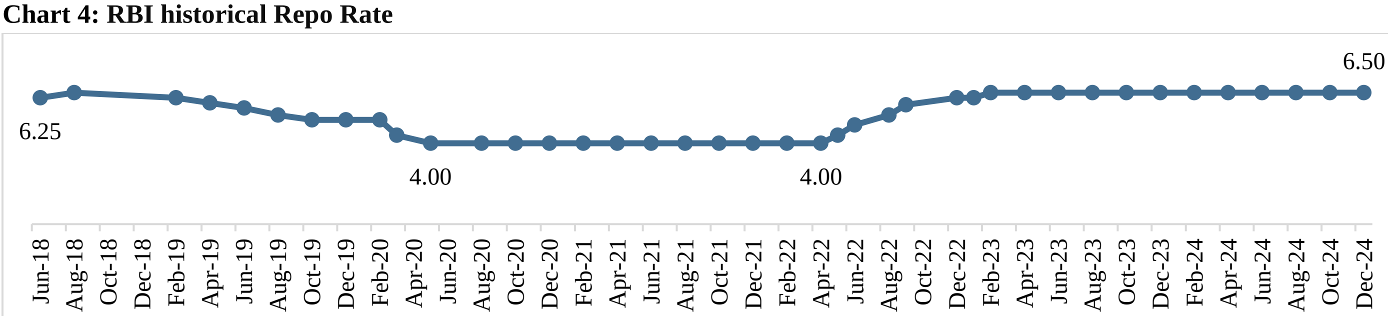


Source: MOSPI

The CPI is primarily factored in by RBI while preparing their bi-monthly monetory policy. At the bi-monthly meeting held in November 2024, RBI projected inflation at 4.8% for FY25 with inflation during Q3FY25 at 5.7%, Q4FY25 at 4.5%, Q1FY26 at 4.6%, and Q2FY26 at 4.0%.

Considering the current inflation situation, RBI has kept the repo rate unchanged at 6.5% again in the November 2024 meeting of the Monetary Policy Committee.

Chart 4: RBI historical Repo Rate



Source: RBI

Further, the central bank continued its stance to be neutral. While headline inflation has saw a sharp pick up due to increase in food inflation. The growth outlook is expected to be resilient but with close monitoring. Core inflation has shown a subdued pick up, and fuel prices are contracting. Domestic growth remains strong, driven by private consumption and investment, allowing the MPC to focus on bringing inflation down to the 4% target. As a result, the MPC decided to adopt a 'neutral' stance, monitoring inflation while supporting growth.

1.4.1 Components of GDP

The main components of GDP include PFCE, GFCE, GFCF, Net exports and others. With increase in disposable income, there has been a gradual change in consumer spending behaviour as well. Private Final Consumption Expenditure (PFCE) which is measure of consumer spending has showcased significant growth in the past decade at a CAGR of 9.46%. A steady growth in GFCG and GFCE has seen a steady growth rate from FY18-FY24.

Table 3: Main Components of GDP (at current GDP prices)

Components	FY19	FY20	FY21	FY22	FY23 [FRE]	FY24 [PE]	H1FY24	H1FY25
PFCE	59.3%	60.9%	61.1%	61.0%	60.9%	60.3%	60.00%	61.20%
GFCF	29.5%	28.5%	27.3%	29.6%	30.7%	30.8%	10.40%	10.10%
GFCE	10.8%	11.0%	11.6%	10.5%	10.7%	10.4%	10.40%	10.10%
Net Exports	-3.8%	-2.6%	-0.4%	-2.6%	-3.6%	-2.2%	-2.6%	-2.8%
Others	4.2%	2.2%	0.4%	1.6%	1.2%	0.7%	0.8%	0.4%

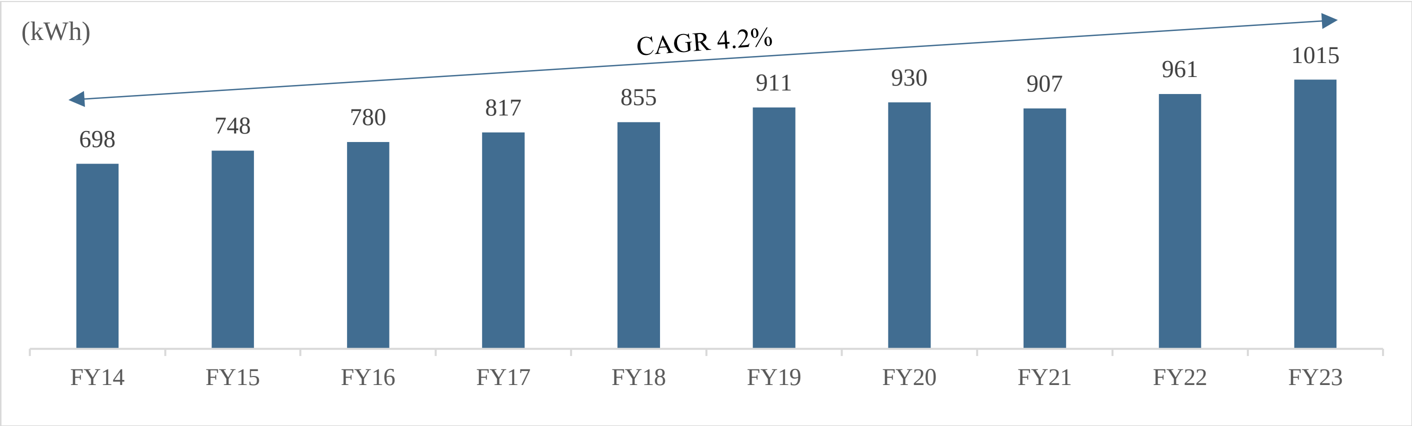
Source: MOSPI
Note: PFCE- Private Final Consumption Expenditure, GFCF- Gross Fixed Capital Formation, GFCE- Government Final Consumption Expenditure
FRE: First Revised Estimates; PE: Provisional Estimates, Others (Valuables, Discrepancies, Changes in Stocks)

1.5 Overview of per capita energy consumption

India's Per Capita Power Consumption

India's per capita power consumption has been on a consistent rise with the government increasingly focusing on electrification of villages and families across the country.

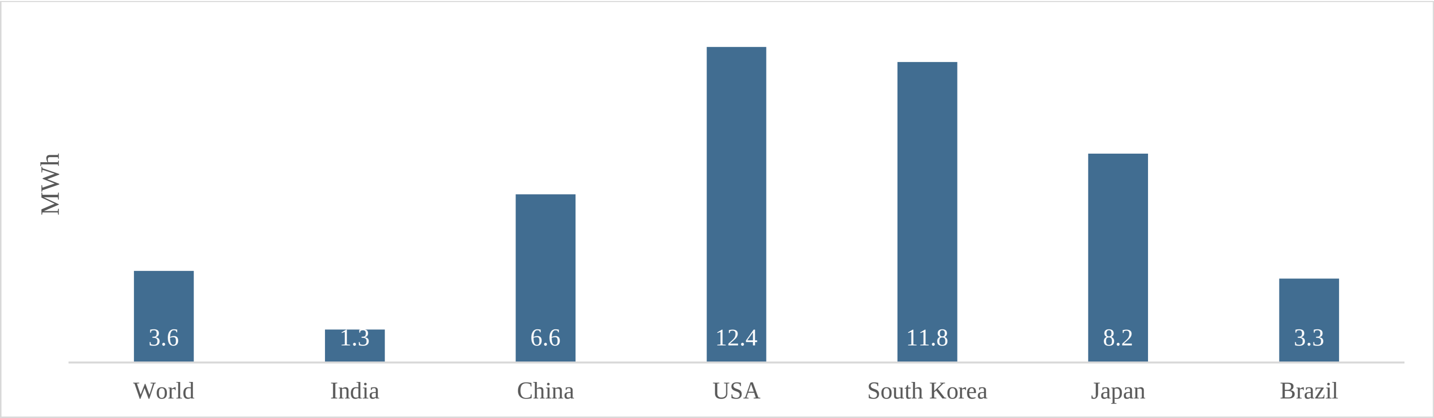
Chart 5: Growth of Electricity Sector in India - Per Capita Consumption



Source: Energy Statistics 2024, MOSPI, CareEdge Research

Developed countries such as Japan, South Korea and the United States have the world's highest per capita electricity consumption. India's per capita consumption has remained low as compared to the emerging countries like Brazil, implying room for significant growth.

Chart 6: Global Per Capita Consumption Comparison (MWh/Capita) (CY23)



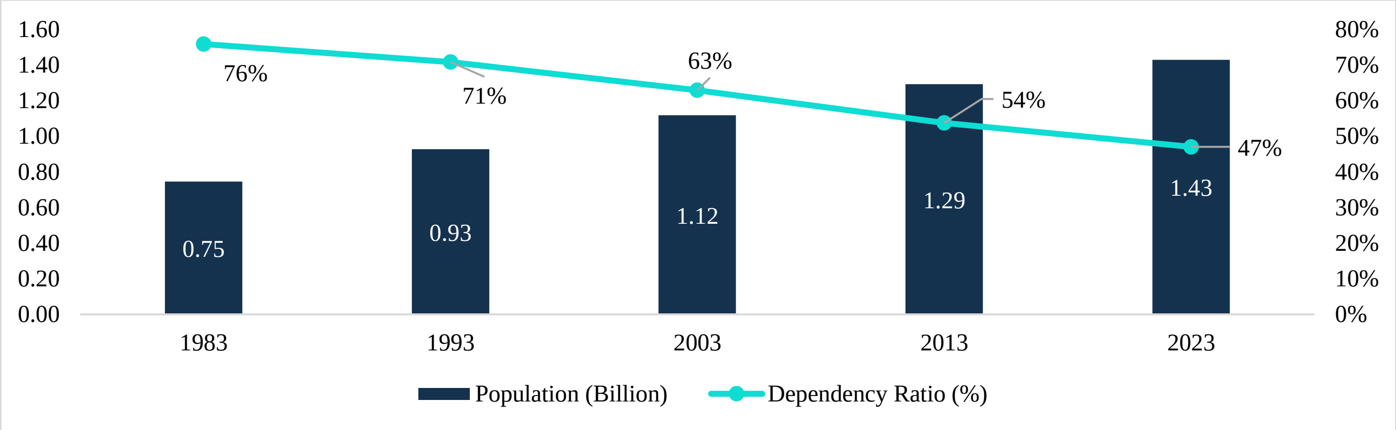
Source: IEA, CareEdge Research

1.6 Overview on Key Demographic Parameters

- **Population growth and Urbanization**

India's economic growth and private consumption are influenced by socio-economic factors like demographics and urbanization. In 2022, India's population surpassed 1.42 billion, making it the most populous country. The Age Dependency Ratio, which measures dependents (under 15 and over 64) to the working-age population (15-64), has declined from 76% in 1983 to 47% in 2023. This decline signals a growing working-age population, benefiting the economy.

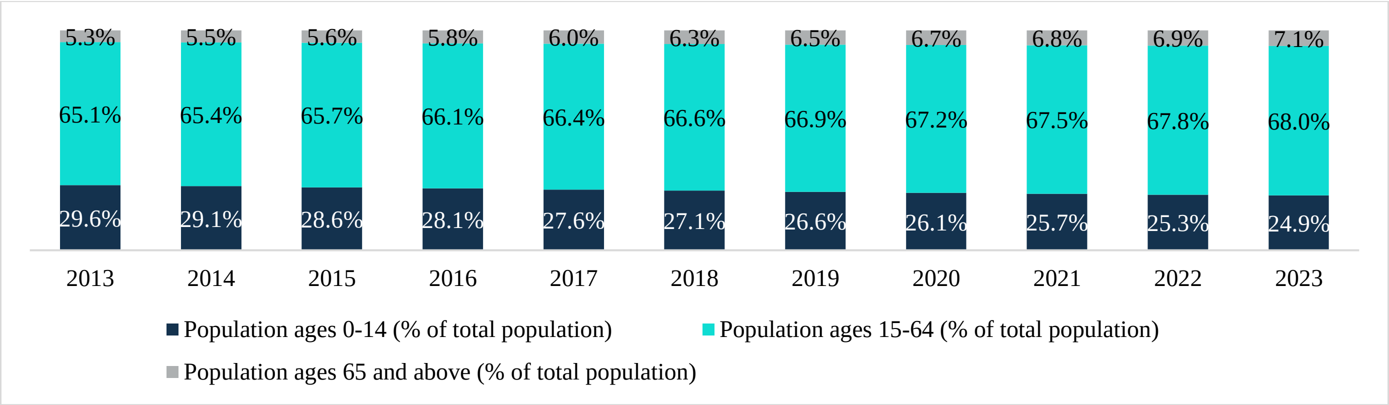
Chart 7: Trend of India Population vis-à-vis dependency ratio



Source: World Bank Database

With an average age of 29, India has one of the youngest populations globally. With vast resources of young citizens entering the workforce every year, it is expected to create a 'demographic dividend'. India is home to a fifth of the world's youth demographic and this population advantage will play a critical role in economic growth.

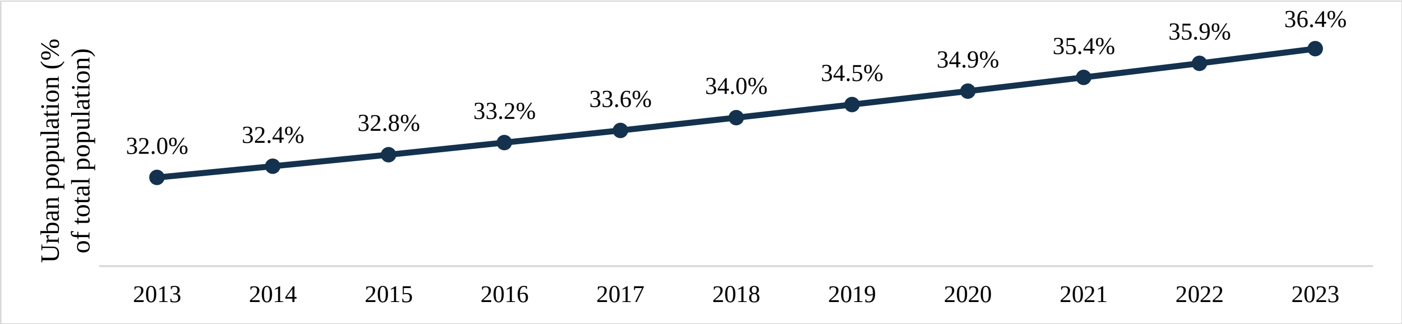
Chart 8: Age-Wise Break Up of Indian population



Source: World Bank Database

The urban population is significantly growing in India. The urban population in India is estimated to have increased from 413 million (32% of total population) in 2013 to 519.5 million (36.4% of total population) in the year 2023.

Chart 9: Urbanization Trend in India



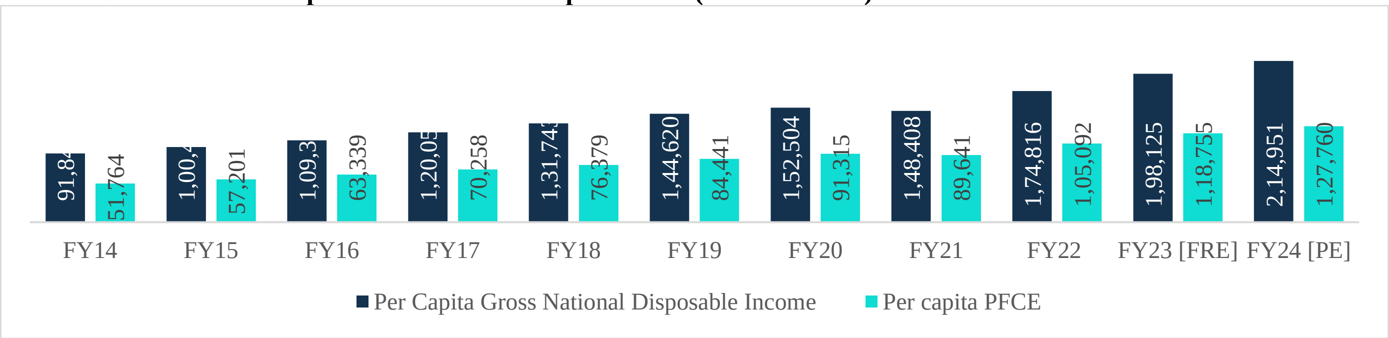
Source: World Bank Database

- **Increasing Disposable Income and Consumer Spending**

Gross National Disposable Income (GNDI) is a measure of the income available to the nation for final consumption and gross savings. Between the period FY14 to FY24, per capita GNDI at current prices registered a CAGR of 8.88%. More disposable income drives more consumption, thereby driving economic growth.

With increase in disposable income, there has been a gradual change in consumer spending behaviour as well. Private Final Consumption Expenditure (PFCE) which is measure of consumer spending has also showcased significant growth in the past decade at a CAGR of 9.46%.

Chart 10: Trend of Per Capita GNDI and Per Capita PFCE (Current Price)



Source: MOSPI, Note: FRE – First Revised Estimates, PE – Provisional Estimate

1.7 Concluding Remarks

The major headwinds to global economic growth are escalating geopolitical tensions, volatile global commodity prices, high interest rates, inflation woes, volatility in international financial markets, climate change, rising public debt, and new technologies. Despite the global economic growth uncertainties, the Indian economy is relatively better placed in terms of GDP growth compared to other emerging economies. According to IMF's forecast, it is expected to be 7% in CY24 compared to the world GDP growth projection of 3.2%. The bright spots for the economy are continued healthy domestic demand, support from the government towards capital expenditure, moderating inflation, investments in technology and improving business confidence.

Likewise, several high-frequency growth indicators including the purchasing managers index, E-way bills, bank credit, toll collections and GST collections have shown improvement in FY24. Moreover, normalizing the employment situation after the opening up of the economy is expected to improve and provide support to consumption expenditure.

At the same time, public investment is expected to exhibit healthy growth as the government has allocated a strong capital expenditure of about Rs. 11.11 lakh crores for FY25. The private sector's intent to invest is also showing improvement as per the data announced on new project investments and resilience shown by the import of capital goods. Additionally, improvement in rural demand owing to healthy sowing, improving reservoir levels, and progress in south-west monsoon along with government's thrust on capex and other policy support will aid the investment cycle in gaining further traction

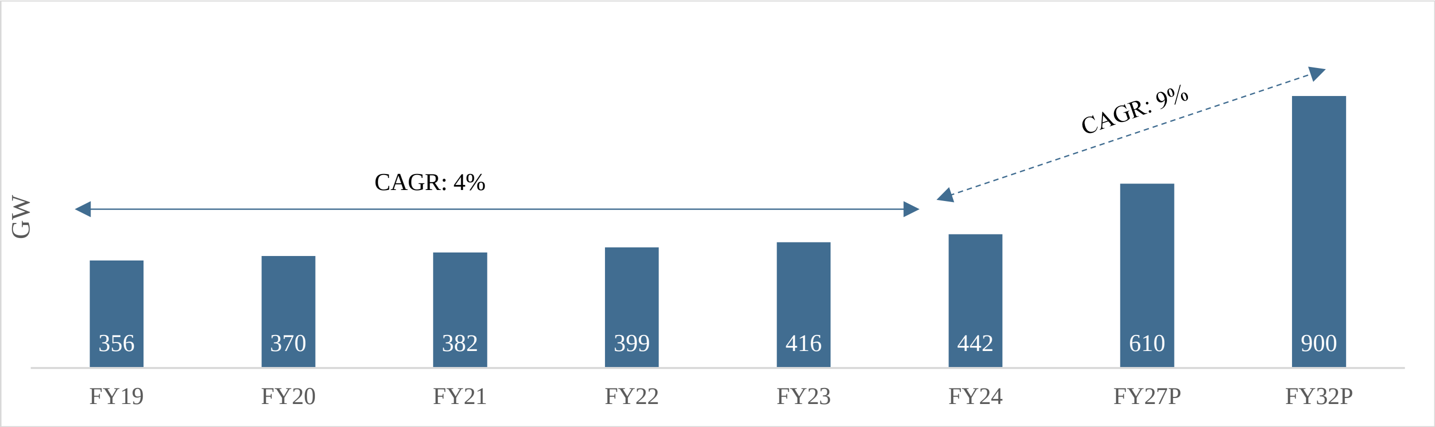
2 Overview of Power sector in India

2.1 Indian Power sector: Market size

India, the world's third-largest electricity producer and consumer, has prioritized expanding power generation, reducing energy deficits, and promoting renewables. Key government initiatives like the National Electricity Plan, UDAY, and the National Solar Mission have been instrumental in driving growth. Targeting 500 GW of non-fossil fuel energy by 2030, India aligns with its sustainability goals and global carbon reduction commitments.

From FY19 to FY24, the power sector grew at a 4% CAGR, driven by rising demand, rural electrification, and infrastructure development. Looking ahead, the sector is projected to grow at a 9% CAGR from FY24 to FY32, fueled by investments in renewables, grid modernization, and efficiency enhancements, positioning India as a leader in the global clean energy transition.

Chart 11: Indian Power Sector Installed Capacity



Source: National Electricity Plan Vol-II, CEA, CareEdge Research

2.2 Long-Term Drivers for Demand Growth

The growth drivers for the increasing power demand are mentioned below:

Key Drivers of Power Demand in India

- **GDP and Energy Intensity**

India’s low per capita power consumption, strong GDP outlook, and growing population highlight its latent power demand. With a projected $5 trillion economy by 2025 and $1 trillion in exports by 2030, power consumption is set to rise significantly.

- **Urbanization**

Rising urbanization drives infrastructure growth, job creation, and expansion of consumer and services sectors. Increasing disposable incomes and favorable demographics further fuel urban power demand.

- **Round-The-Clock Power**

Hybrid energy systems like wind-solar combinations ensure consistent, clean power output by leveraging complementary generation patterns. Integrating renewables with conventional sources enhances energy yields and stabilizes power supply.

- **Rural Electrification**

Government initiatives such as Power for All and rural electrification aim to provide 24x7 electricity access, improving quality of life, boosting economic activity, and driving power demand. Schemes like IPDS, with an outlay of ₹326.12 billion, further support this growth.

- **Cross-Border Power Trading**

India is strengthening power generation capacity and exploring cross-border electricity trade with neighboring countries like Nepal, Bangladesh, Bhutan, Sri Lanka, and the Maldives to achieve regional integration and export surplus power.

- **Railway Electrification**

Indian Railways is on track for 100% electrification by FY25, backed by ₹6,500 crore in the interim budget. With over 58,424 route kms electrified, nearly 50% in the last 5 years, this initiative positions Indian Railways as the world's largest green railway, reducing carbon emissions by FY28.

- **Electrification of Mobility Infrastructure**

India targets 30% EV penetration by 2030, with NITI Aayog projecting 80% adoption for two/three-wheelers and 50% for four-wheelers. At 33% EV penetration, electricity demand for EVs is estimated to reach 37 TWh, constituting less than 2% of total national demand. Grid readiness will be critical to supporting this transition.

Table 4: Charging Demand by Vehicle Segment

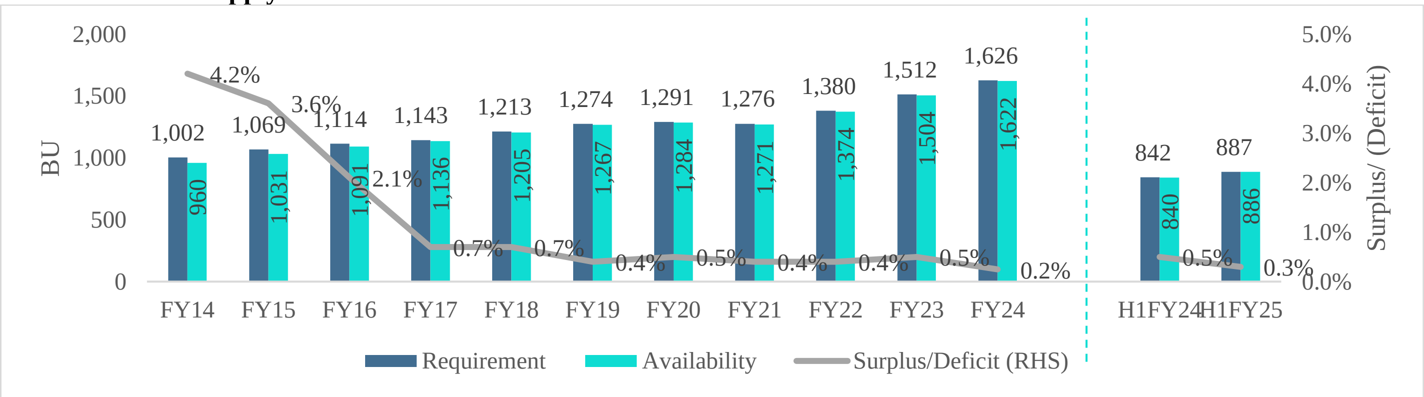
Vehicle segments	Total daily charging demand in kWh - 2025	Total daily charging demand in kWh – 2030
E – 2W	1,25,596	7,65,442
E-3W (passenger / cargo)	2,55,162	9,72,757
E-car (personal)	17,498	1,64,786
E-car (commercial)	55,931	4,91,838
Total	**4,54,187**	**23,94,823**

Source: Handbook of electric vehicle charging infrastructure implementation by NITI Aayog – Version 1

2.3 Power Demand, Supply, and Deficit in India

The electricity requirement has grown from 1,002 BU in FY14 to 1,626 BU in FY24. There has been a continuous deficit between electricity requirement and availability of around 0.3%-4.2% between FY14 and FY24. During April-September 2025, the electricity demand stood at 888 BU, an increase of 5% y-o-y, while the deficit was 0.1%.

Chart 12: Power Supply Position in India

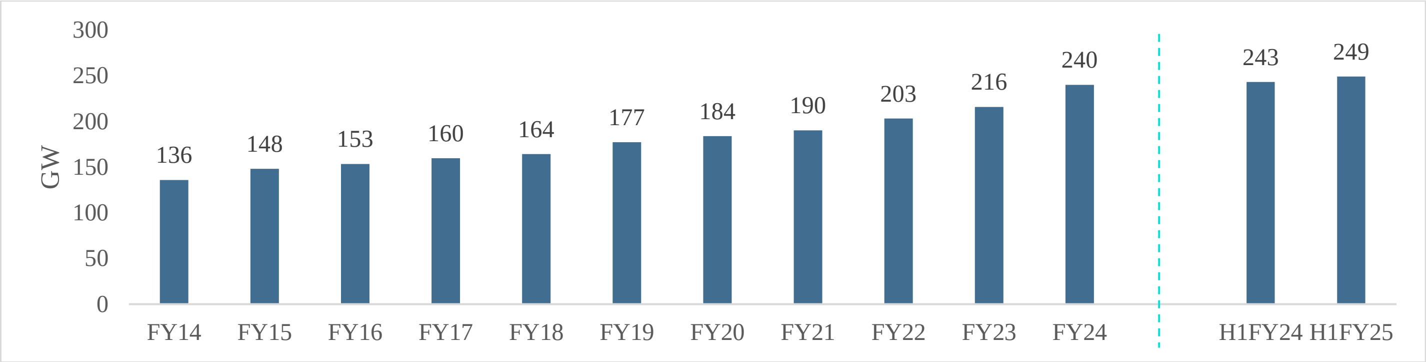


Source: Power Ministry, CEA, CareEdge Research

In FY14, peak demand not met stood at 6 GW, and energy not supplied was 42,428 MU. These figures declined steadily to 2.475 GW and 5,787 MU in FY22. However, due to high power demand, FY24 saw an increase to 3.34 GW peak demand not met and 4,112 MU energy not supplied.

During H1 FY24, the peak demand not met further dropped to 0.002 GW, with energy not supplied at 1,223 MU. Peak energy demand grew at a 5% CAGR from 136 GW in FY14 to 240 GW in FY24, matching a 5% CAGR in peak supply. Power requirements rose 7.5% year-on-year in FY24.

Chart 13: All India Peak Demand

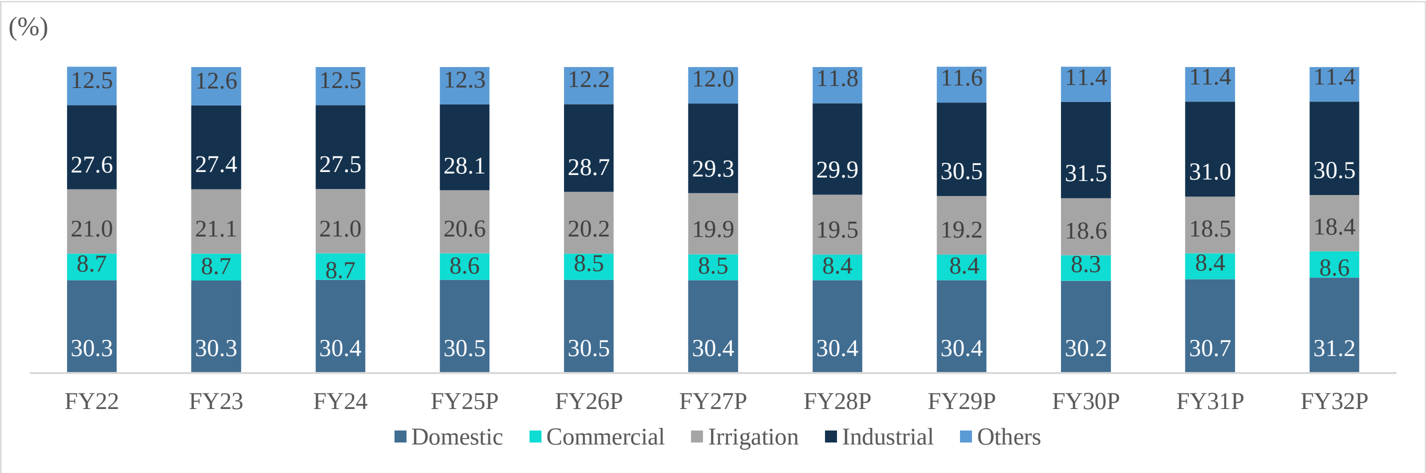


Source: Power Ministry, CEA, CareEdge Research

2.4 Sectoral Consumption of the Power sector

The consumption of power in the allied sectors has witnessed an increasing trend over the past years. The total consumption in the allied sectors stood at 1330 BU in FY24. Consumption grew by 6% in FY24 over FY23. Going forward, with rapid economic expansion coupled with population factors is expected to maintain steady growth in the consumption pattern. The consumption of power in the allied sectors is expected to grow at a CAGR of 6% from FY24 to FY32.

