CareEdge
ANALYTICS & ADVISORY
A subsidiary of CARE Ratings Ltd.

Industry Report On Storage and Power backup solution

February 2025

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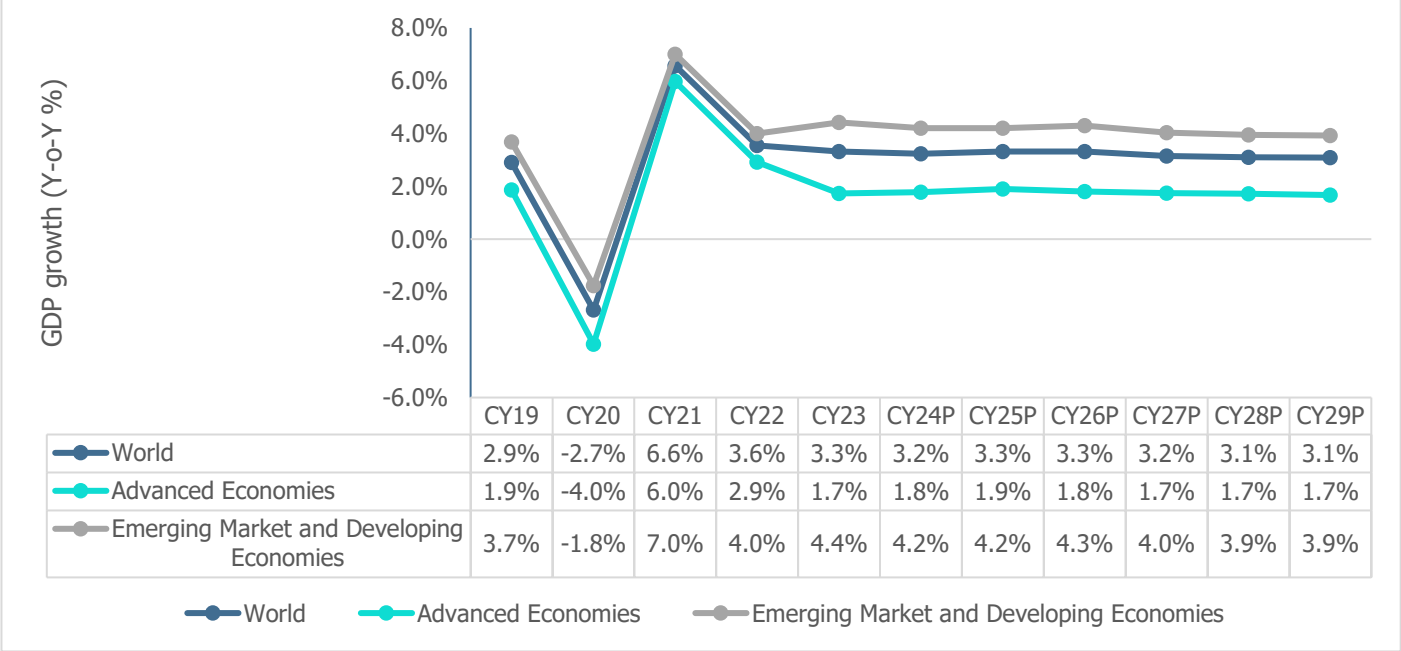
1 Economic Outlook

1.1 Global Economy

Global growth, which reached 3.3% in CY23, is projected to stabilize at 3.2% for CY24 and 3.3% for CY25. The outlook for global real GDP growth indicates potential improvement as cyclical imbalances ease, bringing economic activity in major economies closer to their potential output. 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 %)



	CY19	CY20	CY21	CY22	CY23	CY24P	CY25P	CY26P	CY27P	CY28P	CY29P
World	2.9%	-2.7%	6.6%	3.6%	3.3%	3.2%	3.3%	3.3%	3.2%	3.1%	3.1%
Advanced Economies	1.9%	-4.0%	6.0%	2.9%	1.7%	1.8%	1.9%	1.8%	1.7%	1.7%	1.7%
Emerging Market and Developing Economies	3.7%	-1.8%	7.0%	4.0%	4.4%	4.2%	4.2%	4.3%	4.0%	3.9%	3.9%

Notes: P-Projection; Source: IMF – World Economic Outlook, January 2025

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
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	4.6	4.5	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	3.3	4.1	3.6	3.5	3.5
Brazil	-3.3	4.8	3.0	2.9	3.0	2.2	2.2	2.4	2.5	2.5
Euro Area	-6.1	6.2	3.3	0.4	0.8	1.0	1.4	1.4	1.3	1.2

United States	-2.2	6.1	2.5	2.9	2.8	2.7	2.1	2.1	2.1	2.1

P- Projections; Source: IMF- World Economic Outlook Database (January 2025)

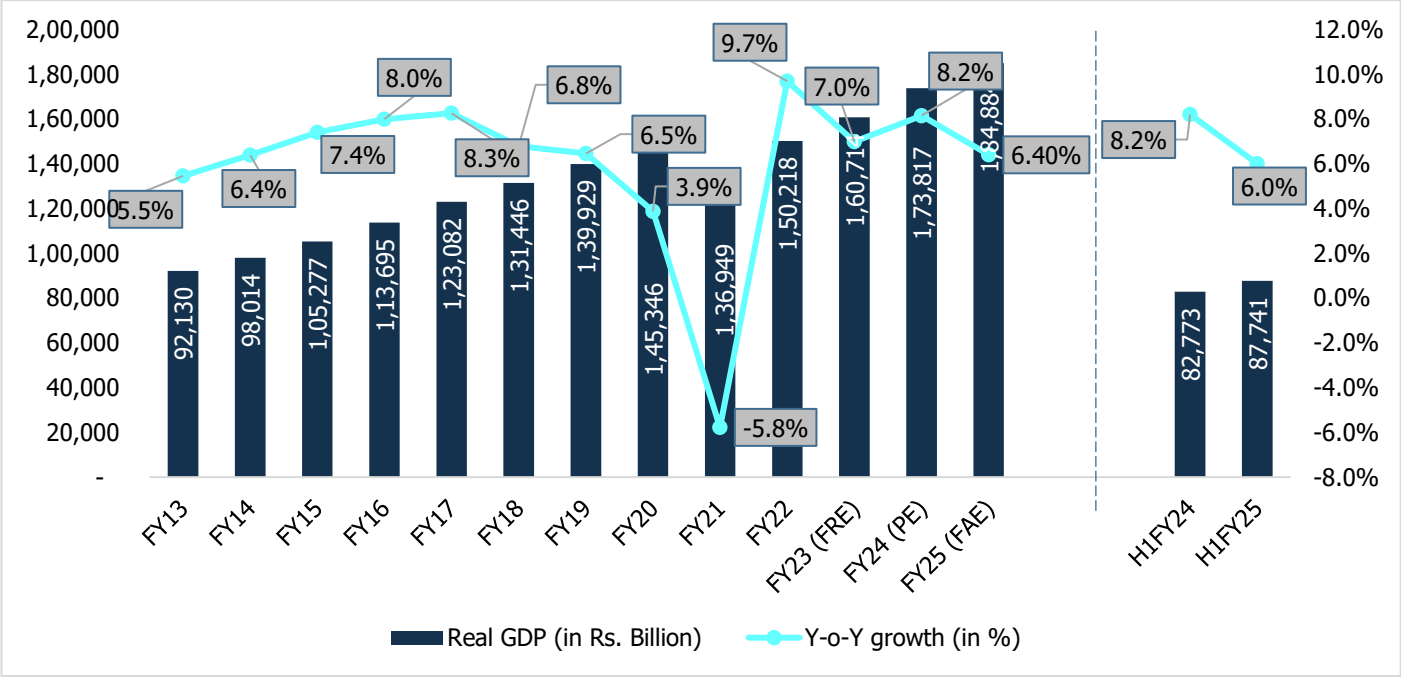
Note: CY20-CY26 data is taken from January 2025 IMF WEO report, while CY27-CY29 data is taken from October 2024 database, as this update is yet to come.

1.2 Indian Economic Outlook

1.2.1 GDP Growth and Outlook

Resilience to External Shocks remains Critical for Near-Term Outlook

Chart 2: Trend in Real Indian GDP growth rate



Note: FAE- First Advance Estimates, FRE – First Revised Estimates, PE – Provisional Estimate; Source: MOSPI

India's real GDP grew by 8.2% in FY24 (Rs. 173,817 billion) and is estimated to grow 6.4% in FY25 (Rs. 184,884 billion), 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

- **FY26 GDP Outlook:** Real GDP growth is projected at 6.7%, balanced risks, driven by rural demand, improving employment, and robust business activity, despite global uncertainties.
- **FY25 GDP Performance:** Real GDP growth for the current year is estimated at 6.4%, with a gradual recovery expected in the coming year driven by strong agricultural activity, improving manufacturing, and resilient services, despite a slight dip in PMI services.

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 6.7% y-o-y for FY26.

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

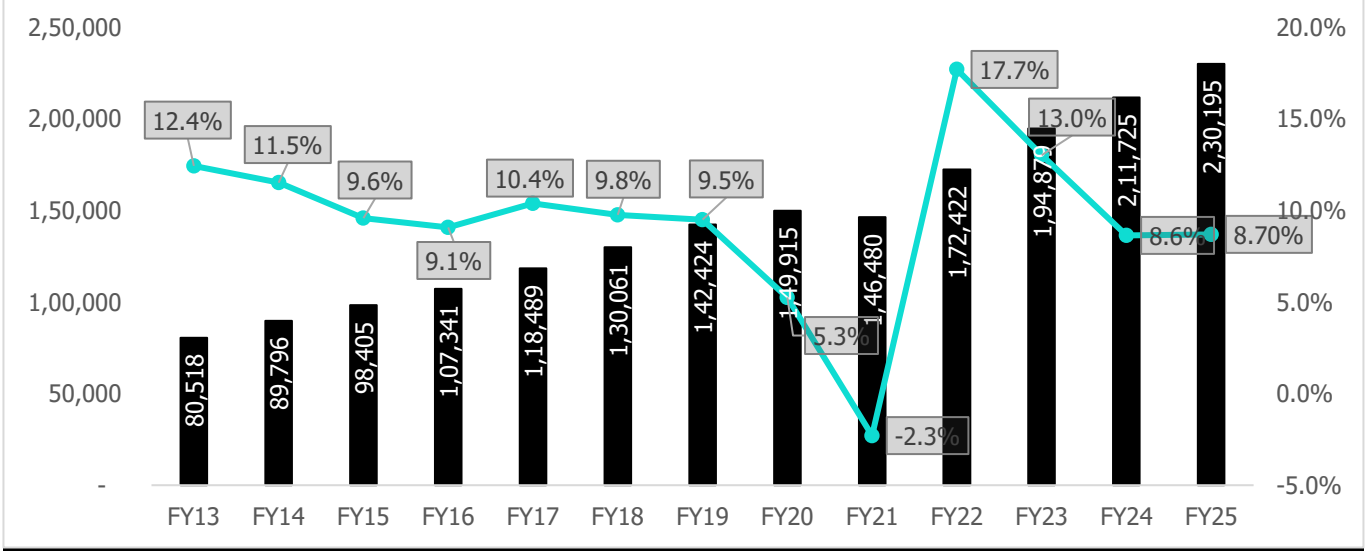
FY26P (complete year)	Q1FY26P	Q2FY26P	Q3FY26P	Q4FY26P
6.7%	6.7%	7.0%	6.5%	6.5%

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

1.2.2 India's GDP Per Capita

India's per capita GDP has shown a consistent upward trend over the past decade, reflecting steady economic growth. From FY13 to FY24, the per capita GDP increased from ₹80,518 to ₹230,195, with an average growth rate of around 9% annually. Key drivers of this growth include structural reforms, digitalization, rising domestic consumption, and increased foreign investment. However, there was a slight dip in FY20, primarily due to the economic impact of the COVID-19 pandemic. Despite this, the country has rebounded with strong growth rates in subsequent years, supported by economic recovery and continued expansion in various sectors.

Chart 3: Per capita GDP (constant prices)



Source: MOSPI

1.2.3 Gross Value Added (GVA)

India's recovery is led by the industrial and services sectors. In FY25, the agriculture sector grew by 3.8%, upward trend from 1.4% in FY24. The industrial sector plummeted to 6.2%, due to weak industrial activities. The services sector grew 7.2%, supported by public administration, defence & other services. Growth in H1FY25 slowed down in agriculture (2.7%) and services (6.1%) as compared to H1FY24.

Table 3: Sectoral Growth (Y-o-Y % Growth) - at Constant Prices

At constant Prices	FY19	FY20	FY21	FY22	FY23 (FRE)	FY24 (PE)	FY25 (FAE)	H1FY24	H1FY25
Agriculture, Forestry & Fishing	**2.1**	**6.2**	**4.1**	**3.5**	**4.7**	**1.4**	**3.8**	**2.8**	**2.7**
Industry	5.3	-1.4	-0.9	11.6	2.1	9.5	6.2	9.7	6.0
Mining & Quarrying	-0.9	-3.0	-8.6	7.1	1.9	7.1	2.9	8.8	3.9
Manufacturing	5.4	-3.0	2.9	11.1	-2.2	9.9	5.3	9.6	4.5

At constant Prices	FY19	FY20	FY21	FY22	FY23 (FRE)	FY24 (PE)	FY25 (FAE)	H1FY24	H1FY25
Electricity, Gas, Water Supply & Other Utility Services	7.9	2.3	-4.3	9.9	9.4	7.5	6.8	6.8	6.8
Construction	6.5	1.6	-5.7	14.8	9.4	9.9	8.6	11.0	9.1
Services	**7.2**	**6.4**	**-8.2**	**8.8**	**10.0**	**7.6**	**7.2**	**9.7**	**6.1**
Trade, Hotels, Transport, Communication & Broadcasting	7.2	6.0	-19.7	13.8	12.0	6.4	5.8	6.9	5.9
Financial, Real Estate & Professional Services	7.0	6.8	2.1	4.7	9.1	8.4	7.3	9.3	6.9
Public Administration, Defence and Other Services	7.5	6.6	-7.6	9.7	8.9	7.8	9.1	8.0	9.3
GVA at Basic Price	**5.8**	**3.9**	**-4.2**	**8.8**	**6.7**	**7.2**	**6.4**	**8.0**	**6.2**

Note: FRE – First Revised Estimates, PE – Provisional Estimate, FAE- First Advance Estimates; Source: MOSPI

1.2.4 Trends in Per capita State Domestic Product (SDP)

State Domestic Product is the total value of goods and services produced, during any financial year, within the geographical boundaries of a state. The top 10 best performing states on per capita SDP include Delhi, Gujarat, Karnataka, and Tamil Nadu.

As of FY24, major states having a per capita SDP below national average include Andhra Pradesh, Rajasthan, Madhya Pradesh, and Uttar Pradesh growing y-o-y by 7.20%, 6.94%, 4.83%, and 6.42% respectively. Bihar is the poorest performing state with a per capita SDP of Rs. 32,174. It has consistently been the performing the poorest since FY18 growing only at a CAGR of 3.14% from FY18 to FY24.

Table 4: Per Capita State Domestic Product (SDP) for Key States (at constant prices, in Rs.)

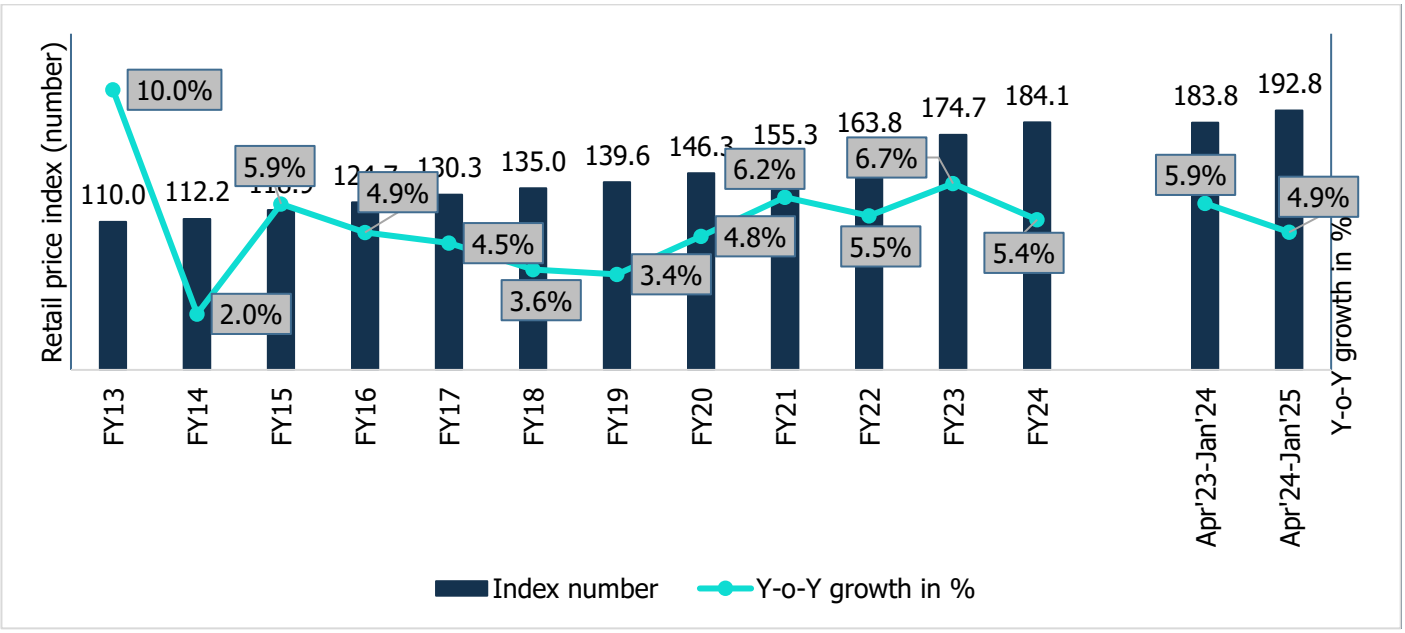
State\UT	FY18	FY19	FY20	FY21	FY22	FY23	FY24
Andhra Pradesh	1,03,177	1,08,853	1,10,587	1,10,971	1,21,762	1,26,690	1,35,806
Bihar	26,719	29,092	29,798	26,839	27,674	29,909	32,174
Gujarat	1,43,604	1,54,887	1,64,060	1,56,285	1,70,519	1,81,963	1,81,963
Karnataka	1,40,747	1,49,024	1,56,478	1,49,673	1,63,732	1,75,895	1,86,038
Madhya Pradesh	54,824	59,005	60,452	56,086	60,166	63,379	6,6441
Maharashtra	1,37,808	1,40,782	1,45,626	1,27,550	1,40,718	1,53,664	163,820
Rajasthan	73,529	73,975	76,840	73,447	79,507	84,935	90,831
Tamil Nadu	1,33,029	1,41,844	1,44,845	1,43,482	1,54,269	1,66,590	1,79,732
Uttar Pradesh	41,771	42,333	43,061	39,866	44,178	47,808	50,875
Delhi	2,52,960	2,57,597	2,60,559	2,28,162	2,44,024	2,58,941	2,73,687

Source: MOSPI

1.2.5 Consumer Price Index

The CPI (general) and food inflation in January, 2025 was the lowest in Y-o-Y inflation after August 2024. CPI moderation was driven by decline in inflation in Vegetables, Eggs, Pulses, Education, Clothing, Health and Cereals etc.

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

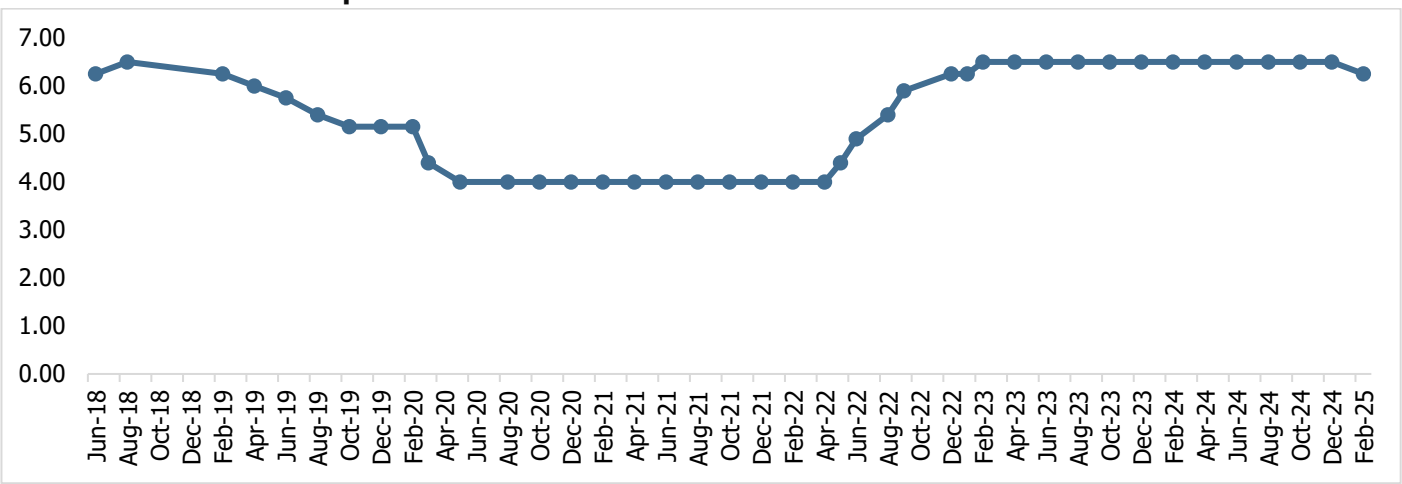


Source: MOSPI

The CPI is primarily factored in by RBI while preparing their bi-monthly monetory policy. At the bi-monthly meeting held in February 2025, RBI projected inflation at 4.2% for FY25 with inflation during Q1FY26 at 4.2%, Q2FY25 at 4.5%, Q1FY26 at 4.6%, and Q3FY26 at 3.8% and Q4FY26 4.2%.

Considering the current inflation situation, RBI has cut the repo rate to 6.25% in the February 2025 meeting of the Monetary Policy Committee.