Chart 14: Sector-wise consumption of the power sector



Source: 20th Electric Power Survey Report, CEA, CareEdge Research; P: Projected

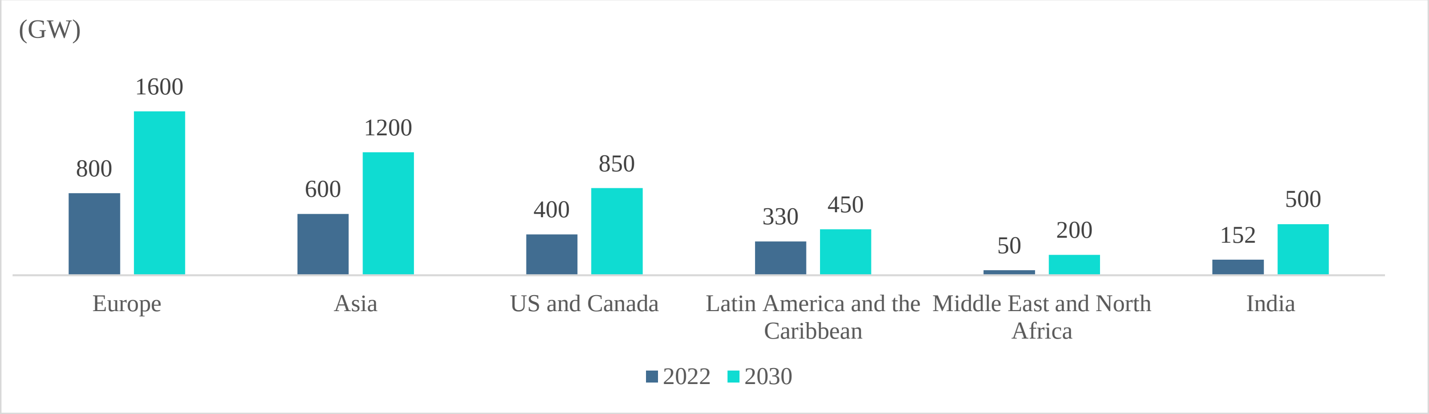
3 Renewable Energy Sector in India

3.1 Global initiatives and policies for boosting renewables growth

By the close of 2023, 90 countries had implemented economy-wide targets for renewable energy. However, only 7 countries had committed to 100% renewable energy targets, and most aimed at achieving them in distant timeframes.

Nearly all regions are expected to double their current targets in the renewable energy space by 2030. As of December 2023, China was the only country on track to meet its target of 28% renewables in its energy mix by 2030, while also surpassing its annual renewable capacity additions. In contrast, the European Union (EU), despite active efforts, remained off track in meeting its target of 42.5% renewables in its energy mix. These disparities underscored the gap between ambition and actual progress, signaling the urgent need for more effective measures to achieve global renewable energy goals.

Chart 15: Region wise Renewable energy targets as per COP28 until 2030



Source: IEA Renewables Energy Report 2024, CareEdge Research

Several other global initiatives and policies have been implemented to accelerate the growth of renewable energy. These efforts aim to transition away from fossil fuels and meet climate goals, such as limiting global warming and achieving net-zero emissions. Other key global initiatives and policies include:

1. Paris Agreement (2015): The Paris Agreement is a legally binding international treaty on climate change. It was adopted by 196 Parties at the UN Climate Change Conference (COP21) in Paris, France, on 12 December 2015. A landmark global accord in which countries committed to limiting global temperature rise to below 2°C, preferably 1.5°C, above pre-industrial levels. This has driven nations to set targets for increasing renewable energy as part of their Nationally Determined Contributions (NDCs).

2. RE100: A global corporate initiative where companies commit to using 100% renewable energy. Major corporations like Google, Apple, and IKEA are part of this initiative, which significantly boosts the demand for clean energy globally.

3. EU Green Deal (2020): The European Union's ambitious plan includes increasing renewable energy share to 40% by 2030. The EU is investing heavily in renewable energy technologies, hydrogen, and energy storage solutions to achieve climate neutrality by 2050.

4. Net Zero by 2050: Countries like the United States, United Kingdom, China, and others have committed to achieving net-zero emissions by 2050 or earlier. This includes large-scale investment in renewable energy, phasing out coal, and advancing technologies like green hydrogen.

5. Sustainable Development Goal 7 (SDG 7): Sustainable Development Goal 7 is one of 17 Sustainable Development Goals established by the United Nations General Assembly in 2015. This United Nations goal aims to ensure access to affordable, reliable, and modern energy services by 2030, with a focus on expanding renewable energy in the global energy mix.

6. International Solar Alliance (ISA): It is an alliance of more than 100 countries, most being sunshine countries with a primary objective of working on efficient consumption of solar energy by reducing the dependency on fossil fuels. Established by India and France, ISA focuses on promoting solar energy across member countries, particularly in tropical regions, through funding, technology transfer, and capacity building.

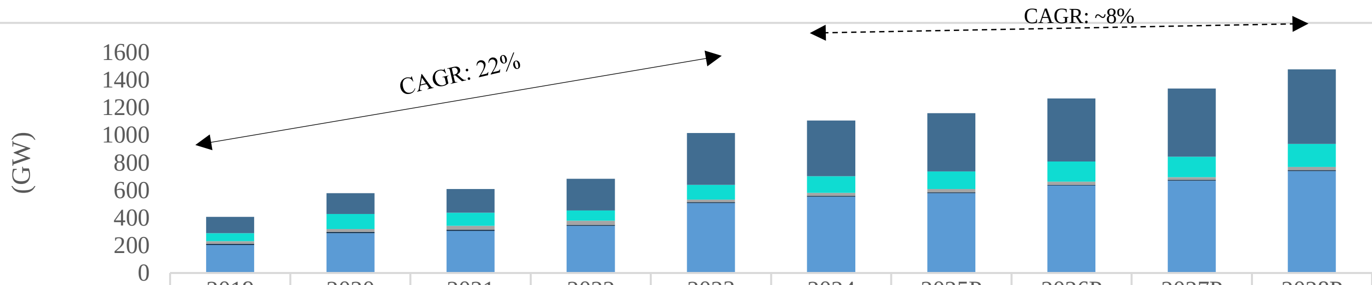
7. China's Renewable Energy Plan: China, the world's largest producer of renewable energy, has committed to peak carbon emissions by 2030 and carbon neutrality by 2060. China continues to lead in wind and solar capacity expansions through aggressive national policies.

These initiatives are creating a global momentum towards decarbonizing the energy sector and pushing renewable energy to the forefront of the climate action agenda.

3.2 Global Renewable Energy: Source wise capacity additions & forecast

According to the International Energy Agency (IEA), global renewable electricity capacity is expanding at its fastest pace in three decades, aligning with the COP28 goal of tripling capacity by 2030. In 2023, global renewable capacity grew by 50% to nearly 510 GW, with solar PV accounting for 75% of additions. China led this growth, installing as much solar PV in CY23 as the world did in CY22, while its wind power additions rose by 66%. Record growth was also seen in Europe, the U.S., and Brazil.
The share of renewables in global power generation is expected to rise from 29% to 35% by CY25, reducing coal and gas dependency and stabilizing CO2 emissions, which peaked at 13.2 Gt in CY22. China is projected to contribute nearly 50% of new renewable capacity, followed by the EU at 15%, driven by strong government investments. In the U.S., the Inflation Reduction Act allocates $370 billion for clean energy.
Nuclear power output is set to grow 3.6% annually, driven by recovery in France after maintenance and the launch of new plants, particularly in Asia.

Chart 16: Forecasted Global Net Renewable Energy Capacity Additions by Source



	2019	2020	2021	2022	2023	2024	2025P	2026P	2027P	2028P
Solar PV	117	151	171	228	375	402	422	459	494	540
Wind	59	108	95	74	108	121	127	144	148	167
Hydropower	19	21	28	32	18	21	24	24	19	24
Bioenergy	8	9	10	7	6	8	6	6	7	7
Total	203	289	304	341	507	552	579	633	668	738

Total Bioenergy Hydropower Wind Solar PV

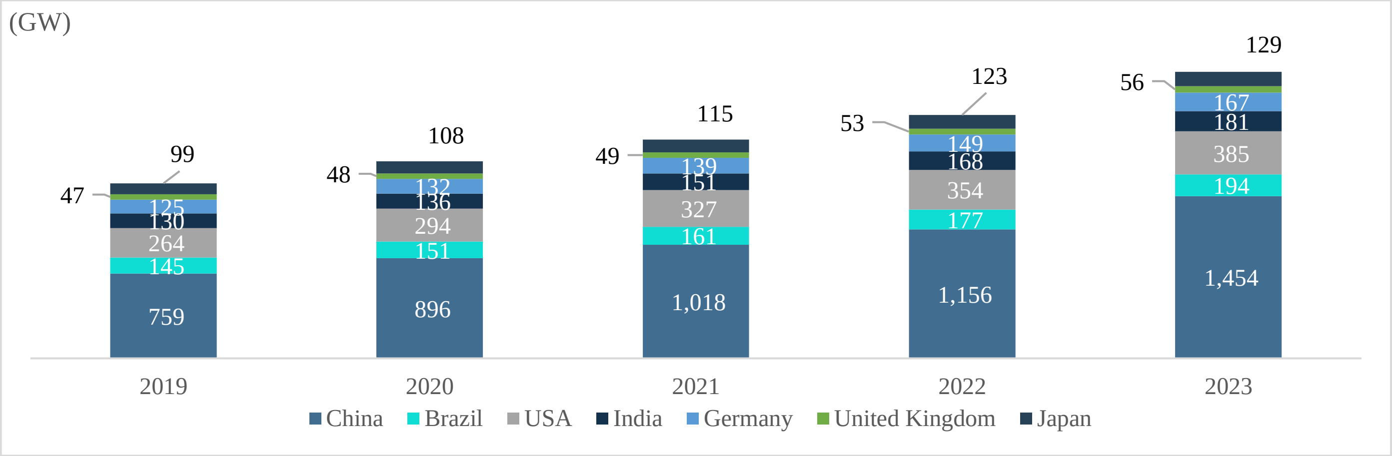
Source: IEA, CareEdge Research; E: Estimated

Solar PV capacity, encompassing both large utility-scale and small distributed systems, constitutes two-thirds of the anticipated growth in global renewable capacity for the current year. Solar PV and wind installed capacity constitute more than 90% of the total renewable energy installed capacity. The installed capacity of renewable energy is expected to reach 11,000 GW by 2030 under COP28 targets.

3.3 RE Capacity in India compared to major economies

Leading global nations are driving renewable energy growth with ambitious targets and substantial installed capacities. China leads the world with 1,454 GW, growing 26% in CY23, fueled by strong policies and significant solar and wind investments. Brazil reached 194 GW (10% growth), expanding its renewable portfolio, while India, at 181 GW (8% growth), is advancing rapidly toward its 500 GW goal by 2030, leveraging vast solar potential. Japan grew 5% to 129 GW, focusing on solar, nuclear, and offshore wind energy despite land constraints. The USA, with 385 GW (9% growth), is scaling solar and wind energy, driven by initiatives like the Inflation Reduction Act. Germany, at 167 GW (12% growth), leads Europe's renewable transition, emphasizing wind, solar, and bioenergy. The UK, with 56 GW, is prioritizing coal phase-out and green hydrogen investments. Collectively, these countries are pivotal in accelerating the global shift toward a cleaner, more sustainable energy future.

Chart 17: Country-wise installed capacity in RE

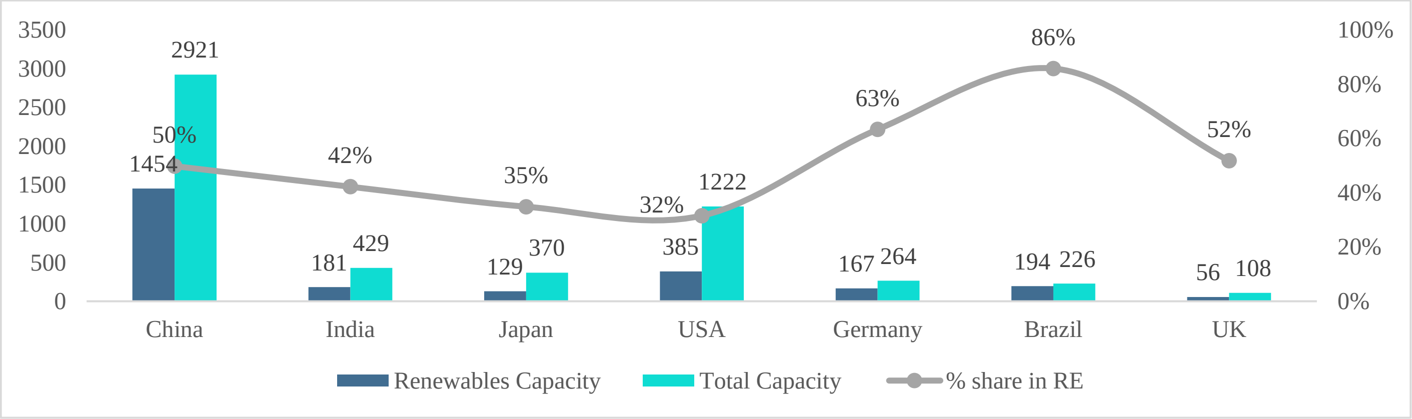


Source: IRENA, CareEdge Research

3.4 RE contribution to power demand across economies

The global energy transition reflects varying national priorities and resources. Germany leads Europe with 63% renewables (167 GW), driven by wind and solar, targeting a coal phase-out by 2038. China, the global leader, has 1,454 GW of renewables, nearly 50% of its 2,921 GW capacity, supported by strong policies and solar-wind investments. Brazil leads in renewable share at 86% (194 GW), dominated by hydropower. India's renewables stand at 42% (181 GW of 429 GW), with plans to surpass 50% by 2030. Japan, at 35% (129 GW of 370 GW), focuses on solar and offshore wind despite land constraints. The USA, with 32% renewables (385 GW), accelerates growth through initiatives like the Inflation Reduction Act. The UK achieves 52% renewables, led by offshore wind.

Chart 18: Country-wise share of installed renewable capacity as of CY23



Source: IRENA, CareEdge Research

3.5 Availability of finance and evolution of funding mechanisms in RE Sector

Table 5: Expected investments in Renewable generation (Rs Crore)

Renewables	FY23-FY27	FY27-FY32
Solar	6,80,970	7,96,771
Wind	2,30,946	3,30,900
BESS	56,647	2,92,637
Hydro	66,148	1,29,777
PSP	54,203	75,240
Offshore Wind	0	27,401
Biomass	24,704	23,105
SHP	1,859	1,669
Total	**11,15,477**	**16,77,500**

Source: National Electricity Plan (NEP) March 2023, CareEdge Research

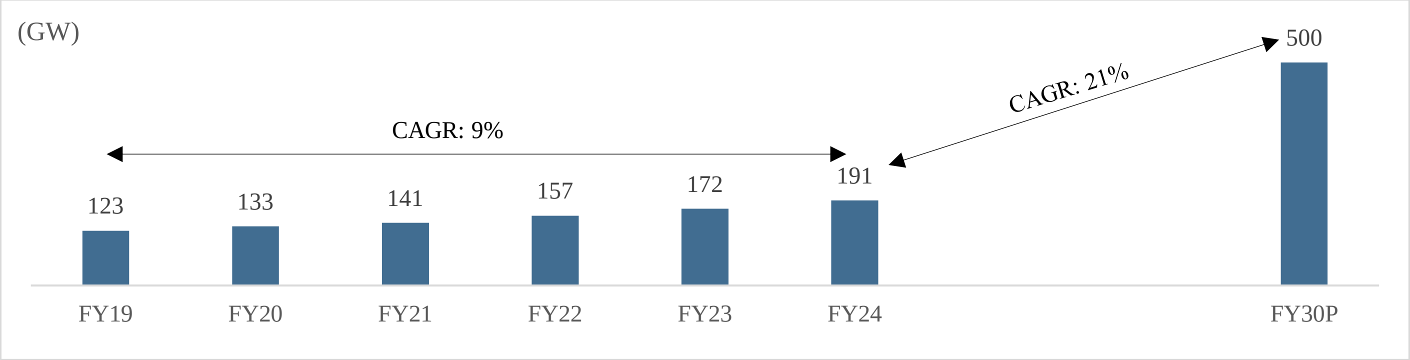
The growth of the global renewable energy sector has been driven by increased financial accessibility through various funding mechanisms. Green bonds, widely used for renewable projects, are prominent in markets like India and China. Government incentives, such as tax credits and grants, along with concessional loans from institutions like the World Bank, have helped reduce project costs. Blended finance models combine concessional and commercial funding to attract private investment in high-risk areas. Institutional investors, including pension funds, are increasingly funding renewables for stable returns, while public-private partnerships enable large-scale projects like offshore wind farms. Corporate PPAs provide stable revenue streams for developers, and carbon pricing mechanisms further incentivize clean energy. Additionally, renewable investment funds and innovative financing models like Energy-as-a-Service and crowdfunding are expanding access, ensuring steady progress toward global clean energy goals.

3.6 India's RE Market Size

Renewable capacity additions in India at CAGR of 9% from FY19 to FY24 with an ambitious target to reach 500GW until FY30, poised to grow at a CAGR of 21% from FY24 to FY30.

The growth from FY19-FY24 was massively backed by government support, mainly central and state-level incentives. As of FY24, the share of renewable energy stood at 43% of the total installed capacity reaching 191 GW. As per CEA, total capacity across all segments as of FY24 stood at 441 GW. The growth was led largely by solar power additions which grew approximately three-fold from 28 GW in FY19 to ~82 GW in FY24.

Chart 19: Historical and forecast of installed capacity for RE in India

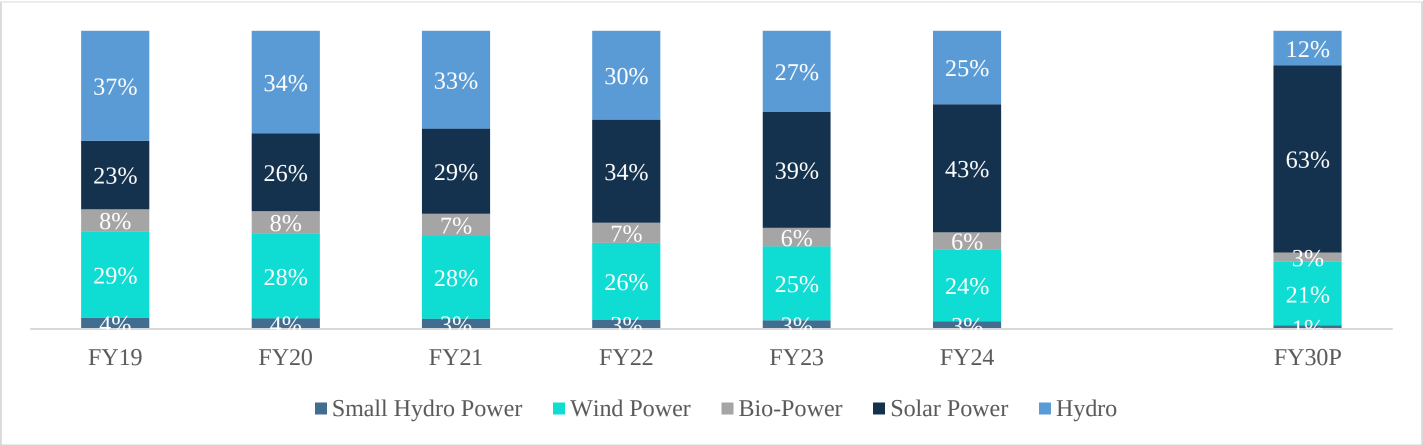


Source: CEA, CareEdge Research; P: Projected

3.7 Source wise breakup of India's RE market

The growth in renewable energy has been backed by the growth of different sources. Solar energy has shown massive developments with increasing its share from 23% in FY19 to 43% in FY24 for renewables. Further, the share of solar is expected to be beyond 60% in 2030 given the robust expansion plans backed by government initiatives. Wind power capacity is also expected to double; however, with solar holding the lion's share, it is likely to reduce wind energy's overall proportion in the renewables mix.

Chart 20: Historical source wise installed capacity of RE in India



Source: CEA, CareEdge Research; P: Projected

3.8 Long Term Drivers for RE growth

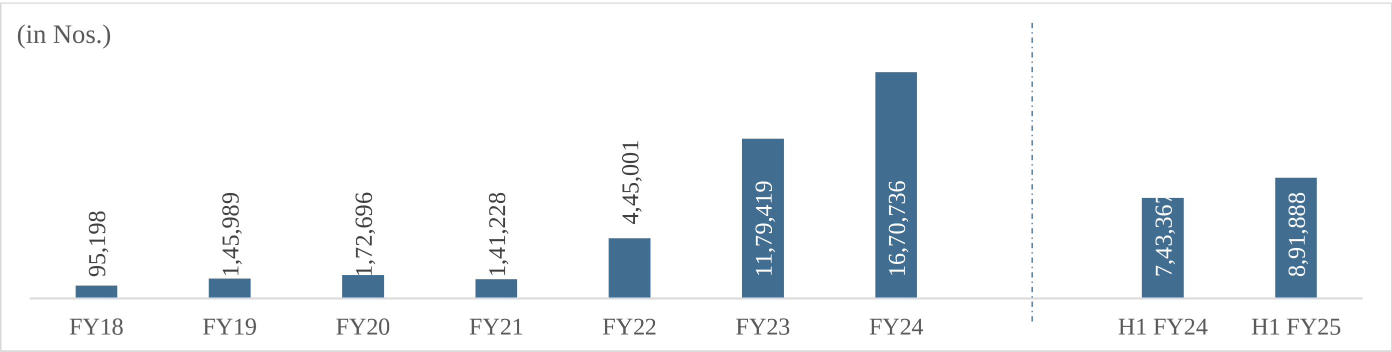
- **Government Policies and Incentives**
  Government policies play a crucial role in shaping the renewable power sector. India has implemented various initiatives, such as the National Solar Mission and the Wind Energy Policy, which set ambitious targets for renewable energy generation. Additionally, state-level policies further support local initiatives, creating a robust framework for renewable energy growth.
- **Rising Energy Demand**
  Renewable energy sources, such as solar and wind, offer a viable alternative to traditional fossil fuels, which are often subject to price volatility and supply constraints. This rising energy demand not only highlights the need for more power generation capacity but also underscores the importance of transitioning to cleaner energy sources that can support long-term growth without compromising environmental integrity.
- **Climate Change Awareness**
  The growing awareness of climate change and its impacts is significantly driving demand for renewable energy. Businesses are also recognizing the need to align their operations with environmental goals, fostering a culture of sustainability that prioritizes clean energy use. This heightened awareness not only influences consumer behavior but also encourages investment in renewable technologies as a means of combating climate change.
- **Technological Advancements**
  The efficiency of solar panels has improved dramatically, enabling greater energy generation from smaller installations. Additionally, advancements in battery technology are facilitating better energy storage, allowing for more consistent energy supply even when production fluctuates. These technological breakthroughs are crucial in driving demand, as they make renewable energy solutions more competitive with traditional energy sources.
- **Investment in Infrastructure**
  Enhanced transmission networks and smart grid technologies allow for better integration of renewables into the energy mix, improving reliability and reducing transmission losses. Furthermore, investments in energy storage infrastructure, such as battery systems, are essential for managing the intermittent nature of renewable sources like solar and wind. This focus on infrastructure development not only supports existing projects but also creates a more resilient energy system that can adapt to future demands.

4 Overview of the EV Sector in India

4.1 Overview

The Electric Vehicle (EV) segment in India has been growing steadily, while Internal Combustion Engine (ICE) vehicle sales have declined due to factors like economic slowdown, COVID-19, rising fuel prices, and semiconductor shortages. From FY18 to FY24, EV sales grew at a strong 61% CAGR, with a dip in FY21 due to the pandemic but a strong recovery in subsequent years. Key drivers of growth include expanding infrastructure, diverse vehicle options, and cost competitiveness with traditional fuels. This upward trend in EV sales is expected to continue as capabilities improve.

Chart 21: Annual EV sales trend in India

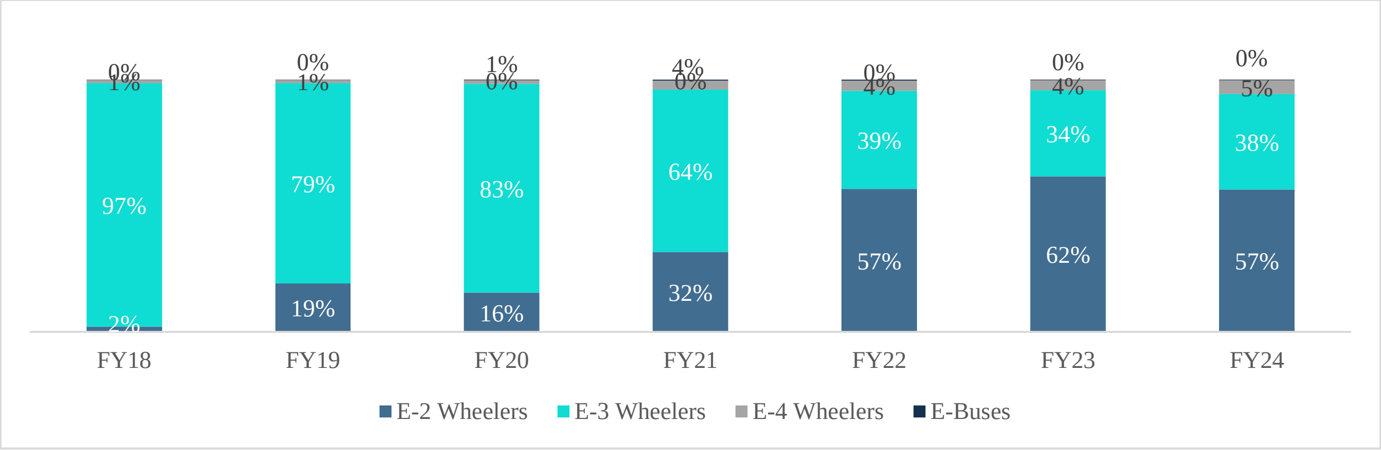


Source: Society of Manufacturers of Electric Vehicles, VAHAN, CareEdge Research

4.2 Category wise split of EV segments

While the 3W segment had a lion's share in FY18, it continues to hold a greater share of more than 35% in the EV category. The share of 3W has grown from 34% in FY23 to 38% in FY24. Going forward, it is expected that the EV category will have a significant share of 3W given the shift towards sustainability.

Chart 22: Category-wise split of EV sales

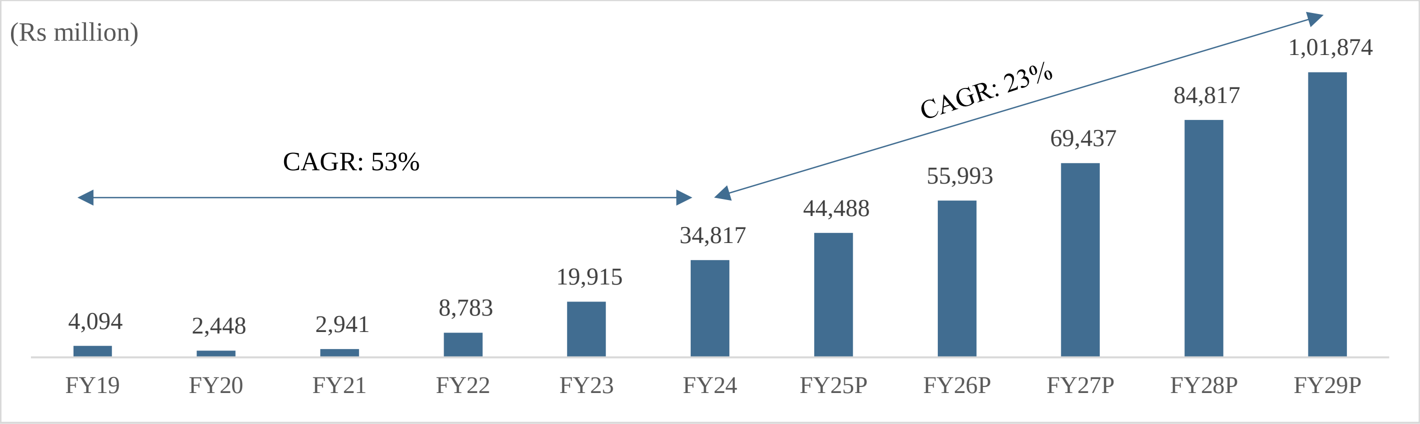


Source: Society of Manufacturers of Electric Vehicles, VAHAN, CareEdge Research

4.3 E-Rickshaw market size

E-rickshaws are cost-effective compared to conventional vehicles due to lower operational and maintenance costs, with rising fossil fuel prices further boosting their appeal. The E-rickshaw market grew at a 53% CAGR from FY19 to FY24, reaching Rs 34,817 million. E-3W sales rose from 91,970 units in FY18 to 632,485 units in FY24, growing at a 38% CAGR. Government initiatives like subsidies and the FAME scheme promote electric mobility, making e-rickshaws more affordable. The market is expected to continue growing at a 23% CAGR from FY24 to FY29, reaching Rs 101,874 million.

Chart 23: E-Rickshaw market size in India



Source: TechSci Market Research, CareEdge Research; P: Projected

4.4 Long term drivers and constraints

Long term demand drivers

The E-3W market in India is poised for significant growth, driven by several long-term demand factors. These vehicles are gaining traction due to their operational advantages and supportive policy frameworks.

- **Low operating and maintenance costs:** Electric three-wheelers (EVs) offer significantly lower operating and maintenance costs compared to internal combustion engine (ICE) models, with an average Total Cost of Ownership (TCO) of Rs. 2.6/km vs. Rs. 4.1/km for CNG three-wheelers.

- **Government incentives and subsidies:** Initiatives like the FAME India Scheme, Production Linked Incentive (PLI) Scheme, and the Electric Mobility Promotion Scheme (EMPS) 2024 provide financial support to drive EV adoption and strengthen domestic manufacturing.

- **Advancements in battery technology:** Falling battery costs and improvements in efficiency and charging capabilities have made EVs more affordable and practical for longer commutes, addressing range anxiety and increasing convenience.

- **Established 3-wheeler market:** The existing demand for 3-wheelers in urban transport has facilitated the transition to electric models, boosted by lower operating costs, reduced emissions, and government incentives.

- **Stringent emission norms:** Regulations like BS-VI, fuel efficiency norms, and the Scrappage Policy have increased costs for ICE vehicles, encouraging the shift toward EVs due to their cleaner and more cost-effective nature.

- **State-level EV policies:** State and local governments play a crucial role in promoting EV adoption through ambitious electrification targets and supportive policies, complementing national efforts.

Table 6: State level policies for E-rickshaw

State	Policy Period	Target
Tamil Nadu	2019-2024	Conversion of all auto-rickshaws within 10 years in a phased manner.
Uttar Pradesh	2019-2024	Achieve 100% electric auto-rickshaw fleet in 5 major cities by 2030.
Punjab	2019-2024	25% of new auto-rickshaw sales to be electric by 2024.
Bihar	2019-2024	Phase out manually pedaled rickshaws and upgrade them to 100% electric rickshaws by 2022.
Maharashtra	2021-2026	• At least 20% of new 3W registrations to be electric by 2025.