Chart 5: RBI historical Repo Rate



Source: RBI

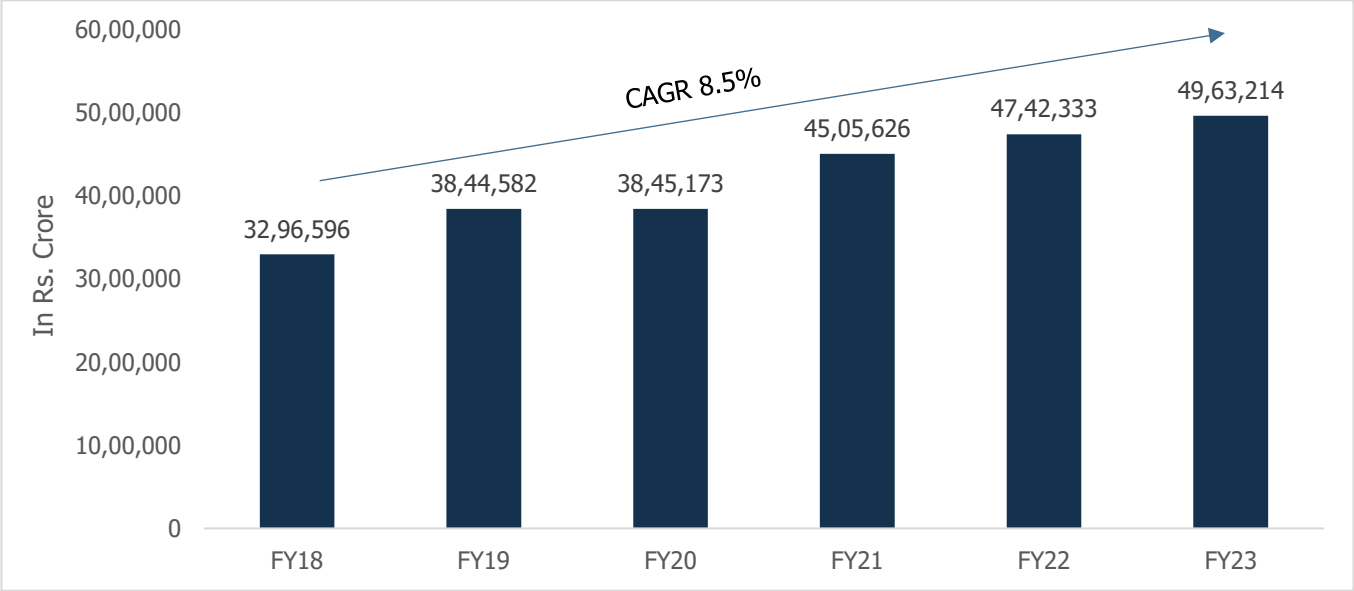
Further, the central bank continued its stance to be neutral. While headline inflation saw a sharp pick up due to increase in food inflation in October, it has moderated in December and January. The growth outlook is expected to be resilient but with close monitoring with the Indian ruppee coming under depreciation in the current months. Core inflation is expected to rise but remain moderate. 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.

1.2.6 Trends in Household and Gross Savings

Household savings in India have grown steadily at a CAGR of 8.5% since FY18, with a slight dip in FY20 due to the pandemic. In FY23, total household savings reached Rs. 49,63,214 crore, growing by 4.7% year-on-year. Significant contributors to this growth include savings in physical assets (real estate, etc.), which increased by 17.4%, and gold and silver ornaments, which grew by 39%. The shift towards physical assets is driven by slow appreciation in monetary assets in a high-inflation environment.

This increase in savings has been supported by higher borrowing, particularly in housing, auto, and personal loans, leading to a 73.2% rise in financial liabilities to Rs. 15,57,190 crore. Additionally, growth in savings in mutual funds (11.5%) and life insurance funds (13.6%) indicates a shift towards newer financial instruments, with increased participation in equity and capital markets for higher returns.

Chart 6: Household Savings (at Current Prices)

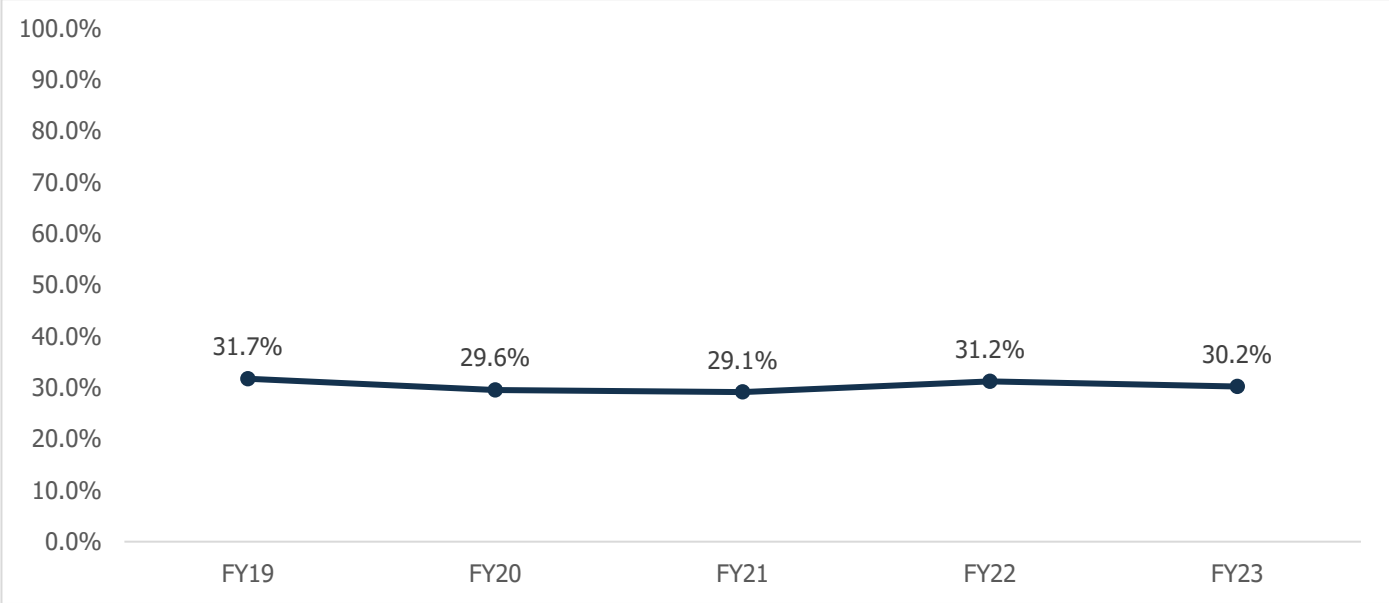


Source: MOSPI

Gross Savings as percentage of GDP, has seen a flat growth moving within a narrow range. Within the last five years, it was highest in FY19 at 31.7%. It declined to less than 30% during FY20 and FY21 on account of pandemic increasing again to 31.2% in FY22 before declining to 30.2% in FY23.

As of FY23, Savings were Rs. 81,50,008 crores indicating a y-o-y growth of 10.7% while GDP was at Rs. 2,69,49,646 crore showing a growth of 14.2%.

Chart 7: Gross Savings (as % of GDP) (at current prices)



Source: MOSPI

1.2.7 Growth of the middle class in India and the rural economy in India

India's rural economy is becoming a significant driver of the Fast-Moving Consumer Goods (FMCG) sector's resurgence, signaling a promising turnaround in aggregate demand after a slow start to the 2024-25 financial year. The Reserve Bank of India (RBI) highlights that rising incomes and improved infrastructure are fueling increased rural consumption of FMCG products. This boost is supported by a rise in rural savings, marked by growing numbers of savings bank accounts and balances, and a reduction in inflationary pressures, which has allowed rural consumption to catch up with urban areas. Additionally, favorable monsoon conditions and improved sowing data are expected to sustain this growth, complemented by increased government spending on rural development and infrastructure.

The expansion of middle-income households in rural India is transforming the country's economic landscape. This growth is driven by rising incomes, increased discretionary spending, a shift towards online and omnichannel shopping, and advancements in payment and logistics infrastructure. There is also a notable dietary shift in rural areas from carb-based foods to more protein-rich diets. India’s middle class, characterized by significant income variability, exhibits diverse spending patterns. Lower-middle-class households allocate much of their income to private healthcare, education, and essential consumer goods, such as motorbikes and basic appliances. In contrast, the upper-middle-class invests in luxury items, entertainment, property, and personal services, with a higher propensity to own assets like cars, computers, and air conditioners. Both segments of the middle class are substantial and emerging as key drivers of consumption and economic growth in India. Recent policies, including the Mahatma Gandhi National Rural Employment Guarantee Act, have increased rural incomes, enabling more rural households to enter the middle class. The growing, more inclusive, and politically engaged middle class reflects broader economic growth, although there is a risk of social strain if growth falters and quality job creation does not keep pace.

The forecasted above-normal southwest monsoon by the India Meteorological Department (IMD) is expected to boost kharif production and replenish reservoir levels, further enhancing rural consumption. Improvements in agriculture and rural spending are emerging as bright spots in demand conditions. The government's Budget measures, which focus on agriculture, infrastructure, and rural development, aim to increase incomes and revitalize the rural sector. These measures include transforming agricultural research, introducing new crop varieties, promoting natural farming, and

enhancing digital infrastructure for agriculture. Successful implementation of these programs, coupled with proper fund allocation, is crucial for improving farm incomes and strengthening supply chains. A shift towards diversified, high-value agricultural production, along with marketing and trade reforms, is needed to foster more inclusive, environmentally friendly, and climate-resilient agriculture.

Despite higher absolute incomes among the wealthy, the sheer size of India's middle class indicates it will become a major force in the economy, creating one of the world's largest markets. This burgeoning middle class, with its growing discretionary spending power, is poised to drive investment, generate employment, and spur further economic growth. Assuming effective reforms are implemented, and the middle class expands to over one billion people, its role will be pivotal in India's economic and social fabric, influencing a wide range of activities from consumption to employment and political change.

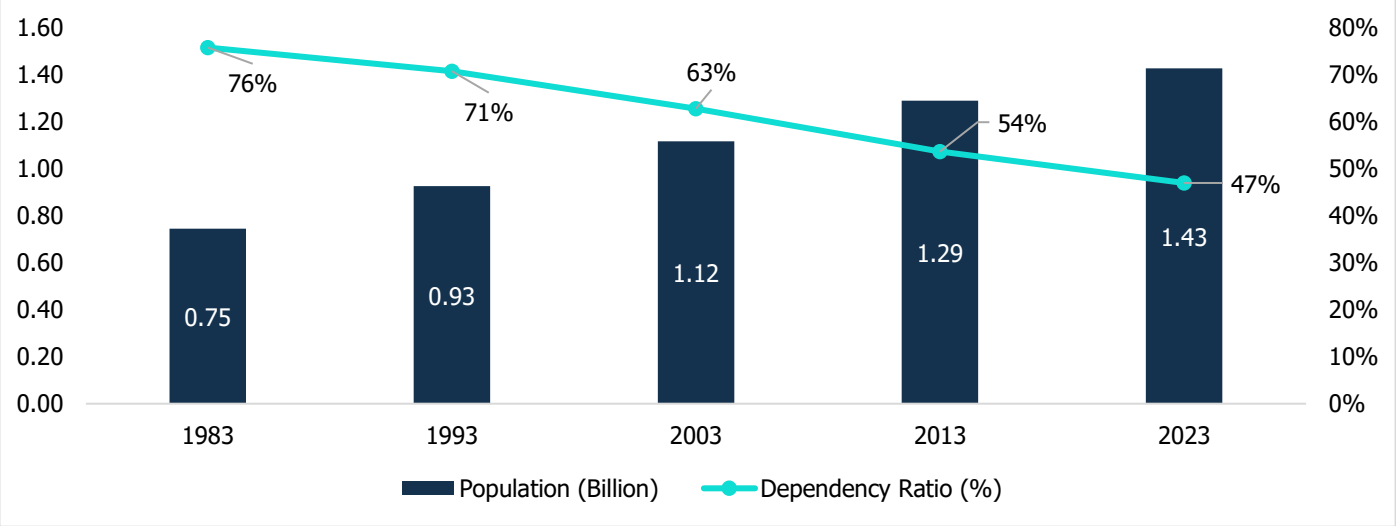
1.2.8 Overview on Key Demographic Parameters

- **Population growth and Urbanization**

The trajectory of economic growth of India and private consumption is driven by socio-economic factors such as demographics and urbanization. According to the world bank, India's population in 2022 surpassed 1.42 billion slightly higher than China's population 1.41 billion and became the most populous country in the world.

Age Dependency Ratio is the ratio of dependents to the working age population, i.e., 15 to 64 years, wherein dependents are population younger than 15 and older than 64. This ratio has been on a declining trend. It was as high as 76% in 1983, which has reduced to 47% in 2023. Declining dependency means the country has an improving share of working-age population generating income, which is a good sign for the economy.

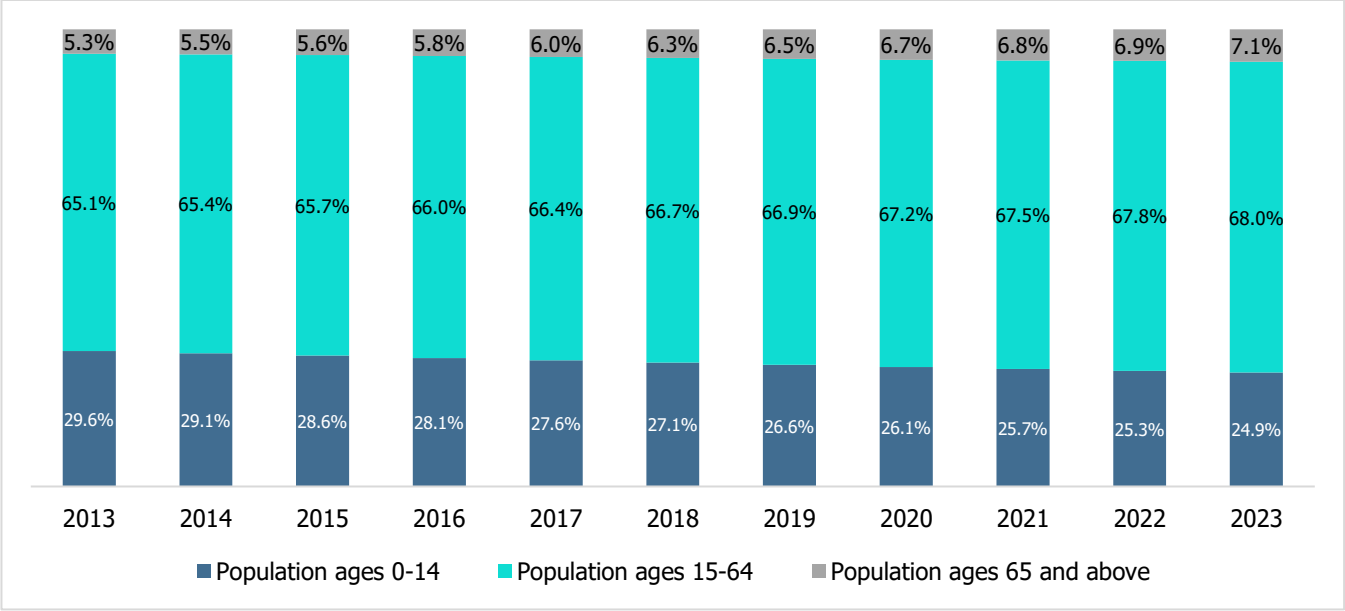
Chart 8: Trend in Population growth vis-à-vis dependency ratio in India



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.

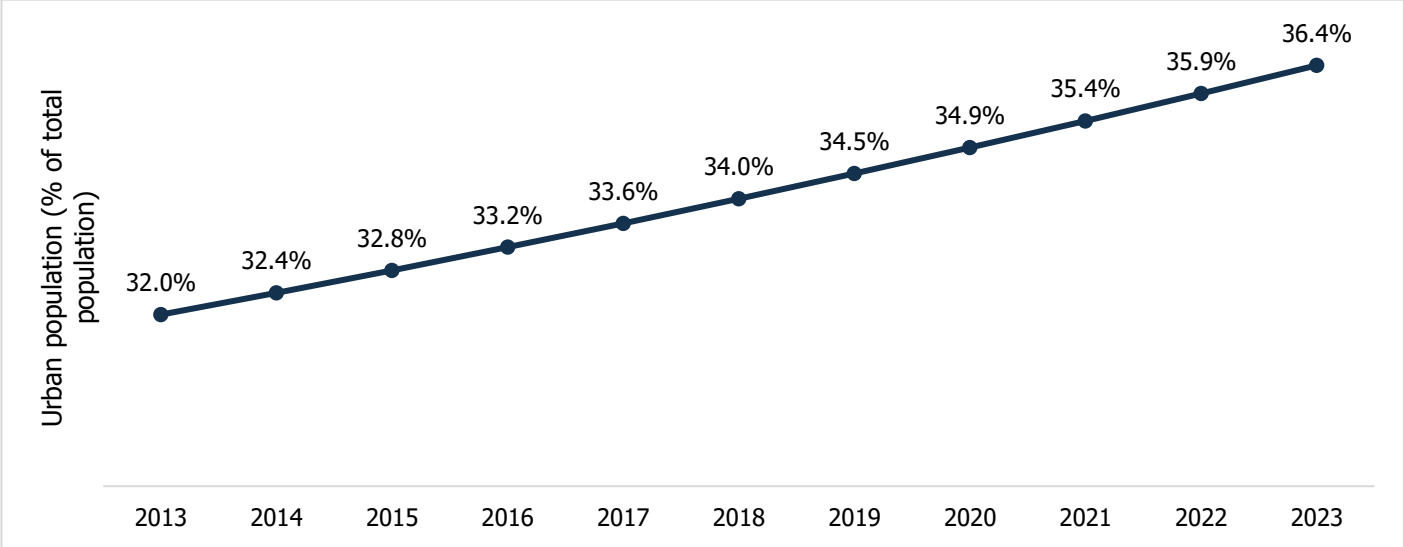
Chart 9: Age-Wise Break Up of Indian population



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 10: Urbanization Trend in India



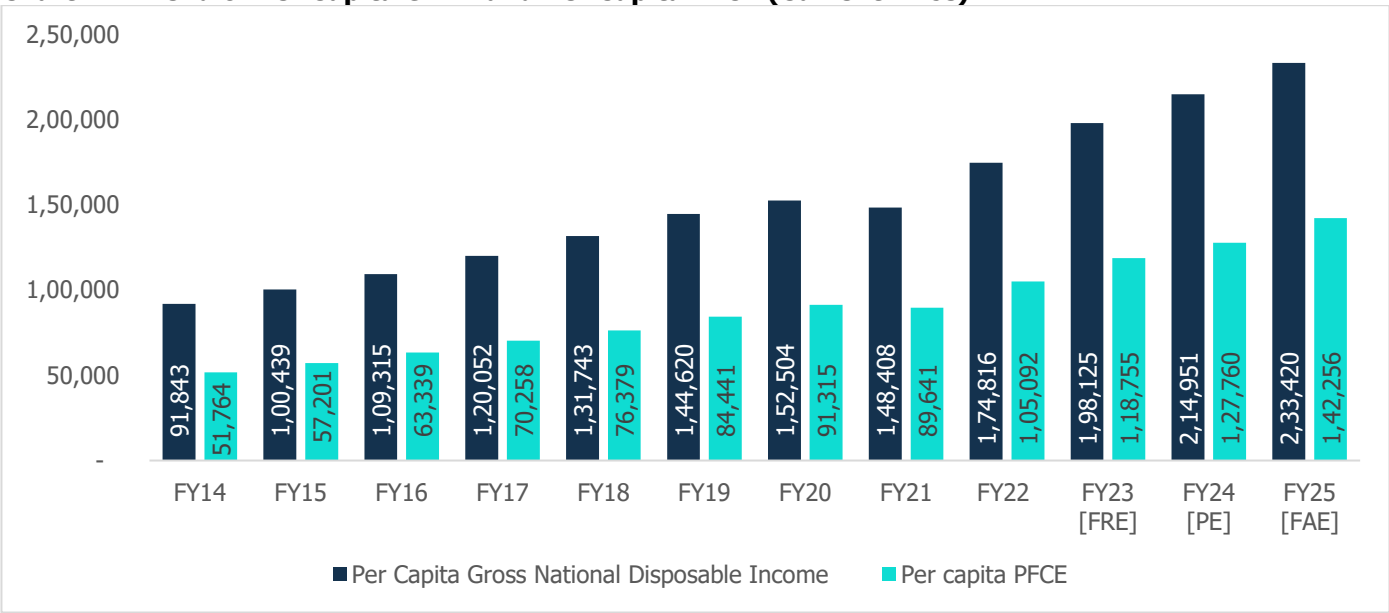
Source: World Bank Database

- **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 FY25, per capita GNDI at current prices registered a CAGR of 8.85%. 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 from FY14 to FY25 at a CAGR of 9.63%.

Chart 11: Trend of Per Capita GNDI and Per Capita PFCE (Current Price)



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

1.2.9 Concluding Remarks

Global economic growth faces headwinds from geopolitical tensions, volatile commodity prices, high interest rates, inflation, financial market volatility, climate change, and rising public debt. However, India's economy remains relatively strong, with an IMF forecast of 7% GDP growth in CY24, compared to the global projection of 3.2%. Key drivers include strong domestic demand, government capital expenditure, moderating inflation, and improving business confidence.

Public investment is expected to exhibit healthy growth as the government has allocated a strong capital expenditure of about Rs. 11.21 lakh crores for FY26. 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.