		• At least 25% of the urban fleet operated by fleet aggregators and operators in the state to be EVs by 2025.
Assam	2021-2026	Deploy 75,000 e-3Ws by 2025.
Goa	2021-2026	30% of annual registrations to be electric from 2025.
Chandigarh	2022-2027	All new auto-rickshaw registrations to be electric by 2025.
Rajasthan	2022-2027	30% of all new 3-wheeler sales to be electric by 2027

Source: CareEdge Research

Constraints

Despite witnessing healthy growth in the past, the EV sector faces significant challenges.

- **Lack of charging infrastructure:** Despite growth in charging stations, with a nine-fold increase from 1,800 in February 2022 to 16,347 in March 2024, limited infrastructure remains a challenge. To reach 30% EV penetration by 2030, over 5 million charging units are needed.
- **High upfront costs:** EVs have high initial costs, primarily due to expensive batteries and imported components, which are further compounded by higher financing and insurance costs. While subsidies help, the financial burden remains a barrier for many consumers.
- **Limited power output and speed:** Many entry-level EVs offer lower power output and speed compared to ICE vehicles, limiting their appeal for consumers seeking performance.
- **Supply chain issues:** Dependence on imported materials for batteries and components has led to delays and cost increases, hindering local production and making EVs less accessible due to extended lead times and higher prices.

4.5 EV penetration in the e-rickshaw segment

A robust growth trajectory is expected in the adoption of electric auto-rickshaws (E-Autos) within the passenger three-wheeler (3W) segment over the coming years. This rise reflects policy support, increasing consumer acceptance, and advancements in EV infrastructure, positioning E-Autos as a vital part of India's sustainable urban mobility landscape.

Table 7: EV penetration in E-3W

Financial Year	No. Of Passenger 3Ws	No. Of E-Autos	EV Penetration
FY23	3,17,503	15,247	4.80%
FY24	3,43,807	35,075	10.20%
FY25P	3,72,289	58,083	15.60%
FY26P	4,03,132	84,663	21.00%
FY27P	4,36,529	1,15,248	26.40%
FY28P	4,72,693	1,50,320	31.80%
FY29P	5,11,854	1,90,412	37.20%
FY30P	5,54,258	2,36,116	42.60%
FY31P	6,00,176	2,88,085	48.00%

Source: WRI Analysis, IEA Report, CareEdge Research; P: Projected

4.6 Overview of various battery technologies

Lithium-ion (Li-ion) batteries dominate the electric vehicle (EV) market due to their high energy density, efficiency, and long lifespan. Key chemistries within Li-ion include Nickel Manganese Cobalt (NMC) for passenger EVs, Lithium Iron Phosphate (LFP) for safety and longevity, and Nickel Cobalt Aluminum (NCA) for high-performance EVs. Li-ion batteries hold over 80% of the market share, benefiting from ongoing advancements and cost reductions.

Other technologies like Nickel-Metal Hydride (NiMH), solid-state, Lithium-Sulfur (Li-S), lead-acid, and sodium-ion batteries show potential but remain either less efficient, still in development, or limited to specific use cases. Despite alternatives, Li-ion remains the preferred choice for EVs due to its superior performance, cost-effectiveness, and established infrastructure.

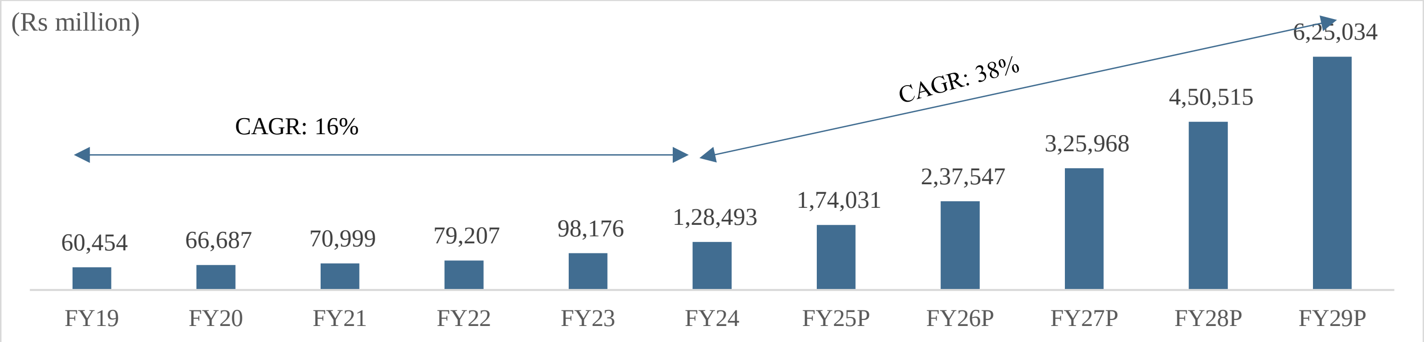
4.7 Government initiatives and investments to boost overall EV sector

India is actively promoting electric auto-rickshaws to reduce pollution and reliance on fossil fuels. Key initiatives include the FAME II scheme with a ₹10,000 crore budget for subsidies, reduced GST on EVs to 5%, and state policies like Delhi and Maharashtra offering purchase incentives, tax waivers, and infrastructure support. The PLI scheme for battery manufacturing (₹18,100 crore) and customs duty exemptions aim to boost domestic production, while subsidized loans and scrappage incentives lower costs for drivers. Efforts also include installing 2,636 charging stations across 62 cities and funding R&D for advanced battery technologies like sodium-ion and solid-state batteries, fostering a sustainable EV ecosystem.

4.8 EV Lithium Battery Market size in India

The market grew at a CAGR of 16% from FY19-FY24 to reach Rs 128,493 million. The increasing adoption of electric vehicles (EVs) in India is a primary driver for the lithium battery market. With government initiatives like the Faster Adoption and Manufacturing of Hybrid and Electric Vehicles (FAME) scheme and state-level incentives, consumers are more inclined to purchase EVs. As the demand for EVs grows, so does the need for efficient and reliable lithium batteries. The Li-ion battery market is expected to grow with a robust CAGR of 38% from Rs 128,493 million in FY24 to reaching Rs 625,034 million by FY29.

Chart 24: Lithium Battery market size

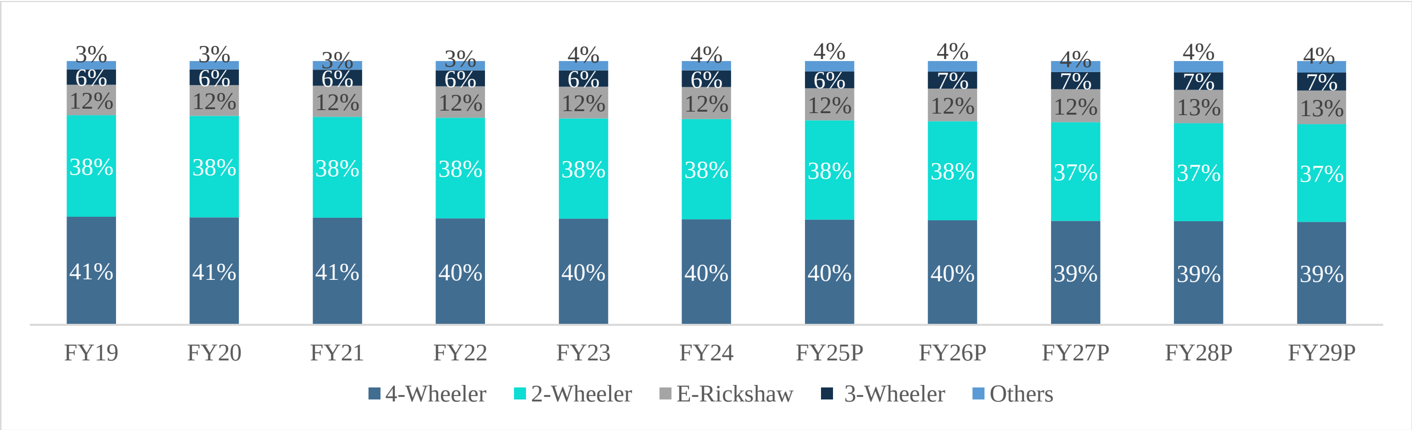


Source: TechSci Market Research, CareEdge Research; P: Projected

4.9 EV Lithium Battery market size by category

Currently 4W and 2W contribute to more than 75% of the market share for the Li-ion battery while 3W contribute to nearly about 18% of the market share. While all the segments across the categories have shown decent growth, the share of 3-Wheeler EVs has also shown gradual growth, expected to rise from 6% to 7% by FY30, indicating a steady interest in this segment.

Chart 25: Lithium Battery market by category



Source: TechSci Market Research, CareEdge Research; P: Projected; Others include minibuses, vans, trucks, etc

4.10 Long term drivers and constraints

Long-Term Growth Drivers for Li-Ion Battery Demand:

1. Electrification of Transportation: The global push for EV adoption, especially for passenger cars, commercial fleets, and public transportation, is a primary driver for Li-ion batteries, which power nearly all EVs due to their high energy density and efficiency.

2. Energy Storage Systems (ESS): As renewable energy sources like solar and wind become more prevalent, the need for efficient energy storage solutions rises. Li-ion batteries are favored for grid storage due to their scalability, longevity, and ability to store intermittent renewable energy.

3. Consumer Electronics Growth: The increasing adoption of high-performance, portable consumer electronics (smartphones, laptops, tablets) continues to drive demand for compact, high-capacity Li-ion batteries.

4. Advancements in Battery Technology: Ongoing innovations in Li-ion battery technology are improving energy density, reducing charging times, and extending battery life, making these batteries more attractive for a wide range of applications.

Constraints:

1. Supply Chain and Material Limitations: Li-ion batteries rely heavily on materials like lithium, cobalt, and nickel, which face supply constraints, price volatility, and environmental and ethical concerns associated with mining.

2. Environmental and Safety Concerns: Li-ion batteries have risks of thermal runaway and are challenging to recycle. This raise concerns over long-term environmental impact and the need for safer disposal or recycling options.

3. Emerging Battery Alternatives: Research in solid-state batteries, sodium-ion, and other emerging technologies could eventually provide safer, more affordable, or more environmentally friendly alternatives to Li-ion batteries, potentially limiting their demand.

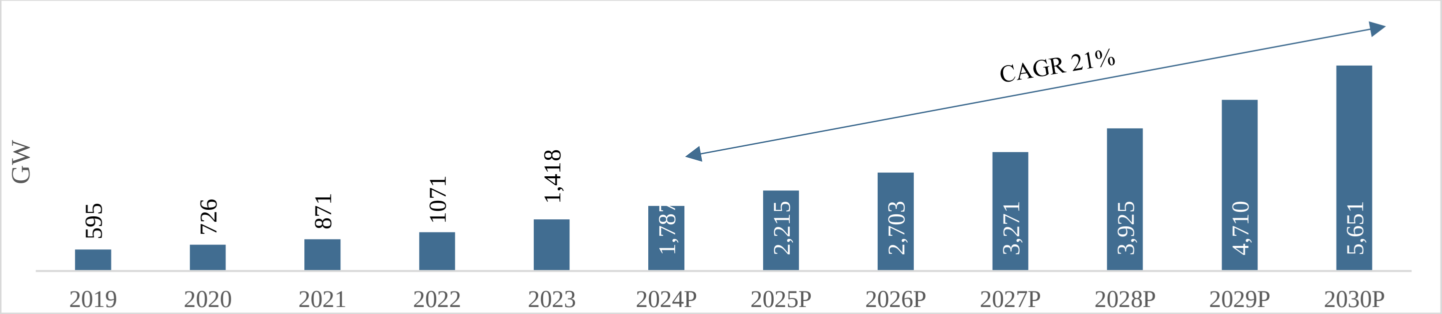
5 Overview of Solar Energy

5.1 Global Market

5.1.1 Global Market Size of Solar Energy

The global solar energy market has been experiencing robust growth, driven by increasing demand for renewable energy sources, advancements in solar technology, and supportive government policies worldwide. In 2023, the market size was valued at approximately 1,418 GW and is projected to expand at a compound annual growth rate (CAGR) of 21% until 2030 reaching 5651 GW. The robust growth is attributable to key factors such as rising investments in utility-scale solar projects, growing adoption of rooftop solar systems, and declining costs of photovoltaic (PV) modules. Regions like Asia-Pacific, North America, and Europe are leading the market, with countries such as China, the U.S., and India dominating both production and installations. As global efforts to transition to clean energy intensify, solar energy is set to play a pivotal role in shaping the future energy landscape.

Chart 26: Global Solar Energy Market size

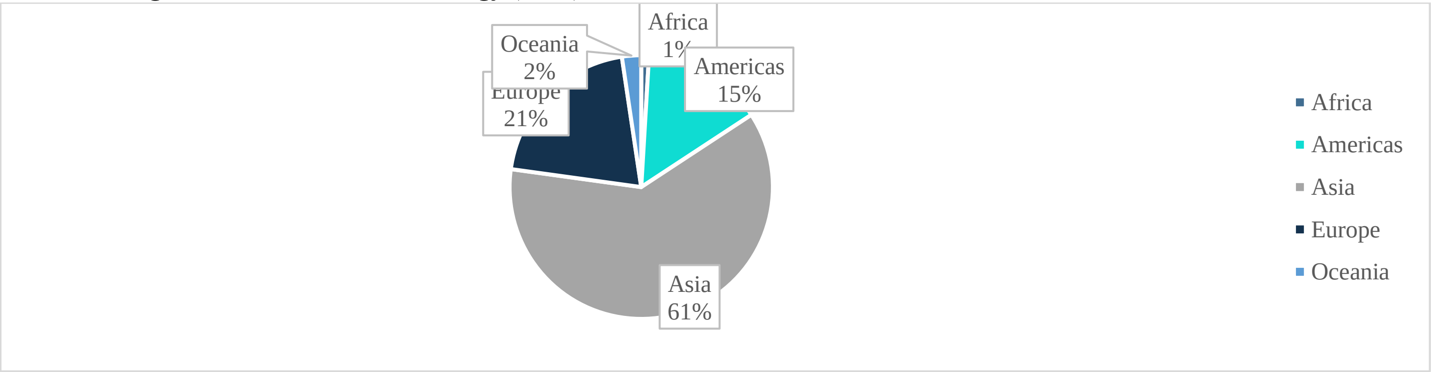


Source: IRENA, CareEdge Research; P: Projected

5.1.2 Market Segmentation by Region

In 2023, global solar energy capacity shows regional disparities. Asia leads with 871 GW, holding 61% of the global share, driven by China and India's rapid solar expansion. Europe follows with 290 GW (21% share), supported by strong policies and a green economy focus. The Americas contribute 210 GW, with the U.S. and Brazil as key drivers. Oceania and Africa together account for 3% of global capacity. This highlights Asia's dominance and emphasizes the need for greater efforts in Africa and Oceania to tap into their solar potential.

Chart 27: Region-wise share of Solar energy (2023)



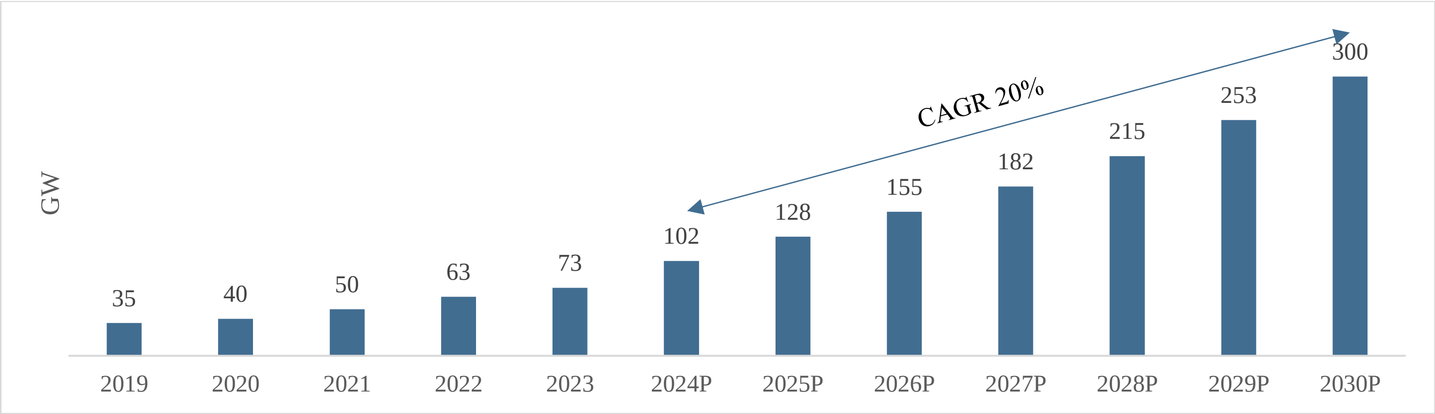
Source: IRENA, CareEdge Research

5.2 Indian Market

5.2.1 India Market Size for Solar Energy

India, with an installed solar capacity of 73 GW in 2023, is rapidly advancing toward its goal of 300 GW by 2030, driven by initiatives like the National Solar Mission and the Renewable Energy Development Program. The government's Production Linked Incentive (PLI) scheme supports domestic solar manufacturing, reducing dependence on imports. India's abundant solar resources fuel growth in utility-scale projects and rooftop installations, aided by falling costs and subsidies like the Rooftop Solar Scheme Phase II. India's leadership in global initiatives, such as the International Solar Alliance (ISA), underscores its role in promoting solar energy globally. With strong policy support and growing domestic and international demand, India is set to shape the future of global solar energy.

Chart 28: India Solar Energy Market size

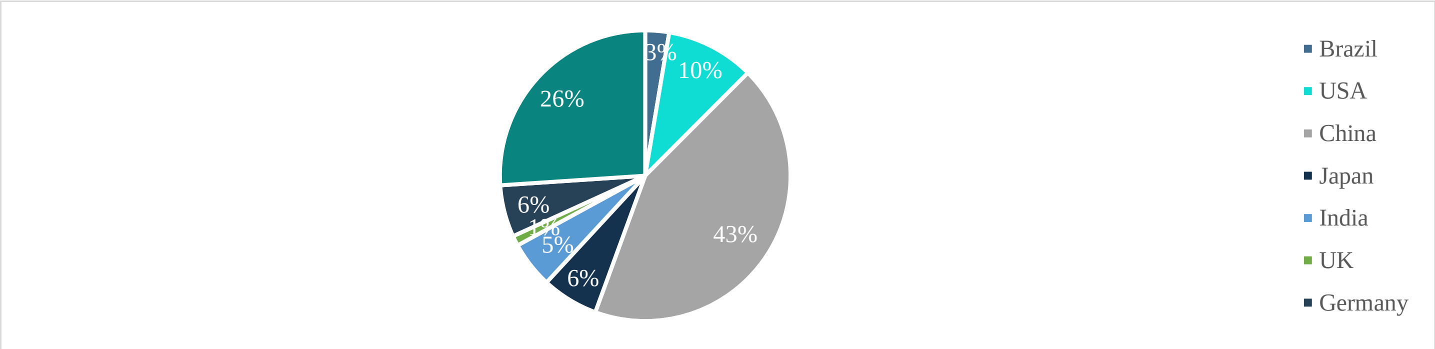


Source: IRENA, CareEdge Research; P: Projected; years refer to Calendar Year

5.2.2 Solar contribution to power demand in India vs other key economies (2023)

China leads globally with 610 GW of solar capacity, holding 43% of the market. The U.S. follows with 139 GW, supported by federal and state incentives. Japan and Germany have 89 GW and 82 GW, respectively, driven by innovation and favorable policies. India, with 73 GW, ranks among the top solar producers, advancing rapidly toward its goal of 300 GW by 2030 through initiatives like the National Solar Mission. Brazil and the UK contribute 37 GW and 16 GW, reflecting growing but smaller solar sectors. India's progress underscores its rising influence in the global renewable energy market, especially in emerging economies.

Chart 29: Global market share of countries in Solar Energy (2023)



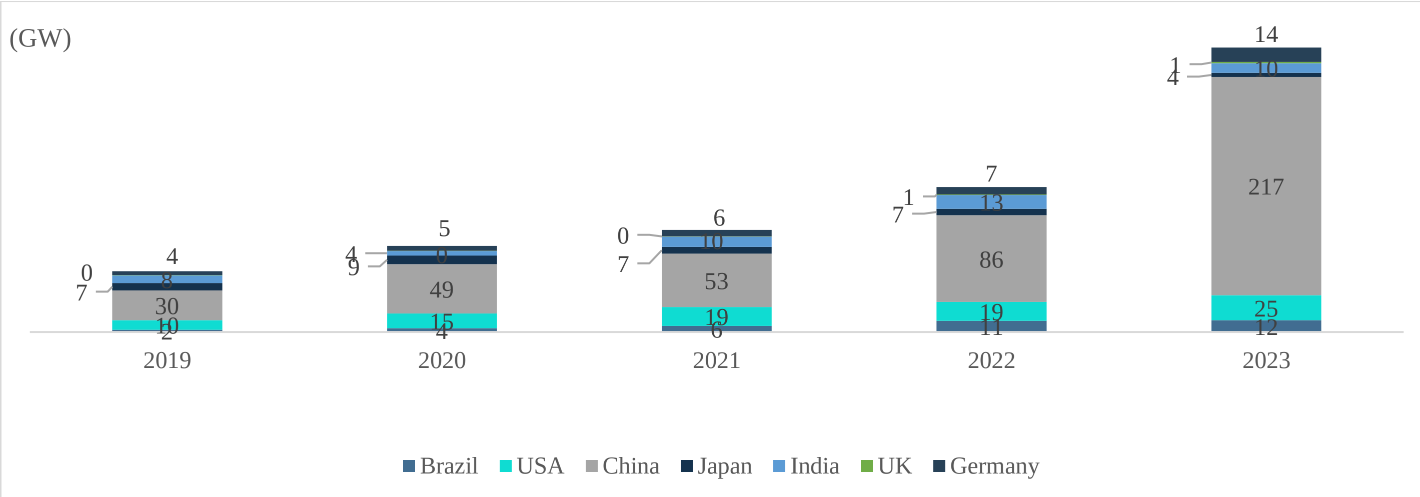
Source: IRENA, CareEdge Research; % denote global market share

5.3 Assessment on Solar Capacity Additions

5.3.1 Annual Solar capacity additions in major economies and outlook

China led global solar growth in 2023, adding 217 GW, more than double its 2022 figures, driven by investments in utility-scale projects and carbon neutrality goals. The U.S. followed with 25 GW, supported by federal tax credits and state mandates. India's additions, ranging from 8 GW in 2019 to 10 GW in 2023, are expected to accelerate, supported by initiatives like the Production Linked Incentive (PLI) scheme and a target of 300 GW by 2030. Global solar capacity is projected to grow at a 21% CAGR over the next decade, with India, Brazil, China, and the U.S. leading, while Europe, Africa, and Southeast Asia will contribute significantly to future growth.

Chart 30: Country-wise annual capacity additions in Solar Energy



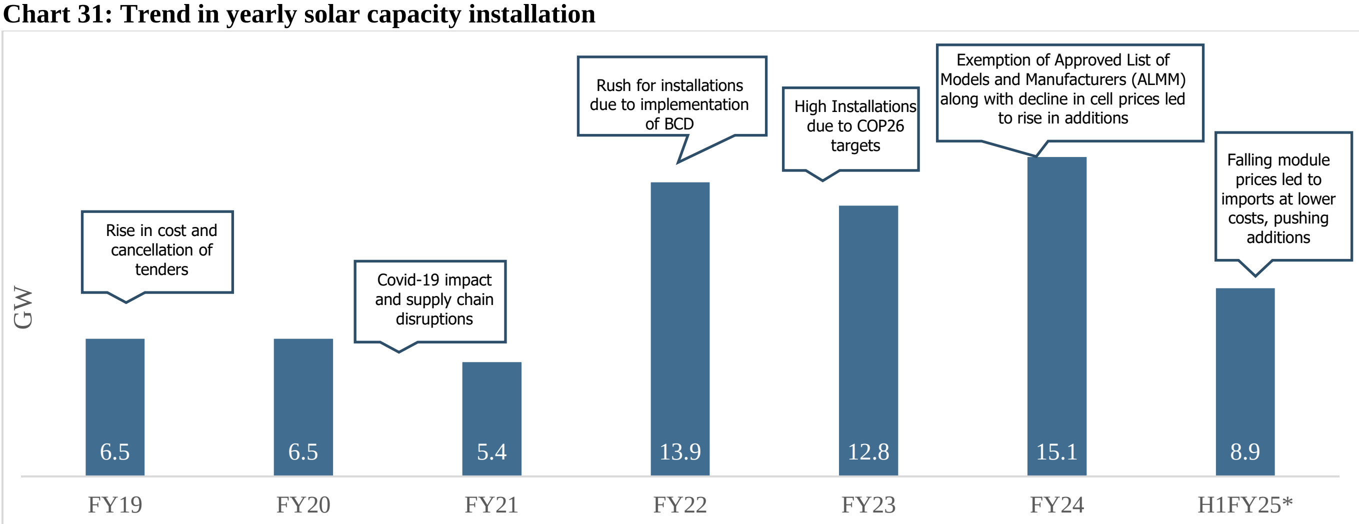
Source: IRENA, CareEdge Research

5.3.2 Growth and Outlook in India's Solar Capacity Additions

India has significant solar energy potential. Approximately 5,000 trillion kWh of energy is incident over India's geographical area each year. Solar photovoltaic electricity can be successfully harvested, allowing for massive scalability in India.

As of September 2024, solar energy contributed nearly 20% of the installed power generation capacity in India. Further, the contribution of solar energy to India's power consumption has grown from 2.8% in FY19 to 7.0% in FY24.

Chart 31: Trend in yearly solar capacity installation



Source: CEA, CareEdge Research
Note: This includes onshore, offshore, rooftop and utility solar capacity installations, *denotes data for FY25 until Q2 (Sep 2024)

The solar power industry in India has seen strong growth, adding 53.7 GW from FY19 to FY24, with a 23.8% CAGR and a peak of 15.1 GW in FY24, driven by falling module and cell prices. This growth is expected to continue in FY25, fueled by the completion of delayed projects and lower module costs. Solar energy plays a key role in India's National Action Plan on Climate Change, with the National Solar Mission (NSM) being a central initiative. India aims to reduce emissions intensity by 45% by 2030, achieve 500 GW of non-fossil fuel-based power capacity, and reach net-zero emissions by 2070. The government supports these goals with policies like the Solar Park Scheme, PM KUSUM, incentives for domestic module production and renewable energy certificates.

Outlook of Solar Capacity Additions in India

India's power sector is undergoing a transformation with a focus on increased capacity and clean energy. Government initiatives like the Basic Customs Duty (BCD) on imported solar modules and the Production-Linked Incentive (PLI) scheme are boosting domestic manufacturing, driving solar capacity growth. By FY32, solar is expected to dominate the energy mix, increasing its share from 19% in FY24 to 40%, with capacity rising from 82 GW to 365 GW. Wind power will also grow significantly from 46 GW to 122 GW. This growth is supported by large-scale solar projects, policy initiatives, and a push to reduce reliance on thermal power, aligning with India's renewable energy targets.

Table 8: Capacity Additions- review and forecast (MW)

	From FY22 to FY27			From FY27 to FY32		
	Under Construction	Additional Capacity Requirement	Total Capacity	Under Construction	Additional Capacity Requirement	Total Capacity
Solar	92,580	38,990	131,570	0	17,900	17,900

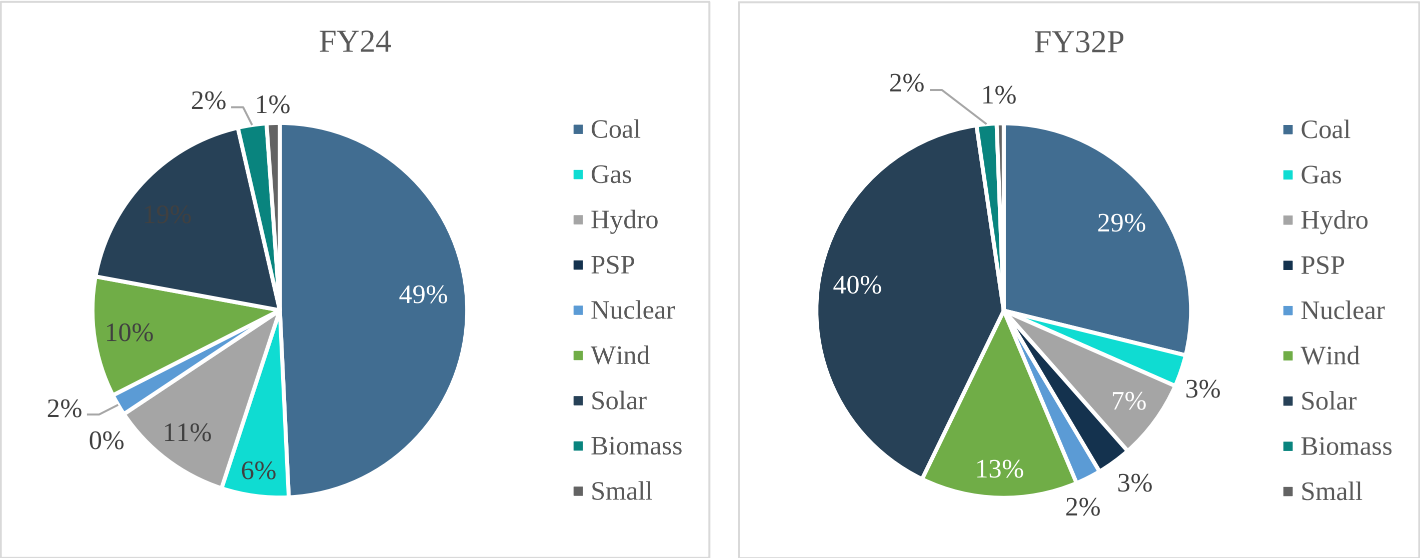
Source: National Electricity Plan (NEP) Vol-1, CareEdge Research

Table 9: Breakup of total installed Capacity

(GW)	Coal	Gas	Hydro	PSP	Nuclear	Wind	Solar	Biomass	Small	Total
FY24	218	26	47	-	8	46	82	11	5	442
FY32P	260	25	62	27	20	122	365	16	5	900

Source: National Electricity Plan (NEP), Vol-II, CEA, CareEdge Research, P: Projected

Chart 32: Break-up of the total installed capacity - FY24 vs FY32



Source: National Electricity Plan (NEP), Vol-II, CEA, CareEdge Research, P: Projected

5.3.3 Key Growth Drivers for Capacity Additions in India

- **Declining Prices of Solar Modules:** Over the past decade, the costs of solar modules and system components have significantly decreased due to technological advancements, improved designs, and economies of scale, enhancing the economics of solar projects and reducing funding requirements.