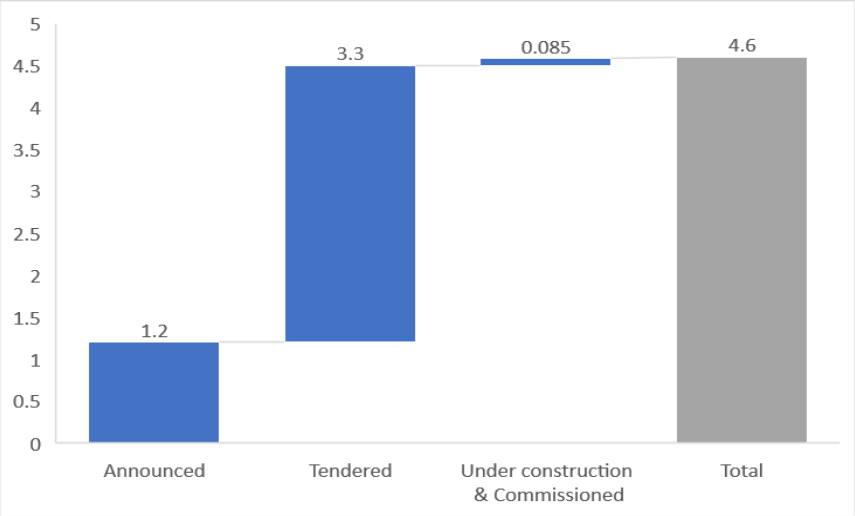
2 Storage Solutions and Power Backup Solutions in India

2.1 Overview of Storage Solutions and Power Backup

The demand for electricity fluctuates throughout the day while the amount of electricity generated is relatively fixed.A major breakthrough in electricity system is developing technology for storage of electricity so it can be available to meet demand whenever it arises. Electricity storage devices can also help balance micro-grids to achieve frequency regulation to maintain the balance between generation and load and can also achieve a more reliable power supply for high tech industrial facilities.

A major driver for early market growth for energy storage generation will be renewable energy integration, replacement of diesel generators on island grids, industrial backup up applications, and use of remote equipment. India has committed to increase its share of non-fossil fuel based generation sources to 50% by 2030 which requires flexibility in power systems. The 'Power for All' target of 24X7 electricity for all had created an increased power requirement and the need to balance the supply and demand of electricity. Hence Energy storage solutions plays a crucial role in increasing the system's overall flexibility. Energy Storage Systems (ESS) is emerging as an essential part of the evolving clean energy in 21st century. Energy storage is going to play an important part in grid integration and management of Renewable Energy as the share of renewable energy in the grid increases.

Chart 12:ESS Capacity under various stages of development in India (GW) by 2030

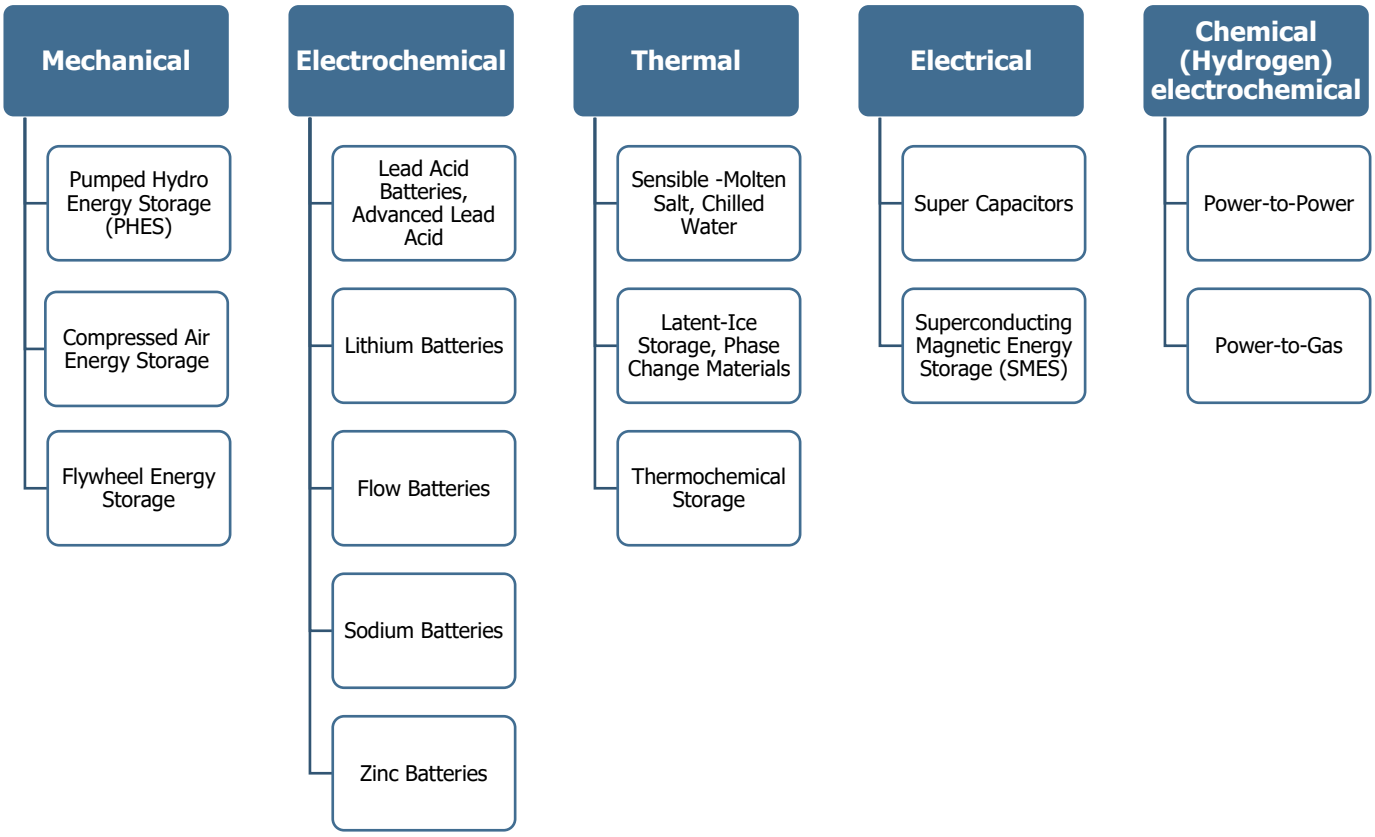


Source – NITI Aayog, CareEdge Research

Energy storage solutions are a set of methods and technologies that are used to store energy. This stored energy is later drawn upon for a number of operations.

There are various methods to store different forms of energy and hence the various types of storage technologies depend on application, economics, integration within the system and availability of resource. Energy storage technologies vary depending upon on the type of energy used for storage.

Chart 13: Classification of Energy Storage Technologies



Energy storage ranges from pumped hydro storage, flywheel, super capacitors, compressed air, flywheels, super capacitors, thermal energy storage, batteries including lithium, etc. depending on the type of technology used. Dispatching electricity within seconds and providing back-up ranging from minutes to many hours are some of the features of advanced energy storage technologies.

Table 5: **Characteristics of Energy Storage Systems**

Energy Storage Technologies	Max Power Rating (MW)	Discharge Time	Max Cycle/ Lifetime	Energy Density (watt-hour per liter)	Efficiency
Pumped Hydro	3,000	4h-16h	30-60 years	0.2-2	70-80%
Compressed Air	1,000	2h-30h	20-40 years	2-6	40-70%
Thermal	150	Hours	30 years	70-210	80-90%
Li-ion Battery	100	1 min-8h	1,000-10,000	200-400	85-95%
Lead-acid Battery	100	1 min-8h	6-40 years	50-80	80-90%
Flow Battery	100	Hours	12,000-14,000	20-70	60-85%
Hydrogen	100	Mins-week	5-30 years	600	25-45%
Flywheel	20	Secs-mins	20,000-100,000	20-80	70-95%

Source: World Energy Council, CareEdge Research

The above list only includes large storage capacity (of at least 20 MW) and excludes the superconducting magnetic energy storage and supercapacitors (less than 1 MW).

Power Backup solutions

There are three types of power backup solutions: Diesel Generator, Uninterruptible Power Supply (UPS) and Inverter.

UPS: A UPS is an electrical system that provides emergency power when the main power fails. When there is supply of power available, it supplies power to the load as well as charges the battery and in case of an outage, the charged batteries immediately supply power to the load. UPS systems can be set up to alert file servers to shut down properly in case of an outage.

Inverters: An inverter is a device that provides power backup by converting DC power from a source (battery) to AC voltage for powering electric equipment and electronics rated at the AC mains voltage. The basic circuit of the inverter include oscillator, control circuit, and drive circuit for power devices, switching devices and transformer.

Inverters are also used to ensure seamless electricity supply to electrical gadgets by using batteries and renewable energy sources like solar and wind.

Solar Inverters is an electrical converter which changes the direct current electricity captured by solar panels into alternating current required for electrical circuits and domestic appliances. Solar high capacity inverters are mainly used for power sector. These inverters are used to store excess solar power that a solar plant produces and supply it to the grid during high demand.

Diesel Generator: A diesel generator is a system that converts the chemical energy in diesel to electrical energy. It is a combination of diesel engine with electric generator and used to generate electricity where there is no connection of power grid or as an emergency power-supply if the grid fails.

While in inverters, the main purpose of the device is to convert DC to AC. The main difference between an UPS and the inverter is the switching time. The switching time of UPS from the main supply to the battery is almost immediate while the inverter takes more time. The main purpose of the UPS is to supply uninterruptable power to devices while for an inverter is to convert DC to AC power.

Previously, for power backups, diesel generators were more commonly used, but due to rising cost and storage challenges of diesel, the shift has happened from diesel generators to power inverters.

The prevalent power outages worldwide and rising demand for power and standby power systems are driving the power backup market. There is a requirement of uninterrupted power source requirement for all residential, industrial, IT/ITeS, BFSI, SME, solar, telecom, hospitals, data centers, communication and retail, education, government, etc. Indian UPS market is growing because of growing installation of high-end electrical equipment and machines and hence commercial sector is expected to have the largest share in the power backup sector. There has also been a change in behavioral pattern of consumers. Earlier in rural areas or small cities/towns, there was tolerance of power cuts by the people but due to the change they are now opting for power backup solutions. There is also growing need for continuous and smooth power supply in various residential uses.

Though the outlook of power backup solutions is positive, there is a need for lookout for new trends in advanced technologies like Internet of Things and smart grids-based systems. This will help UPS and inverters to go beyond traditional usage. For the overall development of the industry, research and development has become one of the major focus areas. Also, cross selling platforms for low-voltages products are expected to bring higher visibility amongst end users.

New technologies like integration of power backup systems along with renewable energy is gaining attention. Power backup solutions manufactures are also investing on creating efficient, highly reliable and robust designs with low cost options.

2.1.1 UPS Market in India

The power back-up systems market is growing due to the problem of power shortage in the country and with the technological advancements. The gap between the demand and supply of power in the country is increasing the demand for uninterrupted power supply by the industrial sectors.

The UPS are used to prevent damage from power loss and common electric occurrences, prevention of loss of data, it prevents connectivity issues. It provides clean, continuous power and is used in various sectors like banking, power, manufacturing, transportation, retail, healthcare, and entertainment, etc.

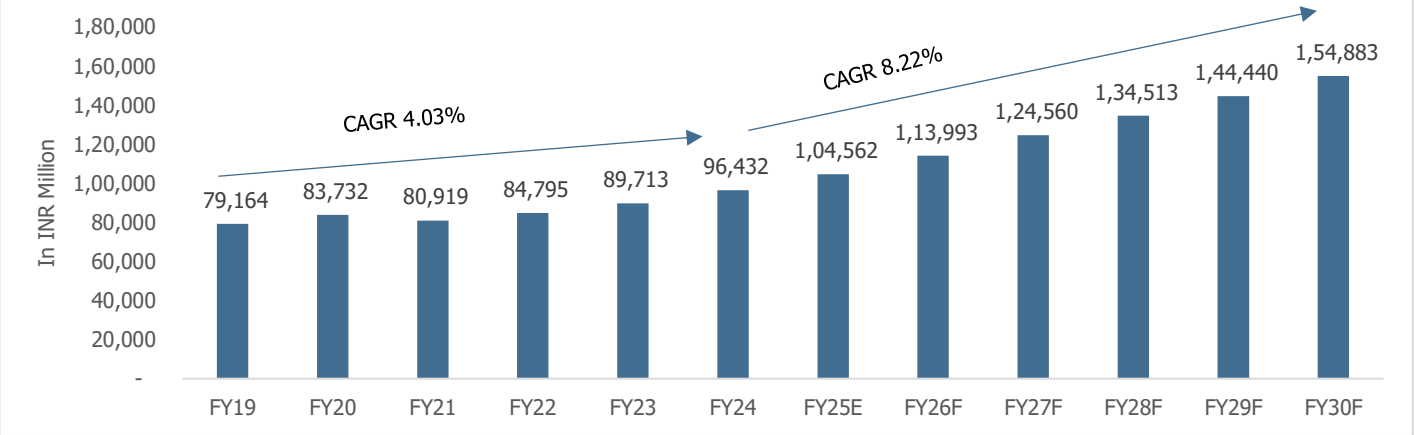
The difference between an inverter device and a UPS is that an inverter is a power backup device while the UPS provides backup as well as power conditioning. Since typically, UPS system provide surge suppressions and voltage regulations, it helps in power conditioning too. The integral part of the UPS is the battery bank since it acts as back-up power source that supports the UPS system. The most common battery system being used in the UPS is the Lead Acid battery system.

The Indian UPS Market has been showcasing an upward trend generating revenues of Rs 96,432 million in FY24 while it was at Rs 89,713 million in FY23. Power outages often affect the commercial and industrial sectors and these industries need power backup solutions. UPS has emerged as a very important appliance since it helps to save important data centers, servers, electronics and medical equipment as they require high amount of uninterruptable power supply.

The market is further expected to grow at a CAGR of 8.22% till FY30. This growth of 8.22% is due to rising dependence on electricity in the country, expanding commercial and industrial segments, and with power outages being a frequent occurrence; especially during peak hours, an uninterrupted power supply has become mandatory.

Further, the government's focus on clean energy and the decentralization of the power grid through off-grid renewable resources, such as wind and solar power, has accelerated the adoption of green UPS systems in India, creating new opportunities in the Indian UPS market. Initiatives like 'Make in India' and the increasing preference for local products under the 'Vocal for Local' campaign positions India to become a global manufacturing hub by 2030. The presence of large industrial clusters, especially in the western and southern regions, has attracted numerous original equipment manufacturers (OEMs), supported by favorable schemes and policy frameworks from both state and central governments.

Chart 14: India UPS market size and outlook



Source – TechSci Research, CareEdge Research
Note – Data is for FY, A – Actual, E – Estiamted, F – Forecasted

2.1.1. 1 Overview of the UPS Market

2.1.1. 2 Market size by type

The UPS systems are divided into 3 major categories by the type of UPS configuration. They are online double conversion, line-interactive and offline. These systems are defined by how power moves through the unit.

a. Online UPS

The term online UPS refers to the fact that there is a continuous electricity supply to the device even when the conditions are optimal. The online UPS is a system where in the UPS is always performing rather than just springing into action when there is an emergency. This means that even when there is a power loss or not, there is a constant flow of stable power. The online UPS consists of a combination of double conversion power circuit and an inverter.

In a double conversion online UPS, AC power is stable and clean upon generation but during the transmission and distribution, it is subject to various irregularities like voltage sags, spikes and complete failure. Hence the online UPS takes the incoming AC current, converts it into DC using a rectifier and feeds it to the battery and connected load via the inverter. This type of UPS protects the critical load from all power disturbances and hence is used for protecting large data centers, critical machinery, medical equipment, etc. by always providing highest level of power quality to the load.

b. Line-interactive

The Line-interactive UPS system provides both power conditioning and battery backup. This system is generally used in areas where outrages are rare, but power fluctuation is common. In the line-interactive system, the inverter is a part of the output and is always on. The inverter operates in reverse to charge the battery while AC input is normal and switch to battery power when input fails which provides filtering and voltage regulations.

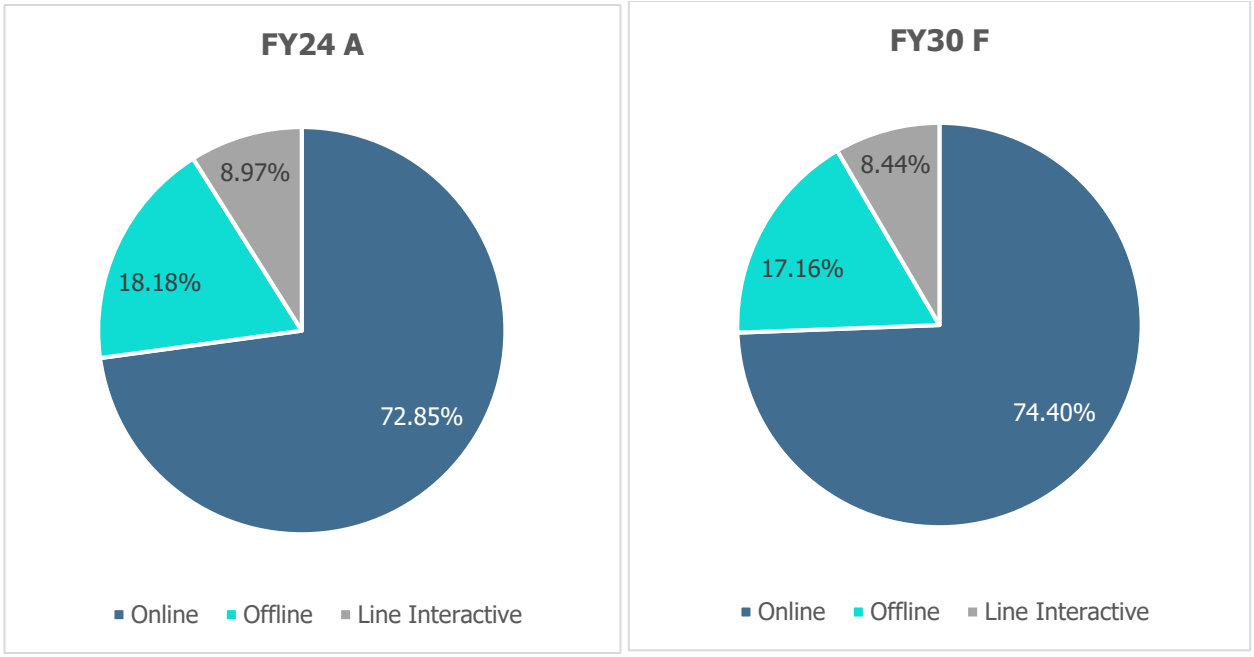
Advantages of a line interactive UPS is high efficiency, small size, low cost and high reliability, and voltage conditioning.

c. Offline

Offline UPS is also called as standby or battery backup. When there is a continuous energy flow from the socket, the UPS system will be bypassed but if the UPS identifies an abnormality the offline power supply switches to the internal battery backup. The offline UPS consists of AC/DC & DC/AC inverter with a battery, switch, low pass filter and a surge suppressor.

The offline UPS is not as high-grade as the online UPS, but they are functional and cost-effective option for domestic purpose. It's main advantages are that it is small in size, low cost and high efficiency.

Chart 15: Indian UPS Market share by type for FY24 and FY30



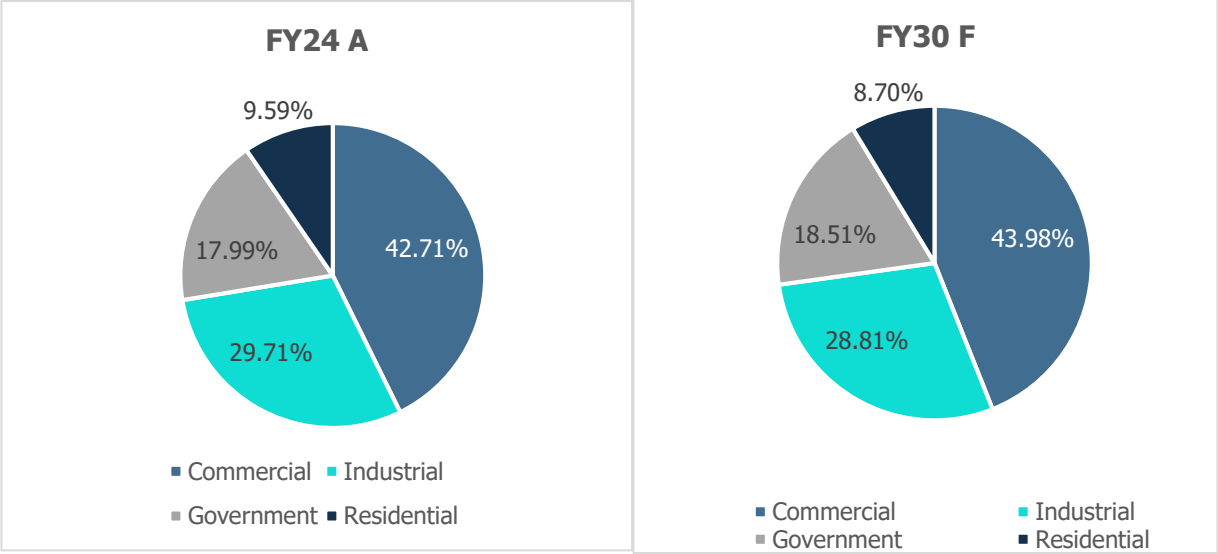
Source – TechSci Research, CareEdge Research

Online UPS systems has the largest market share owing to high performance output and protection from input voltage spikes and distortions. Offline UPS is widely used as a power backup for computers in various IT industries. Online UPS system forms the majority part of the UPS market with 72.85% share in FY24. Even in future years, the trend is expected to continue with Online UPS sytem leading with 74.40% market share followed by offline UPS market system. The market share of line is declining with 8.97% in FY24 and 8.44% in FY30.

2.1.1. 3 Market size by application

Based on application, the commercial sector owns the biggest share in the Indian UPS Market owing to the vast demand and applications of UPS. New trends in industrial applications is transforming industrial processes by incorporating new technologies into production processes, and hence creating new demand for IT systems and UPS. The trend on application has been constant in previous years and is expected to remain same. Also, government initiatives like Digital India are creating new opportunities which are providing ample scope for the UPS market to grow.