- **Fiscal and Regulatory Support:** Government initiatives like PM-KUSUM, Rooftop Phase-II, and the PLI scheme for Solar PV manufacturing are driving solar adoption. The PLI scheme, with ₹24,000 crore allocated for 65,000 MW of manufacturing capacity, reduces import dependence and stabilizes costs. The government has also imposed a 25% Basic Customs Duty on solar cells and 40% on modules, alongside infrastructure support for solar parks, ensuring project development benefits.

- **Renewable Purchase Obligation (RPO):** By FY30, India's RPO targets 43.33% of electricity from renewable sources. Entities can meet these targets through renewable energy certificates (REC). The government also continues to waive inter-state transmission system (ISTS) charges for solar and wind energy, further supporting renewable energy development.

- **Growth in the C&I Segment & GTAM:** The commercial and industrial (C&I) sector, driven by ESG goals and improved cost viability, is increasingly adopting solar energy through rooftop installations and open access, further boosting solar capacity. This segment, consuming over half of the country's power, is key to accelerating solar growth. Green-term Ahead Market (GTAM) was launched in September 2020, the GTAM platform allows bulk electricity buyers, such as DISCOMs and corporates, to procure renewable energy on a short-term basis from sellers like merchant RE producers. It encourages RE-rich states to exceed their RPO targets and boosts the development of merchant power capacities.

- **Low Cost, Construction, and Operational Risk:** Solar is the most cost-effective renewable energy technology per MW, with shorter construction timelines, thus reducing construction risk. However, operational risks related to solar radiation and technological challenges remain significant.

- **Advancement of Technology:** Solar power plant performance, measured by Capacity Utilization Factor (CUF), has improved through advanced module technologies. Innovations like wind-solar hybrids, floating PV, and agrivoltaics are driving improvements in CUF, though these technologies are still in early stages and come with higher installation costs, offering future growth opportunities.

Table 10: Cost Parameters for Thermal and Renewable Power

	Capex (Rs. Million MW)
Coal	83.4
Renewable	
Hydro	60-200
Solar*	41-45
Wind (Onshore)	60-80
Wind (Offshore)	137
Bioenergy	90

Source: National Electricity Plan Vol-1, CareEdge Research

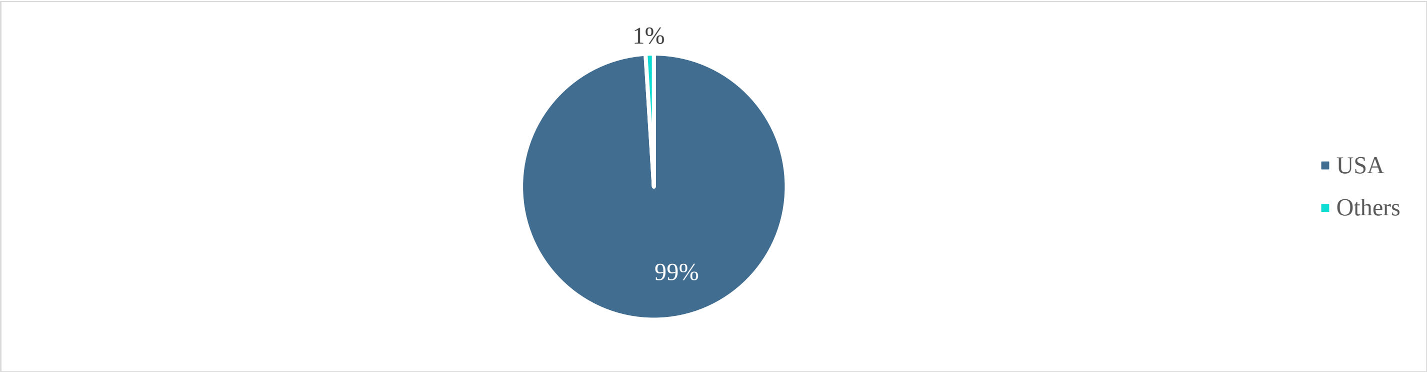
Capex figures are considered on actual basis at cost level of 2021-22

*Solar Cost is assumed to reduce from Rs 4.5 Cr/MW in 2021-22 to Rs 4.1 Cr/MW in 2029-30 beyond which its assumed to be the same for next two years.

5.3.4 Major Export Destination for Solar Modules from India

The United States is the largest destination for India's solar module exports, accounting for 99% of total exports. This dominance is driven by the U.S.'s shift away from Chinese imports due to trade restrictions and the growing demand fueled by initiatives like the Inflation Reduction Act (IRA). Indian manufacturers, known for cost-efficient, high-quality products, have capitalized on this demand. The U.S. industry's efforts to diversify its supply chain have further cemented India's role in supporting the U.S.'s clean energy transition and boosting India's renewable energy export market.

Chart 33: Export destinations for Solar Module from India (FY24)



Source: Ministry of Commerce, CareEdge Research; % share based on value terms, Others include Somalia (0.5%), UAE (0.1%), South Africa (0.2%), Tanzania (0.1%), Canada (0.1%)

5.4 Overview of Solar Power Conditioning products

Solar Panels: Solar panels, or photovoltaic (PV) modules, convert sunlight into direct current (DC) electricity through semiconductor materials like silicon. They come in three types: monocrystalline (high efficiency), polycrystalline (cost-effective), and thin-film (flexible, lightweight). Panels are scalable and used in residential, commercial, and utility projects.

Inverters: Inverters convert DC electricity from solar panels into alternating current (AC) for powering devices and grid integration. Types include string inverters (cost-effective, residential/commercial), microinverters (optimize energy at panel level), and hybrid inverters (support energy storage and independence with battery management).

Batteries: Solar batteries store excess energy for later use, supporting off-grid systems and improving grid reliability. Lithium-ion batteries dominate due to their high energy density, longevity, and fast charging. Emerging technologies like solid-state and flow batteries are enhancing storage capabilities.

Uninterruptible Power Supplies (UPS): UPS systems provide backup power during outages, ensuring continuity for critical equipment. Integrated with inverters and batteries, they are valuable in regions with unreliable grids.

Converters: Converters manage voltage compatibility in solar systems. DC-DC converters transfer energy from panels to batteries, while DC-AC converters integrate off-grid systems with the grid. High-quality converters enhance energy efficiency and system performance.

5.5 Overview of Solar Systems

1. Solar System Configurations by Inverter Type

String Inverter Systems: String inverters are connected to a string of solar panels, converting the combined DC power into AC. These systems are cost-effective, easy to install, and ideal for areas with consistent sunlight. However, a single underperforming panel can reduce overall system output. String inverters are common in large-scale and residential installations, particularly in cost-sensitive markets like India, due to their lower installation and maintenance costs.

Microinverter Systems: Microinverters are paired with each solar panel to convert DC to AC at the panel level. This maximizes energy output, especially in shaded or variable orientations. Though they have higher upfront costs, they are gaining popularity in residential and small commercial projects, particularly in markets like the U.S. and Europe, driven by demand for higher efficiency.

Hybrid Inverter Systems: Hybrid inverters combine traditional inverters with battery storage, enabling energy storage and grid independence. These systems are suitable for energy management and backup power, though they are more expensive. They are growing rapidly in areas with unreliable grids, such as Africa, Southeast Asia, and rural India, and are ideal for off-grid and hybrid solar-plus-storage applications.

Central Inverter Systems: Central inverters are used in large utility-scale solar farms, aggregating power from multiple panels. They are efficient and cost-effective for large projects but have limited flexibility for smaller installations, and a failure can disrupt the entire system. These systems are in high demand for large-scale utility projects in regions like China and the Middle East.

2. Solar System Configurations by Panel Type

Monocrystalline Solar Panels: Monocrystalline panels, made from a single crystal structure, are highly efficient (20%-22%) and durable but are more expensive due to complex manufacturing. They are preferred in developed markets like the U.S., Japan, and Europe, where efficiency and space are critical.

Polycrystalline Solar Panels: Polycrystalline panels are made from multiple silicon crystals, offering a cost-effective option with lower efficiency (15%-18%). They are widely used in emerging markets like India and Southeast Asia, where affordability is a key consideration.

Thin-Film Solar Panels: Thin-film panels, made by depositing thin layers of photovoltaic material, are lightweight, flexible, and better in low-light conditions. However, their efficiency (10%-12%) and lifespan are lower, limiting their use in large-scale projects. They are primarily used in niche applications like building-integrated photovoltaics (BIPV) and portable systems.

5.6 Assessment of key measures undertaken by Government of India to support the Solar Sector

The measures taken by Government of India are as follows:

Rooftop Solar (RTS) Programme: The RTS programme, launched in phases, aims to promote solar power generation on rooftops. Phase I started in December 2015, offering incentives for residential, institutional, and government sectors. Phase II began in February 2019, targeting 40,000 MW by 2022. So far, 10.4 GW of capacity has been installed, with Central Financial Assistance provided for systems up to 3 kW and additional capacity. The RTS capacity grew from 1.8 GW in FY19 to 11.9 GW in FY24, with a 46% CAGR. Phase II timelines have been extended to FY26.

Jawaharlal Nehru National Solar Mission (JNNSM): JNNSM is a key initiative under India's National Action Plan on Climate Change, focusing on sustainable growth and energy security. The government has implemented several policies, including the Solar Park Scheme, PM KUSUM, CPSU, grid-connected solar rooftop schemes, domestic module production, REC, RPO, and ISTS charge waivers to support solar power development.

International Solar Alliance (ISA): ISA is an inter-governmental organization aimed at creating a global market for solar power and clean energy applications. The alliance seeks to mobilize over USD 1000 billion by 2030, helping member countries meet their Nationally Determined Contributions (NDCs) through advancements in solar generation, storage, and technologies.

Pradhan Mantri Kisan Urja Suraksha Evam Utthan Mahabhiyan (PM KUSUM): The PM-KUSUM programme aims to provide renewable energy to over 3.5 million farmers by solarizing agricultural pumps. The scheme plans to install 10 GW of ground-mounted solar power plants, 2 million freestanding solar pumps, and 1.5 million grid-connected pumps, totaling 30.8 GW of additional capacity. By January 2024, 165.28 MW of solar power plants, 295,823 solar pumps, and 7,384 individual pump solarizations had been completed under the scheme.

PM-Surya Ghar: Muft Bijli Yojana: The Government launched the scheme PM-Surya Ghar: Muft Bijli Yojana in February 2024 with a total outlay of Rs. 750.21 Bn. This scheme aims to install rooftop solar and provide up to 300 units of free electricity every month for one crore households.

The scheme includes:

Central Financial Assistance (CFA) for Residential Rooftop Solar

- The scheme offers a CFA of 60% of the system cost for 2 kW systems and 40% of the additional system cost for systems between 2 to 3 kW capacity. The CFA is capped at 3 kW. At current benchmark prices, this translates to a Rs 30,000 subsidy for a 1 kW system, Rs 60,000 for 2 kW systems, and Rs 78,000 for 3 kW systems or higher.
- Households can apply for the subsidy through the National Portal and select a suitable vendor for installing rooftop solar. The National Portal will provide relevant information such as appropriate system sizes, a benefits calculator, vendor ratings, etc., to assist households in their decision-making process.
- Households can access collateral-free low-interest loan products at around 7% for installing residential RTS systems up to 3 kW by virtue of purchasing rooftop solar products from such vendors covered under this National portal e.g. UTL Solar.

- **Solar Parks:**

The Ministry of Power's Solar Parks programme, launched in December 2014, aims to develop 40 GW of solar capacity with a plug-and-play model for developers. By December 2023, 51 solar parks with a total capacity of 37,740 MW have been sanctioned across 12 states, and 10,504 MW of projects have been commissioned in 20 parks.

- **Solar Cities:**

The Solar City programme promotes renewable energy by developing at least one solar-powered city per state, utilizing rooftop solar plants, solar streetlights, and waste-to-energy solutions. It empowers urban local bodies to plan and address energy challenges, with funding drawn from existing schemes. So far, 27 States/UTs have identified solar cities.

- **Public Sector Undertaking (CPSU) Scheme:**

The Cabinet Committee on Economic Affairs (CCEA) has approved the MNRE's proposal for implementing the CPSU Scheme Phase-II, aiming to set up 12,000 MW of grid-connected solar PV power projects with VGF support of ₹858 million. These projects are for self-use or use by government entities, both central and state. The scheme mandates the use of domestically manufactured solar PV cells and modules. As of December 31, 2022, about 8.2 GW of projects have been awarded, with 1.5 GW commissioned and the rest under implementation.

5.7 Outlook on source-wise capacity additions in India and growth drivers

5.7.1 Rooftop Solar Capacity additions

India's rooftop solar PV capacity is set to grow, driven by increasing awareness in the residential and C&I segments. The MNRE’s Phase II Rooftop Solar Programme, launched in March 2019 with an outlay of ₹11,814 crores, provides financial assistance of up to 60% for residential grid-connected systems. The scheme also incentivizes DISCOMs for additional capacity. By FY24, cumulative capacity additions reached around 12 GW, with the segment expected to reach 90-100 GW by FY30, in line with India's goal of 500 GW of renewable energy by 2030.

Technical issues and factors that are likely to hinder growth in rooftop solar capacity additions

Progress under the Rooftop solar program has historically been slow due to lack of information at grassroot level, low awareness among masses and lack of initiatives by DISCOMs. While the government is taking initiatives to address the challenges certain issues continue including regulatory issues such as inconsistent net metering and other policies across states, delay in net metering approvals by DISCOMs etc. continue to persist. Further, financing also continues to be a challenge for rooftop solar as it is perceived to be risky compared to other types of installations.

5.7.2 Utility Access Systems

Utility-scale systems in India refer to large-scale solar power installations, typically exceeding 1 MW in capacity, designed to supply electricity directly to the grid. These systems are a key component of India’s renewable energy strategy, contributing significantly to its ambitious goal of achieving 500 GW of non-fossil fuel energy by 2030. With government support through initiatives like the Solar Park Scheme and favorable policies, utility-scale systems are driving India's transition toward sustainable energy.

Model of Solar Park Operations

Solar Parks are developed in collaboration with the state governments and their agencies, Central Public Sector Undertakings (CPSUs) and private entrepreneurs. The implementing agency is termed as Solar Power Park Developer (SPPD) and are selected in from any of the eight modes as per the scheme.

Approved and Established Solar Parks

59 solar parks of aggregating capacity of 40,000 MW in 13 states have been approved based on the proposals received from the states. These solar parks are at various stages of development.

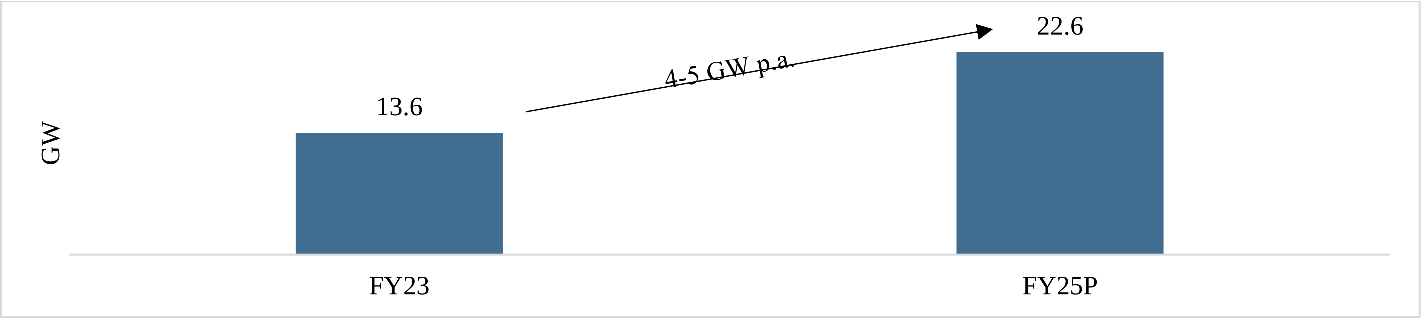
Outlook

The Development of Solar Parks and Ultra-Mega Solar Power Projects scheme provides a conducive environment for solar power developers by addressing issues such as land acquisition, clearances, permissions and other regulatory approvals, and availability of transmission and other essential infrastructure, the scheme has shown progress in the past few years with almost 25% of the targeted capacities being commissioned and another 10% under development. The scheme proposes to achieve installed capacity of 40,000 MW by FY26, for which the target capacity has been approved basis the proposals received by FY24.

5.7.3 Open Access additions

The open access market has grown over the last two years driven by supportive policies in some of the key states and improvement in the competitiveness of renewable tariffs against the grid tariffs. The annual open access installations in India have remained below 3.5 GW thus far, with cumulative installations at approximately 13.6 GW. The C&I market presents significant growth opportunities for the renewable sector and is expected to attract substantial private investments. The annual open-access installations are projected to remain within the range of 4 to 5 GW for the next two years i.e. till FY25.

Chart 34: Additions in OA installations in India



Source: Industry Sources, CareEdge Group; P: Projected

Key drivers for the growth in open access market include the following:

- **Commitment of Corporates to Decarbonizing Operations:** Corporate commitment to decarbonization is rising due to ESG considerations, with investors pushing for adherence to best practices. In line with India's net-zero target by 2070, many ministries have set their own net-zero goals, prompting companies to reduce carbon emissions by increasing renewable energy in their power mix, either through open access procurement or on-site solar projects.

- **Improvement in Economic Viability:** The economic viability of solar projects has improved due to a decline in installation costs, reducing funding requirements and electricity costs for corporates.

- **Compliance with RPO Norms:** Compliance with the Renewable Purchase Obligation (RPO) trajectory, which increases from 24.58% in FY23 to 43.33% by FY30, will drive greater renewable energy consumption in the C&I sector.

- **Diversification of RE Portfolio by Leading Utility-Scale RE Developers:** Utility-scale RE developers are diversifying their portfolios by entering corporate PPAs with C&I entities, reducing reliance on DISCOMs and mitigating risks like payment delays.

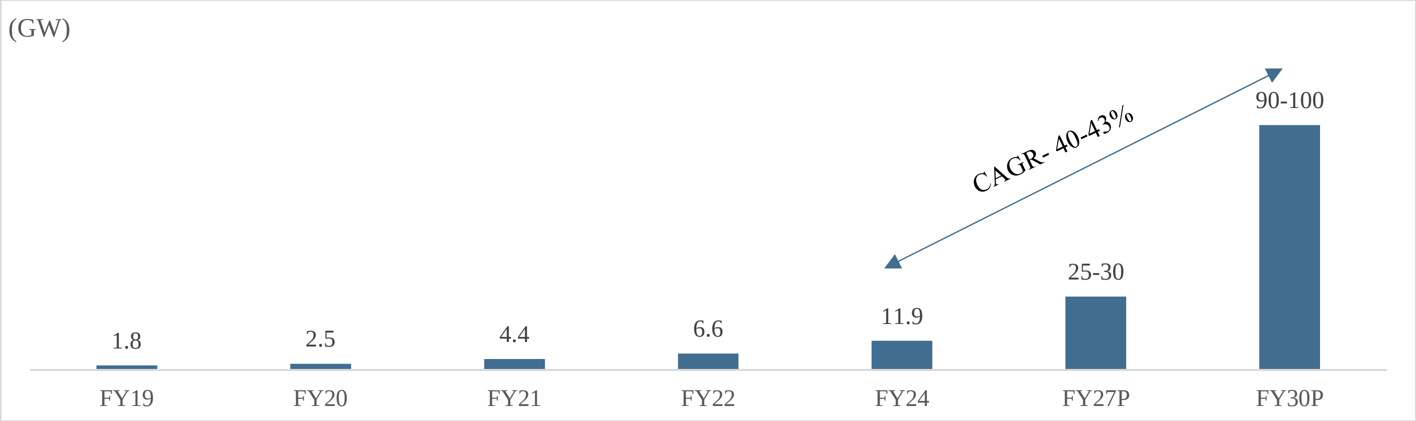
- **Availability of Adequate Financing Avenues:** Various financing avenues are available for C&I customers, including green financing from domestic institutions and climate-focused funds. The OPEX model, where the customer pays for energy generated while the developer owns the project, is also gaining traction, particularly in rooftop solar installations.

5.8 India Rooftop Solar Market

5.8.1 Market size

The rooftop solar market in India is projected to grow at a CAGR of 40-43% from FY24 to FY29, driven by favorable government policies, rising awareness, and a focus on energy independence. Initiatives like the National Solar Mission and incentives for various sectors are fueling adoption, while declining costs of solar panels and inverters, along with advancements in energy storage, support this growth. The sector is expected to expand from ~12 GW in FY24 to 100 GW by FY30, aligning with India's broader solar energy targets and carbon reduction commitments.

Chart 35: India Rooftop Solar Market Size

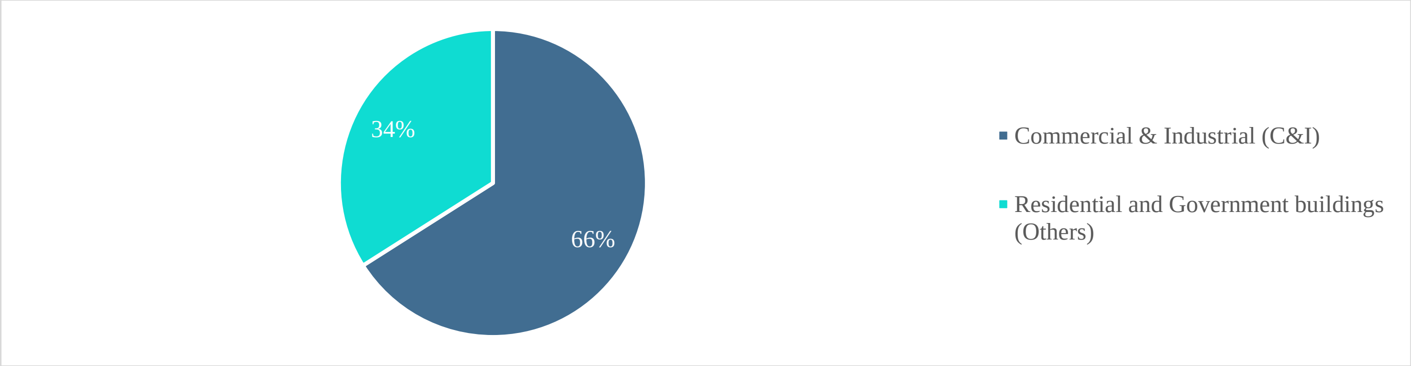


Source: MNRE, CareEdge Research; P: Projected; Data refers to Cumulative Capacity; FY23 data not available

5.8.2 Market split by commercial and residential applications

In India, rooftop solar capacity is largely dominated by the commercial and industrial sectors, driven by high energy consumption and cost-saving incentives. The residential sector, though growing, faces challenges such as limited awareness, financing constraints, and regulatory issues like net metering. However, with improved policy support and financial mechanisms, the residential sector is expected to grow steadily. While the commercial sector benefits from significant energy savings and favorable returns, the residential market requires more targeted incentives and awareness to accelerate adoption.

Chart 36: Average market split for Rooftop Solar Market



Source: IEEFA, CareEdge Research

5.8.3 Long term drivers for growth

The rooftop solar market in India is expected to experience substantial growth in the long term due to several key drivers:

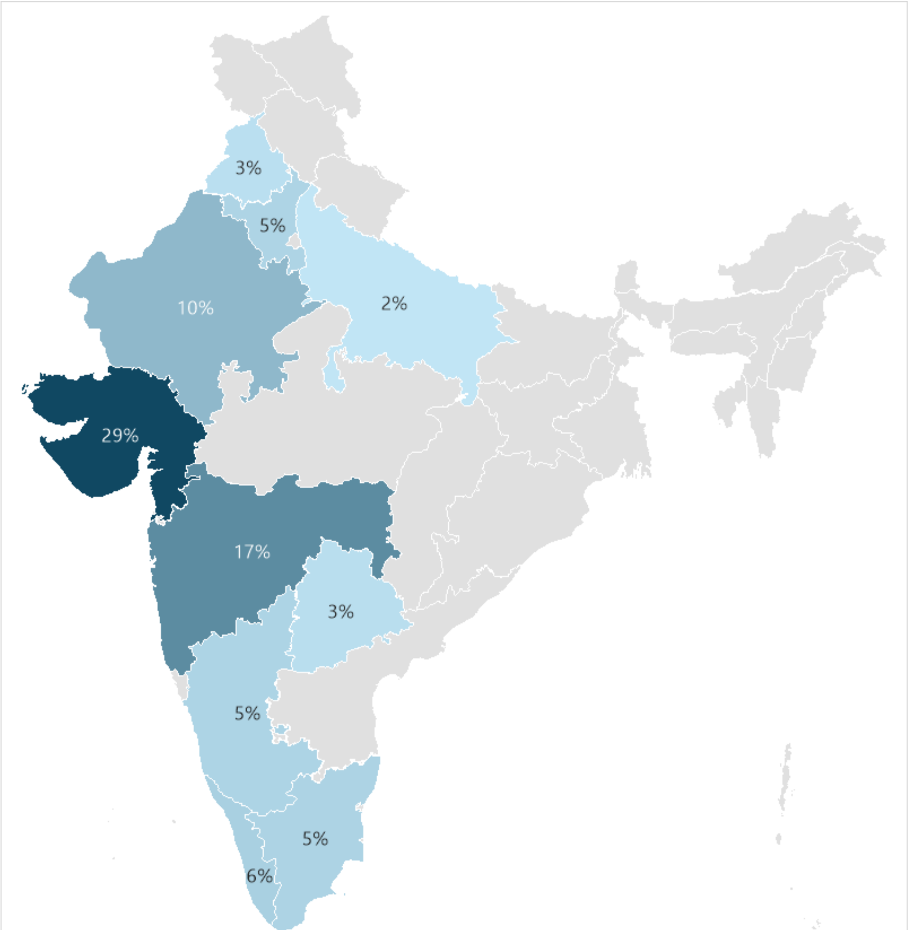
- **Government Policies and Incentives:** The Indian government has introduced various schemes like the National Solar Mission and Solar Rooftop Subsidy Scheme, which encourage both residential and commercial solar adoption by offering subsidies and incentives. The implementation of Net Metering policies also makes rooftop solar more attractive, especially for businesses and households looking to reduce energy bills.
- **Rising Electricity Costs:** As electricity prices continue to rise, both commercial and residential consumers are increasingly turning to rooftop solar as a means to cut energy costs. Rooftop solar systems offer significant savings, particularly for high-energy users like industries and businesses.
- **Technological Advancements:** With ongoing improvements in solar panel efficiency, energy storage solutions, and inverter technologies, the cost-effectiveness of rooftop solar systems is continually increasing. Innovations such as bifacial solar panels (which capture sunlight from both sides) and smart inverters that enable real-time monitoring and optimization are expected to further boost market growth.
- **Corporate Sustainability Goals:** An increasing number of businesses are adopting rooftop solar as part of their Corporate Social Responsibility (CSR) and sustainability strategies. Many companies are seeking to meet renewable energy targets, and rooftop solar provides a feasible and scalable solution to reduce their carbon footprint.
- **Improved Financing Models:** The availability of better financing options, including solar loans, power purchase agreements (PPAs), and lease-based financing, is making rooftop solar more accessible to a wider range of consumers. This is particularly crucial in the residential sector, where upfront costs can be a barrier.
- **Energy Security and Reliability:** India's frequent power shortages and grid reliability issues have pushed both businesses and residential users to invest in alternative energy sources like rooftop solar. As the country aims for energy independence, distributed energy generation systems such as rooftop solar will play an essential role in ensuring reliable and uninterrupted power supply.

These long-term drivers, coupled with continued support from both the government and private sector, are expected to make rooftop solar a central component of India's energy transition over the next decade.

5.8.4 Geographical Analysis of Rooftop Solar Market in India

In India, rooftop solar capacity is unevenly distributed across states, with Gujarat leading at 29% due to proactive policies, ample sunlight, and strong infrastructure. Maharashtra follows with 17%, driven by urban centers like Mumbai and Pune, and supported by government incentives. Rajasthan contributes 10%, benefiting from abundant sunlight and a focus on solar development, especially in rural areas. Kerala, with 6%, is growing despite space constraints, supported by the Kerala Solar Energy Policy. Other states, including Haryana, Karnataka, Tamil Nadu, Punjab, and Telangana, contribute 3-5%, with steady growth fueled by incentives and increasing awareness. While Gujarat and Maharashtra dominate, the recognition of solar energy's potential is expected to drive broader adoption across India.

Chart 37: State wise penetration of Rooftop Solar Market in India

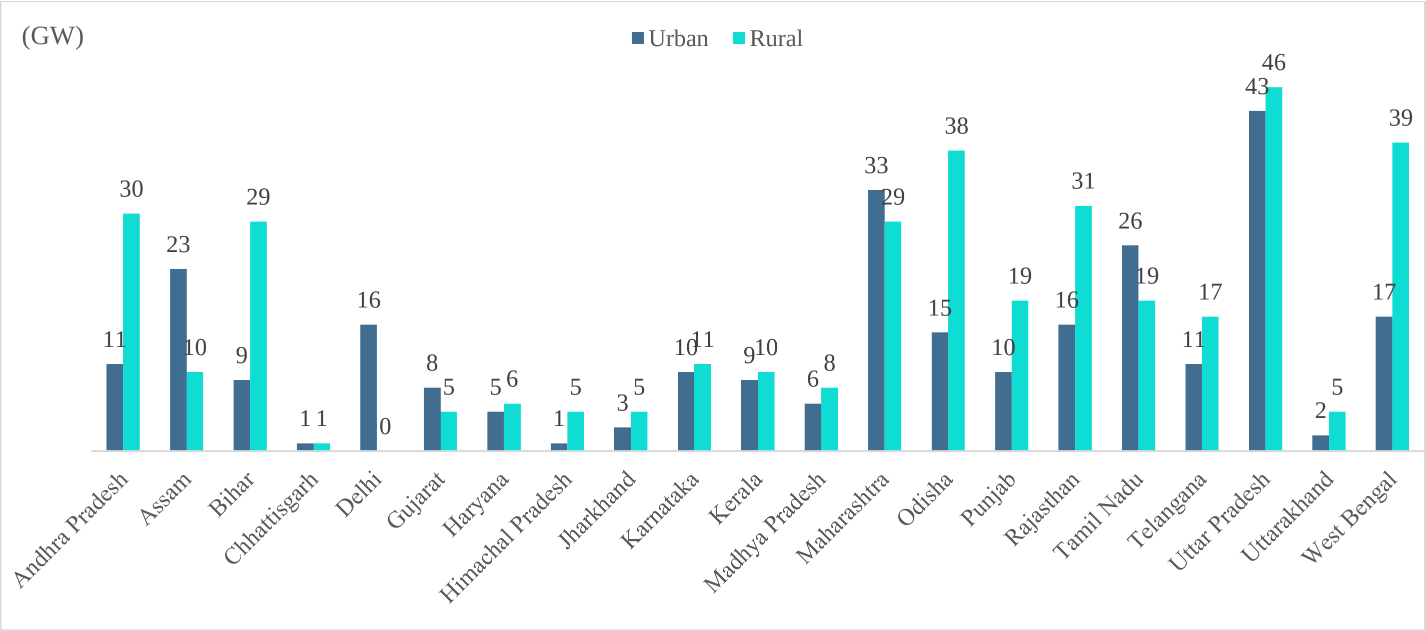


Source: MNRE, CareEdge Research

5.8.5 Upcoming potential for states of Rooftop Solar Market in India

India's rooftop solar potential shows a significant disparity between rural and urban areas, with rural regions offering greater deployment opportunities until 2030. Rural areas, such as Uttar Pradesh (46 GW), Odisha (38 GW), Rajasthan (31 GW), and West Bengal (39 GW), have vast spaces, untapped markets, and a growing demand for off-grid solar solutions. Government initiatives like PM-KUSUM, which focuses on solarizing irrigation pumps, further support rural solar adoption. In contrast, urban areas like Maharashtra (33 GW) and Tamil Nadu (26 GW) have substantial potential due to industrialization, though they face challenges like limited rooftop space and higher installation costs. The rural advantage offers a unique opportunity for India's energy transition, supporting renewable energy targets and driving socio-economic development. Tailored policies are needed to fully capitalize on rooftop solar potential across both rural and urban areas.