Chart 16: Market size of UPS by application

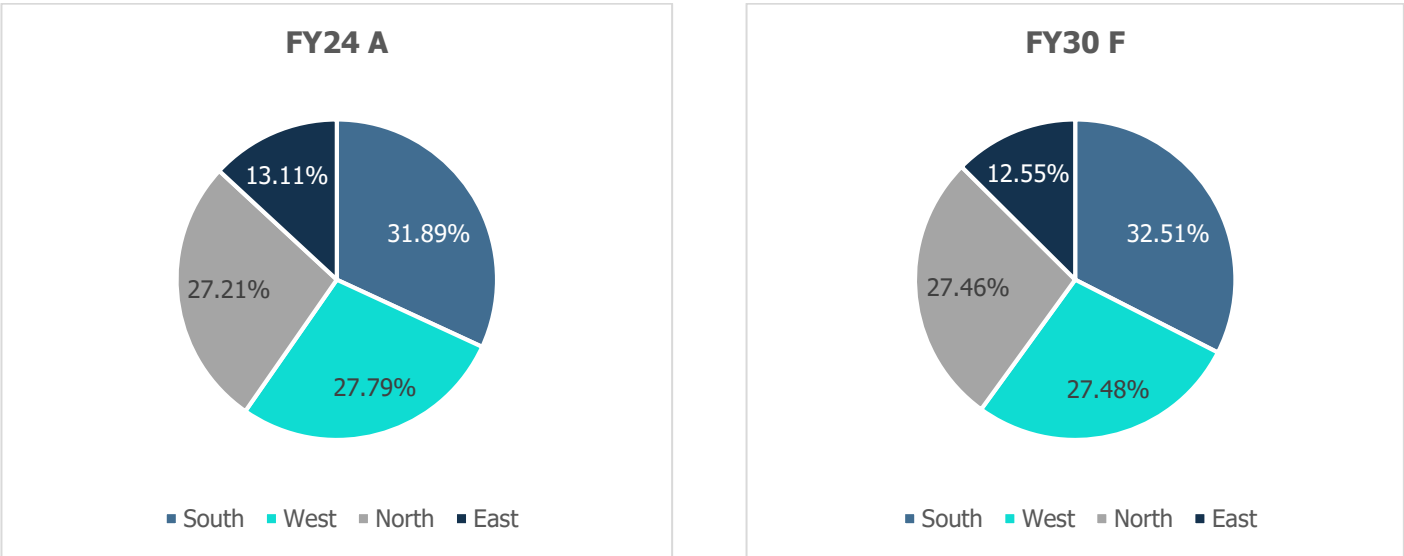


Source – TechSci Research, CareEdge Research

2.1.1. 4 Market size by region

Cities in southern India like Bangalore and Chennai are home to major IT companies and have high power requirement, which makes South India a major shareholder in the Indian UPS market. The growth is due to various parameters such as number of factories, power requirement, number of hospitals, number of manufacturing plants, etc. South India is followed by West India, especially in the state of Gujarat.

Chart 17: Market size of UPS by region



Source – TechSci Research, CareEdge Research

2.1.2 Overview of the Battery Market including Lithium cells in India

A battery is device with one or more electrochemical cells and majorly works on the principle of electromotive force. Based on battery type, their market is divided into lithium-ion batteries, lead-acid batteries, nickel batteries, flow batteries and others. Even though lead-acid batteries are the most common type of battery, lithium-ion batteries is gaining popularity due to various applications in end user industries such as renewable, telecommunication, and power generation industries. It also has the benefit of being rechargeable battery and hence is used for portable electronics and electric vehicles. The Li-ion battery market is majorly dominated by the electric vehicle sector which consumes 60% of the Li-ion batteries.

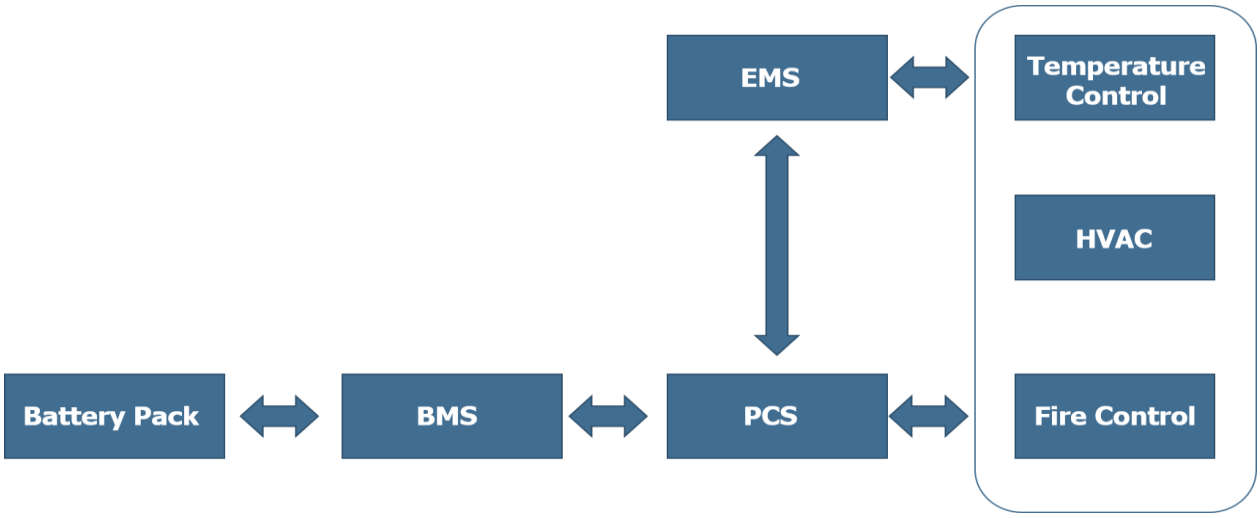
Battery Energy Storage Systems

Energy storage systems collects energy from different sources including solar arrays and electric grid, accumulates and stores this energy in rechargeable batteries for later use. A battery energy storage system (BESS) is a compound system that contains various hardware and software components. The main components of the battery energy storage system (BESS) are as follows:

- **Battery system**- A battery system contains individual batteries that are arranged in modules and that in turn is in the form of battery packs. These batteries convert chemical energy into electrical energy.
- **Battery Management System (BMS)** - The battery management system ensures the safety of the battery system. Monitoring the condition of battery cells, measuring the state-of-charge (SOC) and state-of-health (SOH), protecting the batteries from fires and hazards are the functions of the battery management system.
- **Power Conversion System (PCS)** - The power conversion system (PCS) converts the direct current by batteries into alternating current supplied to the facilities. The bi-directional inverters are present in the battery energy storage systems to allow the charging and discharging.
- **Energy Management System (EMS)** - The energy management system is responsible for the monitoring and control of the energy flow within a battery storage system. The coordination between the work of BMS, PCS and other components of a BESS is done by the energy management system by collecting and analysing energy data.

There are other components of the BESS like safety systems such as fire control system, smoke detector, temperature control system, cooling, heating, ventilation and air-cooling systems depending on the functionality and operating conditions. These safety systems have their own monitoring and control units for the purpose of safe operations of the BESS.

Chart 18: Battery Energy Storage Systems Architecture



BESS collects energy from an electricity grid or renewable energy and stores it using battery storage technology. Batteries then discharge and release the energy when necessary in variety of other applications. BESS require robust software solutions along with electronics. BESSs can accommodate various kinds of batteries ranging from lithium-ion, lead-acid, nickel-cadmium and others. Each type of batteries has certain technical specifications that BESS uses and hence the efficiency of battery energy storage varies depending upon the battery type.

BESSs vary depending on the electrochemistry or battery technology. The main type of BESS battery types are as below:

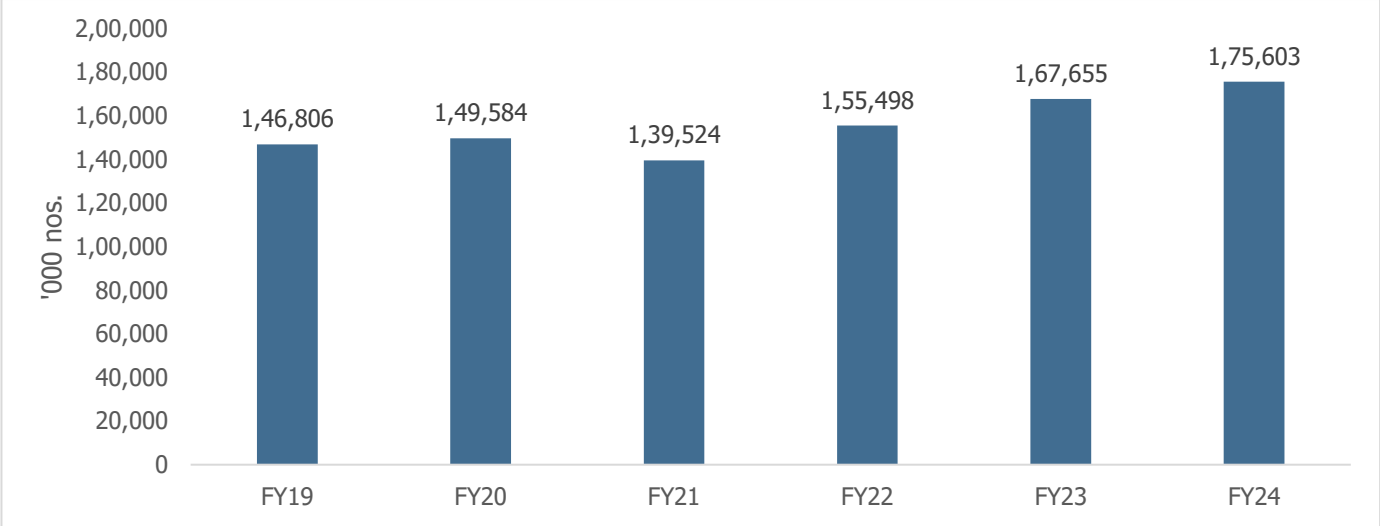
- Lithium-Ion (Li-Ion) Batteries
- Lead-Acid (PbA) Batteries
- Nickel-Cadmium (Ni-Cd) Batteries
- Sodium-Sulfur (Na-S) Batteries
- Flow Batteries

Lead Acid Batteries/Advanced Lead Acid: These batteries have been in commercial use in different applications and are most widely used battery technology worldwide. Advanced Lead Acid batteries are the high-performance variation of lead acid batteries. The growth is anticipated in the sector due to booming demand for automobiles, in addition to increasing focus of the government towards penetration of electric vehicles. Also, development of smart grids, technological developments, increase in the budget allocation and shifting government focus from conventional to renewable sources is expected to accelerate the growth in lead acid battery market in the country.

Lead acid batteries are used in various devices battery powered UPS, inverters backed by lead acid batteries widely used in homes, offices, banks, shops, schools, etc. along with in renewable energy sector where it is used for power storage.

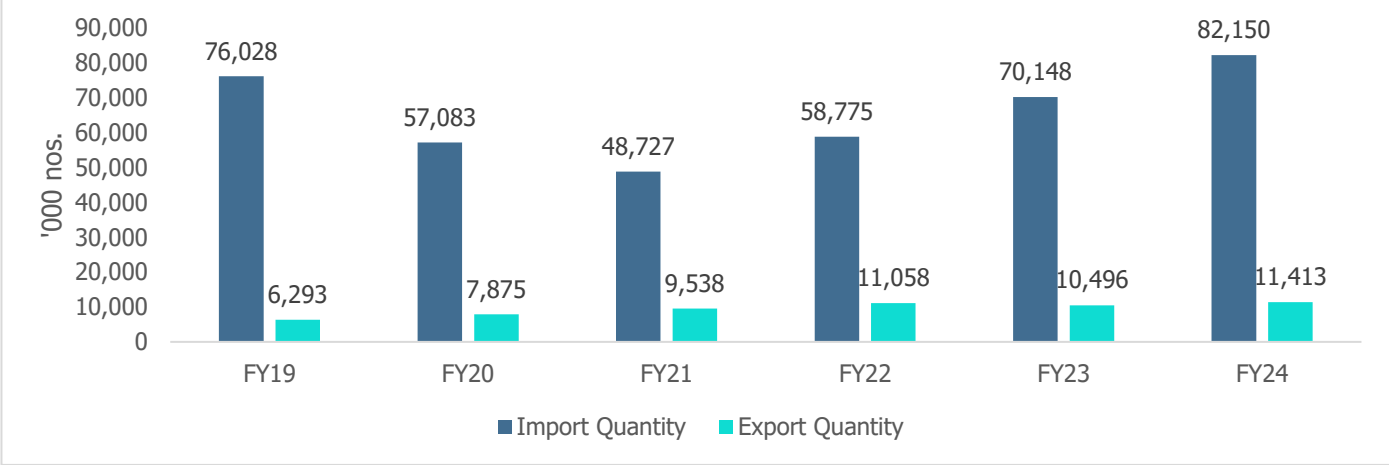
India also has sufficient lead deposits including primary and secondary (recycled). India produces 0.8-1 million tonnes of lead out of used batteries, while primary lead production is around 0.25 million tonnes. Out of the total domestic lead production, 75-80% goes for manufacturing of batteries.

Chart 19: Production of lead acid battery



Source – CMIE, CareEdge Research

Chart 20: Import and Export of Lead acid battery



Source – CMIE, CareEdge Research

Lithium Ion Batteries (LiB): Depending on the internal chemistry, there are many variations of the Lithium Ion batteries namely: Lithium Cobalt Oxide (LCO), Lithium Manganese Oxide (LMO), Lithium Titanate Oxide (LTO), Lithium Iron Phosphate (LFP), Lithium Nickel Manganese Cobalt Oxide (NMC), and Lithium Nickel Cobalt Aluminium Oxide (NCA). These batteries are particularly suitable for portable applications (EVs, electronic devices, etc.) as these are lightweight and have high energy density. The increased demand for lithium batteries is due to their application in electric vehicles.

The demand for lithium-ion batteries is driven by portable applications like consumer electronics, stationary energy storage systems and electric vehicles. The majority i.e. 80% of the demand being from EVs while 20% is from non-automotive application (energy storage). This is due to the higher charging efficiency, longer service life, lighter in weight, and low maintenance cost compared to lead acid batteries. Hence the demand potential from EV sector has been realized.

Though there is demand potential, the lithium-ion battery sector has been dormant due to unavailability of raw material like lithium, cobalt, nickel, research and development is adequate and the large-scale investment requirement is limited.

The lithium ion battery market size is expected to reach around 90 GW in 2030, with EVs accounting for majority of the demand. The end user segments of Lithium-ion are as follows:

- *Automotive*

The lithium ion battery is an integral part of the EV ecosystem. There are various favorable policies by central government like Faster Adoption and Manufacturing of Hybrid & EV (FAME) scheme Phase-II which offers incentives to EV buyers in order to boost EV adoption.

- *Non-Automotive*

The demand for renewable energy sources namely solar and wind are growing and hence there will be an increasing need to store excess energy to improve the flexibility. Lithium ion batteries are preferred due to higher charge rates and higher life cycle. Telecom operators and data centers are also shifting to lithium ion batteries and the demand is likely to increase in future.

The non-automotive market for lithium ion batteries is dominated by telecom sector. Some of the other major application segments are:

- Telecom Towers
- UPS
- Grid-scale Renewable Energy Integration
- Rooftop Solar
- Consumer Electronics
- Material Handling Equipment
- Power Tools

Chart 21: India's Annual Lithium-ion battery demand by 2025 and 2030

Segment	Sub - Segment	2025 Market size (GWh)	2030 Market size (GWh)
Mobility	2 - Wheeler	10 - 12	40 - 45
	3 - Wheeler	1.2 - 1.7	5 - 6
	4 - Wheeler	4 - 5	40 - 45
	LCV + HCV	0.9 - 1.2	3 - 4
	Buses	1 - 1.5	4 - 5
	Tractors	1 - 1.5	6 - 7
	Mobility total	**20 - 30**	**100 -110**
Stationary		**20 - 25**	**50 - 60**
Total		**40 - 50**	**150 - 160**

Source: Exide Industries, CareEdge Research

The table shows the annual targets for storing the renewable energy between 2022-23 to 2029-30. Ministry of Power's Energy Storage Obligations 2029-30 are used for estimating the utility-scale storage requirements. 19th Electric Power Survey (CEA 2022) to get India's peak energy demand (GWh) during the period is used to estimate the obligated stored energy (GWh) and corresponding batter requirement.

Chart 22: Projections for utility-scale energy storage requirement

Year	ndia's projected peak demand (BU)	Energy Storage Obligation (%)	Energy from storage (GWh)	Battery Requirement (GWh)
2023-24	1,600	1.0%	16,002	57
2024-25	1,695	1.5%	25,420	91
2025-26	1,797	2.0%	35,933	129
2026-27	1,908	2.5%	47,696	171
2027-28	2,021	3.0%	60,632	217
2028-29	2,139	3.5%	74,869	268
2029-30	2,280	4.0%	91,187	327

Source: CEEW Study based on CEA 2022 and MoP 2022

*Assumptions for battery capacity: 1 cycle/day with 85% roundtrip efficiency and 90% depth of discharge.

The cumulative energy storage demand from grid applications comes about 327 GWh by 2030. India can capture significant value within local economy with the help of successful local battery manufacturing industry and supportive local supply chain. NITI Aayog estimates the market size of battery sector to be around USD 2 billion in FY22 and in the accelerated case scenario, the market size for stationery and mobile batteries could surpass USD 6 billion by 2026 and USD 15 billion by 2030.

In order to meet the demand for battery with domestic supply, India will require rapid buildout of battery manufacturing. To increase the development for advanced cell batteries, policy push and demand-supply incentives is required. The PLI scheme promises to put India in strong global position and realize its full value from its technology.

Budget Focus on Green Growth for Sustainable Development

- Focus on Green Growth, emphasis on Hydrogen energy and battery storage.
- Under the "Panchamrit" goal set up by COP26 forum, Battery Energy Storage Systems (BESS) with a capacity of 4000 Mwh will be supported by viability gap fund. Further, a detailed framework for pumped storage projects will be formulated. This proposal is expected to incentivise the setting up of utility-scale storage projects as the VGF shall improve its cost competitiveness.

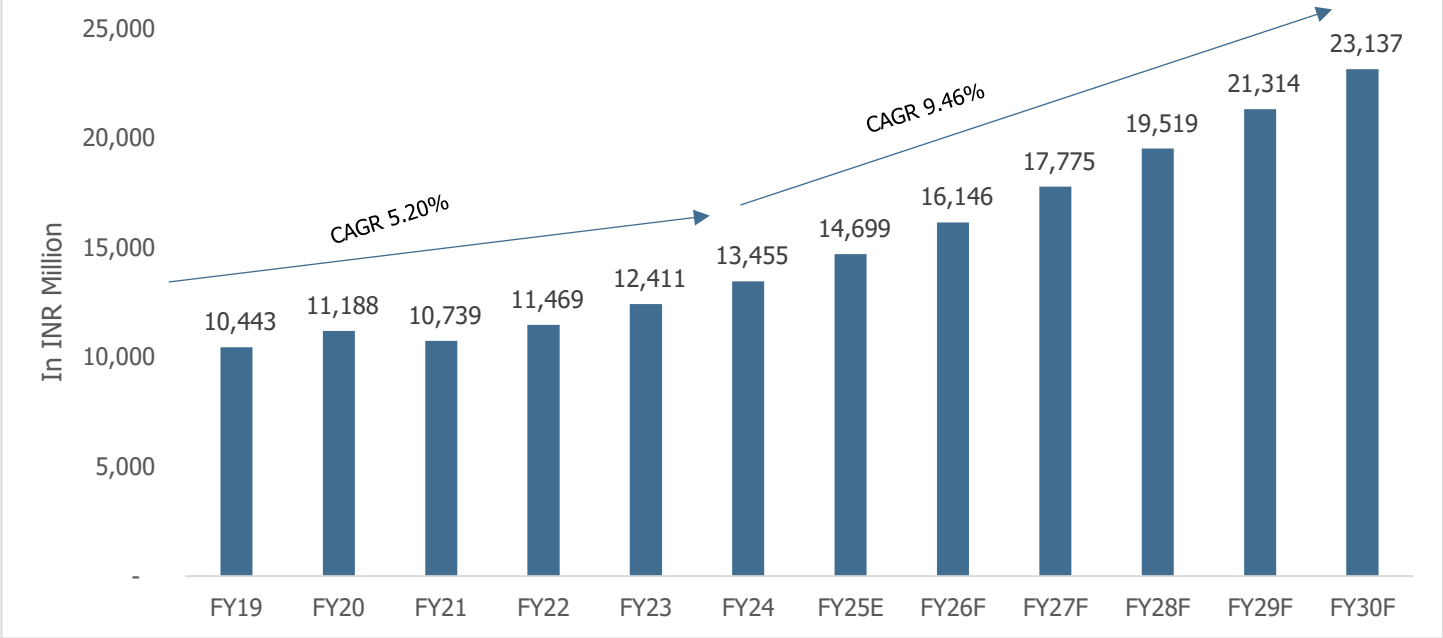
2.1.3 Overview of Servo Stabilizer Market in India

A servo stabilizer is a servo motor-controlled stabilization system that performs the function of providing optimum voltage supply by capturing voltage fluctuations from input and regulates current to the output. There are two types of stabilizers; one is relay and other is servo based. In relay stabilizer, the switch corrects the output voltage accuracy at +/-10% while in servo stabilizer, it provides +/-1% voltage output where input voltage alters up to +/-50%. The major difference between the two is that servo is a stepless correction technologically superior to the traditional relay transformers.

There are a lot of advantages of servo stabilizers, like precision of high voltage correction with output correction of +/-1% voltage, modify the variable voltage on desired levels, inbuilt pass system, strong loading power up to and above 5,000 KVA, tension is based on less correction phase and great stability for complex machines like X-Ray, CT Scan radiation, etc. Also, superior properties including stabilizing large and small fluctuations in the current and thereby avoiding uncertain casualties improves overall machinery life. There is necessity for servo stabilizers to avoid high replacement cost of equipment in several end-user industries.

The servo stabilizers market is driven by the growing demand for cost effective voltage stabilization solutions in numerous industries. Growing trends in urbanization, development in technology and heavy engineering sector is likely to fuel growth of servo stabilizers in near future. Rising demand for servo stabilizers in the commercial sector is another driving force which is expected to boost the market.

Chart 23: Servo stabilizer market in India



Source – TechSci Research, CareEdge Research

The Indian Servo Stabilizer market has reached Rs 13,455 million in FY24 and is expected to reach Rs 23,137 million in FY30 growing at CAGR 9.46%. The market is primarily driven by growing demand from end user industries. Moreover, increasing research and development spending for development in new products and equipment will propel product demand in the future.

2.1.4 Solar EPC Market in India

2.1.4.1 Overview of Solar EPC market

In the solar industry, Engineering, Procurement, and Construction is referred to as EPC. Solar EPC (Engineering, Procurement, and Construction) offers a comprehensive method for creating and implementing solar power projects.