Chart 38: State wise potential of Rooftop Solar Market in India until 2030



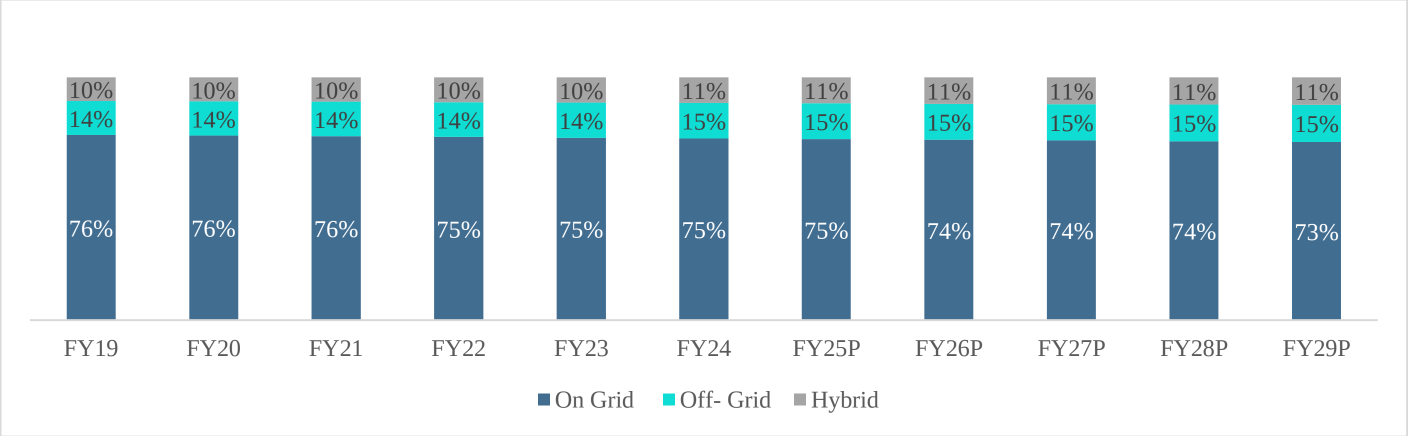
Source: CEEW, CareEdge Research

5.9 Assessment of 'on-grid, off-grid, hybrid' systems in India for Rooftop Solar Market

5.9.1 Market size and Outlook

India's rooftop solar market features a mix of on-grid, off-grid, hybrid systems, each addressing specific energy needs. On-grid systems dominate, holding nearly 75% of the market due to their integration with the power grid, which allows energy drawing during low solar output and surplus feeding into the grid. By FY29, their share is expected to slightly dip to 73%. Hybrid systems, combining solar power with battery storage, are growing, with their market share projected to increase from 10% in FY23 to 11% by FY29. This diverse mix reflects India's tailored approach to rooftop solar adoption, catering to regional and sectoral needs while supporting sustainable energy goals.

Chart 39: Rooftop Solar Market by Type in India



Source: TechSci Market Research, CareEdge Research; P: Projected

5.9.2 Key growth drivers

- **On-Grid Rooftop Solar Systems:** On-grid systems are popular due to net metering policies and MNRE subsidies, making them financially attractive. They are in high demand in urban and commercial areas, where users seek to reduce electricity costs by integrating solar energy. The declining costs of solar panels and inverters further increase their affordability for both residential and commercial consumers.

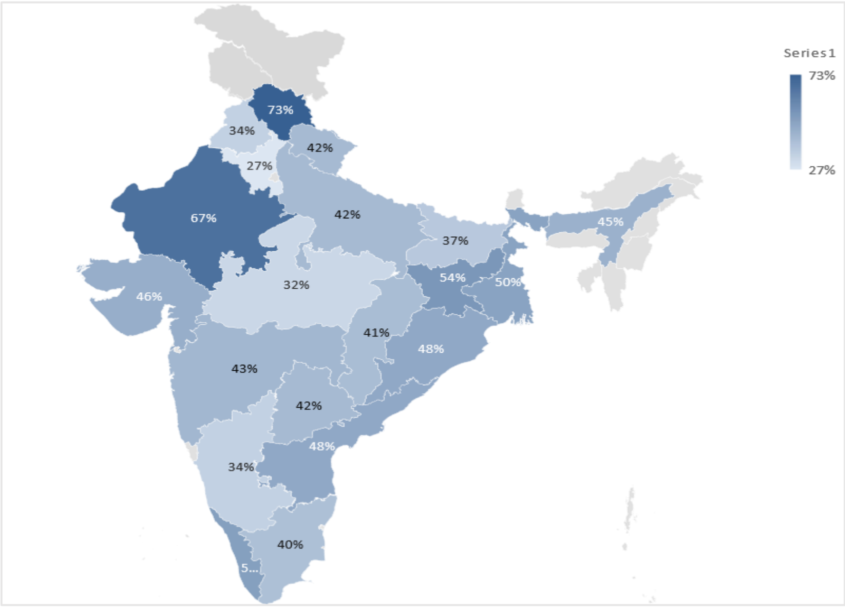
- **Off-Grid Rooftop Solar Systems:** Off-grid systems are crucial for rural electrification, providing energy independence for agricultural and household use. Programs like PM-KUSUM support solar pumps and off-grid installations. Additionally, the rise of micro-grids to tackle last-mile connectivity is driving the off-grid market.

- **Hybrid Rooftop Solar Systems:** Hybrid systems, combining solar, battery storage, and grid connectivity, are gaining popularity due to demand for uninterrupted power. Falling battery costs and government incentives for energy storage integration make these systems more viable, with hybrid products now included in expanded rooftop solar schemes.

5.9.3 Consumer adoption trends and barriers including regional penetration levels

Consumer awareness about solar energy adoption in India varies by state, influenced by socio-economic factors, government initiatives, and geographic suitability. Himachal Pradesh leads with 73% awareness, followed by Rajasthan (67%), Jharkhand (54%), Kerala (51%), and West Bengal (50%). Himachal's strong state support for renewable energy contributes to its leadership, while Rajasthan's status as a solar hub drives high awareness. Jharkhand's awareness growth is fueled by grassroots education and rural electrification, and Kerala and West Bengal benefit from urban engagement, subsidy schemes, and net metering policies. These states reflect growing confidence in solar energy across India.

Chart 40: State wise consumer awareness for Rooftop Solar Market in India



Source: CEWW, CareEdge Research

5.9.4 Government initiatives for the distributed solar segment

The Indian government has been promoting distributed solar generation through initiatives like the National Solar Mission (NSM), which aims for 40 GW of rooftop solar by 2022 as part of a broader 175 GW renewable energy target. The Ministry of New and Renewable Energy (MNRE) offers subsidies of up to 60% for residential rooftop systems up to 3 kW. Programs such as Solar Power for All (SPFA) target affordable energy for rural areas, while net metering and feed-in tariffs incentivize adoption by allowing consumers to sell excess power. Additional state incentives and programs for MSMEs further support growth, making India's rooftop solar market poised for rapid expansion.

5.9.5 Key players in the Rooftop Solar segment

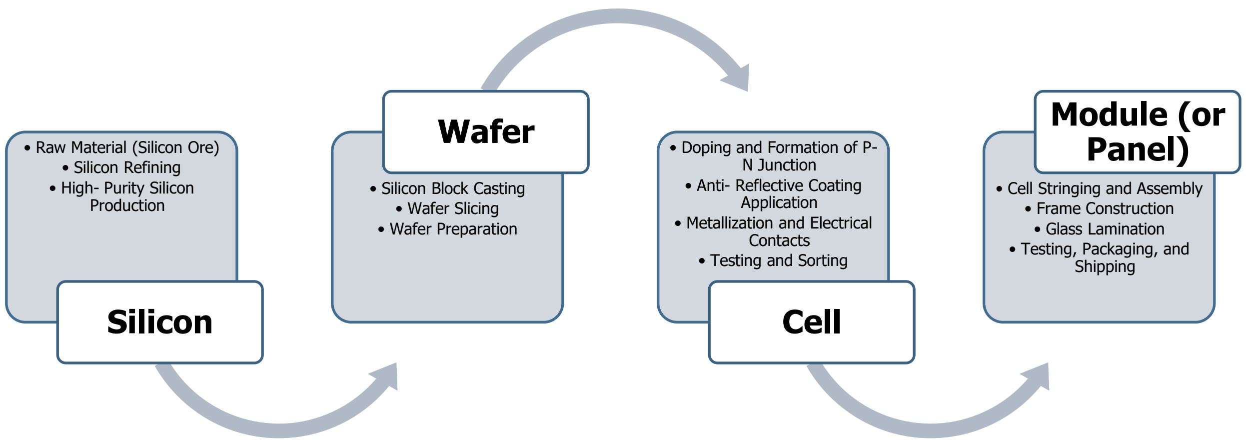
- **UTL Solar**: UTL Solar is an Indian company involved in manufacturing and supplying solar energy solutions. It provides a range of products, including solar panels, inverters, and power systems for residential, commercial, and industrial use. Over the last five years, the company has delivered a cumulative capacity of 0.5 GW of solar panels, 1.4 GW of solar inverters, and 2.1 GW of solar batteries for rooftop solar operations across India.
- **Tata Power**: Tata Power Solar Systems manages the deployment of rooftop solar solutions for residential, commercial, and industrial users. The company focuses on installing and maintaining solar systems that help users generate electricity and reduce grid dependency.
- **Amplus Solar Power**: Amplus Solar provides rooftop solar installations for businesses and industrial facilities, delivering customized systems tailored to specific energy needs. It specializes in offering on-site solar solutions to help reduce operational energy costs.
- **Clean Max Enviro Energy**: Clean Max focuses on installing rooftop solar systems for commercial and industrial buildings. It handles the design, installation, and operation of these systems, catering to energy efficiency requirements of large-scale enterprises.
- **Orb Energy Private Limited**: Orb Energy focuses on delivering rooftop solar installations primarily for small businesses. The company undertakes system design and installation, ensuring that users can access reliable solar power for their facilities.

6 Solar energy sector in India – Product market analysis

India's solar energy industry has grown significantly over the past decade, driven by government goals, technological advancements, and the need for sustainability. This growth has positioned India as one of the largest solar markets globally, with abundant sunlight and supportive policies. Key factors include investments in solar PV systems, inverters, and energy storage, along with rising demand for clean energy and improved financing options. The sector is crucial for enhancing energy security, meeting Paris Agreement commitments, and achieving sustainable development, highlighting India's commitment to a greener future.

6.1 Overview of solar manufacturing value chain

The solar module manufacturing value chain involves a series of steps to convert raw materials into finished solar modules (also known as solar panels), which can generate electricity from sunlight.



6.2 Overview of the distributed solar products market

Distributed solar products refer to solar energy systems that are installed at the point of consumption, typically on rooftops or other structures. These systems generate electricity for residential, commercial, and industrial consumers, reducing reliance on traditional grid power. The distributed solar power market in India has experienced remarkable growth, driven by supportive government policies, declining prices of solar modules, and heightened awareness regarding clean energy solutions.

Key types of distributed solar products include:

1. **Residential Solar Systems**: Designed for homeowners to generate electricity for personal use, these systems consist of solar panels, inverters, energy storage (like lithium-ion batteries), and smart meters for monitoring energy use.
2. **Commercial and Industrial Solar Systems**: Larger-scale solar installations for businesses, offering cost savings, energy independence, and environmental benefits. C&I consumers can buy power via third-party plants (without capital investment) or through captive/group captive plants, which offer exemptions from certain open access charges.
3. **Community Solar Systems**: These allow individuals to purchase or lease a share of an off-site solar array, making solar energy accessible to renters or those unable to install systems on their own properties.

Geographic distribution

The distributed solar market in India is rapidly growing, with regional variations based on solar resources, urbanization, government support, and energy needs:

- **Northern India**:
  - **Rajasthan** leads in rural solar adoption, with solar water pumps and home systems.
  - **Punjab** promotes rooftop solar through the Solar Power Policy.
  - **Uttar Pradesh** focuses on urban solar rooftops and rural irrigation.
  - **Haryana** and **Delhi** have strong adoption, with incentives for residential and commercial sectors.
- **Western India**:
  - **Gujarat** is a pioneer, with strong growth in rooftop solar, led by policies like Net Metering.
  - **Maharashtra** promotes solar in urban areas, especially Pune and Mumbai.
  - **Goa** focuses on residential solar with government incentives.
- **Southern India**:
  - **Tamil Nadu** is a leader in rooftop solar, driven by the Tamil Nadu Solar Energy Policy.
  - **Karnataka** has a thriving market, particularly in Bengaluru.
  - **Andhra Pradesh** and **Telangana** emphasize decentralized solutions in rural areas.
  - **Kerala** promotes solar home systems, especially in off-grid regions.
- **Eastern India**:
  - **West Bengal** has growing urban and rural markets but slower adoption due to inconsistent policies.
  - **Odisha** focuses on rural electrification with decentralized solar solutions.
  - **Bihar** and **Jharkhand** are investing heavily in off-grid solar.
- **Central India**:
  - **Madhya Pradesh** promotes both residential and industrial rooftop solar.
  - **Chhattisgarh** focuses on rural solar electrification, especially for agriculture.

Market by project size

Small-scale (Up to 10 kW):
This category mainly serves residential customers and small businesses with rooftop or ground-mounted systems. Benefits include lower initial costs due to government subsidies, ease of installation and maintenance, and the ability for users to generate their own electricity, reducing reliance on the grid.

Medium-scale (10 kW to 1 MW):
Medium-scale projects cater to larger homes, small businesses, and public buildings. These installations require more space but offer quicker payback periods due to higher energy consumption. Many medium-scale systems are part of community solar programs, allowing multiple users to share the generated power.

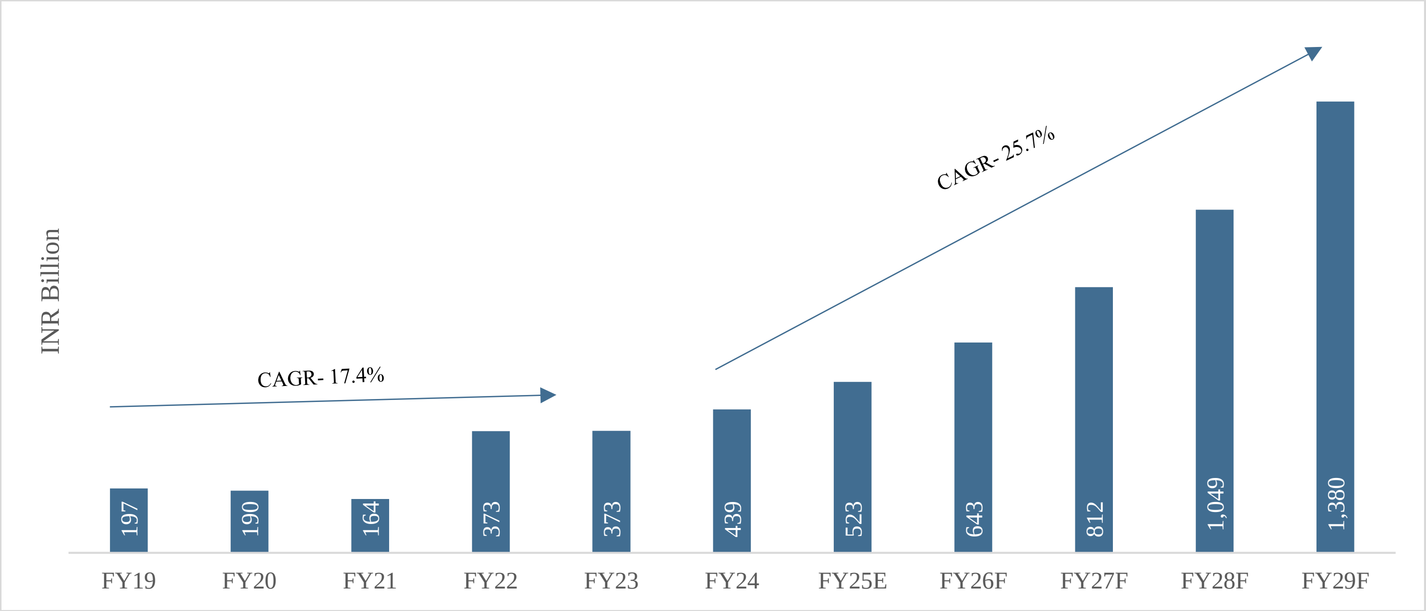
Large-scale (1 MW and above):
Large-scale systems, typically ground-mounted, serve utility and large commercial/industrial needs. These projects generate significant electricity, contributing to local grids and helping meet state energy targets. They often support community solar initiatives and are growing in popularity as businesses pursue sustainable energy solutions aligned with corporate social responsibility and regulatory goals.

6.3 Overview of Solar Panel Market

6.3.1 Market Size

Global climate initiatives like the Paris Agreement and COP28 are driving nations to increase renewable energy generation to reduce carbon emissions. Solar energy, once niche, is now a mainstream source, with India's renewable energy capacity surpassing 200 GW by October 2024. The solar panel market in India has grown rapidly, with a CAGR of 17.4% from FY19 to FY24 and is expected to accelerate to 25.7% CAGR from FY24 to FY29. India's government has introduced various initiatives to boost renewable energy, targeting 500 GW of non-fossil fuel capacity by 2030.

Chart 41: Solar Panel Market in India



Source: TechSci Research, CareEdge Research

Long-term growth drivers

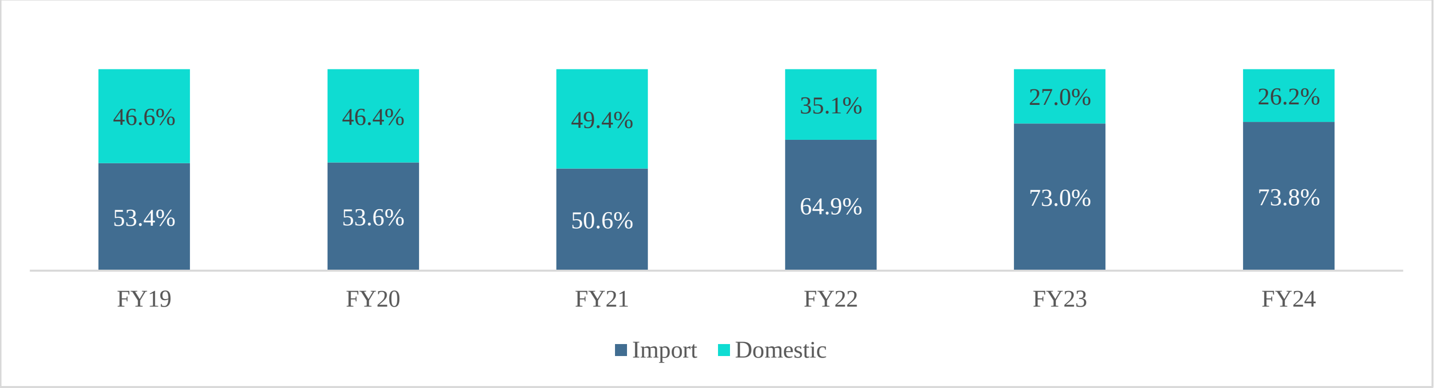
The solar panel market has experienced significant growth over the past decade, as mentioned earlier. Below are outlined the key drivers contributing to the long-term expansion of the solar panel market:

1. **National Solar Mission and Policy Support:** India's National Solar Mission is a key driver for solar market growth, aiming for 500 GW of non-fossil fuel capacity by 2030, with solar energy at the core.
2. **Declining Costs of Solar Technology:** Advances in manufacturing and efficiency, along with reduced material costs, have made solar panels more affordable, driving widespread adoption in residential, commercial, and rural markets.
3. **Energy Security and Rural Electrification:** Solar solutions like home systems, microgrids, and irrigation pumps address energy access challenges in rural India, reducing reliance on the grid and fossil fuels, while boosting agricultural productivity.
4. **Government Incentives and Regulatory Support:** Government incentives, net metering, and financing options lower adoption costs, while programs like Saubhagya and rooftop schemes promote solar adoption in rural and urban areas.
5. **Sustainability and Climate Change Commitments:** India's commitment to sustainability and the Paris Agreement drives solar adoption as a key solution for reducing carbon emissions and achieving clean energy targets.
6. **Urbanization and Industrialization:** Rising energy demand due to urbanization and industrialization makes solar panels an attractive solution for reducing energy costs and improving energy security in cities and commercial sectors.

India solar module demand: Domestic vs Import

India's solar module demand is rapidly growing due to ambitious renewable energy goals and sustainability efforts. While domestic manufacturing is expanding, the country still heavily relies on imports, particularly from China, due to lower production costs and advanced technology. Challenges like high production costs and limited economies of scale hinder domestic competitiveness. The government's Production-Linked Incentive (PLI) scheme aims to boost local production and reduce import dependency. However, the import market remains significant, and balancing domestic production with imports will be key to India's solar energy future.

Chart 42: Solar Panel Consumption Market Share (%)



Source: TechSci, CareEdge Research

India's solar manufacturing industry remains heavily dependent on imports, primarily focusing on the final stages of production. Approximately 85-90% of solar manufacturing involves assembling modules from imported cells, with local value addition limited to just 10-15%. Most solar projects in the country rely on imported, ready-to-use modules. Only a few companies produce solar cells at a commercial scale, using imported polysilicon or wafers, achieving 35-40% local value addition. However, there are no facilities manufacturing solar cells entirely from scratch, starting with silica sands.

Reducing this reliance on imports would require India to develop a complete value chain, starting from silica refining and polysilicon production—a process that demands advanced technology and significant energy investment. While initiatives like the production-linked incentive (PLI) scheme aim to strengthen local manufacturing, their impact is constrained by continued dependence on imported inputs. Given these challenges, solar equipment imports are projected to increase, highlighting the urgent need for technological and infrastructure advancements to build a self-reliant solar ecosystem.

6.3.2 Overview of technologies existing and upcoming technologies

Solar energy, a clean and renewable energy source, is harnessed through photovoltaic (PV) technology and concentrated solar power (CSP) technology. Technology has evolved significantly over the years, leading to increased efficiency and reduced costs.

1. Existing solar module technologies

- **Monocrystalline panels:** Monocrystalline panels are renowned for their superior efficiency and space-saving design. These are manufactured from a single silicon crystal structure and feature silicon wafers cut from cylindrical ingots. Their uniform structure allows electrons to move more freely, resulting in higher electricity output compared to other panel types. These panels typically achieve efficiency ratings of 15% to over 22%, making them highly efficient.
- **Polycrystalline silicon panels**: Polycrystalline panels, the second most prevalent technology in the market, are composed of multiple crystals melted together. This manufacturing process leads to slightly lower efficiency, typically ranging between 13% and 16%. While they may underperform in low-light or high-temperature conditions compared to monocrystalline panels, their cost-effectiveness makes them an appealing option for budget-conscious users.
- **Thin-Film solar modules:** Thin-film modules are made by depositing layers of photovoltaic material on a substrate such as glass, plastic, or metal. Common materials include cadmium telluride (CdTe) and amorphous silicon (a-Si). Thin-film modules are

lightweight and flexible, making them suitable for unconventional installations like building-integrated photovoltaics (BIPV) and portable solar chargers.

- **Passivated emitter rear cell (PERC):** PERC technology improves the efficiency of traditional monocrystalline modules by adding an additional passivation layer on the rear side of the cell. This design reduces electron recombination and enhances light absorption. With efficiency levels exceeding 22%, PERC modules are gaining popularity in both rooftop and utility-scale projects.

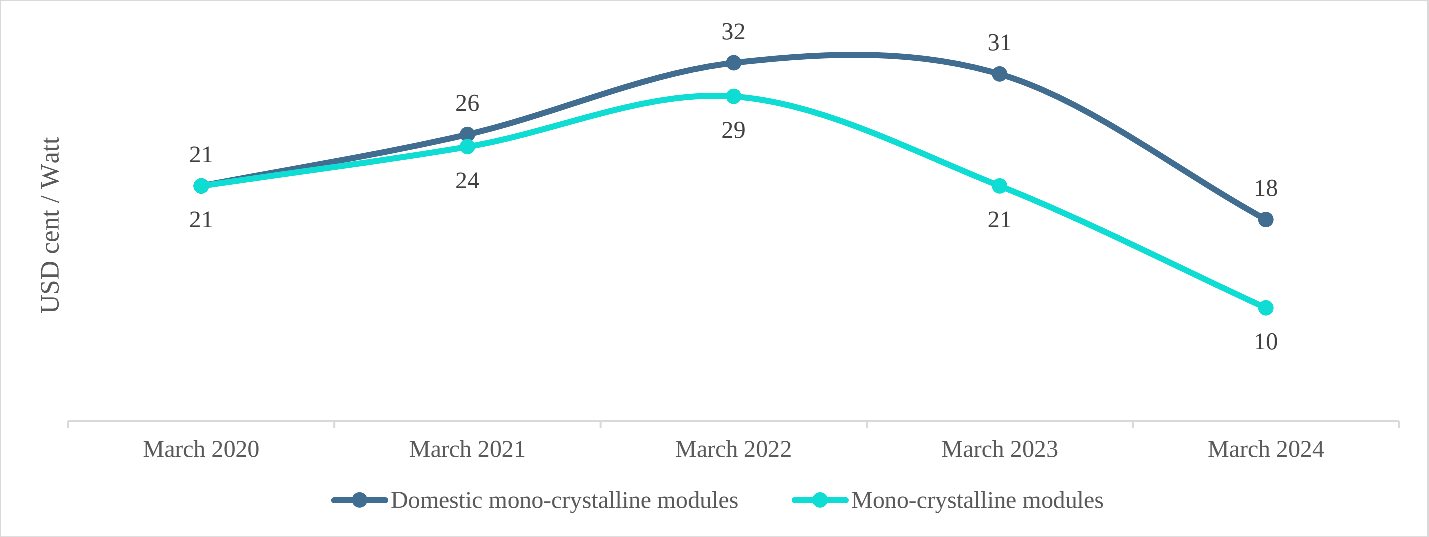
2. Emerging solar module technologies:

- **Perovskite solar cells:** Perovskite solar cells represent a breakthrough in solar technology due to their high efficiency potential, lightweight nature, and flexibility. These cells can achieve efficiencies exceeding 25% in laboratory settings. Perovskite cells are being explored for tandem applications, where they are combined with silicon cells to further boost performance.
- **Bifacial solar modules:** These modules generate power from both sides of the panel, capturing reflected and scattered light from the ground. This technology can increase energy output by 10-20% compared to traditional modules. Bifacial modules are especially effective in regions with high albedo surfaces, such as snowy or desert environments.
- **Organic Photovoltaics (OPV):** OPVs utilize organic compounds to convert sunlight into electricity. They are lightweight, flexible, and can be printed onto various surfaces, making them suitable for wearable electronics and integrated applications.
- **Heterojunction Technology (HJT):** HJT combines crystalline silicon with thin layers of amorphous silicon to create highly efficient cells with low degradation rates. Efficiencies for HJT modules are typically above 23%. Their enhanced performance in low-light conditions makes them ideal for regions with variable sunlight.

6.3.3 Trend in Solar Panel Price trends

Solar panel prices have dropped over 80%, though prices stabilized or slightly increased between 2021-2023 due to supply chain disruptions, rising polysilicon costs, and energy shortages in China. As supply chains recovered in late 2023, prices began to stabilize and are expected to decline further with new manufacturing capacities and technological innovations. For instance, in FY24, solar panel prices underwent a significant decline reaching 18 USD cent/watt, down by almost 95% in more than a decade. The sharp decline in global prices was attributable to the supply glut in China. Domestic solar panel prices declined in line with global prices reaching 18 USD cent/watt, down by 42% in FY24 from the previous year. IRENA projects a 59% cost reduction in electricity generated by solar PV by 2025.