The Solar EPC providers offer comprehensive solar energy services, which include system design, system purchase information, and system installation. The provider ensures a smooth and effective process from project inception to operational status by taking complete responsibility for the design, procurement, and construction of a solar power system.

Engineering: The solar power system's intricate design and planning are done during the engineering phase. This comprises:

- *Site assessment:* Analyzing the site to determine its suitability for sunlight, shade, and space limitations.
- *System design:* It is the process of developing technical standards for the mounting systems, inverters, solar panels, and other parts. Engineering calculations are also required in order to maximize system performance and guarantee adherence to regional norms and laws.
- *License:* Obtaining the required permissions and making sure the design complies with all legal and safety criteria require navigating the regulatory environment.

Procurement: Purchasing the tools and supplies required for the project is referred to as procurement. This comprises:

- *Sourcing:* Choosing and acquiring premium solar panels, inverters, batteries and additional parts is known as equipment sourcing.
- *Management:* Vendor management is the process of working with suppliers and manufacturers to guarantee prompt delivery and high standards of quality.
- *Logistics:* Organizing the delivery and transportation of supplies to the installation location.

Construction:The design is implemented throughout the building phase. It includes:

- *Installation:* Putting the solar panels, inverters, mounting mechanisms, wiring, and other infrastructure pieces together and getting them in place.
- *Testing:* Verifying the system's safe and effective operation through testing. System inspections and performance tests are included in this.
- *Integration:* Assuring that the solar power system satisfies all operating requirements and, if required, connecting it to the local grid.

The Solar EPC market was recorded at Rs 135,464 million in FY24 and has grown at a CAGR of 4.97% between FY19 and FY24. It is further expected to reach Rs 2,22,112 million by FY30.

The Solar EPC market is poised for significant growth due to the country's strategic focus on increasing renewable energy capacity and achieving solar energy targets. The government's commitment to the sector is highlighted by the National Solar Mission, which aims to achieve 100 GW of installed solar power capacity by 2030. The policy framework, along with other state-specific incentives, has established a favorable environment for solar energy investments and growth in the Solar EPC Market.

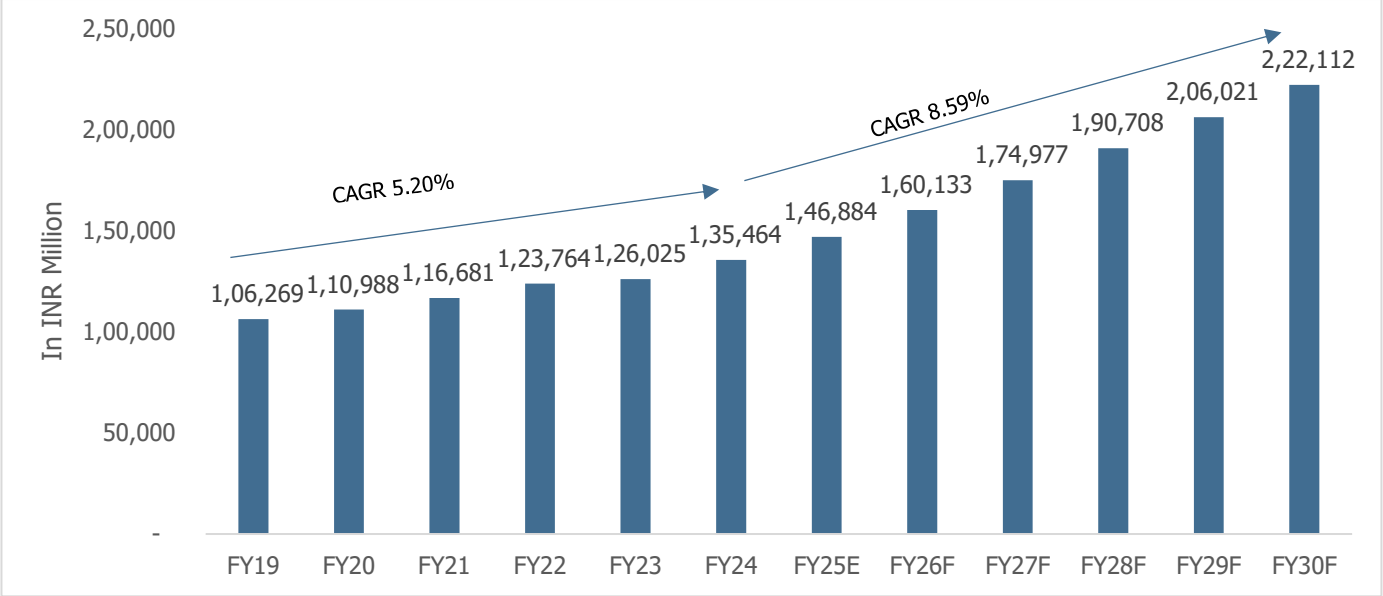
The Indian Solar EPC Market is currently experiencing strong activity due to the rise in large-scale solar installations and rooftop solar projects. Solar power has become more economically feasible as a result of the decreasing cost of solar photovoltaic (PV) technology and advancements in solar cell efficiency and manufacturing processes. The improved attractiveness of solar projects for investors and developers is a direct result of the continuous decline in the cost of solar modules. Additionally, the overall efficiency and reliability of solar power systems are being enhanced by the integration of energy storage solutions and smart grid technologies.

Furthermore, there is a growing market for rooftop solar installations, driven by lower installation expenses and favorable policies like net metering and accelerated depreciation. Opting for rooftop solar EPC services presents an opportunity to tap into the expansion within the residential, commercial, and industrial sectors. Additionally, the rise in urbanization and energy requirements in urban areas enhances the prospects for rooftop solar solutions.

The need for clean energy solutions is also being driven by rising environmental consciousness and the need to cut carbon emissions. India's renewable energy strategy places a strong emphasis on solar power, which is becoming more and more popular in the commercial, industrial, and residential sectors. This is driving up market growth.

Large-scale solar farms are also a key area of growth, supported by supportive policy frameworks and government incentives. High-insolation project locations offer economies of scale, steady income streams, and long-term power purchase agreements (PPAs) that draw significant investment.

Chart 24: Solar EPC market in India



Source – TechSci Research, CareEdge Research

2.1.4.2 Total Investment in Solar power over FY24 - FY27 & EPC Opportunity

In the field of renewable energy, especially solar power, India has become a global leader. The nation is poised to revolutionize its energy environment with significant investments, strong governmental backing, and ambitious goals. Driven by government initiatives, private sector participation, and technology improvements, India has a substantial investment in solar power and has major prospects for Engineering, Procurement, and Construction (EPC) businesses.

Government initiatives and investments:

- As part of its National Solar Mission, the Indian government has set a goal to reach 100 GW of solar capacity by 2030. Many programs and policies have been put in place to promote this goal, resulting in significant spending. Large sums of money have been set aside by the government to create solar parks, subsidize rooftop solar arrays, and promote solar manufacturing.

- The Kisan Urja Suraksha evam Utthaan Mahabhiyan (KUSUM) program is a prominent initiative that endeavors to establish solar power plants and solar pumps that are connected to the grid in rural regions. Billions of dollars have been invested in this program alone, which encourages decentralized solar power generation and eases the load on the national grid.

Private sector participation:

- Private sector involvement is crucial in achieving India's solar energy targets. Companies like Adani Green Energy, Tata Power Solar, and ReNew Power have made significant investments in large-scale solar projects. For instance, Adani Green Energy has committed to investing over Rs 1,12,0000 million to develop 25 GW of

renewable energy capacity by 2025. Similarly, ReNew Power plans to add 4.8 GW of solar and wind capacity annually, accounting for 10.1% of the total capacity.

- International investors are also showing keen interest in India's solar market. For instance, Adani Green Energy Limited (AGEL) announced the completion of its 1,050 MW joint venture (JV) with TotalEnergies. As part of this JV, TotalEnergies invested Rs 25.17 billion in an AGEL subsidiary, acquiring 50% stakes in the project. This transaction follows the binding agreement announced between AGEL and TotalEnergies in September 2023. The JV includes a 1,050 MW portfolio, comprising a mix of already operational (300 MW), under construction (500 MW), and under development assets (250 MW), with a blend of both solar and wind power projects across India. This collaboration further strengthens TotalEnergies' strategic alliance with AGEL and supports AGEL's target of achieving 45 GW of renewable energy capacity by 2030.

EPC Opportunities in Solar Power

- For EPC companies, the growth of solar parks in several states presents a sizable market. The scope of the prospects is demonstrated by projects like the Pavagada Solar Park in Karnataka and the Rewa Ultra Mega Solar Park in Madhya Pradesh. To ensure timely and effective completion, these large-scale projects require comprehensive EPC services, including design, material procurement, and construction management. The market share and reputation of the participating EPC businesses are improved by the successful completion of such projects.
- For EPC businesses, rooftop solar systems represent yet another profitable market. The need for EPC services in the commercial, industrial, and residential sectors is rising as a result of government subsidies and incentives supporting rooftop solar installations. Companies offering complete end-to-end EPC solutions for rooftop installations, such as Azure Power and Tata Power Solar, are at the forefront of the industry. These services address a variety of client demands and aid in the decentralized production of solar energy. They include site evaluation, system design, installation, and maintenance.
- Hybrid renewable energy initiatives, integrating solar and wind power, are increasingly popular in India. The Gujarat Hybrid Renewable Energy Park, poised to become the largest globally with a 30 GW capacity, exemplifies the opportunities for EPC (Engineering, Procurement, and Construction) firms in these cutting-edge projects. Managing the complexities of hybrid systems demands sophisticated technical skills and comprehensive solutions. EPC companies that provide effective, dependable, and adaptable solutions are strategically placed to benefit from this expanding market sector.
- Energy storage solutions combined with solar power systems are becoming more crucial for maintaining grid stability and ensuring energy reliability. Projects such as the Ananthapuramu - II Solar Park in Andhra Pradesh, which features battery storage, underscore the growing need for EPC services that integrate advanced technologies. EPC companies that provide comprehensive solar and storage solutions can strengthen their value proposition, draw in additional clients, and broaden their market footprint.
- The Indian solar power sector is also gaining from green financing and innovative financial tools. Green bonds, sustainability-linked loans, and specialized renewable energy funds are streamlining the flow of capital into solar initiatives. EPC companies can utilize these financial mechanisms to aid in project development and implementation, ensuring funding is available for extensive and intricate projects.

2.1.4.3 Solar projects pipeline of Public sector entities

NTPC Renwable Energy Ltd:

- NTPC Renewable Energy Ltd's first solar project. (NTPC-REL) in Chhattisgarh has announced the start of commercial operation with a capacity of 70 MW on February 21, 2024. With this, the installed capacity of the NTPC Group has reached 73,958 MW. Currently, NTPC-REL is also implementing 17 projects with a total capacity of 6000 MW.
- The project is designed to generate 370 million units of electricity per year, sufficient for 60,000 households, and save 3 lakh tonnes of CO2 emissions and 1000 MMTPA of water per year. That's enough for more than 5,000 homes a year.

Raghanesda Solar Power Station

- In February 2024, SJVN Limited commissioned its 100 MW solar power plant in Banaskatha district, Gujarat, reinforcing its commitment to sustainable energy solutions. This project generated 252 million units of electricity in the first year and is estimated to generate 5,805 million units of electricity in 25 years.
- Under a long-term power purchase agreement signed in January 2022, the power generated by Raghanesda solar power plant has been supplied to Gujarat Urja Vikas Nigam Limited (GUVNL) for 25 years.
- With the addition of this project, the installed capacity of SJVN has reached 2,377 MW. The milestone marked the commissioning of SJVN's second power project of the month, following the commissioning of the 50 MW Gujrai power plant in Uttar Pradesh on 23 February 2024.
- SJVN Green Energy Limited, the renewable arm of SJVN Limited, acquired 100 MW Raghanseda Solar Power Plant at a price of INR 2.64 per unit through a tender offer conducted by GUVNL. The construction and development cost of the project is Rs 6,420 million.
- A listed company, SJVN has 55% of its shares with the Government of India, 26.85% with the Government of Himachal Pradesh and the rest 18.15%. SJVN has generally diversified into all forms of energy such as hydro, thermal, wind, solar, electricity trading and transmission. Looking ahead, SJVN is growing by setting ambitious goals to achieve the joint vision of 25,000 MW installed capacity by 2030 and 50,000 MW installed capacity by 2040.

Development of Solar Parks and Ultra Mega Solar Power Projects

- A solar park is a large developed land with common construction facilities such as transmission infrastructure, roads, water, drainage, communication network, etc., with all legal approvals. So solar project developers can launch solar projects efficiently.
- This project was implemented by The Ministry of New Energy and Renewable Energy on 12/12/2014. According to the plan, at least 25 solar parks and ultra mega solar projects targeting 20,000 MW installed capacity for solar power were proposed in 5 years from 2014-15.
- Design capacity increased from 20,000 MW to 40,000 MW on 21/03/2017. The parks are expected to be operational by 2025-26.
- The scheme envisages to support the states/UTs to set up solar parks in different parts of the country with the aim of creating the necessary infrastructure to set up solar power projects . Solar parks provide fully developed land with all available facilities, transportation system, water access, road connectivity, communication network, etc. The project will facilitate and accelerate the installation of solar-powered solar energy projects for large-scale power generation.
- All States and Union Territories are eligible for benefits under this scheme.

- Solar panels must have a capacity of 500 megawatts or more. However, small plots where the land is adjacent can be problematic because the terrain is difficult and there is not enough agricultural land to be considered.
- Solar parks are developed in cooperation with government authorities and their departments, CPSU and private entrepreneurs. The implementing agency is the Solar Power Park Developer (SPPD).

Power Usage Agreement for supply of 500 MW to Rajasthan

- SJVN Green Energy Limited (SGEL), a wholly owned subsidiary of SJVN, has signed a power use agreement (PUA) for 500 MW of solar power and a power purchase agreement (PPA) for 100 MW of solar power and Rajasthan Urja Vikas and IT Services Limited (RUVITL) in Jaipur March 10, 2024.
- Power Usage Agreement is for 500 MW Solar Power from Bikaner Solar Power Project and the Power Purchase Agreement (PPA) is for 100 MW Solar Power from Rajasthan Solar Power Project, both for a period of 25 years.
- According to the agreement, SGEL will supply 500 MW of electricity at a price of Rs 2.57 per unit from the Bikaner 1,000 MW hydroelectric project being developed by SGEL in phase-3 of the public utility.
- This project is the largest in the country. The 1,000 MW solar power project to be developed at Bandarewala village in Rajasthan's Bikaner will generate 2,454.84 million units of energy in the first year and a cumulative capacity of 56,474 million units over 25 years.
- The project is being developed at a cost of Rs. 54,910 million and expected to be released by September 30, 2024.
- SGEL has secured tie-up of the full project capacity of 1,000 MW, with 200 MW to be supplied to Uttar Pradesh Power Corporation Limited (UPPCL) and 300 MW to Jammu and Kashmir Power Corporation Limited (JKPCL).

2.1.4.4 Solar EPC – Invertor overview

In solar, Engineering, Procurement and Construction (EPC), inverters are essential to convert the direct current (DC) generated by solar panels to alternating current (AC) for use in homes, businesses and grid. This change is essential to integrate solar energy into existing power systems and ensure that the system works efficiently.

Several important factors fuel the inverter market in the solar sector. The surge in solar energy adoption, as a feasible substitute for conventional fossil fuels, is a significant motivator. With increasing global energy needs and growing worries about climate change, solar power is becoming a more appealing and environmentally friendly energy option. The increasing popularity of solar energy drives the need for advanced inverter technologies to improve the effectiveness and dependability of solar power systems.

Additionally, technological advances are having a major impact on the invertor industry. Innovations like better semiconductor materials, improved control algorithms, and the incorporation of AI are leading to increased efficiency and improved performance in inverters. Moreover, the evolution of intelligent inverters, which offer functionalities such as remote monitoring and grid management capabilities, is transforming the industry. These intelligent inverters improve energy conversion efficiency and also enhance grid integration, allowing for advanced energy management techniques.

Another important driver of the invertor market is the reduction of costs. As the solar sector develops, the prices of solar energy systems, including invertors, have dropped because of increased production and improvements in technology. The decrease in expenses allows a wider variety of consumers and uses to afford and benefit from solar energy, ultimately broadening the demand for inverters.

Moreover, present market tendencies show a movement towards advanced inverter technologies. Hybrid inverters, which integrate solar inverters with battery storage functions, are becoming increasingly popular for their all-encompassing approach to energy storage and control. The rise of this trend is fueled by the growing demand for energy reliability and

the push for increased energy self-sufficiency. Moreover, the increasing popularity of energy storage solutions for both homes and businesses is driving the need for inverters that can easily work with these systems.

On grid invertors:

On-grid inverters are vital elements in Solar, Engineering, Procurement, and Construction (EPC) projects as they are essential for connecting solar power systems to the public electrical grid. These devices transform the DC electricity generated by solar panels into AC electricity that matches the grid's voltage and frequency. This transformation permits the solar power produced to be utilized by the grid directly, adding to the total power provision and allowing households and companies to enjoy solar energy while still being connected to grid electricity.

Several important factors impact the on-grid inverter market. The growing worldwide use of solar energy is driven by its environmental and economic advantages. As the world transitions to renewable energy sources to address climate change and decrease dependence on fossil fuels, the need for solar power systems and on-grid inverters is increasing. Various government incentives, subsidies, and regulatory frameworks are in place to encourage the adoption of solar energy, thus contributing to this trend.

Technological progress also plays a crucial role in the on-grid inverter market. Advancements like more efficient conversion technologies, upgraded grid management capabilities, and advanced monitoring and control systems are improving the effectiveness and operation of on-grid inverters. These advancements enhance both the effectiveness of converting energy and make it easier to connect to the grid, giving utilities and consumers more power and options for managing their energy usage.

Regulatory policies and market incentives have a significant influence on the on-grid inverter market. Governments worldwide are enacting different policies to help incorporate renewable energy sources into the grid, such as net metering, feed-in tariffs, and renewable energy standards. These rules promote the use of solar power systems and also set particular guidelines for inverter performance and safety standards. Adherence to these rules is crucial for the effective installation and functioning of on-grid inverters.

Current market patterns show a move towards advanced and integrated inverter technologies. For example, the growing use of smart inverters is changing the way solar energy systems engage with the grid. Smart inverters come with advanced features for communication and control, allowing them to offer real-time information, aid in grid stability, and take part in demand response initiatives. This trend shows the increasing significance of grid support and energy management features in on-grid inverter design.

Hybrid invertors:

Hybrid inverters are a major innovation in solar energy technology, as they not only convert DC from solar panels to AC but also can control energy storage systems. These inverters allow users to use solar energy immediately and save extra energy in batteries for future use, offering a flexible solution for managing energy and improving system effectiveness.

The growth of the hybrid inverter industry is mainly fueled by the rising demand for energy reliability and independence. With energy security becoming increasingly important and power outages becoming more common and severe, both residential and commercial clients are looking for reliable backup power options. Hybrid inverters fulfill this requirement by enabling users to save surplus solar energy, guaranteeing a steady power source even in times of no solar generation.

The advancement of technology is driving the expansion of hybrid inverters. Contemporary hybrid inverters come equipped with advanced functions like built-in battery management systems, which enhance the efficiency and durability of energy storage solutions. These developments also involve enhancements in energy efficiency and incorporation of renewable energy sources, which boost the overall effectiveness of solar systems and increase the appeal of hybrid inverters for various uses.

The rising popularity of hybrid inverters is also greatly influenced by economic factors. Advancements in technology and competition in the market have led to reduced prices for solar panels and batteries, resulting in hybrid systems becoming more cost-effective. As the price of installing hybrid solar energy systems goes down, the profitability increases, allowing these systems to be more widely used by a larger variety of people, ranging from individuals to big businesses.

Government policies and financial incentives provide additional support to boost the hybrid inverter market. Numerous regions provide financial support, refunds, and tax breaks for renewable energy installations and energy storage solutions. These financial methods decrease the upfront expense for customers, rendering hybrid inverters a more viable and appealing choice. Moreover, rules that support energy storage and grid reliability foster a conducive setting for the advancement of hybrid inverter technologies.

Current trends in the hybrid inverter industry highlight the incorporation of intelligent technologies and sophisticated energy control. Hybrid inverters are becoming more and more equipped to connect with smart home systems and grid management platforms. This enables users to better track and manage their energy consumption, take part in demand response initiatives, and support grid stability, aligning with the overall shift towards interconnected and intelligent energy networks.

2.1.5 Lithium – Ion Battery market in India

2.1.5.1 Overview of the market

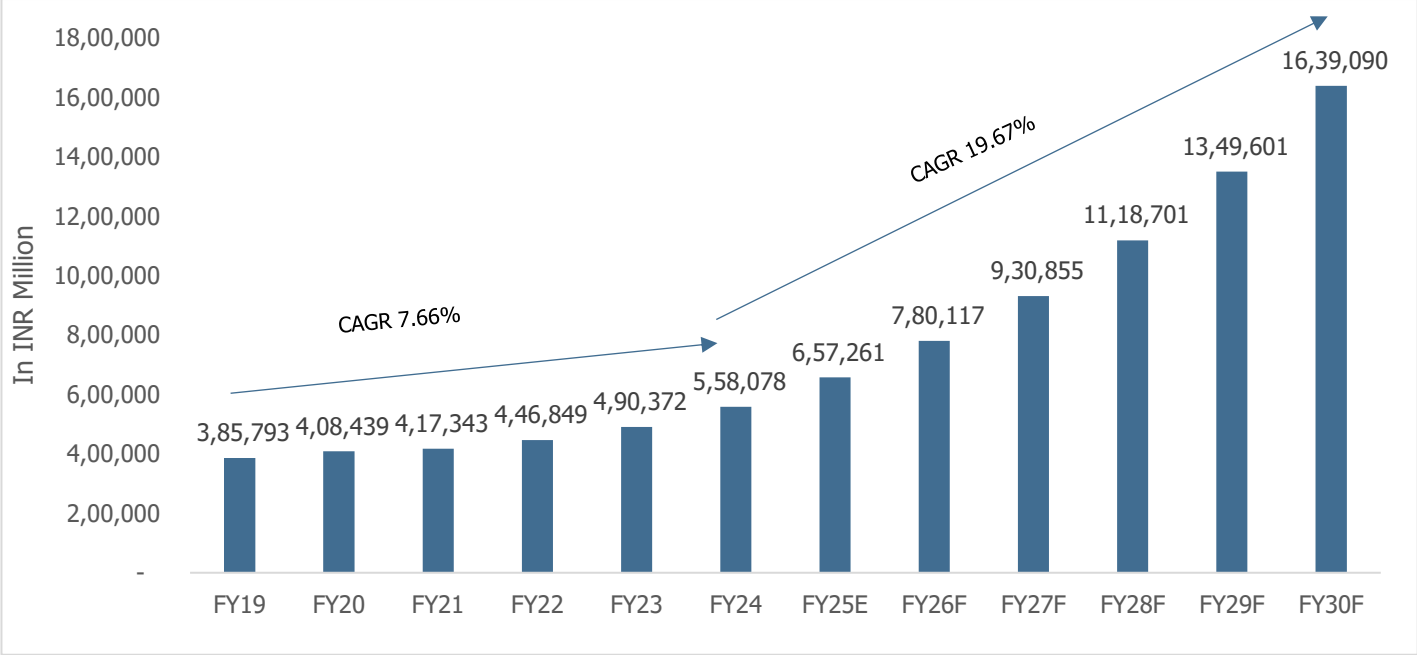
An individual battery is made of an anode, cathode, separator, electrolyte and two current collectors (positive and negative). The anode and cathode store the lithium. The electrolyte transports positively charged lithium ions from the anode to the cathode and vice versa through the separator. This movement of the lithium ions creates free electrons in the anode that creates a charge at the positive current collector. The electrical current then flows from the current collector through a device being powered (cell phone, computer, etc.) to the negative current collector. The separator blocks the flow of electrons inside the battery.

Lithium-ion batteries are systems for storing electrochemical energy using lithium ions as the charge carrier between electrodes. Several factors, such as cost, energy density, cycle life, and required charging rate, influence the choice of chemistry for a specific application. Among the numerous energy storage technologies existing, lithium-ion batteries are anticipated to lead the market during the upcoming decade.

2.1.5.2 Indian Lithium – Ion Battery Market size and Demand forecast

The Indian Lithium – Ion battery market in India was recorded at Rs 5,58,078 million in FY24 and grew at a CAGR of 7.66% between FY19 and FY24. Further, going ahead the market is expected to grow at a 19.67% till FY30. It is forecasted to reach Rs 16,39,090 million by FY30. The Indian Lithium-Ion Battery Market is growing rapidly, driven by the surging demand for energy storage solutions in various sectors, including automotive, consumer electronics, and renewable energy.

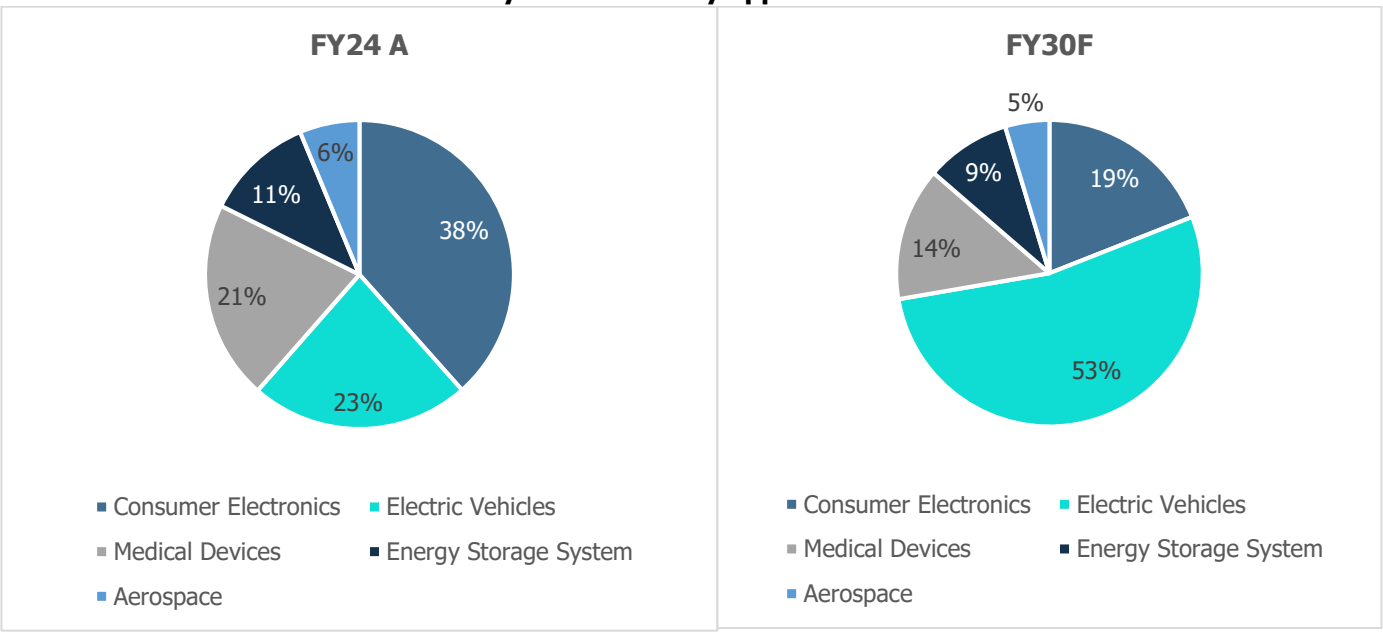
Chart 25: Indian Lithium – Ion Battery Market size and Demand forecast



Source – TechSci Research, CareEdge Research

The rising popularity of electric vehicles (EVs) is a major driver of market expansion, backed by government programs like the FAME scheme that promote the use of EVs and build infrastructure. Furthermore, the increasing presence of smartphones, laptops, and other portable devices in the consumer electronics industry is also driving the demand for these batteries. Therefore, the India Lithium-Ion Battery Market is anticipated to increase in the forecast period because of the factors mentioned above.

2.1.5.3 Indian Lithium – Ion Battery market size by application



Source – TechSci Research, CareEdge Research

2.1.5.4 Global Lithium – Ion Battery price trend analysis

The global lithium-ion battery market has experienced significant price fluctuations from 2019, driven by a combination of technological advancements, economies of scale and increased demand across various sectors.

Table 6: Lithium – Ion price trend

FY19	FY20	FY21	FY22
Rs 13,076.45/kWh	Rs 11,483.81 /kWh	Rs 11,316.16 /kWh	Rs 11,316.16 /kWh

- Between 2019 to 2020, the average price of lithium-ion batteries saw a noticeable decline, falling from Rs 13,076.45/kWh to Rs 11,483.81 /kWh. This reduction in price was mainly due to advancements in manufacturing processes, which increased efficiency and reduced production costs. In addition to this, the increased production capacities, spurred due to the growing demand from the consumer electronics and automotive sectors, contributed to the competitive market dynamics that drove prices down. This period also marked the early stages of mainstream electric vehicle (EV) uptake, which further fueled demand and economies of scale.

- However, in 2021 and 2022, the global lithium-ion battery market faced price stabilization, with average prices holding steady around Rs 11,316.16 /kWh. The key reason for the price stabilization was the disruption in supply chains caused by the COVID-19 pandemic. The pandemic led lockdowns and restrictions affected the production and transportation of raw materials, leading to temporary supply shortages and increased costs. Despite these challenges, continued investments in battery technologies and infrastructure ensured that the long-term trend of price decline was not derailed.

- Looking forward to the period till 2025, the market is projected to experience an accelerated decline in prices, with forecasts suggesting an average price of Rs 8,801.46 /kWh by 2025. This anticipated decline will be driven by a number of factors, that includes innovations in battery chemistry, such as the development of solid-state batteries and other next-generation technologies. Further, advancements in recycling technologies will help reduce raw material costs and improve the sustainability of battery production. The establishment of gigafactories, which benefit from economies of scale, will also contribute to the reduction in production costs. Hence, there will be a significant surge in EV adoption, an expansion of renewable energy storage solutions, and increased penetration of lithium-ion batteries into grid storage applications.

- Between 2026 to 2030, the lithium-ion battery market is expected to mature, with prices projected to plateau at around Rs 6,286.76/kWh by 2030. These years of market maturity will be characterized by optimized supply chains, further technological developments and a balanced supply-demand dynamic. The widespread commercial and residential adoption of lithium-ion batteries will be evident, alongside significant EV market expansion and robust support for renewable energy initiatives.

The ongoing reduction in lithium-ion battery costs boosts the affordability of electric vehicles compared to traditional internal combustion engine cars, leading to an increase in market demand. Decreased battery expenses create profitable chances for investing in renewable energy projects and energy storage systems, promoting innovation and sustainable practices. Businesses need to prioritize the securing of raw materials and the optimization of supply chains in order to reduce risks related to price fluctuations and maintain consistent production. It will be essential to invest in research and development (R&D) for future battery technologies to stay competitive and meet changing market needs. Furthermore,

focusing on sustainability by implementing recycling programs and eco-friendly manufacturing methods is in accordance with international environmental objectives and policies.

It's important for organizations to also think about forming strategic partnerships and collaborations in order to improve their market position and take advantage of technological advances. Businesses can enhance innovation and increase production efficiency by establishing partnerships with important stakeholders in the renewable energy, automotive, and technology industries. Expanding product ranges to incorporate energy storage options for homes, businesses, and industries will create additional sources of income and reduce risks related to market fluctuations. Additionally, it is important for companies to keep up to date on changes in regulations and incentives that promote the use of lithium-ion batteries and renewable energy solutions, so that they can take advantage of favorable policy conditions.

2.1.6 Solar Hybrid Inverter Market

A solar inverter is a device that converts the direct current (DC) electricity generated by solar panels into alternating current (AC), which can be used to power appliances and equipment in homes, businesses, or fed into the electrical grid. They also help optimize the power output from solar panels and ensure safety by shutting down during grid failures. There are several types of solar inverters like, String Inverters, Microinverters, Power Optimizers, Central Inverters, Grid-Tied Inverters, Off-Grid Inverters and Hybrid Inverters.

A Solar Hybrid Inverter is a critical component in renewable energy systems, particularly in solar power setups. It combines the functionality of a traditional solar inverter with additional capabilities to manage multiple power sources, such as solar panels, batteries, and the grid. Solar hybrid inverters are popular in both residential and commercial setups due to their ability to integrate renewable energy with reliable grid power, offering flexibility and cost savings.

A solar hybrid inverter converts the direct current (DC) electricity generated by solar panels into alternating current (AC), which is the type of electricity used in homes. What makes it different from a regular solar inverter is that it can also manage energy storage. When the solar panels generate more electricity than needed, a hybrid inverter stores the excess energy in batteries. This stored power can then be used later, for instance, at night or during cloudy days when solar panels aren't producing much electricity.

A solar hybrid inverter helps to make the most of the solar energy system, offering cost savings, reliable power backup, and environmental benefits, all while simplifying energy management. It's an investment that pays off both in the short term and the long run.

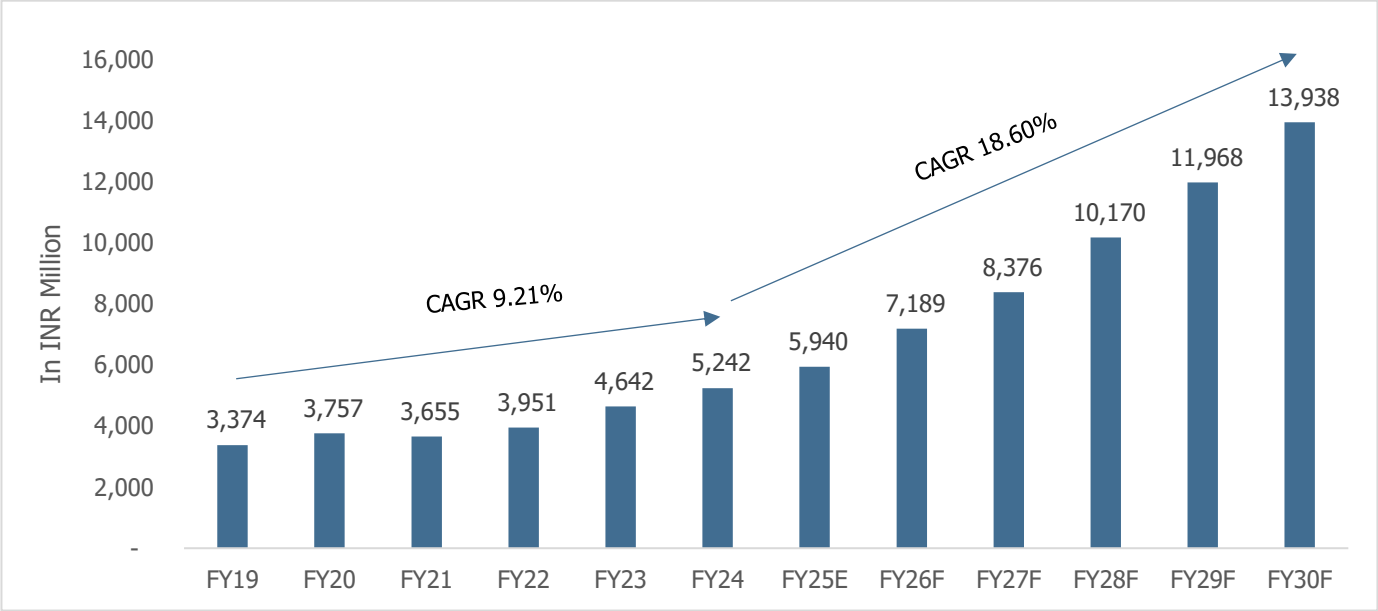
2.1.6.1 Benefits of Solar Hybrid Inverter:

1. **Efficient Power Management**: Efficient power management is a key advantage of a solar hybrid inverter. It balances power generated from solar panels, stored in batteries, and drawn from the electrical grid. During periods of high solar energy production, any excess energy is stored in the battery for future use, ensuring that no power is wasted. This stored energy can be used during low solar generation periods, such as at night or during cloudy days, minimizing dependence on grid electricity. By prioritizing solar energy and stored battery power, the hybrid inverter reduces energy costs, as it allows consumers to use cheaper solar power instead of more expensive grid electricity. This smart management system leads to substantial savings on electricity bills while enhancing energy efficiency.

2. **Power Backup**: Solar hybrid inverters are designed to provide reliable power backup during electricity outages, ensuring that essential appliances and devices continue running without disruption. In areas prone to frequent power cuts, this feature becomes highly valuable, offering a sense of energy security. The inverter intelligently switches to stored energy in the battery when the grid goes down, keeping vital systems like lights, fans, refrigerators, and even medical equipment operational. This eliminates the need for traditional backup sources like generators, which can be noisy, expensive, and less environmentally friendly. Additionally, the ability to store excess solar energy for use during outages means you are less reliant on the grid, making hybrid inverters ideal for households and businesses in power-unstable regions.

3. **Environment Friendly**: Solar hybrid inverters are environment friendly because they maximize the use of clean, renewable energy from solar panels while minimizing reliance on non-renewable energy sources such as coal, gas, and oil. By efficiently converting solar energy and storing excess power in batteries for later use, they help reduce the demand for electricity from fossil-fuel-based power plants. This reduces greenhouse gas emissions, which are a major contributor to global warming and climate change. Moreover, solar hybrid inverters promote sustainable energy consumption by enabling users to rely on solar power even when the sun isn't shining, leading to a more consistent use of renewable energy throughout the day. This eco-friendly approach supports global efforts to reduce carbon footprints and promote a greener, cleaner environment.

Chart 26: Solar Hybrid Inverter market in India



Source: TechSci Research, CareEdge Research

The Indian Solar Hybrid Inverter market in India was recorded at Rs 5,242 million in FY24 and grew at a CAGR of 9.21% between FY19 and FY24. Further, going ahead the market is expected to grow at a 18.60% till FY30. It is forecasted to reach Rs 13,938 million by FY30. This growth is expected to be driven by the rising demand for renewable energy as India transits from fossil fuels to more sustainable energy sources to combat climate change and improve energy security. Solar hybrid systems, which combine solar power with other energy sources, provide reliable and efficient energy solutions for both urban and rural areas. Technological advancements have also played a key role, with enhanced efficiency and lower costs making these inverters more accessible and attractive, while improving their integration with various power sources.

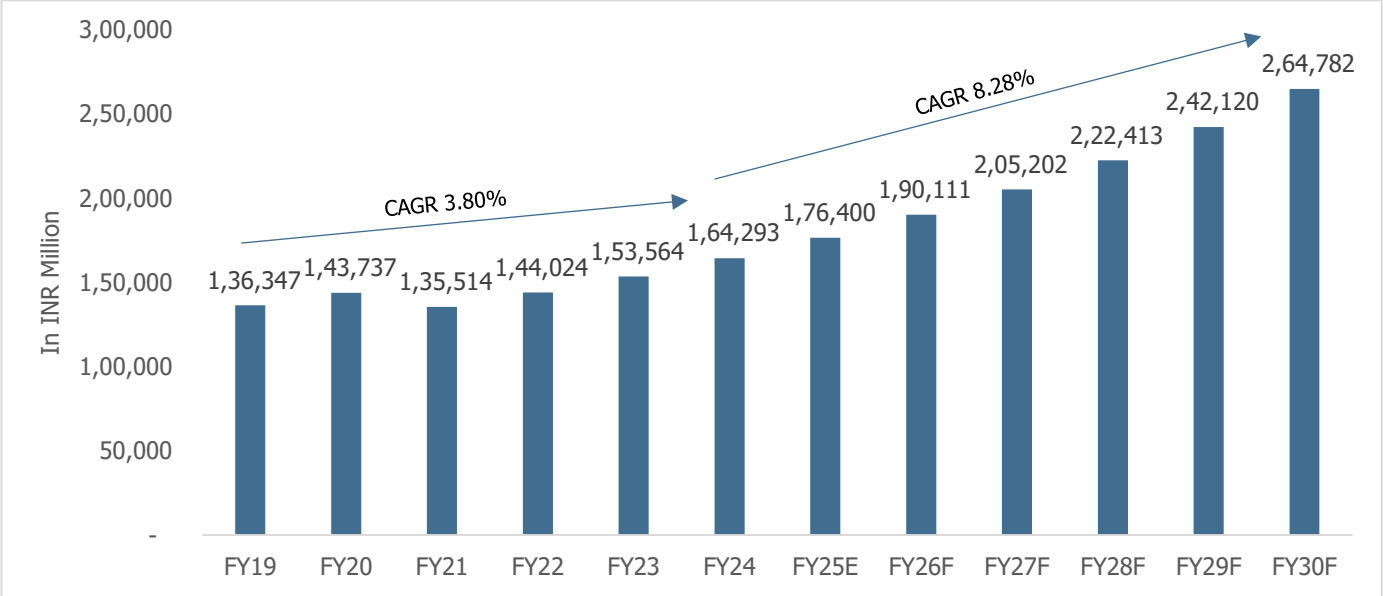
2.1.7 India Lift Inverter Market

The surge in high-rise buildings in India is indeed driving the lift market's growth. Lift inverters play a crucial role in ensuring the safety and efficiency of these systems. They provide smoother operation, energy efficiency, and better control over lift speed and stopping, significantly enhancing passenger comfort and safety. Compared to diesel-run lifts, inverter-driven lifts are quieter, more environment friendly, and typically have lower operational costs. As urbanization continues, the demand for advanced lift systems, including inverter technology, is expected to rise, making them essential for modern infrastructure.

The India Lift Inverter Market is a niche yet growing segment within the broader power backup and elevator systems market. The increasing adoption of elevators in residential, commercial, and industrial buildings, driven by rapid urbanization and infrastructure development, has spurred demand for reliable lift inverter systems. Frequent power outages in many parts of India make reliable power backup systems crucial for uninterrupted elevator operation, especially in high-rise buildings. Lift inverters provide this crucial backup, ensuring smooth and safe elevator function during power failures. Additionally, government-backed infrastructure projects, such as the Smart Cities Mission and affordable housing schemes, are further stimulating demand for elevators, indirectly supporting the lift inverter market. Regulatory safety mandates that require elevators to be operational even during power outages are pushing developers to invest in high-quality inverter solutions.

On the technology front, the market is seeing a shift toward energy-efficient and regenerative inverter systems that not only provide reliable power but also enhance energy conservation. IoT-enabled lift inverters that allow remote monitoring and diagnostics are gaining popularity, particularly in high-end commercial projects.

Chart 27: Lift Inverter Market in India



Source – TechSci Research, CareEdge Research

The India Lift Inverter Market was valued at INR 164,292.82 million in FY24 and is projected to exhibit a CAGR of 8.28% during the forecast period. Rapid urbanization and ongoing infrastructure development in India drive the demand for modern buildings and high-rise structures. Lift inverters, which are crucial for the efficient operation of elevators in such buildings, see increased demand as construction projects expand.

By Product Types:

- **Single-Phase Inverters:** These are typically used in low-rise buildings and smaller elevators where the power demand is lower. Single-phase inverters are generally more cost-effective and are suitable for residential buildings with moderate usage.
- **Three-Phase Inverters:** These inverters are designed for high-rise buildings, commercial complexes, and industrial facilities where elevators operate at higher capacities and need more power. Three-phase inverters provide greater efficiency, stability, and reliability during power outages, making them ideal for larger projects and heavy-duty operations.

By End-User Segments:

- **Residential Buildings:** The growing number of high-rise residential complexes across urban and semi-urban areas has increased the demand for lift inverters. In this segment, the focus is often on affordability and space-efficient inverter solutions that ensure uninterrupted operation of elevators during power cuts.
- **Commercial Spaces:** Office buildings, shopping malls, hotels, and other commercial establishments have high elevator usage, requiring advanced inverter systems that can handle frequent operation and ensure safety during power outages. These establishments often adopt three-phase inverters with more sophisticated technology, including energy regeneration and IoT integration.
- **Industrial and Public Infrastructure:** Hospitals, airports, railway stations, and metro systems have critical operational requirements, where even short downtime can be disruptive or dangerous. Lift inverters in this segment are generally more robust and integrated with backup systems like generators, ensuring the highest level of reliability. Safety regulations in these sectors often mandate uninterrupted elevator function, which has led to the adoption of premium inverter technologies.The expansion of the real estate sector, including residential, commercial, and mixed-use developments, boosts the need for reliable elevator systems. Lift inverters are integral to these systems, ensuring smooth and efficient elevator operation, which contributes to market growth.