Chart 43: Price Trend of Mono-crystalline Panels



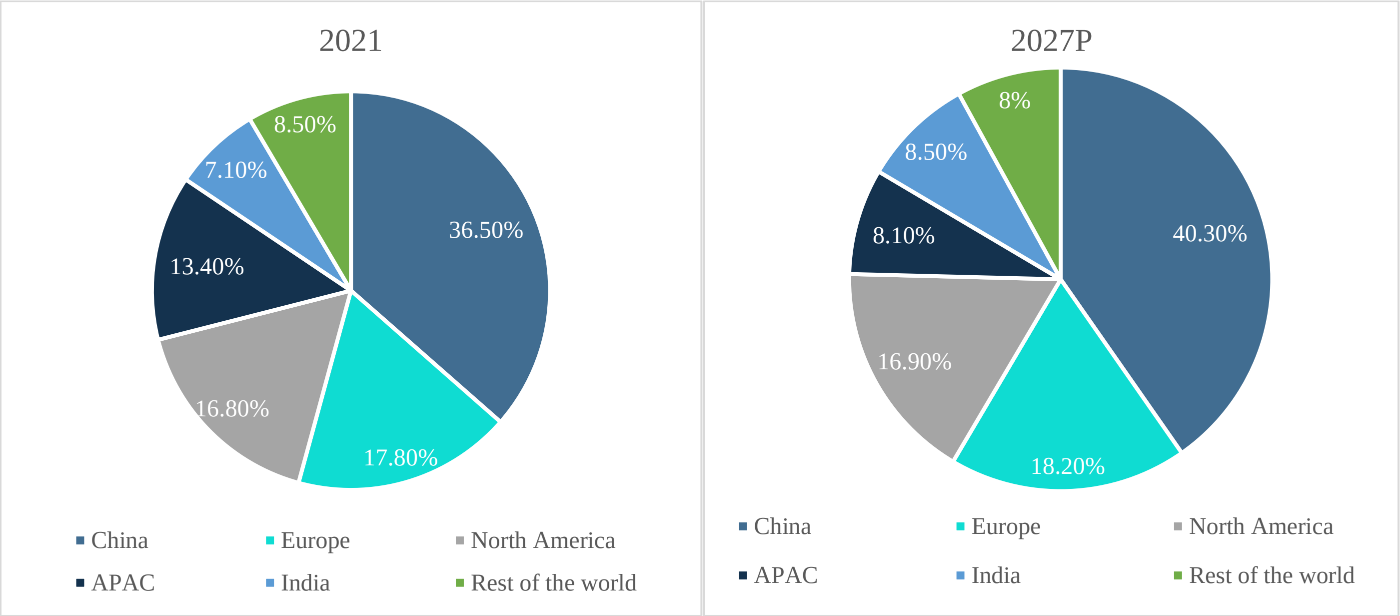
Source: CareEdge Research

Moving forward, the decline in costs is expected to resume as technological advancements such as high-efficiency modules (PERC, HJT, and tandem cells) and automation in production processes reduce manufacturing costs. Additionally, increased adoption of bifacial and large-format modules will drive down the levelized cost of energy (LCOE), further enhancing Solar's affordability.

6.3.4 Solar panel export trends

India has emerged as a significant player in the global solar manufacturing ecosystem, leveraging its growing manufacturing capabilities and policy support. The export of solar panels from India is experiencing a steady rise, driven by increasing global demand, a focus on diversifying supply chains, and competitive pricing. Currently, China dominates global solar module manufacturing, controlling a large portion of the supply chain. In CY23, China maintained a dominant position in the PV landscape, accounting for more than 75% of the manufacturing capacity.

Chart 44: Regional demand assessment



Source: IEA; Note: The demand in the chart shows the percentage demand for Solar products in the respective regions

The United States is the second-largest solar consumer globally, following China, and is leading the adoption of advanced solar technologies. As on FY24, Indian solar manufacturers supply the US with high-quality, efficient PV modules, primarily consisting of monocrystalline passivated emitter and rear cell (Mono PERC) bi-facial modules.

In addition to the US, Indian PV products are in demand across African countries like South Africa, Somalia, and Kenya, as well as Asian nations such as the UAE, Afghanistan, Nepal, and Bangladesh. Due to lower transportation costs and strong trade ties, neighboring countries like Bangladesh, Nepal, and Afghanistan are expected to continue importing significant quantities of Indian-made PV modules.

In the coming years, demand in these markets is expected to grow, but supply growth will be uneven, creating export opportunities for countries like India to meet this demand. India aims to reduce reliance on Chinese imports by building a strong domestic solar manufacturing base, with a long-term vision to become self-sufficient and a potential exporter of solar technology. By developing local expertise, India plans to offer competitive, high-efficiency modules globally. In FY24, India's PV exports surged to approximately USD 2 billion, a 23-fold increase from FY22, according to Institute for Energy Economics and Financial Analysis (IEEFA).

Key drivers of this growth include:

- **Delay in Approved List of Models and Manufacturers (ALMM) implementation**: The ALMM list is approved by MNRE and allows only listed models and manufacturers to be used in government projects. The postponement of the ALMM until April 2024 reduced domestic demand, prompting manufacturers to seek international markets.

- **"China Plus One" Strategy**: However, nations, concerned with supply chain risks, have been aiming to reduce dependence on Chinese imports and this has turned out well for India as a viable alternative, including solar panel exports.

- **Better margins**: Indian PV manufacturers enjoy higher profit margins on sales in developed markets like the U.S., Europe, despite higher logistics costs.

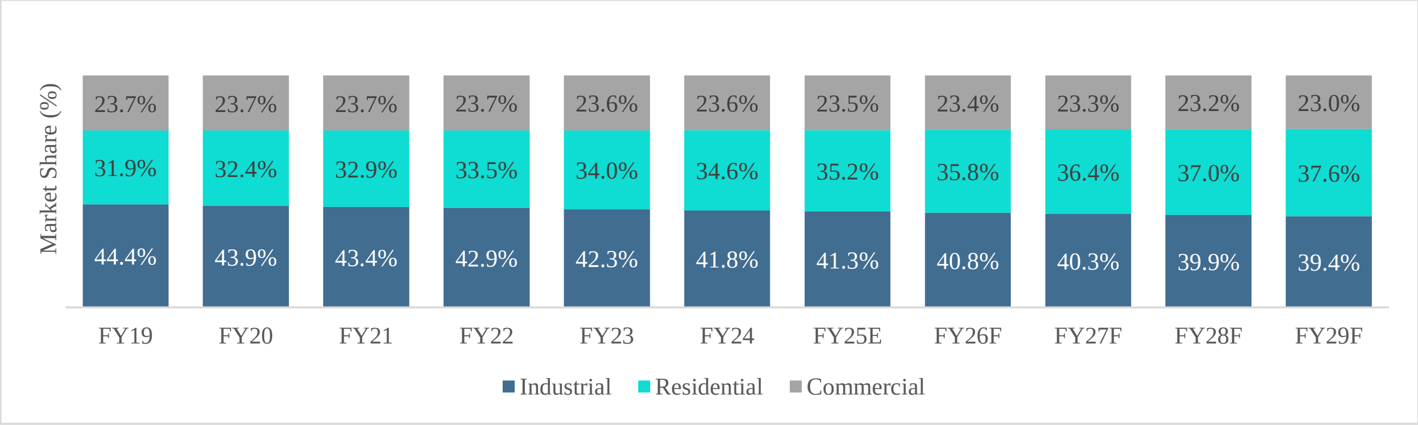
India has become a key player in the global solar PV market, exporting nearly 99% of its output to the United States, driven by competitive pricing and a reliable supply chain. Supportive government policies have boosted domestic manufacturing and export growth. In FY23, exports surged, especially to Southeast Asia, the US, and Europe. In FY24, exports are expected to continue growing despite challenges like the Uyghur Forced Labor Prevention Act, safeguard duties, and the expiration of FTA exemptions.

6.3.5 Market Segmentation

End – Users

The solar panel market is witnessing a steady shift in end-user demand. While the industrial sector has been the dominant user, its market share has gradually declined from 44.4% in FY19 to 41.8% in FY24. The residential sector has seen a consistent rise, increasing from 31.9% to 34.6% over the same period, driven by government incentives for rooftop solar installations, and falling solar panel prices. The commercial sector has maintained a relatively stable market share between 23%-24%.

Chart 45: Solar panel end user market share (%)



Source: TechSci Research, CareEdge Research

The end users of solar panels in India span various sectors, ranging from residential to commercial and industrial applications. Here are the primary categories:

- **Residential Consumers**: With increasing electricity costs and a growing awareness of environmental issues, many households in India are adopting solar panels for domestic use. Solar systems are used to power homes, including for lighting, water heating, and air conditioning. This sector is particularly attractive in off-grid areas where access to reliable electricity is limited.
- **Commercial Establishments:** Businesses, including offices, retail stores, and shopping malls, are increasingly adopting solar power to reduce energy costs and enhance sustainability. Solar panels are often installed on rooftops or open land to power operations, lighting, and HVAC systems, offering long-term savings and improving corporate social responsibility profiles.
- **Industrial Users:** Large industries, especially those with high energy consumption like manufacturing, textiles, cement, and chemical plants, are investing in solar panels to reduce dependency on conventional electricity sources and lower their operational costs. Industrial users often install large-scale solar power systems to meet a significant portion of their energy needs.

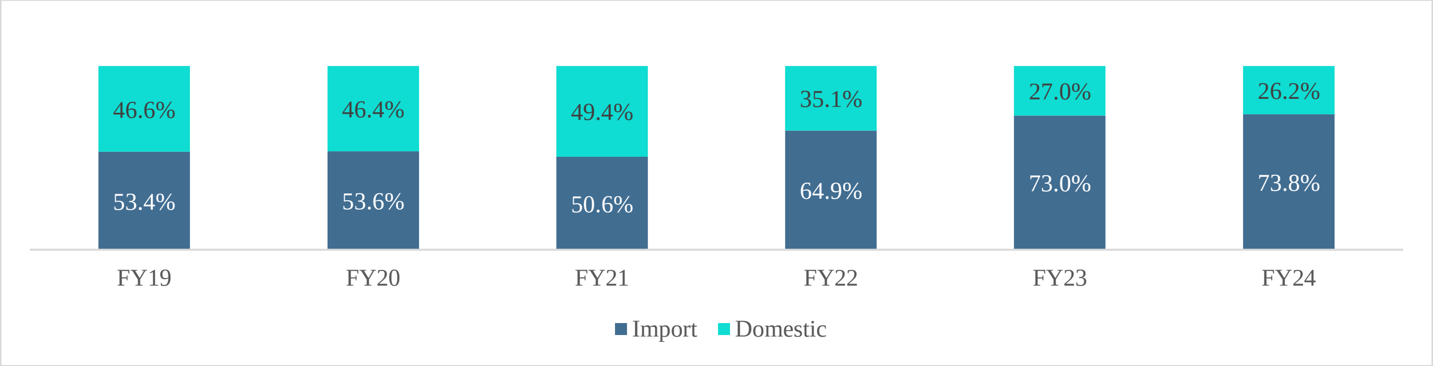
- **Key Players**

- **UTL Solar**: UTL Solar is an Indian company that specializes in providing solar energy solutions. The company manufactures and supplies various solar products, including solar panels based on advanced technologies such as TOPCon bifacial and glass-to-glass panels with a capacity of 590 Wp, as well as MonoPerc bifacial modules with capacities up to 670 Wp. In addition to solar panels, the company also provides solar inverters and solar power systems for residential, commercial, and industrial use.The company is committed to promoting renewable energy and sustainability by offering high-quality, efficient, and cost-effective solar solutions.
- **Waaree Energies**: Headquartered in Mumbai, is one of India's solar module manufacturers. The product range includes monocrystalline PERC, bifacial, and high-efficiency half-cut modules. It operates manufacturing facilities in Gujarat with a combined production capacity exceeding 12 GW. The company exports extensively, with the U.S. being a primary market, accounting for over half of its production.
- **Vikram Solar**: Based in Kolkata, Vikram Solar produces monocrystalline PERC, bifacial, and smart modules equipped with artificial intelligence-based optimization. Vikram Solar exports more than half its production, with a significant share directed to the U.S. and emerging markets in Europe and Africa. It is also planning to set up manufacturing capacities in the U.S. to capitalize on export opportunities.
- **Adani Solar:** Adani Solar, a part of the Adani Group, is a player in the Indian solar market, offering a wide range of solar products, including high-efficiency monocrystalline and polycrystalline modules. It has a manufacturing capacity of 3 GW for solar modules and is based in Mundra, Gujarat. It is a supplier to both domestic and international markets, with exports to regions such as the U.S., the Middle East, Southeast Asia, and Africa.
- **Havells India Ltd.:** Havells is a player in the solar sector, offering residential and small business segments. The company Offers polycrystalline and monocrystalline solar panels, solar inverters, and solar batteries primarily in rooftop applications.
- **Grew Energy:** Grew is a player in the Indian solar PV market, providing a variety of solar products including monocrystalline and polycrystalline modules. The company has a manufacturing capacity of 500 MW annually and is headquartered in Maharashtra. Grew Energy is increasingly focusing on export markets, targeting regions such as Southeast Asia, the Middle East, and Africa. It aims to establish itself as a key supplier in emerging markets by offering cost-effective and reliable solar solutions.
- **Navitas Solar:** Navitas Solar is an Indian solar PV manufacturer, offering a range of solar products, including monocrystalline and bifacial modules. The company operates with an annual manufacturing capacity of 1 GW. Navitas Solar has a presence in export markets, with products being shipped to countries in the Middle East, Africa, and Southeast Asia.

- **Domestic vs Import Mix**

India's domestic solar panel manufacturing faces challenges, including high production costs, limited technology, and reliance on imported raw materials. In FY24, about 73.8% of solar panels are imported, primarily from China, due to lower production costs and advanced manufacturing. This reliance raises concerns about energy security and supply chain sustainability. To address this, the Indian government has implemented policies like the Production-Linked Incentive (PLI) scheme, tariffs, and duties to boost domestic manufacturing and reduce import dependence. The increase in imports is driven by limited domestic capacity for solar PV cell production and the cost-effectiveness of imported modules.

Chart 46: Domestic vs Import Mix for Solar Panels



Source: TechSci, CareEdge Research

6.4 Solar Battery Market in India

6.4.1 Overview of market

The Indian solar battery market is experiencing a rapid transformation fueled by increasing demand for renewable energy and a national push toward sustainable, decentralized energy solutions. Solar batteries, which allow for energy storage from solar PV systems, are becoming essential components in India's broader renewable energy infrastructure.

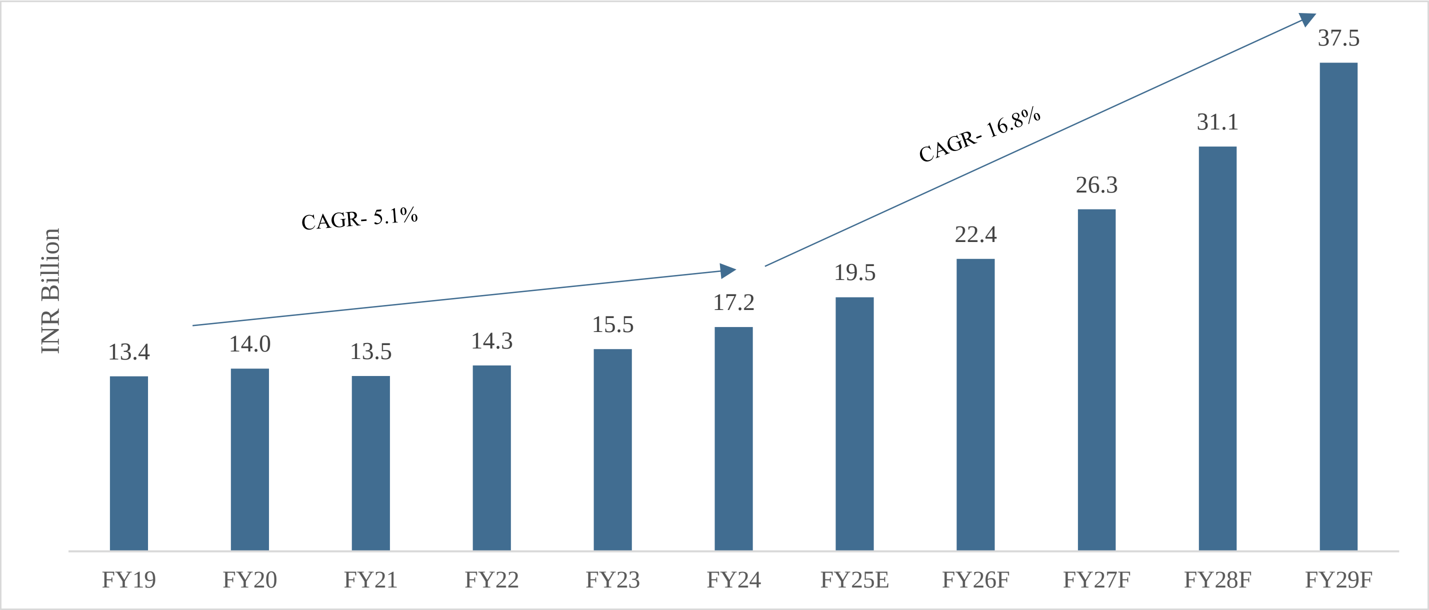
Key Stakeholders

- **Solar Battery Manufacturers**: Companies that produce solar batteries to store excess energy from solar panels. Key players include Exide Industries, Luminous Power Technologies, Amara Raja Batteries, Tesla, BYD, and LG Chem.
- **Solar Panel Manufacturers**: Companies that focus on solar panels, often partnering with battery manufacturers for integrated solutions. Notable names include UTL Solar, Waaree Energies, Tata Power Solar, and Vikram Solar.
- **Renewable Energy Developers and Installers**: These companies design, install, and integrate solar systems, including batteries, and provide after-sales support. Key players include Fourth Partner Energy, CleanMax, and ReNew Power.
- **Government and Regulatory Bodies**: The government shapes the solar battery market through policies, incentives, and regulations. Important bodies include MNRE, BIS, and state electricity boards.
- **Consumers (End Users)**: Residential, business, industrial, and agricultural customers purchase solar batteries to lower energy costs, gain independence, and reduce carbon footprints.
- **Electricity Utilities and Grid Operators**: They integrate solar energy and battery storage into the grid, ensuring efficient use of stored energy.

6.4.2 Market Size

Solar battery systems are valuable across various applications from large scale commercial and utility installations to residential setups, underscoring the critical role of energy storage in enhancing renewable energy reliability. The Indian solar battery market has grown at a CAGR of 5.1% during FY19-24. This growth is largely due to government support through favourable policies, incentives for solar adoption and increasing affordability of solar technology and battery storage solutions. The CAGR is expected to grow at 16.8% from FY24 to FY29.

Chart 47: Solar Battery Market in India



Source: TechSci Research, CareEdge Research

With the country receiving abundant solar irradiation, the potential for solar energy is enormous, making solar battery storage an attractive solution to counter the intermittent nature of solar power. Solar batteries provide a backup during low sunlight hours and enable users to store excess energy generated during peak sunlight.

6.4.3 Key long-term drivers

The solar battery market in India is poised for significant growth driven by various factors, including technological advancements, government policies, and increasing demand for renewable energy solutions. Here are the key drivers that will shape the market's future:

1. **Growing Adoption of Solar Energy**: The expansion of solar energy in India, with a target of 500 GW by 2030, is driving demand for solar batteries to manage intermittency. As of September 2024, India's solar capacity reached 90.76 GW, fueling the need for energy storage.
2. **Technological Advancements**: Innovations in battery technology, such as lithium-ion, solid-state, and sodium-ion batteries, are improving the efficiency and affordability of solar storage solutions.
3. **Government Policies and Incentives**: Policies like the National Solar Mission, PLI Scheme, and Solar Rooftop Phase II are encouraging investments in solar power and battery systems.
4. **Increasing Energy Independence and Security**: Growing demand for energy independence is driving solar battery adoption, especially in residential markets, as consumers seek to reduce reliance on utility grids and mitigate rising electricity costs.
5. **Rising Demand from Industrial Sectors**: Industries are adopting solar batteries to improve energy efficiency, support sustainability, and reduce energy procurement costs.
6. **Environmental Concerns and Sustainability Goals**: Awareness of climate change is pushing both consumers and businesses toward renewable energy solutions, increasing demand for solar batteries as part of broader sustainability efforts.

6.4.4 Overview of existing and upcoming technologies in solar batteries

Solar batteries are essential components of solar energy systems, enabling the storage of excess energy generated during peak sunlight hours for later use. The solar battery market is evolving rapidly, with existing technologies dominating the landscape while new innovations are on the horizon. Different battery technologies offer varying performance, cost, and lifespan characteristics.

Existing technologies

1. **Lithium-Ion Batteries:** Known for high energy density and efficiency, these batteries offer long cycle life (4,000 to 10,000 cycles). However, they are more expensive than alternatives and pose safety risks, particularly with thermal runaway in NMC variants.

2. **Lead-Acid Batteries (LAB):** With a lower initial cost and reliability for short-term storage, LABs are commonly used but have a shorter lifespan (1,000 to 3,000 cycles) and lower efficiency, leading to a shift toward more advanced technologies.

3. **Sodium-Ion Batteries:** An emerging, cost-effective alternative to lithium-ion, these batteries benefit from abundant sodium resources and reduced fire risk. However, they have lower energy density compared to lithium-ion batteries.

Upcoming technologies

1. **Lithium Iron Phosphate (LFP) Batteries**: Known for safety and longevity, LFP batteries offer a lifespan over 10 years and more than 2,000 cycles. As production scales, they are becoming more affordable, making them ideal for residential solar installations with lower ownership costs.
2. **Silicon Anode Technology**: By using silicon, these batteries offer higher energy densities, lasting longer and improving performance. However, challenges remain, such as silicon's expansion during charging, which can cause degradation.
3. **Iron Flow Batteries**: These offer long lifecycles, low cost, and scalability, making them ideal for utility-scale storage. Their non-toxic materials, like iron and saltwater, contribute to sustainability and make them suitable for large-scale renewable energy storage.
4. **Saltwater Batteries**: Utilizing saltwater as an electrolyte, these batteries are less toxic but bulky and expensive for residential use. They show potential for commercial or utility-scale applications as technology advances.

6.4.5 Trend in solar battery prices

The solar battery prices have been on a downward slope since 2016. The price of lithium-ion batteries dipped to their lowest in 2023 to around USD 139/kWh, mainly due to decrease in material and component prices as can be seen in the graph representing the price index.

Battery pack prices dropped by almost 14% between 2023 and 2022, despite lithium carbonate prices being about 50% higher at the end of 2023 compared to their 2015-2020 average.

Factors impacting price trends

1. **Technological Advancements**: Innovations in solar panels and battery storage are improving efficiency and lowering costs. As production scales up and competition grows, prices are expected to continue decreasing. The semiconductor policy also aims to reduce costs by promoting local manufacturing of solar cells.
2. **Market Demand**: Rising electricity prices and increased environmental awareness are driving demand for solar installations, leading to cost-optimizing production and more investments in solar batteries due to long-term savings.
3. **Global Supply Chain**: Fluctuations in raw material prices, particularly lithium, impact costs. Emerging technologies like sodium-ion batteries may alleviate some cost pressures.
4. **Government Policies**: Indian government subsidies, covering up to 60% of installation costs, along with programs like PM KUSUM and PM Surya Ghar Muft Bijli Yojana, support solar adoption. Policies such as the National Solar Mission and the Electricity Act of 2003 create a favorable investment environment.

6.4.6 Market Segmentation

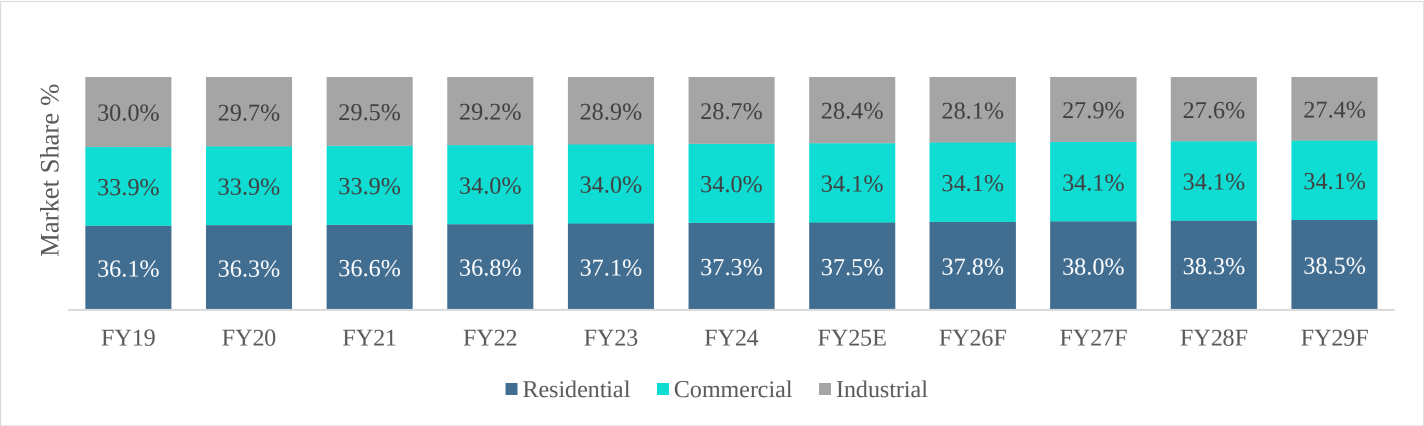
Key players in the Indian solar battery market

- **UTL Solar:** UTL Solar is a prominent Indian company that specializes in providing solar energy solutions. Known for its innovative approach, UTL Solar manufactures and supplies a wide range of solar products, including solar panels, solar inverters, and solar power systems for residential, commercial, and industrial applications. The company is committed to promoting renewable energy and sustainability by offering high-quality, efficient, and cost-effective solar solutions. As of FY24, the company has approximately 13% market share in the total Indian Solar Battery.
- **Amara Raja Batteries Ltd (**now rebranded as Amara Raja Energy & Mobility Limited) is involved in the energy storage sector, specializing in the manufacture of lead-acid and lithium-ion solar batteries. The company serves across various segments, catering to both automotive and industrial applications. Its primary manufacturing facility is located in Tirupati, Andhra Pradesh.
- **Exide Industries Ltd.** is a player in the solar battery market, offering a diverse range of products, including tubular flooded and tubular gel batteries specifically designed for solar applications.] Exide operates widespread manufacturing facilities across India, with major plants located in Kolkata and Haryana.
- **Luminous Power Technologies** is involved in providing solar energy solutions, focusing on solar batteries (lithium-ion and lead-acid), inverters, and solar power systems. It has a production manufacturing facilities are located in Himachal Pradesh and Uttarakhand.
- **Waaree Energies Ltd**. is a player in India's solar energy sector and produces lithium-ion solar batteries. The company's manufacturing facilities are strategically located in Surat, Gujarat.
- **Okaya Power Pvt. Ltd**: manufactures a diverse range of solar batteries, including both tubular and lithium-ion and has production capacity of over 1 million batteries annually at facilities in Haridwar, Uttarakhand.

End- Users

Within the solar battery, the residential segment has consistently maintained the largest market share, ranging between 36.1% to 37.3% during FY19-24. The share is expected to grow to 38.5% till FY2029 driven by factors such as increasing electricity costs, concerns about grid reliability, and a desire for energy independence. The commercial segment has also shown a stable market share, fluctuating close to 34% during FY19-24. This suggests a consistent demand for solar battery solutions in commercial establishments, such as offices, retail outlets, and industrial facilities. The industrial segment, having the availability of alternative energy sources, has witnessed a declining trend in market share, from 30.0% in FY19 to 28.7% in FY24.

Chart 48: Solar Battery end user market share (%)



Source: TechSci Research, CareEdge Research

Residential Solar Energy Systems: In residential setups, solar batteries are used to store energy generated by solar panels during the day. This stored energy can be used during the night or during power outages, providing homeowners with a reliable and uninterrupted power supply. Solar batteries also help reduce electricity bills by allowing families to use their own solar energy rather than relying on grid power.

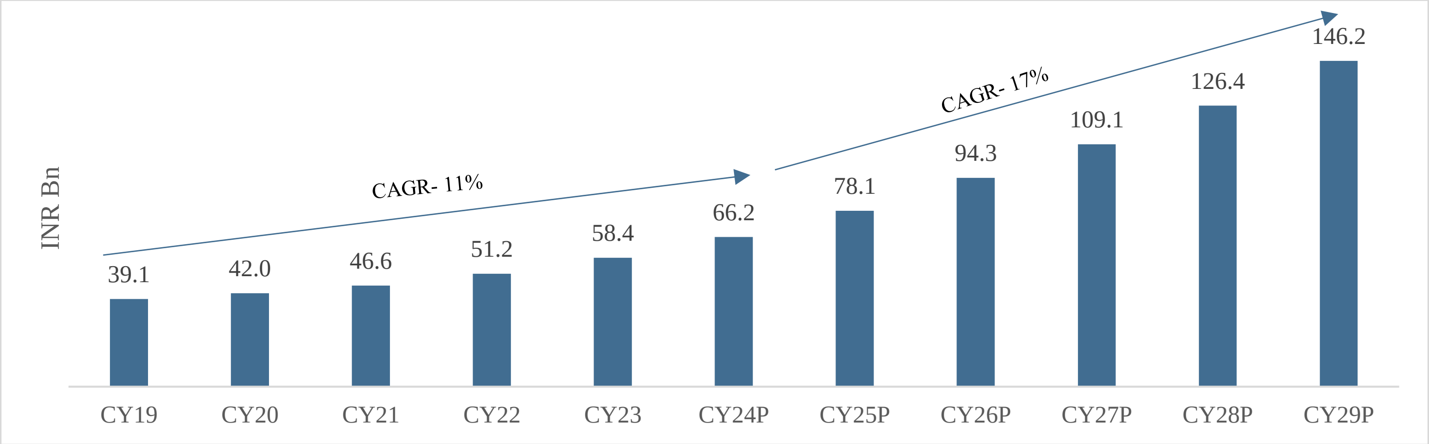
Commercial and Industrial Applications: Commercial establishments and industries are increasingly adopting solar battery systems to reduce their reliance on grid electricity, cut energy costs, and improve sustainability. By combining solar panels with energy storage, businesses can optimize energy consumption during peak and off-peak hours, avoiding high electricity tariffs and ensuring that critical operations continue even during grid failures.

6.5 Overview of Solar UPS, Solar Inverter & Converter Market

6.5.1 Solar Inverter market

The solar inverter market in India has grown steadily, from ₹39.25 billion in 2019 to ₹57.65 billion in 2023, driven by the country's shift to renewable energy and government support. Projections show the market will reach ₹66.99 billion in 2024 and ₹145.97 billion by 2029, with a CAGR of about 17% from 2024 to 2029. The growth is fueled by the rapid adoption of solar energy, technological advancements in inverters, and favorable policies like subsidies and incentives, positioning the market as crucial for India's renewable energy goals.