Advancements in lift inverter technology, such as improved energy efficiency, better performance, and enhanced safety features, make these systems more attractive to builders and property developers. Innovations that reduce energy consumption and maintenance costs further drive market adoption.

Moreover, there is a growing emphasis on energy efficiency and sustainability in the construction industry. Lift inverters contribute to energy savings by optimizing elevator performance and reducing power consumption. This aligns with broader sustainability goals and regulatory requirements, encouraging the adoption of modern lift inverter solutions.

Government initiatives and regulations promoting energy efficiency and green building standards support the use of advanced lift inverter technology. Policies that encourage energy-efficient infrastructure and provide incentives for adopting modern systems boost market growth.

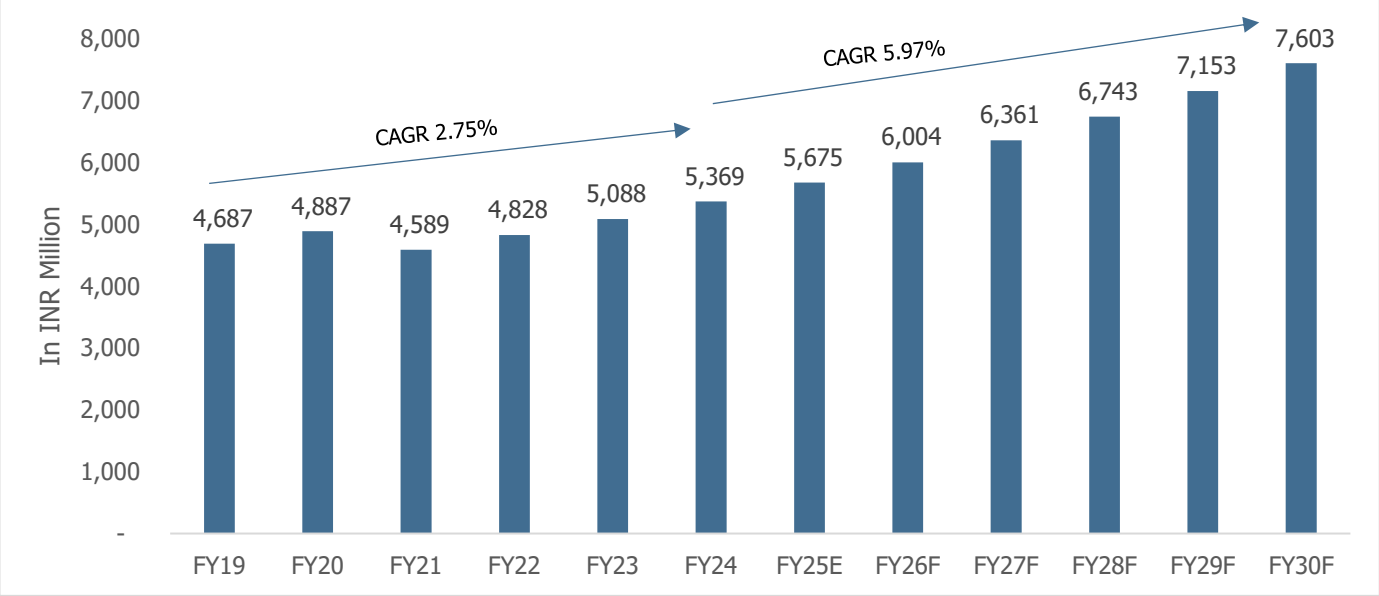
Hence, due to all the mentioned factors, the India Lift Inverter Market is likely to grow with a rapid pace during the coming years.

2.1.8 India Battery Charger for Railway Sector Market

Battery chargers are vital in the railway sector for providing dependable power to signaling, communication, and lighting systems during outages. They ensure that onboard batteries, which power auxiliary systems, remain charged, enhance safety through emergency lighting and communication, and support signaling equipment for effective train management. In electric locomotives, chargers are key to maintaining optimal performance by keeping batteries charged, thereby enhancing the reliability and safety of railway operations.

The Indian Battery Charger for the Railways Sector Market is a crucial part of the nation's overall railway infrastructure development, supporting essential operations and safety systems across its extensive and growing railway network. Battery chargers are fundamental for maintaining an uninterrupted power supply to various railway systems, including signaling, communications, lighting, and emergency backup. As Indian Railways undergoes significant modernization, electrification, and safety enhancements, the demand for reliable and efficient battery charging systems has increased significantly.

Chart 28: Battery Charger for Railway Sector Market in India



Source – TechSci Research, CareEdge Research

The India Battery Charger for Railways Sector Market has witnessed a positive trend with a market size of INR 5,087.57 million in FY24 and is projected to exhibit a CAGR of 5.97% during the forecast period. India's focus on expanding and modernizing its rail infrastructure, including the introduction of new trains and upgrades to existing systems, drives the demand for advanced battery chargers. Modern rail systems require reliable battery chargers to ensure the efficient operation of onboard and stationary battery systems.

By Application:

- **Traction Systems:** Battery chargers for traction applications provide power backup for electric locomotives, hybrid trains, and railcars. These systems require high-capacity chargers that can quickly charge large batteries and support high-power demands for efficient rail operations. As Indian Railways expands its electric traction network, the demand for traction battery chargers is expected to grow significantly.
- **Signaling and Telecommunication Systems:** Railways rely on signaling and telecommunications systems to manage train movements, safety, and communication. Battery chargers in this segment ensure an uninterrupted

power supply to these critical systems, which must function even during power outages. These chargers are designed for high reliability and durability, as any failure in these systems could lead to safety issues.

- **Emergency and Power Backup Systems:** Railway stations, coaches, and essential infrastructure like tunnels and bridges use battery chargers to provide power for emergency lighting, ventilation, and safety systems during power failures. These chargers are crucial for maintaining passenger safety and comfort and are typically integrated with uninterrupted power supply (UPS) systems.
- **Auxiliary Power Systems:** Chargers used for auxiliary systems power a range of equipment like train lighting, air conditioning, and heating systems. These systems ensure passenger comfort and are especially important for long-distance trains, where prolonged battery backup is necessary.

By Technology:

- **Conventional Chargers:** Traditional chargers use simple, reliable designs that provide steady power to railway batteries. These chargers are commonly used in systems where basic functionality is required, and cost constraints are higher. They do not have smart features or energy-efficient capabilities but are dependable for straightforward applications like small stations or older signaling systems.
- **Smart Chargers:** These chargers incorporate modern features such as automatic voltage regulation, real-time monitoring, and Internet of Things (IoT) integration. Smart chargers are becoming increasingly popular in the Indian Railways sector as they offer enhanced efficiency, remote monitoring, and predictive maintenance. These chargers can adapt to the battery's state of charge and optimize charging performance, extending battery life and improving system reliability.
- **Regenerative Chargers:** Regenerative charging systems are a newer technology that allows energy recovered from braking systems (in electric trains or metro systems) to be fed back into the battery system. This technology is particularly useful for enhancing energy efficiency in electric rail networks and high-speed trains, contributing to the overall sustainability efforts of Indian Railways.

By End-User Type:

- **Public Sector (Indian Railways):** Indian Railways is the primary consumer of battery chargers, using them across its expansive network for both freight and passenger services. The public sector's demand is driven by government policies, electrification goals, and safety requirements.
- **Private Sector (Metro and Private Rail Operators):** With the rise of public-private partnerships (PPP) in metro rail projects and other transportation infrastructure, private sector players are also emerging as significant consumers of advanced battery chargers. These operators focus on efficient, high-performance charging systems to maintain reliability and passenger service quality.

The Indian Railways is progressively incorporating electric and hybrid trains into its fleet to reduce reliance on diesel and improve energy efficiency. These trains rely on advanced battery systems that require efficient battery chargers to maintain performance and reliability.

Advancements in battery charger technology, such as improved efficiency, faster charging times, and enhanced safety features, drive the adoption of new battery chargers in the railways sector. Modern chargers offer better performance and integration with evolving railway technologies.

The push towards energy efficiency and sustainability within the rail sector has increased the demand for high-performance battery chargers. Energy-efficient chargers help reduce operational costs and contribute to the Indian Railways' goals of reducing its carbon footprint and overall energy consumption.

Government initiatives to modernize the rail network and invest in advanced infrastructure support the growth of the battery charger market. Programs aimed at upgrading railway systems and enhancing operational efficiency include investments in new technologies, including battery chargers.

The ongoing replacement and upgrading of outdated battery chargers in existing railway systems drive market growth. As older equipment is phased out in favor of more efficient and technologically advanced chargers, the market for new battery chargers expands.

2.1.9 India Emergency Battery Charger and Regulated Battery Charger for LHB Coaches Market

Indian Railways primarily used Integral Coach Factory (ICF) Coaches: The most common type, made from steel and designed for durability, but less advanced in terms of safety features and passenger comfort compared to LHB coaches. Linke-Hofmann-Busch (LHB) coaches are designed with advanced safety features, and reliable emergency and regulated battery chargers which are crucial for maintaining these systems.

Linke-Hofmann-Busch (LHB) coaches enhance battery usage through greater energy efficiency and advanced electrical systems that optimize power consumption. The use of LED lighting reduces power load, while regenerative braking helps recharge batteries during operation. Improved thermal insulation further decreases the need for heating and cooling, minimizing battery demand. These features collectively ensure more efficient battery usage compared to older coach models. Emergency battery chargers ensure that power backup is available during emergencies, while regulated chargers maintain the proper voltage and current for optimal battery performance.

The Linke-Hofmann-Busch (LHB) coaches have become a standard in modern Indian Railways, known for their enhanced safety features, passenger comfort, and advanced technology. To support the operational efficiency and reliability of these coaches, the development of specialized battery charging systems, including Emergency Battery Chargers and Regulated Battery Chargers, are crucial. This write-up explores the functionalities, importance, and implementation of these charging systems in LHB coaches.

Importance of Battery Charging System in LHB Coaches

1. **Reliability of Power Supply**

Battery charging systems ensure a stable and reliable power supply for various onboard systems which includes -

- Continuous lighting in passenger areas is crucial for safety and comfort, particularly during emergencies or power outages
- Communication Systems to keep the crew connected with control centres and other train personnel, essential for operational coordination
- Powering alarms and emergency signalling systems is vital for passenger safety during emergencies.

2. **Operational Efficiency**

The seamless operation of LHB coaches relies heavily on effective battery management. The battery chargers automatically switch to emergency power modes during outages, minimizing disruption. The chargers are charged quickly, allowing for minimal downtime and enhancing overall operational efficiency.

3. Enhanced Safety Features

Battery charging systems contribute significantly to safety protocols within LHB coaches as well. In the event of a power failure, emergency battery chargers maintain essential systems, ensuring passenger safety and comfort. Advanced systems can also monitor battery health and performance, alerting personnel to potential issues before they escalate.

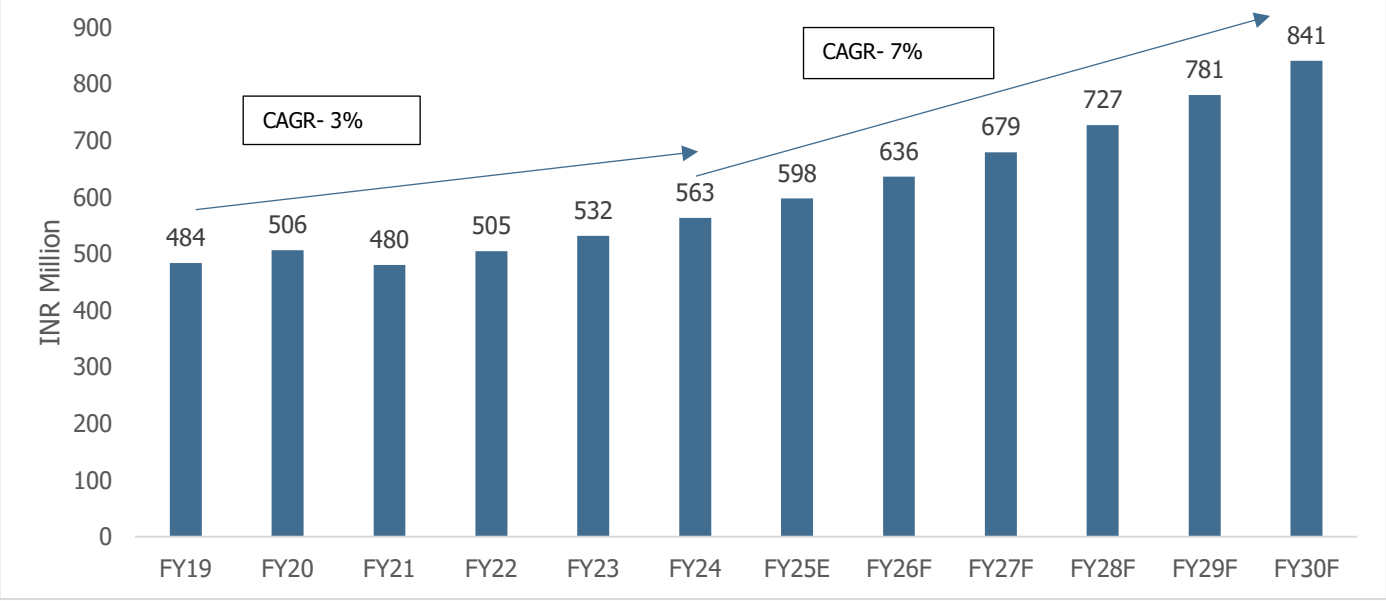
4. Passenger Comfort

Comfort is a priority in modern train travel, and battery charging systems play a key role. These emergency systems support air conditioning units, ensuring a comfortable environment for passengers during their journey. Reliable power also supports various amenities like entertainment systems and charging points for personal devices to enhance the travel experience.

Emergency batteries in Linke-Hofmann-Busch (LHB) coaches of Indian Railways play a vital role in ensuring passenger safety and comfort during unforeseen circumstances. These batteries provide essential power to critical systems such as emergency lighting, communication devices, and safety alarms when the main power supply fails. In the event of a power outage, the emergency battery system automatically activates, ensuring that passengers are not left in darkness and that the crew can maintain communication with control centers. This capability not only enhances the overall safety of train operations but also instils confidence in passengers regarding their well-being during travel. Additionally, emergency batteries support other vital functions, ensuring that essential systems remain operational until normal power is restored.

The India Emergency Battery Charger and Regulated Battery Charger for Linke-Hofmann-Busch (LHB) Coaches Market was valued at INR 563.21 million in FY24 and has grew at a CAGR of 3% from INR 484 Million in FY19. It is projected to exhibit a CAGR of 7% during the forecast period. The Indian Railways has been actively expanding its fleet of LHB coaches due to their improved safety, comfort, and efficiency compared to older designs. As the number of LHB coaches increases, so does the demand for specialized components, including emergency and regulated battery chargers.

Chart 29: Market for Emergency Battery Charger for LHB coaches



Source: TechSci Research, CareEdge Research

The development of more efficient and reliable emergency and regulated battery chargers contributes to market growth. Innovations in battery technology and charger design lead to improved performance, energy efficiency, and longevity, making these chargers more appealing for LHB coaches.

There is a growing emphasis on enhancing passenger safety and comfort in Indian Railways. LHB coaches, being a key part of this initiative, require advanced charging systems to support safety features like emergency lighting and communication systems. This drives the demand for high-quality emergency and regulated battery chargers.

Government investments in upgrading railway infrastructure and modernizing coach systems support the growth of the battery charger market. Projects aimed at enhancing the functionality and reliability of LHB coaches include the installation of advanced battery chargers.

2.1.10 Isolation Transformers (Non- Distribution Transformers) Market

A transformer is an electrical device used to change the voltage level of alternating current (AC) in a circuit. It works on the principle of electromagnetic induction to either step-up (increase) or step-down (decrease) voltage, ensuring efficient power transmission over long distances. Commonly found in power grids, transformers help minimize energy loss and facilitate the safe delivery of electricity from power plants to homes and industries. There are different types of transformers like Step-Up Transformer, Step-Down Transformer, Auto Transformer, Three-Phase Transformer, Instrument Transformer and Isolation Transformer.

An isolation transformer is a type of transformer designed to transfer electrical energy between two or more circuits while providing electrical isolation between them. This is achieved by having separate windings for the input and output, which are not electrically connected but magnetically linked.

Isolation transformers are crucial in high-voltage applications where electrical isolation is needed to ensure safety and system reliability. As industries and infrastructure projects require high-voltage solutions, the demand for isolation transformers grows correspondingly.

Isolation transformers help in improving power quality by isolating electrical circuits and minimizing electrical noise and interference. This is important for maintaining the integrity of sensitive electronic equipment and systems, leading to increased adoption in sectors that prioritize power quality and safety.

India is the 3rd largest electricity generator globally, and the transformer industry plays a crucial role in the further growth of the sector. The push for renewable energy projects worldwide and the Government of India's initiatives has driven the demand for transformers to support the integration of solar and wind energy into existing power grids. The industry caters to a diverse range of applications, including power distribution, renewable energy projects, industrial project, and grid infrastructure. The Asia-Pacific region, particularly China and India, has been a significant contributor to the growth of the transformer manufacturing industry, driven by rapid industrialization and infrastructure development. In India, transformer manufacturing is concentrated in Gujarat, Maharashtra and Tamil Nadu.

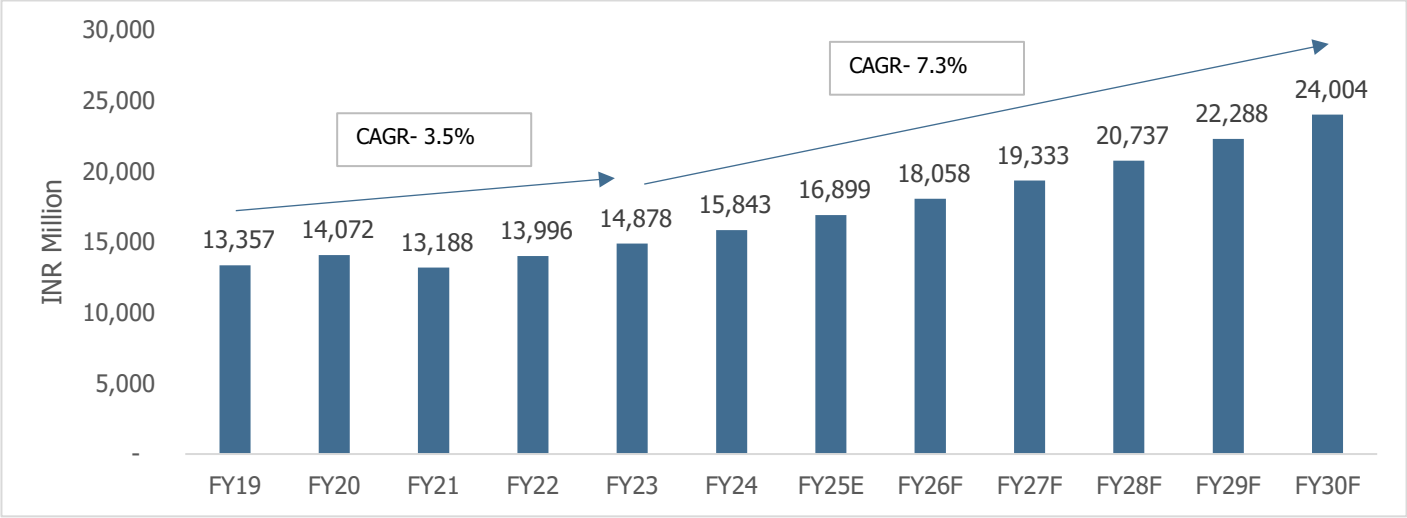
Isolation transformers play a crucial role in ensuring safety, reliability, and performance in various electrical systems. In India, several types of isolation transformers are used across different applications. Here's an overview of the key types:

- **Step-Up Isolation Transformers**: These transformers increase the voltage from the primary to the secondary winding. They are commonly used in applications where the voltage needs to be boosted for transmission or to match the operational requirements of specific equipment.

- **Step-Down Isolation Transformers:** These transformers reduce the voltage from the primary to the secondary side. They are widely used in residential and commercial applications, providing safe voltage levels for household appliances and equipment.
- **Auto Isolation Transformers**: Auto isolation transformers have a single winding that serves as both the primary and secondary winding. They are often more compact and economical, suitable for applications requiring voltage adjustment with isolation.
- **Control Isolation Transformers**: These transformers are specifically designed for control circuits in industrial applications. They isolate control circuits from power circuits, ensuring safety and preventing electrical interference.
- **Phase-Shifting Isolation Transformers**: These transformers are used in applications requiring phase shifting for load balancing and improved power quality, commonly found in industrial settings.

The India Isolation Transformers (Non- Distribution Transformers) Market was valued at INR 15,843 million in FY24 which grew at CAGR of 3.5% from INR 13,357 million in FY19 and is projected to exhibit a CAGR of 7.3% during the forecast period from FY25 TO FY30. Rapid industrialization and infrastructure development in India drive the demand for various types of transformers, including isolation transformers. These transformers are essential for providing electrical isolation and protecting sensitive equipment in industrial settings and large infrastructure projects. India is about to become one of the major power nations among developing economies. Electricity is a key constituent for the economic growth of the country and is directly linked to GDP of the country. There has been a surge in demand for power in India due to increase in capacity utilisation, industrialisation, urbanisation and population.