Chart 49: Solar Inverter market in India

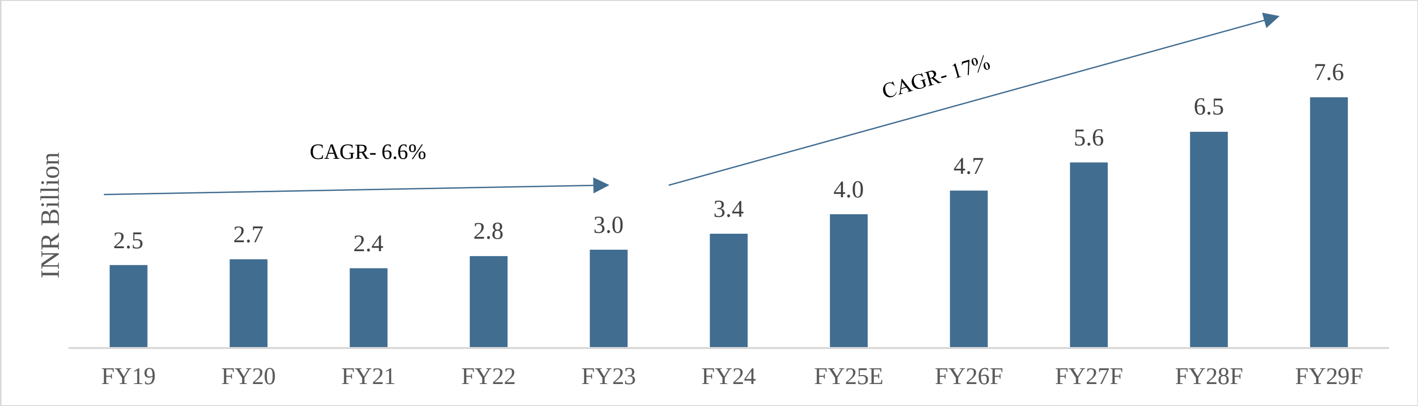


Source: TechSci Research, CareEdge Research

6.5.2 Solar UPS market

Solar UPS systems offer a reliable and cost-effective solution, especially in areas with frequent power cuts. The market in India is currently in a growth phase, evidenced by a modest CAGR of 6.6% from FY19 to FY24 and is expected to grow at a CAGR of 17% from FY24 to FY29. While the growth reflects the increasing adoption of solar energy solutions, driven by rising electricity costs, government incentives, and a growing emphasis on renewable energy sources, the market faces challenges of higher initial costs.

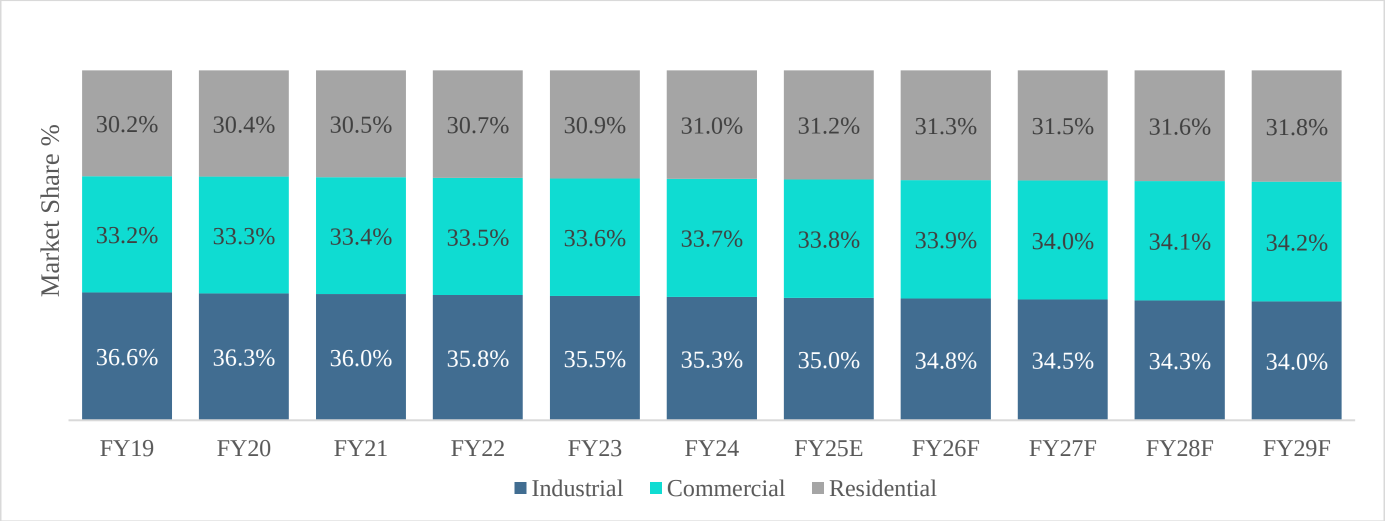
Chart 50: Solar UPS Market in India



Source: TechSci Research, CareEdge Research

Despite the challenges, the solar UPS market is expected to grow to Rs 7.6 billion by FY29 growing at a of CAGR of 17.0% from FY24, driven by declining cost of solar products, rising thermal electricity prices and growing awareness.

Chart 51: Solar UPS end user market share (%)



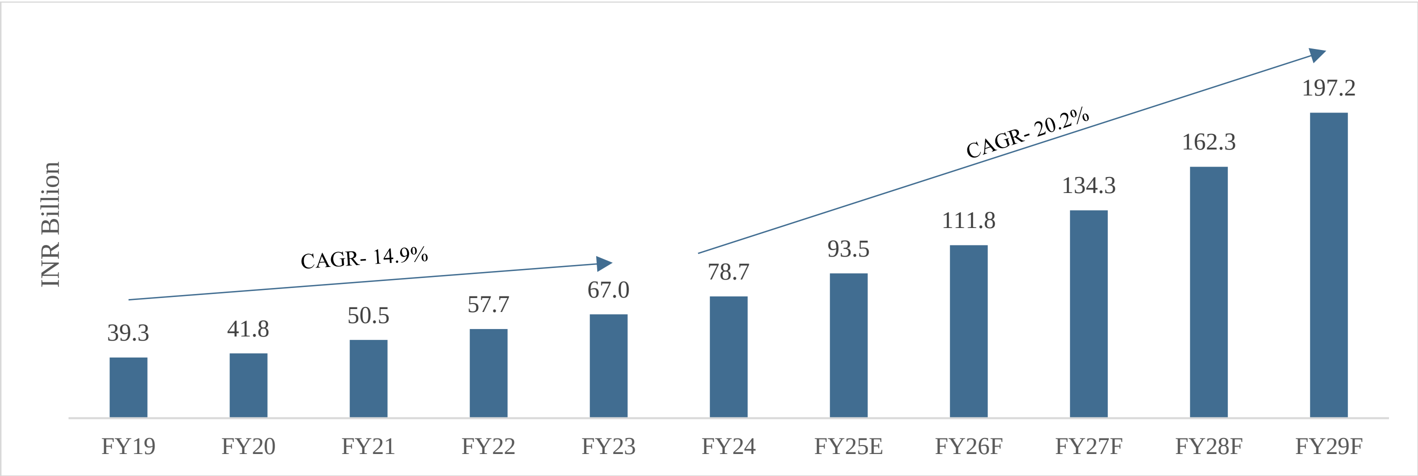
Source: TechSci Research, CareEdge Research

The industrial segment has consistently held the largest market share in Solar UPS, ranging from 35%-37% between FY19-24, driven by the need for reliable power in manufacturing and government energy efficiency initiatives. The residential segment saw modest growth, increasing from 30.2% in FY19 to 31.0% in FY24, supported by rising electricity costs, power outages, and government subsidies. The commercial segment grew slightly from 33.2% in FY19 to 33.7% in FY24, driven by the adoption of solar power in businesses like offices, malls, and hotels.

6.5.3 Solar Converter market

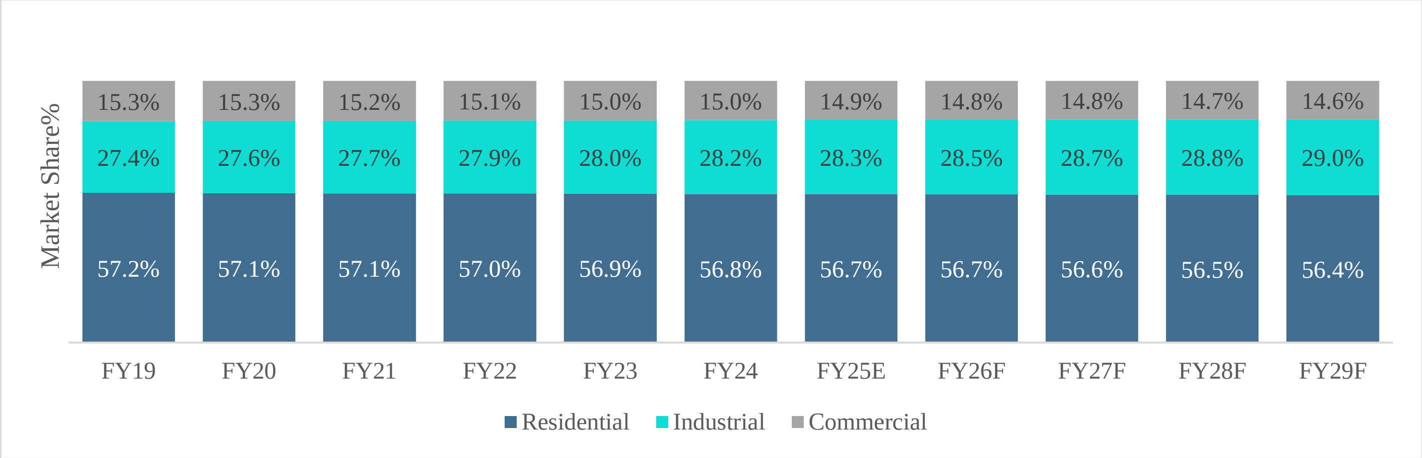
Solar converters are essential components in solar power systems, converting DC power generated by solar panels into AC power that can be used to power homes, businesses, and industries. The Indian solar converter market is experiencing significant growth, driven by various factors such as increasing electricity costs, government incentives, and rising environmental concerns. The market is witnessed strong growth from FY19 to FY24 at a CAGR of 14.9%.

Chart 52: Solar Converter market in India



Source: TechSci Research, CareEdge Research

Chart 53: Solar Converter end user market share (%)



Source: TechSci Research, CareEdge Research

Within the solar converter market, the residential segment has consistently maintained the largest market share, ranged between 56%-57% during FY19-24, driven by factors such as increasing awareness about solar energy benefits, government incentives, and declining solar panel prices. The share is expected to remain in the range till FY29. The commercial segment has also shown a stable market share, fluctuating close to 27-28% during FY19-24. This suggests consistent demand for solar power solutions in commercial establishments, such as offices, retail outlets, and industrial facilities. Despite having the availability of alternative energy sources, the industrial segment has witnessed a stagnant market share of close to 15% during FY19 to FY24.

6.5.4 Long term growth drivers

The solar UPS, inverter, and converter market is poised for significant long-term growth, driven by several key factors:

1. **Growing demand for renewable energy**: India's renewable energy push, supported by subsidies and the PLI scheme, has increased demand for solar products, benefiting inverter manufacturers. Awareness of climate change also drives demand for solar solutions.
2. **Reliability and electricity costs**: Power outages and rising electricity prices make solar inverters a reliable and cost-effective alternative, particularly in rural areas where inconsistent electricity is a concern.

3. **Technological advancements**: Innovations in hybrid and micro-inverters, along with advanced energy storage systems, have improved efficiency and affordability, driving demand for integrated solar solutions.
4. **Grid integration and energy storage**: Solar inverters enable bi-directional energy flow, allowing consumers to sell excess power back to the grid and ensuring consistent energy availability with solar-plus-storage solutions.
5. **Government initiatives**: Policies like Net Metering and feed-in tariffs in states like Gujarat and Rajasthan are promoting solar inverter adoption, offsetting electricity bills and encouraging investments.
6. **Rise of rooftop solar installations**: Increased adoption in urban and rural areas, coupled with declining panel costs and new policies like PM-KUSUM, is boosting inverter demand, especially for higher-capacity systems.

6.5.5 Technology trends in solar UPS

Solar UPS systems are an essential component of modern energy solutions, combining solar energy with backup power capabilities to ensure a reliable energy supply. Below are the key existing technologies shaping the solar UPS landscape:

1. **Traditional inverter-based systems**: These systems use solar inverters with lead-acid or lithium-ion batteries for backup power, offering basic functionality with limited energy storage and efficiency. They're suitable for residential and small commercial use but not for long-term energy demands or extended outages.
2. **PWM (Pulse Width Modulation) technology**: PWM inverters control output voltage by rapidly switching between on and off states, offering stable power but moderate efficiency. They're cost-effective for smaller loads and basic solar UPS systems.
3. **MPPT (Maximum Power Point Tracking) controllers**: MPPT controllers optimize energy extraction by dynamically adjusting voltage and current to the solar panels' optimal power point, improving system efficiency by up to 30% compared to PWM controllers.

Emerging technologies

1. **IoT-Enabled Solar UPS**: IoT integration allows remote monitoring and control of solar UPS systems, providing real-time insights on performance, battery health, and energy consumption, enhancing efficiency, especially for commercial installations and smart grids.
2. **Solid-State Batteries**: These batteries use solid electrolytes, offering higher energy density, faster charging, longer lifecycles, and improved safety compared to traditional lithium-ion batteries.
3. **Bi-Directional Solar UPS Systems**: These systems allow energy to flow both ways, enabling users to send excess solar power back to the grid, optimizing energy use and cost savings, particularly in urban areas with net metering policies.

6.5.6 Existing technologies in solar converters

1. **Centralized Solar Converters:** Used in large-scale solar plants, these converters efficiently convert DC to AC for grid integration, offering high capacity and cost-efficiency, ideal for solar farms and large commercial projects.
2. **Micro-Converters:** These convert DC to AC at the panel level, enabling MPPT for each module, reducing shading losses and enhancing performance, making them ideal for residential installations with partial shading or irregular configurations.
3. **String Converters:** Designed to process output from a series of connected panels, string converters provide modularity and improved efficiency, making them suitable for residential and small commercial installations with varying sunlight conditions.

Emerging technologies in solar converters

1. **Bi-Directional Solar Converters**: These converters allow energy to flow both ways, enabling users to feed excess power back into the grid or use it during outages. They support energy arbitrage, enhancing energy autonomy and are increasingly adopted in grid-tied and hybrid systems.
2. **SiC and GaN Converters**: Utilizing wide bandgap semiconductors, these converters offer higher efficiency, compactness, and greater power efficiency, with reduced energy loss and longer lifespans, making them ideal for residential, commercial, and utility-scale solar systems.
3. **AI-Driven Smart Converters**: These converters use AI for real-time load management, predictive analytics, and adaptive power delivery, improving efficiency, performance, and reliability in smart grids and large solar projects.

6.5.7 Technologies in solar inverters

Solar inverters play a pivotal role in solar energy systems by DC generated by PV panels into alternating AC for practical usage. Innovations in this domain have led to significant improvements in efficiency, reliability, and versatility, making inverters indispensable for diverse applications. Below is an overview of existing and emerging technologies in solar inverters.

Existing

1. **String Inverters**: Cost-effective and efficient, string inverters process DC output from interconnected panels. Their centralized design simplifies installation and maintenance, making them ideal for residential and small-to-medium commercial projects.
2. **Central Inverters**: High-capacity and centralized, these inverters are designed for utility-scale installations, using components like MOSFETs and IGBTs. They are typically used in solar farms and industrial applications.
3. **Micro-Inverters**: Installed at the panel level, micro-inverters optimize energy production with individual MPPT for each panel, enhancing performance in shaded systems. They also allow for easy scalability of solar installations.

Emerging

1. **AI-Powered Inverters**: These inverters use AI for real-time monitoring, fault detection, and performance optimization, making them ideal for large-scale solar farms and smart grids.
2. **Bi-Directional Inverters**: Supporting two-way power flow, these inverters allow energy storage systems to supply power back to the grid, enhancing grid stability and enabling energy arbitrage in hybrid and grid-interactive systems.
3. **Hybrid Multilevel Inverters**: These inverters reduce harmonics and improve output waveform quality, making them suitable for utility-scale applications where high efficiency and large power management are needed.

6.5.8 Key Players

- **UTL Solar:** UTL Solar is a prominent Indian company that specializes in providing solar energy solutions. Known for its innovative approach, UTL Solar manufactures and supplies a wide range of solar products, including solar panels, solar inverters, and solar power systems for residential, commercial, and industrial applications. The company is committed to promoting renewable energy and sustainability by offering high-quality, efficient, and cost-effective solar solutions. According to MNRE, the cumulative rooftop solar capacity as of November 2024 is 15.1 GW. Over the past five years, UTL Solar has supplied 1.4GW of solar inverters across the country, accounting for 9.2% for the mentioned installed capacity.
- **Sungrow Power Supply Co. Ltd. (India):** Sungrow is a company in the solar inverter industry. They provide a range of solar inverters and energy storage systems that are widely used in both residential and commercial installations.
- **Luminous Power Technologies:** Luminous Power Technologies, a part of the Schneider Electric group, is one of the players in the solar power solutions space in India. The company manufactures solar inverters and solar UPS systems for both residential and commercial applications. Luminous is known for its durable and efficient products, which are widely used in both off-grid and grid-connected systems.
- **Microtek International Pvt. Ltd.:** Microtek is one of India's manufacturers of power backup solutions, including solar inverters and UPS systems. They offer a range of high-quality products that cater to both residential and commercial applications. Their solar inverters are known for their efficiency and reliability in various weather conditions.
- **Kotak Solar**: Kotak Solar, a player in the Indian solar market, focuses on solar inverters and UPS systems, offering efficient and affordable solutions for both off-grid and grid-connected systems. Their products are known for their high quality and are suitable for residential, commercial, and industrial sectors.

6.5.9 Scope of DCR on India's Solar Manufacturing

The Indian government promotes renewable energy, focusing on solar power. The Domestic Content Requirement (DCR) mandates that a certain proportion of components in solar projects be sourced locally, aiming to boost India's solar manufacturing sector, reduce import reliance, and create jobs in the renewable energy industry.

Current Government-Supported Environment

1. **Make in India Initiative**: The DCR policy under the National Solar Mission mandates the use of Indian-made solar equipment for government-funded projects, with the PLI Schemes providing financial incentives to domestic manufacturers.

2. **Financial and Policy Support**: Government subsidies, GST exemptions, and net metering policies make DCR solar panels and inverters more affordable. Low-interest loans from NABARD and IREDA further encourage solar adoption.
3. **Economic and Social Impact**: The focus on DCR solar panels creates jobs in manufacturing, installation, and maintenance. It reduces import reliance and boosts local manufacturers like Waaree Energies, Vikram Solar, and Adani Solar, enhancing their global competitiveness.
4. **Increased Demand for Solar Power**: As solar power becomes more cost-competitive, government targets for 500 GW of non-fossil fuel-based power by 2030 will drive greater demand for DCR-compliant equipment.

Future scope of DCR products

1. **Expansion of Manufacturing Capacities**: Government focus on PLI schemes and DCR requirements will boost domestic manufacturing, fostering competition and improving technology, cost efficiency, and quality, driving growth in the DCR solar panel and inverter market.
2. **Technological Advancements**: Advances in high-efficiency modules (e.g., bifacial, perovskite) and smart inverters (with AI and IoT) will enhance India's technological edge, supported by government-funded R&D initiatives.
3. **Export Market**: India's growing solar manufacturing capacity, aligned with the "China Plus One" strategy, will increase exports, especially to developed markets like the US and Europe, driven by trade agreements and global clean energy demand.
4. **Support for Rooftop and Off-Grid Solar**: Government subsidies for rooftop and off-grid solar systems will drive demand for domestically produced DCR panels and inverters, particularly in rural and remote areas.

Key threats and weaknesses for Solar UPS, inverters and converters

1. **Technological Obsolescence**: The fast-paced innovation in solar energy requires constant R&D to stay competitive. Failure to integrate new technologies, such as advanced inverters and smart grid solutions, may lead to obsolescence, especially for smaller manufacturers lacking resources to keep up.
2. **Raw Material Price Volatility**: Fluctuations in raw material prices, driven by global disruptions and geopolitical issues, can increase production costs, affecting competitiveness and delaying production timelines, particularly due to heavy dependence on imports.
3. **Competition from Low-Cost International Players**: Intense competition, especially from low-cost suppliers like China, pressures domestic manufacturers to lower prices, potentially impacting profit margins and market share.
4. **Regulatory and Policy Uncertainty**: Changes in government policies, subsidies, or regulations can disrupt market stability. Over-reliance on government incentives makes the industry vulnerable to policy shifts, particularly in emerging markets like India.
5. **Limited Domestic Manufacturing**: India's solar manufacturing capacity is limited compared to global competitors, leading to dependency on imports. Trade disruptions or tariffs could undermine local price competitiveness.
6. **Environmental and Climatic Risks**: Climate change and extreme weather events can affect solar energy generation, reduce demand for solar systems, and increase repair needs, putting pressure on manufacturers.
7. **Grid Integration Challenges**: Weak grid infrastructure in remote areas and difficulties in integrating solar with existing grids can limit adoption. Investment in grid and storage technologies is needed, increasing complexity and costs for solar solutions.

7 Executive Summary

7.1 Industry Brief

India's economy is poised for robust growth, with projections of 7% growth in CY24 and 6.5% in CY25. This trajectory is driven by strong domestic demand, infrastructure development under flagship initiatives like Make in India, expanding exports, and rising urbanization. The power sector, as a critical pillar of India's infrastructure, is central to this economic expansion. With a focus on transitioning to renewable energy and modernizing the grid, it continues to address the country's growing energy demands sustainably.

As the third-largest global producer and consumer of electricity, India has witnessed steady growth in power demand, underpinned by initiatives such as UDAY, the National Solar Mission, and electrification schemes like SAUBHAGYA and DDUGJY. Between FY24 and FY32, the power sector is expected to grow at a CAGR of 9%, supported by industrialization, urbanization, rising EV adoption, and the proliferation of renewable energy systems. Renewable energy has emerged as a cornerstone, contributing 43% out of the total overall installed capacity of 442 GW as of FY24, driven largely by the remarkable expansion of solar power.

Solar energy plays a pivotal role in India's renewable landscape. The country's installed solar capacity surged from 28 GW in FY19 to ~82 GW in FY24 and is expected to reach 365 GW by 2032, achieving ~63% of the renewable energy mix. This rapid growth, supported by a CAGR of 21% between FY24 and FY32, reflects robust policy support through initiatives like the National Solar Mission, state and central incentives, and the Production Linked Incentive (PLI) scheme. As solar becomes the dominant source of power by FY32, its share in India's energy mix is projected to rise from 19% in FY24 to 40%, highlighting its critical role in the country's clean energy transition

The rooftop solar market has also witnessed significant momentum and is expected to register robust growth at a projected CAGR of 42% from FY24 to FY30, reaching almost 100 GW. Gujarat leads with a 29% market share, followed by Maharashtra and Rajasthan, while rural areas present untapped potential for decentralized solar installations. Programs like PM-KUSUM are accelerating adoption in rural regions by promoting solar-powered agricultural solutions. Alongside, large-scale initiatives like solar parks and ultra-mega solar power projects aim to deliver 30GW of installed capacity by FY27, addressing challenges like land acquisition and regulatory approvals, thus driving India's solar ambitions further.

The global EV ecosystem intersects dynamically with India's energy landscape. EV sales in India have grown at an impressive CAGR of 61% from FY18 to FY24, led by the dominance of the 3-wheeler segment, which accounts for over 35% of total sales. E-rickshaws, specifically, have grown at a CAGR of 53% from FY19 to FY24 and are projected to maintain a 23% CAGR till FY29. This growth is driven by declining battery prices, government incentives under the FAME scheme, and advancements in lithium-ion technology, the preferred battery choice for EVs. The penetration of EVs in the 3W segment is expected to rise from 4.8% in FY23 to 48% by FY31, reflecting the shift toward sustainable mobility solutions.

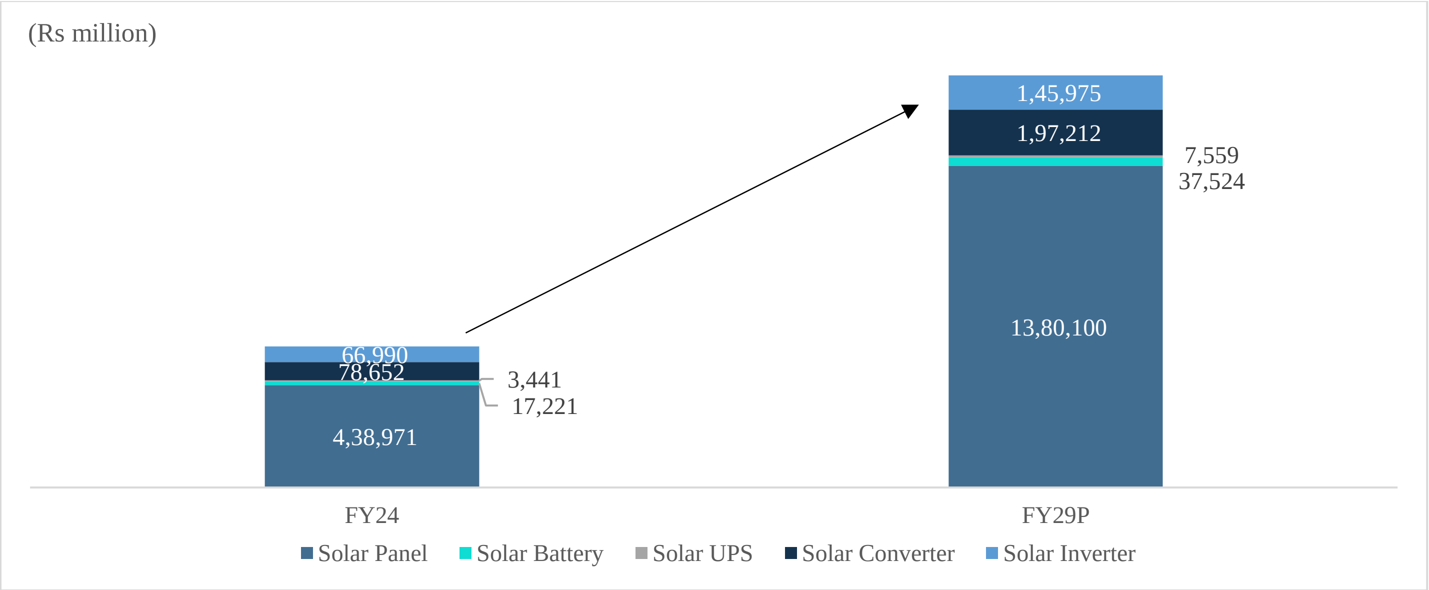
Lithium-ion batteries remain at the forefront of EV and renewable energy storage due to their high energy density, long lifecycle, and decreasing costs. Emerging technologies like solid-state and advanced nickel-metal hydride batteries are being explored to enhance safety and efficiency. These advancements, coupled with growing global demand, further strengthen the nexus between renewable energy and the EV market. The global demand for batteries is expected to grow significantly.

The Indian solar manufacturing market is also flourishing, covering critical components like panels, batteries, UPS systems, and inverters. Between FY19 and FY24, solar panel demand grew at a CAGR of 17.4%, with projections of 25.7% growth from FY24 to FY29. Similarly, the solar battery and hybrid inverter markets are set to expand significantly, driven by rising energy costs, technological advancements, and government support. Solar UPS and converter segments, essential for optimizing energy usage, are expected to grow at a CAGR of over 17% and 20.2%, respectively, between FY24 and FY29.

End-users in the residential, commercial, and industrial sectors are driving this growth. Residential consumers benefit from reduced energy bills and independence from grid fluctuations, while businesses leverage solar energy to lower operational costs and enhance sustainability. Together, they create a vibrant market for components like inverters, batteries, and converters, which ensure efficient energy management and performance.

With its strategic investments, supportive policies, and commitment to sustainability, India is set to lead the global renewable energy transition. The interplay between its expanding solar capacity, EV adoption, and advanced energy storage solutions underscores a future where economic growth and environmental stewardship go hand in hand. This trajectory not only strengthens India's position in the global energy landscape but also underscores its role in shaping a cleaner, more sustainable future.

Chart 54: Total Addressable Market



Source: TechSci Research, CareEdge Research

7.2 About the company

Founded in 1996 as a sole proprietorship firm under the name ‘UTL Electronics’, the entity transitioned into a private company in 2008, becoming Fujiyama Power Systems Ltd, also known as UTL Solar. This is an Indian company that manufactures power backup and solar energy solutions, including solar panels, solar inverters and batteries. The company is engaged in manufacturing of solar products in rooftop solar segment which includes Solar Inverter of On-grid, Hybrid and Off-grid type, Solar Panels, Batteries (Lead acid and Lithium-ion batteries), Online UPS, Online Solar PCU, E-rickshaw and other chargers, Hybrid charge controller unit, Solar management unit and charge controllers, etc. The company manufactures products under two brands- “UTL Solar” and “Fujiyama Solar”.

The company has three manufacturing units in India. The company caters to both domestic and international markets in the solar energy sector, having its exports to 10 countries globally. The operations of the company include manufacturing cutting-edge solar products for generation and storage of solar power, both for residential and commercial use. The company's products help in reducing emissions and carbon footprints of their customers and contribute towards environmental sustainability. Amongst the peer set mentioned in the Competitive Landscape section below, Fujiyama Power Systems Limited (UTL Solar) has the widest variety of SKU.

Rooftop solar is still a relatively new concept for Indian consumers, making it challenging to procure solar inverters, batteries, and panels individually. However, the company's comprehensive presence across all segments enables it to offer "One Stop Solar Solutions" to its customers.

As per the CEO Magazine, the company was the First Indian company to develop SMT inverter with single card in the year 2000. Additionally, the company has been involved in continuous innovations and development of technologies in its initial years. UTL has been one of the first few companies to develop Online UPS with single card, Combo UPS along with AVR in India. Moreover, the company has also been one of the first few manufacturers of high frequency based online UPS and inverter in India in the year 2010. The company began manufacturing solar PCU in 2012 whereas online solar PCUs in 2014.

The company generates more than 85% of its revenue from Rooftop Solar operations, supported by a large network of 480+ distributors, 3,600+ dealers and 1000+ Shoppe across India. It has a strong presence in rural areas, ensuring reliable energy solutions for remote communities as well as urban regions. Moreover, the company was certified as "India's Most Preferred Smart City Brand" and "India's

Most Preferred Solar Energy Brand" for two consecutive years in FY19 and FY20 by UBM and Informa. Additionally, the company was also recognized by 'The CEO Magazine' as one of the 25 Fastest Growing Electronic Manufacturing Companies in India. According to MNRE, the cumulative rooftop solar capacity as of November 2024 is 15.1 GW. Over the past five years, UTL Solar has supplied 1.4GW of solar inverters across the country, accounting for 9.2% for the mentioned installed capacity.

The company is gearing up for significant expansion, with ambitious targets set for the coming years. By FY25, it aims to enhance its solar panel manufacturing capacity by 600 MW through the addition of a new production line. The company is further expanding its operations by adding a 500 MWh production capacity for lithium-ion batteries and a 600 MW manufacturing capacity for solar inverters by FY25. Looking ahead to FY26, the company plans to further scale its operations by adding 2 GW of solar panel capacity, 2 GW of solar inverter capacity, and 2 GWh of lithium battery capacity.

7.3 Operational Benchmarking

The below chart compares various solar energy companies across key parameters: solar panel manufacturing, inverter manufacturing (on-grid, hybrid, and off-grid), battery manufacturing (lead acid and lithium-ion), R&D capabilities in inverter technologies, and availability of a wide range of solar SKUs.

Fujiyama Power Systems Ltd. stands out as a competitor with its comprehensive offerings across all parameters. It excels in solar panel manufacturing, inverter manufacturing (covering on-grid, hybrid, and off-grid solutions), and both lead acid and lithium-ion battery production. Additionally, it supports robust R&D capabilities in inverter technology and provides a wide variety of solar SKUs, distinguishing itself as a well-rounded leader in the industry.

In contrast, while other companies like Waaree Energies and Luminous Power Technologies show strength in solar panel and battery manufacturing, their offerings in other areas, such as R&D and diverse inverter solutions, are not as extensive as Fujiyama's. Notably, companies like Exicom Telesystems and Okaya Power lack availability in most parameters, limiting their competitiveness in comparison.

Fujiyama's ability to meet diverse market demands with comprehensive product lines and R&D focus highlights its firm position in the solar energy and power backup industry.

Chart 55: Operational Benchmarking across companies

	Criteria											
				Battery Manufacturing					R&D Facilities			
Peers	Solar Panel Manufacturing	Solar Inverter Manufacturing	DC Power Supply System and EV Charger Manufacturing	Lead acid	Lithium Ion	Chanel Sales Netwok	Service Network	Exclusive Shopee	Solar Inverter	DC Power Supply System and EV Charge	Battery	Wide Variety of SKU's
Fujiyama Power systems Limited	Available	Available	Available	Available	Available	Available	Available	Available	Available	Available	Available	Available
Waaree energies limited	Available	Available	Not Available	Not Available	Available	Available	Not Available	Available	Not Available	Not Available	Not Available	Not Available
Exicom Telesystems Ltd	Not Available	Available	Available	Not Available	Available	Not Available	Available	Not Available	Available	Available	Available	Available
Genus Innovation Limited	Available	Available	Available	Available	Available	Available	Available	Not Available	Available	Available	Not Available	Available
Insolation Energy Limited	Available	Not Available	Not Available	Not Available	Not Available	Not Available	Not Available	Not Available	Not Available	Not Available	Not Available	Not Available
Premier Energies Limited	Available	Not Available	Not Available	Not Available	Not Available	Available	Not Available	Not Available	Not Available	Not Available	Not Available	Not Available
Luminous Power Technologies Private Limited	Available	Available	Not Available	Available	Available	Available	Available	Not Available	Available	Available	Available	Available
Livguard Energy Technologies Private Limited	Not Available	Not Available	Not Available	Available	Not Available	Available	Available	Not Available	Not Available	Not Available	Not Available	Available
Microtek International Private Limited	Not Available	Available	Not Available	Available	Available	Available	Available	Not Available	Available	Not Available	Available	Available
Okaya Power Private Limited	Not Available	Not Available	Not Available	Available	Available	Available	Available	Not Available	Not Available	Not Available	Not Available	Not Available

Source: Company disclosures, CareEdge Research

Available Not Available

8 Competitive Landscape

The competitive landscape in the solar industry is dynamic and evolving. The market is witnessing strong competition based on factors such as product features, pricing, brand reputation, after-sales service, and technological advancements. While established brands hold significant market share, emerging players are challenging the status quo with innovative solutions and competitive pricing.

8.1 Peer Profiling

1. Fujiyama Power Systems Limited (UTL Solar)

Founded in 1996 as a sole proprietorship firm under the name 'UTL Electronics', the entity transitioned into a private company in 2008, becoming Fujiyama Power Systems Ltd, also known as UTL Solar. The company manufactures power backup and solar energy solutions, including solar inverters and batteries. The company is engaged in manufacturing and trading of batteries, producing and selling UPS systems, inverters and solar and non-solar batteries and battery chargers under its own brand 'UTL Solar'. With three manufacturing facilities in India, UTL Solar serves both domestic and international markets, exporting its products to 10 countries worldwide. The revenue of the company has grown at an impressive CAGR of 35% over FY22 to FY24, followed by a strong growth in EBITDA of 49% over the same period. The net profit too has grown at a CAGR of 26%.

Fujiyama Power Systems Limited (Consolidated)				
Parameters	**FY22**	**FY23**	**FY24**	**H1 FY25**
Financial Parameters				
Net Sales (Rs. Million)	5,068.38	6,640.83	9,246.88	7,217.35
Operating profit (EBITDA) (Rs. Million)	442.78	515.99	986.37	1166.49
Operating margin (in %)	8.74%	7.77%	10.67%	16.16%
Net profit (Rs. Million)	285.43	243.66	453.03	750.90
Net profit margin (in %)	5.63%	3.67%	4.90%	10.40%
Total debt (Rs. Million)	1,414.24	2,111.44	2,001.87	1,505.61
Debt -to- Equity	0.78	1.09	0.84	0.48
Marketing Expenses	130.27	171.28	97.68	114.95
Marketing Expense as a % of Revenue	2.57%	2.58%	1.06%	1.59%
Revenue by product category				
Solar Panel	1,413.15	1,928.01	3,319.66	2,634.91
Solar Battery	1,663.12	1,677.75	2,166.42	1,776.41
Solar UPS/ Inverter/Converter	1,128.56	1,191.59	1,680.46	1,743.45
Other Product	334.68	1,010.16	1,147.79	563.52
E-Rickshaw Charger	206.38	389.32	593.23	314.93
Online UPS	322.48	443.99	339.32	184.13
Revenue by Sales Channel (B2B vs B2C)				
B2B	326.90	840.02	2018.78	698.93
B2C	4741.48	5800.81	7228.10	6518.42
Return on Capital Employed (ROCE) (in %)	21.54%	16.81%	26.60%	26.47%

Fujiyama Power Systems Limited (Consolidated)				
Parameters	**FY22**	**FY23**	**FY24**	**H1 FY25**
Return on Equity (ROE) (in %)	15.76%	12.62%	18.91%	23.84%
Exports as % of revenue	2.78%	4.96%	4.19%	2.28%
Revenue CAGR (FY22 – FY24)	35.07%			
Operational Parameters				
No. of SKUs in portfolio	423	452	487	509
Channel Partner*	2922	3771	4587	5104

Source: Company disclosures, CareEdge Research; *includes dealers, distributors and Shoppe

2. Waaree Energies Limited (WEL)

Founded in 1989, Waaree Energies Limited is an Indian solar energy company involved in manufacturing solar panels and providing solar power solutions for various applications. It has its operations in solar modules, EPC (Engineering, Procurement, and Construction) services, and solar water pumps. The company caters to both domestic and international markets.

Waaree Energies Limited (Consolidated)				
Parameters	**FY22**	**FY23**	**FY24**	**H1FY25**
Financial Parameters				
Net Sales (Rs. Million)	28,542.65	67,508.73	113,976.09	69,832.78
Operating profit (EBITDA) (Rs. Million)	1,109.46	8,140.63	19,157.65	10,773.28
Operating margin (in %)	3.89%	12.06%	16.81%	15.43%
Net profit (Rs. Million)	796.50	5,002.77	12,743.77	7,767.84
Net profit margin (in %)	2.79%	7.41%	11.18%	11.12%
Total debt (Rs. Million)	3,130.83	2,734.80	3,173.19	7,375.40
Debt -to- Equity	0.73	0.15	0.08	0.15
Return on Capital Employed (ROCE) (in %)	9.15%	26.09%	27.82%	14.89%
Return on Equity (ROE) (in %)	18.63%	27.21%	31.18%	16.03%
Export as % of Revenue	23.05%	68.38%	57.64%	NA
Marketing Expenses	91.94	205.73	326.16	NA
Marketing Expense as a % of Revenue	0.32%	0.30%	0.29%	NA
Revenue by product category				
Solar Panel	NA	NA	NA	NA
Solar Battery	NA	NA	NA	NA
Solar UPS/ Inverter/Converter	NA	NA	NA	NA
Other Product	NA	NA	NA	NA
E-Rickshaw Charger	NA	NA	NA	NA
Online UPS	NA	NA	NA	NA
Revenue by Sales Channel (B2B vs B2C)				
B2B	NA	NA	NA	NA

B2C	NA	NA	NA	NA
Revenue CAGR (FY22 – FY24)	99.83%			
Operational Parameters				
No. of SKUs in portfolio	NA	NA	NA	NA
Channel Partner*	373	253	334	NA

Source: Company disclosures, CareEdge Research; *includes franchise outlets, NA: Not Available

3. Insolation Energy Limited (IEL)

Incorporated in 2015, Insolation Energy Limited is an Indian solar manufacturer producing a range of solar PV modules for various applications, including residential, commercial, and industrial uses. The company supplies Poly and Mono Crystalline Solar PV Modules and innovative products like Half Cut, Dual glass (Glass to Glass), BIPV, Poly, Monofacial/ Bifacial, Topcon modules.

Insolation Energy Limited (Consolidated)				
Parameters	**FY22**	**FY23**	**FY24**	**H1FY25**
Financial Parameters				
Net Sales (Rs. Million)	2153.93	2793.65	7371.74	6,120.26
Operating profit (EBITDA) (Rs. Million)	135.14	184.17	800.31	801.77
Operating margin (in %)	6.27%	6.59%	10.86%	13.10%
Net profit (Rs. Million)	69.46	106.82	554.73	612.74
Net profit margin (in %)	3.22%	3.82%	7.53%	10.01%
Total debt (Rs. Million)	312.59	679.18	960.26	688.10
Debt -to- Equity	1.41	1.28	0.89	0.41
Return on Capital Employed (ROCE) (in %)	35.71%	18.10%	51.57%	40.42%
Return on Equity (ROE) (in %)	31.37%	20.20%	51.20%	36.13%
Marketing Expenses	5.08	6.37	10.51	NA
Marketing Expense as a % of Revenue	0.24%	0.23%	0.14%	NA
Revenue by product category				
Solar Panel	NA	NA	NA	NA
Solar Battery	NA	NA	NA	NA
Solar UPS/ Inverter/Converter	NA	NA	NA	NA
Other Product	NA	NA	NA	NA
E-Rickshaw Charger	NA	NA	NA	NA
Online UPS	NA	NA	NA	NA
Revenue by Sales Channel (B2B vs B2C)				
B2B	NA	NA	NA	NA
B2C	NA	NA	NA	NA
Revenue CAGR (FY22 – FY24)	85.00%			
Operational Parameters				
No. of SKUs in portfolio	NA	NA	NA	NA
No. of dealers and distributors	NA	300+	770+	NA

Source: Company disclosures, CareEdge Research; NA: Not Available

4. Exicom Tele-Systems Limited (ETSL)

Founded in 1994, Exicom Tele-Systems provides energy storage and EV charging solutions, as well as telecom power systems. The company is engaged in developing technology for lithium-ion batteries. The company has its domestic and international presence along with an occurrence in fifteen countries. The company supports technological advancements in EV chargers, battery systems, and industrial power systems services.

Exicom Tele-Systems Limited (Consolidated)				
Parameters	**FY22**	**FY23**	**FY24**	**H1FY25**
Financial parameters				
Net Sales (Rs. Million)	8,428.05	7,079.31	10,195.98	4054.50
Operating profit (EBITDA) (Rs. Million)	421.62	276.51	1,120.85	102.30
Operating margin (in %)	5.00%	3.91%	10.99%	2.52 %
Net profit (Rs. Million)	51.36	80.15	639.16	12.10
Net profit margin (in %)	0.61%	1.13%	6.27%	0.30%
Total debt (Rs. Million)	1076.68	1179.15	301.05	4,096.57
Debt -to- Equity	0.49	0.51	0.04	0.56
Return on Capital Employed (ROCE) (in %)	8.26%	3.33%	12.44%	(0.13%)
Return on Equity (ROE) (in %)	2.32%	3.45%	8.86%	0.17%
Marketing Expenses	0.71	19.41	24.69	NA
Marketing Expense as a % of Revenue	0.01%	0.27%	0.24%	NA
Revenue by product category				
Solar Panel	NA	NA	NA	NA
Solar Battery	NA	NA	NA	NA
Solar UPS/ Inverter/Converter	NA	NA	NA	NA
Other Product	NA	NA	NA	NA
E-Rickshaw Charger	NA	NA	NA	NA
Online UPS	NA	NA	NA	NA
Revenue by Sales Channel (B2B vs B2C)				
B2B	NA	NA	NA	NA
B2C	NA	NA	NA	NA
Exports as % of revenue	NA	32.79%	19.88%	NA
Revenue CAGR (FY22 – FY24)	9.99%			
Operational Parameters				
No. of SKUs in portfolio	NA	NA	NA	NA
No. of dealers and distributors	NA	NA	NA	04

Source: Company disclosures, CareEdge Research; NA: Not Available

5. Premier Energies Limited (PEL)

Established in 1995, Premier Energies Limited is involved in the manufacturing of solar products, including solar panels, modules, and other related components. The company has three units in Telangana. It has an annual production capacity of 2 GW, along with module lines capable of producing 3.36 GW.

Premier Energies Limited (Consolidated)				
Parameters	**FY22**	**FY23**	**FY24**	**H1FY25**
Financial parameters				
Net Sales (Rs. Million)	7,428.71	14,285.34	31,437.93	31,845.87
Operating profit (EBITDA) (Rs. Million)	307.51	794.22	4,791.23	7,395.48
Operating margin (in %)	4.14%	5.56%	15.24%	23.22%
Net profit (Rs. Million)	-144.08	-133.36	2,313.60	4,041.06
Net profit margin (in %)	-1.94%	-0.93%	7.36%	12.69%
Total debt (Rs. Million)	4,532.97	7,635.42	13,922.40	12,492.54
Debt -to- Equity	1.15	1.86	2.15	0.54
Return on Capital Employed (ROCE) (in %)	0.38%	2.44%	22.96%	16.62%
Return on Equity (ROE) (in %)	-3.65%	-3.24%	35.77%	17.58%
Marketing Expenses	NA	7.17	40.17	NA
Marketing Expense as a % of Revenue	0.00%	0.05%	0.13%	NA
Revenue by product category				
Solar Panel	NA	NA	NA	NA
Solar Battery	NA	NA	NA	NA
Solar UPS/ Inverter/Converter	NA	NA	NA	NA
Other Product	NA	NA	NA	NA
E-Rickshaw Charger	NA	NA	NA	NA
Online UPS	NA	NA	NA	NA
Revenue by Sales Channel (B2B vs B2C)				
B2B	NA	NA	NA	NA
B2C	NA	NA	NA	NA
Exports as % of revenue	0.92%	0.52%	13.99%	NA
Revenue CAGR (FY22 – FY24)	105.72%			
Operational Parameters				
No. of SKUs in portfolio	NA	NA	NA	NA
No. of dealers and distributors	NA	NA	NA	NA

Source: Company disclosures, CareEdge Research, NM- Not Meaningful, NA: Not Available

6. Genus Innovation Limited

Genus Innovation Limited is a company engaged in Design, Development and Manufacturing of Power Back-up & Solar Power products such as UPS & Inverters, Online UPS, off grid/on grid Solar Inverters, Solar Power Conditioning Units, Solar Panels, Solar MPPT Charge Controllers, Batteries, EV & E-rickshaw Battery Chargers, On-grid & Off-grid rooftop solar solutions with net metering, and Solar EPC Solutions. The company caters to both domestic and international markets with innovative, sustainable energy solutions.

Genus Innovation Limited (Consolidated)			
Parameters	**FY22**	**FY23**	**FY24**
Financial parameters			
Net Sales (Rs. Million)	3,237.15	3,308.05	3,301.03
Operating profit (EBITDA) (Rs. Million)	156.05	161.23	116.40
Operating margin (in %)	4.82%	4.87%	3.53%
Net profit (Rs. Million)	50.32	56.82	-0.57
Net profit margin (in %)	1.55%	1.72%	-0.02%
Total debt (Rs. Million)	576.82	671.59	574.99
Debt -to- Equity	0.97	1.17	1.01
Return on Capital Employed (ROCE) (in %)	12.91%	14.62%	9.86%
Return on Equity (ROE) (in %)	8.45%	9.93%	-0.10%
Marketing Expenses	24.61	41.32	61.89
Marketing Expense as a % of Revenue	0.76%	1.25%	1.87%
Revenue by product category			
Solar Panel	NA	NA	NA
Solar Battery	NA	NA	NA
Solar UPS/ Inverter/Converter	NA	NA	NA
Other Product	NA	NA	NA
E-Rickshaw Charger	NA	NA	NA
Online UPS	NA	NA	NA
Revenue by Sales Channel (B2B vs B2C)			
B2B	NA	NA	NA
B2C	NA	NA	NA
Exports as % of revenue	NA	NA	NA
Revenue CAGR (FY22 – FY24)	0.98%		
Operational Parameters			
No. of SKUs in portfolio	NA	NA	NA
No. of dealers and distributors*	9000+		

Source: Company disclosures, CareEdge Research, NA- Not Available; * Data sourced from company website

7. Livguard Energy Technologies Private Limited

Livguard Energy Technologies Private Limited is an Indian company that manufactures batteries, inverters, and power backup solutions. It also provides products for solar energy and automotive applications. The company is part of the SAR Group and focuses on energy storage and backup systems.

Livguard Energy Technologies Private Limited (Consolidated)			
Parameters	**FY22**	**FY23**	**FY24**
Financial parameters			
Net Sales (Rs. Million)	24,083.24	37,674.07	34,994.07
Operating profit (EBITDA) (Rs. Million)	-602.90	1,653.83	269.87
Operating margin (in %)	-2.50%	4.39%	0.77%
Net profit (Rs. Million)	-488.41	505.49	-846.90
Net profit margin (in %)	-2.03%	1.34%	-2.42%
Total debt (Rs. Million)	628.01	4,498.04	5,579.47
Debt -to- Equity	0.36	1.07	1.64
Return on Capital Employed (ROCE) (in %)	-34.19%	19.07%	-4.40%
Return on Equity (ROE) (in %)	-27.89%	12.04%	-24.85%
Marketing Expenses	543.93	882.86	888.65
Marketing Expense as a % of Revenue	2.26%	2.34%	2.54%
Revenue by product			
Solar Panel	NA	NA	NA
Solar Battery	NA	NA	NA
Solar UPS/ Inverter/Converter	NA	NA	NA
Other Product	NA	NA	NA
E-Rickshaw Charger	NA	NA	NA
Online UPS	NA	NA	NA
Revenue by Sales Channel (B2B vs B2C)			
B2B	NA	NA	NA
B2C	NA	NA	NA
Exports as % of revenue	NA	NA	NA
Revenue CAGR (FY22 – FY24)	20.54%		
Operational Parameters			
No. of SKUs in portfolio	NA	NA	NA
No. of dealers and distributors	4000+		

Source: Company disclosures, CareEdge Research, NM- Not Meaningful, NA- Not Available; * Data sourced from company website

8. Okaya Power Private Limited (OPPL)

Okaya Power Private Limited is an Indian company that manufactures batteries, inverters, and energy storage systems. It also provides solutions for solar energy and electric vehicle charging infrastructure. The company is part of the Okaya Group and focuses on providing energy products for domestic and commercial use.

Okaya Power Private Limited (Consolidated)			
Parameters	**FY22**	**FY23**	**FY24**
Financial parameters			
Net Sales (Rs. Million)	12,199.71	10,460.68	NA

Okaya Power Private Limited (Consolidated)			
Parameters	**FY22**	**FY23**	**FY24**
Operating profit (EBITDA) (Rs. Million)	164.32	44.93	NA
Operating margin (in %)	1.35%	0.43%	NA
Net profit (Rs. Million)	148.66	28.48	NA
Net profit margin (in %)	1.22%	0.27%	NA
Total debt (Rs. Million)	1,593.17	1,306.28	NA
Debt -to- Equity	0.91	0.73	NA
Return on Capital Employed (ROCE) (in %)	5.58%	-0.59%	NA
Return on Equity (ROE) (in %)	8.53%	1.60%	NA
Marketing Expenses	785.46	482.42	NA
Marketing Expense as a % of Revenue	6.44%	4.61%	NA
Revenue by product			
Solar Panel	NA	NA	NA
Solar Battery	NA	NA	NA
Solar UPS/ Inverter/Converter	NA	NA	NA
Other Product	NA	NA	NA
E-Rickshaw Charger	NA	NA	NA
Online UPS	NA	NA	NA
Revenue by sales channel			
B2B	NA	NA	NA
B2C	NA	NA	NA
Exports as % of revenue	NA	NA	NA
Revenue CAGR (FY22 – FY24)	NM		
Operational Parameters			
No. of SKUs in portfolio	NA	NA	NA
No. of dealers and distributors*	55000+		

Source: Company disclosures, CareEdge Research; NA- Not Available, NM- Not Meaningful, * Data sourced from company website

9. Luminous Power Technologies Private Limited (LPTPL)

Luminous Power Technologies Private Limited is a company that provides energy and power backup solutions. Its products include inverters, batteries, solar power systems, and home electricals such as fans and lighting. The company serves both residential and commercial markets and is part of Schneider Electric’s global portfolio.

Luminous Power Technologies Private Limited (Consolidated)			
Parameters	**FY22**	**FY23**	**FY24**
Financial parameters			
Net Sales (Rs. Million)	36,905.28	42,313.45	43,870.33
Operating profit (EBITDA) (Rs. Million)	4,337.66	5,149.83	5,732.29

Luminous Power Technologies Private Limited (Consolidated)			
Parameters	**FY22**	**FY23**	**FY24**
Operating margin (in %)	11.75%	12.17%	13.07%
Net profit (Rs. Million)	2,876.47	3,572.93	4,003.79
Net profit margin (in %)	7.79%	8.44%	9.13%
Total debt (Rs. Million)	839.97	500.01	68.14
Debt -to- Equity	0.06	0.03	0.00
Return on Capital Employed (ROCE) (in %)	22.38%	23.94%	21.39%
Return on Equity (ROE) (in %)	19.33%	20.44%	18.64%
Marketing Expenses	981.44	1,012.60	812.15
Marketing Expense as a % of Revenue	2.66%	2.39%	1.85%
Revenue by product			
Solar Panel	NA	NA	NA
Solar Battery	NA	NA	NA
Solar UPS/ Inverter/Converter	NA	NA	NA
Other Product	NA	NA	NA
E-Rickshaw Charger	NA	NA	NA
Online UPS	NA	NA	NA
Revenue by sales channel			
B2B	NA	NA	NA
B2C	NA	NA	NA
Exports as % of revenue	NA	NA	NA
Revenue CAGR (FY22 – FY24)	9.03%		
Operational Parameters			
No. of SKUs in portfolio	NA	NA	NA
No. of dealers and distributors*	72900+		

Source: Company disclosures, CareEdge Research; NA: Not Available; *Data sourced from company website

10. Microtek International Private Limited (MIPL)

Microtek International Private Limited is an Indian company that manufactures power backup and energy solutions. Its product range includes inverters, UPS systems, solar solutions, and batteries for residential, commercial, and industrial applications. The company has a presence in domestic and international markets both.

Microtek International Private Limited (Consolidated)			
Parameters	**FY22**	**FY23**	**FY24**
Financial parameters			
Net Sales (Rs. Million)	17,275.24	17,365.89	NA
Operating profit (EBITDA) (Rs. Million)	731.21	1,757.99	NA
Operating margin (in %)	4.23%	10.12%	NA
Net profit (Rs. Million)	389.12	913.94	NA

Microtek International Private Limited (Consolidated)			
Parameters	**FY22**	**FY23**	**FY24**
Net profit margin (in %)	2.25%	5.26%	NA
Total debt (Rs. Million)	3,700.39	7,572.07	NA
Debt -to- Equity	3.71	2.65	NA
Return on Capital Employed (ROCE) (in %)	20.69%	29.79%	NA
Return on Equity (ROE) (in %)	38.98%	31.93%	NA
Marketing Expenses	128.44	286.27	NA
Marketing Expense as a % of Revenue	0.74%	1.65%	NA
Revenue by product			
Solar Panel	NA	NA	NA
Solar Battery	NA	NA	NA
Solar UPS/ Inverter/Converter	NA	NA	NA
Other Product	NA	NA	NA
E-Rickshaw Charger	NA	NA	NA
Online UPS	NA	NA	NA
Revenue by sales channel			
B2B	NA	NA	NA
B2C	NA	NA	NA
Exports as % of revenue	NA	NA	NA
Operational Parameters			
No. of SKUs in portfolio	NA	NA	NA
No. of dealers and distributors*	1,00,000+		

Source: Company disclosures, CareEdge Research; NA: Not Available; *Data sourced from company website

8.2 Benchmarking Based on Financial Parameters

1. Operating Profit margin

Operating Profit Margin (OPM) is a measure of profitability that indicates the percentage of revenue remaining after covering operating expenses, excluding non-operating items like taxes and interest. The margins have remained competitive in the industry. While few companies have witnessed volatility in margins over the past three years, companies like Luminous Power Technologies and Fujiyama Power Systems have shown resilient margins. Margins for Fujiyama Power Systems have expanded from 7.8% in FY23 to 10.7% in FY24.

Operating Profit Margin (%)	FY22	FY23	FY24
Premier Energies Limited	4.14%	5.56%	15.24%
Waaree Energies Limited	3.89%	12.06%	16.81%
Luminous Power Technologies Private Limited	11.75%	12.17%	13.07%
Exicom Telesystems Limited	5.00%	3.91%	10.99%
Insolation Energy Limited	6.27%	6.59%	10.86%
Fujiyama Power Systems Limited	**8.74%**	**7.77%**	**10.67%**
Genus Innovation Limited	4.82%	4.87%	3.53%

Livguard Energy Technologies Private Limited	-2.50%	4.39%%	0.77%
Okaya Power Private Limited	1.35%	0.43%	N/A
Microtek International Private Limited	4.23%	10.12%	N/A

Source: Company disclosures, CareEdge Research; N/A- Not Available

2. Net Profit Margin

Net Profit Margin (NPM) represents the percentage of revenue left after all expenses, taxes, and interest, showing a company's profitability. Majority players show improvement in Net Profit margins with notable gains for companies like Waaree Energies and Luminous delivering highest margins, while Fujiyama Power Systems and Insolation Energy Limited has registered steady growth. Net profits have grown from 3.7% in FY23 to 4.9% in FY24 for Fujiyama Power Systems.

Net Profit Margin (%)	FY22	FY23	FY24
Waaree Energies Limited	2.79%	7.41%	11.18%
Luminous Power Technologies Private Limited	7.79%	8.44%	9.13%
Insolation Energy Limited	3.22%	3.82%	7.53%
Premier Energies Limited	-1.94%	-0.93%	7.36%
Exicom Telesystems Limited	0.61%	1.13%	6.27%
Fujiyama Power Systems Limited	**5.63%**	**3.67%**	**4.90%**
Genus Innovation Limited	1.55%	1.72%	-0.02%
Livguard Energy Technologies Private Limited	-2.03%	1.34%	-2.42%
Okaya Power Private Limited	1.22%	0.27%	N/A
Microtek International Private Limited	2.25%	5.26%	N/A

Source: Company disclosures, CareEdge Research, N/A- Not Available

3. Return On Equity (ROE)

Return on Equity (ROE) measures a company's profitability in relation to shareholders' equity, indicating how effectively the company generates profits from its equity. While certain companies registered negative returns, companies like Insolation Energy Limited and Fujiyama Power Systems delivered consistent growth over the past three years. Fujiyama Power has been delivering consistent returns and has increased from 12.6% in FY23 to 18.9% in FY24.

Return on Equity (%)	FY22	FY23	FY24
Insolation Energy Limited	31.37%	20.20%	51.20%
Premier Energies Limited	-3.65%	-3.24%	35.77%
Waaree Energies Limited	18.63%	27.21%	31.18%
Fujiyama Power Systems Limited	**15.76%**	**12.62%**	**18.91%**
Luminous Power Technologies Private Limited	19.33%	20.44%	18.64%
Exicom Telesystems Limited	2.32%	3.45%	8.86%
Genus Innovation Limited	8.45%	9.93%	-0.10%
Livguard Energy Technologies Private Limited	-27.89%	12.04%	-24.85%
Okaya Power Private Limited	8.53%	1.60%	N/A
Microtek International Private Limited	38.98%	31.93%	N/A

Source: Company disclosures, CareEdge Research. N/A- Not Available

4. Return On Capital Employed (ROCE)

Return on Capital Employed (ROCE) measures a company's profitability and the efficiency with which it uses its capital to generate earnings. This metric plays a vital role in defining the efficiency of the company. Few companies have delivered negative growth whereas companies such as Luminous Power, Waaree Energies and Fujiyama Power Systems has delivered consistent growth delivering decent growth. ROCE for Fujiyama Power has grown from 16.8% in FY23 to 26.6% in FY24.

Return on Capital Employed (%)	FY22	FY23	FY24
Insolation Energy Limited	35.71%	18.10%	51.57%
Fujiyama Power Systems Limited	**21.54%**	**16.81%**	**26.60%**
Premier Energies Limited	0.38%	2.44%	22.96%
Waaree Energies Limited	9.15%	26.09%	27.82%
Luminous Power Technologies Private Limited	22.38%	23.94%	21.39%
Exicom Telesystems Limited	8.26%	3.33%	12.44%
Genus Innovation Limited	12.91%	14.62%%	9.86%
Livguard Energy Technologies Private Limited	-34.19%	19.07%	-4.40%
Okaya Power Private Limited	5.58%	-0.59%	N/A
Microtek International Private Limited	20.69%	29.79%	N/A

Source: Company disclosures, CareEdge Research. N/A- Not Available

5. Debt-Equity Ratio

The Debt-to-Equity Ratio compares a company's total debt to its shareholders' equity, indicating the proportion of financing that comes from debt versus equity. The debt-to-equity ratio has been maintained consistent with the peers in the industry indicating a balanced profile across the operations.

Debt-Equity Ratio (times)	FY22	FY23	FY24
Premier Energies Limited	1.15	1.86	2.15
Livguard Energy Technologies Private Limited	0.36	1.07	1.64
Genus Innovation Limited	0.97	1.17	1.01
Insolation Energy Limited	1.41	1.28	0.89
Fujiyama Power Systems Limited	**0.78**	**1.09**	**0.84**
Waaree Energies Limited	0.73	0.15	0.08
Exicom Telesystems Limited	0.49	0.51	0.04
Luminous Power Technologies Private Limited	0.06	0.03	0.00
Okaya Power Private Limited	0.91	0.73	N/A
Microtek International Private Limited	3.71	2.65	N/A

Source: Company disclosures, CareEdge Research. N/A- Not Available

9 Annexure

Formulas:

Parameter	Formula
Operating Profit Margin	EBITDA / Revenue from Operations
Net Profit Margin	Net Profit / Revenue from Operations
Debt-to-Equity	Total Debt / Total Equity
EBIT	EBITDA - Depreciation
Return on Capital Employed (ROCE)	EBIT / (Total Assets – Current Liabilities)
Return on Equity (ROE)	PAT/ Shareholder's Equity [Total Equity excluding minority interest]

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