Chart 30: Market for Isolation Transformers Market in India

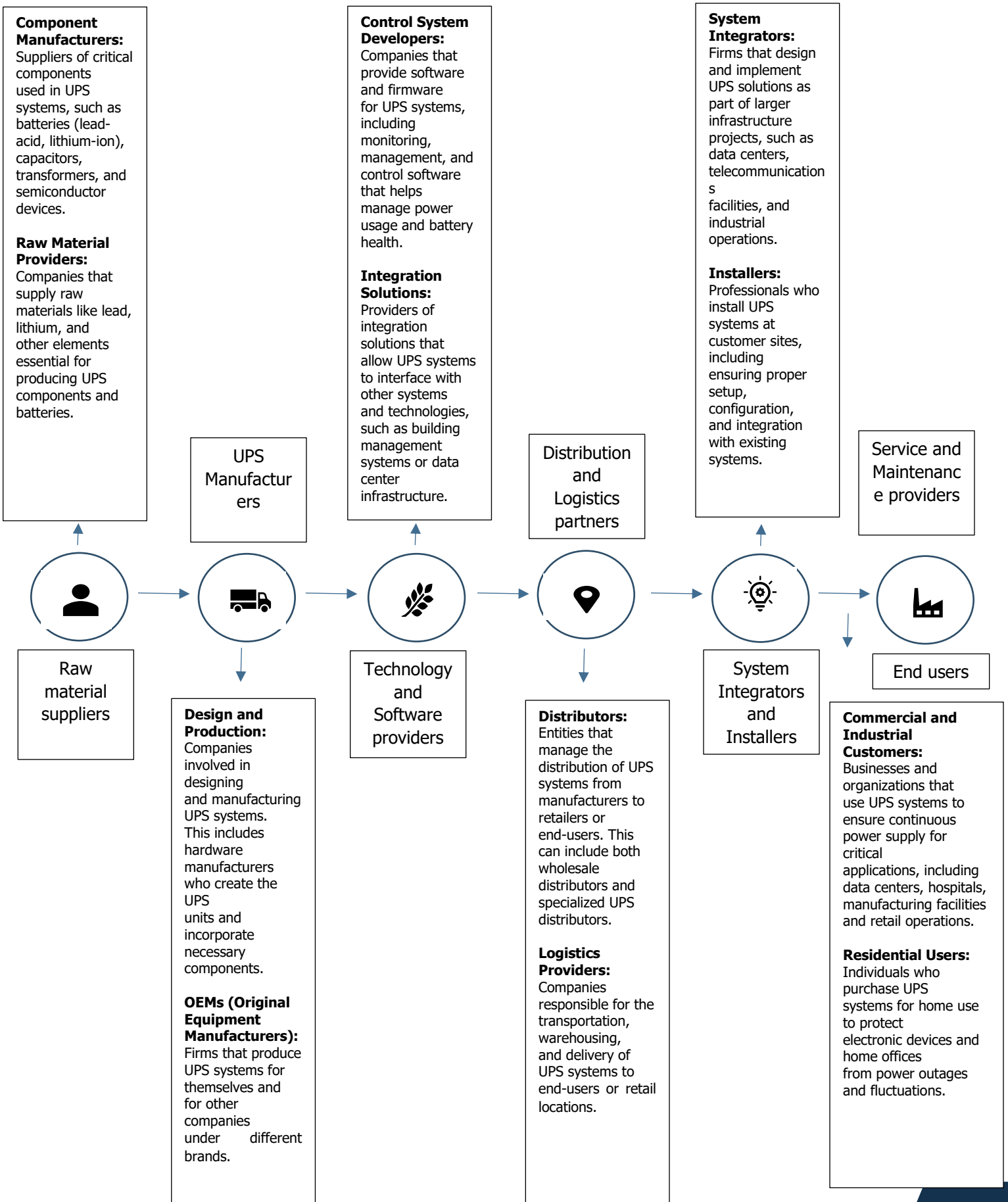


Source: TechSci Research, CareEdge Research

The expansion of the electronics and telecommunications sectors in India drives the need for isolation transformers. These sectors require reliable power supply and protection for sensitive equipment, which isolation transformers provide.

Isolation transformers are used in medical and laboratory equipment to ensure accurate and safe operation. As the healthcare and research sectors grow, the need for isolation transformers in these applications increases.

2.2 Value chain analysis



2.3 Drivers, opportunities and challenges in the sector

Drivers:

- **Prevalent power interruption issue in India:** Frequent power cuts in India lead to many people depending on UPS systems for backup power. Various reasons contribute to this upward trend, such as insufficient electricity generation, coal scarcity from heavy rainfall, and fewer coal-powered facilities. Moreover, industries like oil and gas, petrochemicals, refining, and automotive engineering are more and more implementing UPS systems to protect against data and productivity disruptions. Due to the substantial growth of the industrial sector in India, there is an increasing need for electricity, leading to an expected high compound annual growth rate (CAGR) for the UPS market in the future. These factors together lead to the rising need for UPS solutions to guarantee uninterrupted operational continuity.

- **Increase in numberof data centres:** India is becoming an important global player in offering cloud computing and data center services, leading to an increased need for UPS in the future. UPS systems are crucial in data centers as they offer battery backup for safe equipment shutdown in case of utility power outages. They not just maintain the functionality of extensive data centers but also protect sensitive electronics with uninterrupted power supply. During the forecast period, there would be a growing need for UPS due to investments in the expansion of data centers. An uninterrupted power supply is essential for constant operations in data centers. UPS systems are essential backups during power failures, protecting against data loss and downtime. Organizations are investing in strong IT infrastructure, such as building new data centers, due to the increasing emphasis on digital transformation and advanced technology adoption. As a result, there is a growing need for power protection options, resulting in higher usage of UPS systems in India to fulfill power backup requirements.

- **Supply push for booming businesses:** There is a significant commercial growth opportunity for all players, including Original Equipment Manufacturers (OEM), in the UPS industry in India. This is because there are both organized and unorganized sectors that serve a wide range of consumers. Organized companies must provide high-quality products at a competitive price to stay ahead, even though unorganized industries have lower costs. Local brands help in keeping prices stable in this scenario. As a result, there is expected to be an increase in demand for the India UPS Market, creating growth prospects for new companies.

- **Government initiatives:** The National e-Governance Plan aims to bring about a new era by providing additional momentum. The main goal of this project is to automate and digitalize different government offices and organizations, requiring a steady electricity source, thus boosting the growth of the UPS sector. In addition, programs such as Pradhan Mantri Gramin Digital Saksharta Abhiyan (PMGDISHA) and Pradhan Mantri Kaushal Vikas Yojana (PMKVY) aim to narrow the gap in digital access. The focused initiatives aimed at creating a digital India are projected to boost the growth of the UPS market in India.

- **High electricity demand in India:** The demand for UPS is projected to greatly increase in the future due to the growing need for dependable and efficient power supply systems. Understanding the significance of maintaining consistent power supply during peak hours has become extremely crucial. The increasing requirement for top-notch UPS systems is fueled by the rising need for electricity. UPS is acknowledged by large manufacturing facilities in various sectors such as retail, healthcare, telecom, and commercial and residential industries.

Opportunities:

- **Increased adoption of renewable energy sources**: The shift to new energy sources, such as solar and wind, has increased the demand for UPS systems in India. Renewable energy plants often experience power outages, making reliable backup solutions essential. UPS systems are stable and ensure continuous power supply in the event of fluctuations or lack of renewable energy production. As India increasingly focuses on green energy and sustainable practices, the need for UPS systems to complement renewable energy sources and increase grid reliability will increase. The UPS market uses renewable energy, including solar and wind power for sustainable, efficient and environmentally friendly solutions, due to technological advances and the push for various green alternatives.

- **Growth in E – commerce and retail sectors**: The increasing growth of the e-commerce and retail industries in India is fueling the need for dependable power solutions. Due to the rise in online transactions, digital payment platforms, and automated retail processes, companies in these industries need constant power to maintain efficiency and prevent any disruptions. UPS systems are necessary for providing support to point-of-sale (POS) systems, inventory management, and online transaction processing. As the e-commerce and retail sectors expand, there will be an increasing demand for reliable UPS systems to safeguard important infrastructure and maintain uninterrupted service delivery. This trend offers a great market potential for UPS manufacturers and service providers.

- **Rising demand for healthcare infrastructure:** The growth of healthcare facilities in India, such as hospitals, clinics, and diagnostic centers, is increasing the need for UPS systems. Healthcare establishments need a consistent power source to guarantee the constant functioning of important tools like life support devices, diagnostic equipment, and digital medical records. The demand for dependable and high-capacity UPS solutions is rising due to the growing emphasis on healthcare quality and accessibility. Hospitals and healthcare providers are purchasing sophisticated power backup systems to protect patient care and operational efficiency. The increasing need for healthcare infrastructure offers a hopeful chance for UPS market participants to provide customized solutions that meet the strict demands of the healthcare industry.

Challenges:

- **Disparity in power supply:** Robust UPS systems are crucial in India due to frequent power outages, voltage fluctuations, and unreliable grid infrastructure in many areas. Nevertheless, the gap between urban and rural regions worsens this difficulty. Cities usually have more consistent electricity supply, which decreases the necessity for UPS systems. In contrast, rural regions often deal with frequent power outages, increasing the need for dependable backup options. The unequal distribution impacts market expansion by requiring UPS providers to manage different customer demands and infrastructure obstacles. In order to tackle this issue, businesses must create customized strategies that meet specific regional needs, enhance awareness, and improve accessibility.
- **High technological complexities and lack of standrads:** The high level of technological complexity and absence of standards in UPS products have resulted in the emergence of many local manufacturers in the market, who are providing cheap low-quality products. Regrettably, these items frequently have flaws or a brief longevity. Consequently, well-known companies have seen a decrease in their share of the market. Moreover, the complex technical aspects of UPS systems are made even more challenging by the unique needs of individual clients. In UPS operations, technological advancements like energy storage, modularity, and scalability are essential. Nevertheless, manufacturers face challenges in meeting the varied requirements of different end-use manufacturing companies.

2.4 Growth of Railway sector

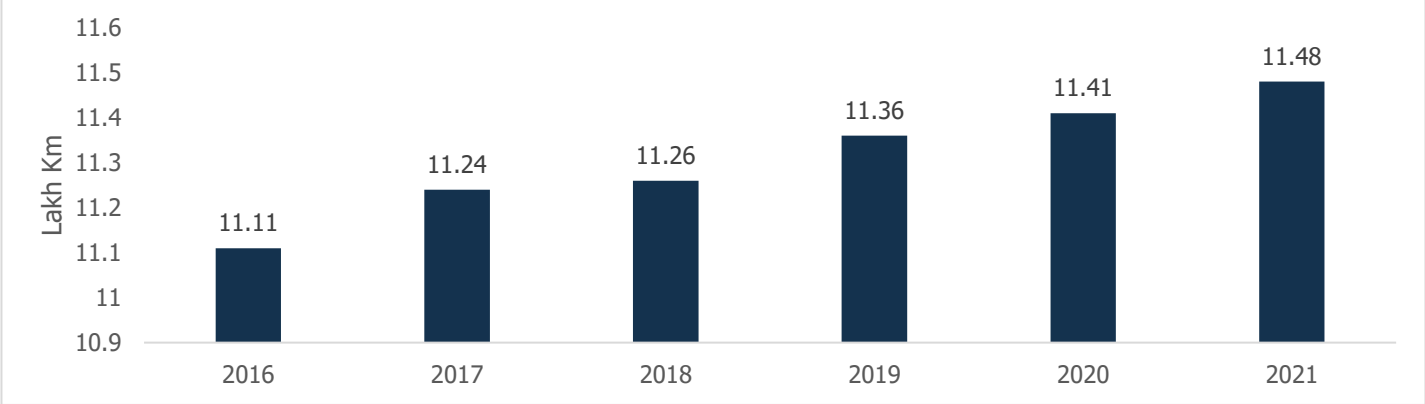
UPS is used to provide uninterrupted power or continuous power to the connected loads. In Railways there are several applications such as Passenger Reservation System and Unreserved Ticketing System centers etc. where even a temporary power supply failure can cause a great inconvenience to public at large/passengers and also may lead to financial loss to the railways.

UPS is a device that has an alternate source of energy in the form of a battery that can provide power when the primary power source is temporarily disabled. The function of an UPS is to supply uninterrupted power to the critical load, such as Computers, vital alarm systems and process control systems etc. UPS systems are necessary to guarantee the smooth operation of these vital components without any disruptions. These systems must be paired with renewable energy solutions to handle fluctuations in power supply and guarantee uninterrupted operation. The increase in demand for UPS systems in the railways sector is fueled by the expansion of passenger and freight services due to the growth of economic activity and urbanization. Increased levels of passengers and cargo being transported necessitate improved power solutions for the railway infrastructure to manage the higher operational demand. As a result, the UPS market is well-positioned to take advantage of the growth and upgrade initiatives in the railways sector by providing customized solutions that address the unique needs of this crucial industry. As the Indian Railways grows and develops, incorporating modern UPS systems will be crucial to support its technological progress, operational effectiveness, and overall expansion path.

Railways is one of the most efficient and cost-effective mode of transport globally as it can carry higher numbers of passengers and cargo at higher speed over long distances. It is also the most environment friendly mode of land transport with much lower energy consumption and carbon dioxide emission compared to roadways or waterways.

As per the International Union of Railways, the world railway lines stood at 11.48 lakh km at the end of 2021 with Asia and Oceania having the largest share of 32%.

Chart 31: Trend in Global Railway Track Length



Source: International Union of Railways

Railways are transitioning from the conventional stream and diesel engines to alternate fuel based electric engines and more recently developed hydrogen engines. Of the total global rail network, about 30% is estimated to be electrified. Countries targeting to achieve net zero carbon emissions is driving the transition to alternative fuels.

Indian Railways is the fourth-largest railway system in the world behind the US, Russia, and China. India has over 68,043 km of the route km along with 7,308 stations as of FY22. The number of passengers carried and freight transported has been on the rise over the past few years. While there was a significant decline in the passengers carried during FY21 on account of COVID-19 pandemic, the number of passengers carried has been increasing over the past two years. The

Indian Railways carried 6,438 million passenger and 1,509 million tonnes of cargo in FY23 and 2,860 million passengers and 634 million tonnes of cargo in FY24 (April- August).

The Indian railway sector has seen multiple developments in the last decade such as expansion of metro rail network, introduction of high-speed trains, modernization of railway stations etc. For the next four to five years, India Railways has set out massive network expansion and decongestion targets. It plans to undertake 17,000 track km of new lines, doubling and gauge conversion work by 2024, out of which, 5,243 km was achieved during FY23 as compared to 2,909 km during FY22. It also plans to become a net zero carbon emitter by 2030 as part of countries strategy to combat climate change. It plans to source 1,000 MW of solar power and 200 MW of wind power across zonal railway and production units.

The increase in continuous modernization and expansion of the nation's railway infrastructure offers substantial chances for the Indian UPS market. Indian railways, which is one of the biggest and most intricate systems in the world, is currently going through a significant change to improve effectiveness, safety, and service standards. This updating involves the installation of high-tech signaling systems, electrification initiatives, automated ticketing methods, and integrated communication networks, all of which are dependent on a consistent power source. UPS systems play a vital role in supporting technological advancements by keeping critical operations like signaling, station management, and communication networks functional in power outages. Furthermore, the rising utilization of intelligent railway systems that utilize IoT and big data analysis for immediate monitoring and control heightens the demand for dependable UPS.

Continuous power is needed for these intelligent systems to function properly and prevent any interruptions in train schedules and passenger information services. As the Indian Railways network expands with new high-speed rail corridors and modern train stations, the need for strong and high-capacity UPS systems will also increase.

The government's emphasis on improving rail safety and efficiency by updating track and station infrastructure and implementing advanced safety systems highlights the necessity of having a dependable power backup. In the Budget 2024-25, Rs 2,50,0000 million has been earmarked for the Ministry of Railways to enhance railway infrastructure. 100% foreign direct investment has been approved by the government in the railway industry. The National Rail Plan (NRP) for India - 2030 was created by Indian Railways to improve the country's railway system. By 2050, India is expected to represent 40% of the entire global rail market. The aim for 2024-2025 is to enhance 40,000 traditional rail bogies to comply with the 'Vande Bharat' criteria. Traffic revenue is projected to be Rs 2,64,6000 Million in 2023-24, making up 99.8% of the total revenue. Indian Railways is advancing technology in signaling and telecommunication, with plans to convert 15,000 km to automatic signaling and install 'KAVACH' on 37,000 km to prevent train collisions, a system developed domestically. The average speed of Freight Trains rose to 44.36 kmph in 2021-22 from 42.97 kmph in 2020-21, marking a 3.23% increase (as of December 31). The year 2021. The objective of the National Rail Plan is to raise the percentage of freight traffic from 27% to 45% by 2030.

3 Application of UPS

3.1 Overview of applications of UPS

3.1.1 BFSI

Data centers and IT infrastructure are essential to the BFSI industry because they house the servers, databases, and network equipment needed to handle large amounts of financial data and transactions. In order to avoid power outages that can cause system breakdowns, data loss, and large financial losses, UPS systems are essential. In the event of a power loss, these systems offer immediate electrical backup, facilitating smooth transitions and guarding against data corruption—all of which contribute to the **protection of critical financial data and business continuity**.

Banks along with other financial companies' branch offices also rely extensively on UPS systems. These offices oversee regular client interactions, account administration, and an array of financial services. Power outages can impede business operations, create hold-ups, and upset clients. Through the use of UPS systems, these branches can provide constant power for necessary devices like **computers, ATMs, and communication devices**, preserving operational effectiveness and raising customer satisfaction even in the event of power outages.

Since **trading** occurs in real time, trading floors and financial markets are especially vulnerable to power outages. Missed trade chances and significant financial losses can result from even short interruptions. For trading terminals, communication networks, and data feeds to continue operating without interruption, UPS systems are necessary. Investor confidence and market integrity depend heavily on this dependability.

The BFSI industry's **customer care centers** deal with a lot of questions, transactions, and support requests. To efficiently handle interactions, these centers rely on reliable IT infrastructure, communication tools, and CRM software. Power outages can negatively affect customer service, resulting in unsatisfactory interactions and possibly lost revenue. By ensuring that all necessary equipment is powered on, UPS systems enable continuous operation and effective customer inquiry handling, which enhances service reliability and sustains good customer connections.

In the BFSI industry, UPS systems also assist with disaster recovery and regulatory compliance procedures. Financial organizations are required by regulatory agencies to maintain data integrity and manage power outages with comprehensive backup plans. These plans would not be possible without UPS systems, which offer instantaneous power backup, protect data, complete ongoing transactions, and permit orderly shutdowns of crucial systems as needed. Meeting regulatory standards, reducing operational risk, and guaranteeing a speedy recovery from power-related catastrophes all depend on this expertise. Financial institutions can more effectively handle power outages and stay in compliance with regulations by integrating UPS systems.

3.1.2 OEM

UPS systems are essential for preserving the dependability and continuity of manufacturing operations in the OEM (Original Equipment Manufacturer) sector.

Automated production lines are one important application where accurate, continuous power is necessary. Any power outage has the potential to seriously impair productivity and efficiency by resulting in equipment faults, production failures, and lengthy downtime. In order to preserve sensitive equipment and minimize expensive disruptions, UPS systems offer instant backup power, enabling these automated systems to continue running smoothly until the main power is restored or an orderly shutdown can be carried out.

Operation of **industrial robots** is a critical and so is the use of UPS systems in the OEM sector. These robots, which are being utilized more often for jobs like welding, packaging, and assembling, need steady power in order to perform at their best. Robotic arms could stop working in the middle of a task due to an abrupt power outage, which could harm the robots as well as the products being developed. Industrial robots can finish their jobs without interruption thanks to UPS systems, which also guard against equipment damage and maintain the integrity of the manufacturing process.

Additionally, **vital control systems** in OEM plants depend on UPS systems to function. Temperature, pressure, and chemical composition are just a few of the variables that these control systems keep an eye on and manage during production. Power outages can cause a loss of control, endangering consumer safety and compromising the quality of products. UPS systems guarantee that control systems continue to function during power outages, preserving uniform production quality and preventing any mishaps. They do this by continuously supplying power.

Furthermore, UPS systems are essential for protecting OEM operations' **communication networks**. Real-time data interchange between various departments and machinery, as well as interconnected systems, are critical components of manufacturing facilities. These communication networks may be interfered with by power outages, resulting in inefficiencies and delays. UPS systems provide constant power to network equipment, maintaining data integrity and facilitating consistent connectivity that facilitates efficient coordination throughout the manufacturing floor.

Additionally, UPS systems are essential for **safeguarding delicate electronic equipment** utilized in OEM facilities. Precision measurement instruments, 3D printers, and CNC machines are a few examples of equipment that is extremely vulnerable to power outages and fluctuations. For these gadgets to operate precisely and effectively, a steady power source is necessary. By protecting delicate equipment from voltage spikes and ensuring that it operates within ideal parameters, UPS systems offer clean, constant power, extending the equipment's lifespan and lowering maintenance expenses.

Power outages might put compliance at risk by impairing quality control procedures and resulting in production errors. UPS systems assist OEMs in meeting regulatory requirements, avoiding fines, and preserving their reputation for dependability and superior manufacturing by guaranteeing a constant power supply.

3.1.3 Solar

UPS systems are essential for preserving the dependability and effectiveness of energy output in solar power projects. When solar panels are unable to produce electricity, as happens at night or in overcast weather, they step in to fill the void. Power storage batteries can be charged during times of excess solar generation and then used to deliver power when needed by integrating UPS systems with solar setups. This guarantees a steady and continuous energy supply. In off-grid solar applications, where there is no connection to the main power grid, UPS systems are very crucial. Solar energy is frequently the dominant power source in these situations, and preserving power availability and controlling energy flow require the use of a UPS. This ensures that these necessary processes continue even when solar energy generation is minimal or nonexistent, which is especially important in rural places where consistent power is essential for applications like communication, healthcare, and emergency services.

UPS systems enable seamless integration and transition between power sources in hybrid solar power systems, which mix solar energy with alternate sources like wind or diesel generators. This prevents power disturbances that could cause equipment damage or operational downtime. In domestic solar setups, UPS systems are also critical because they keep vital home appliances, security systems, and medical equipment operating during blackouts. By keeping activities from being disrupted by power outages, UPS systems in commercial and industrial settings assist preserve business continuity, safeguarding investments and sustaining productivity. Additionally, by controlling variations in solar energy production, UPS systems facilitate the integration of solar power into the main grid. This guarantees dependable integration without producing interruptions, so encouraging a wider adoption of renewable energy sources for a more sustainable future.

3.1.4 Railways

In order to control **train movements** and **maintain safety on the tracks**, UPS systems are essential components of railway signaling systems. Signal failures brought on by power outages may result in delays and even accidents. Railroad operations are kept safe and efficient by UPS systems, which offer a constant power supply to signaling equipment during blackouts. In order to operate efficiently, railway communication systems such as intercoms, public address systems, and radio communication also significantly depend on constant electricity. These technologies are critical for managing train movements, giving passengers real-time updates, and guaranteeing effective communication amongst various railway departments. In order to avoid any disturbance in coordination and information flow during power outages, UPS systems make sure that these communication channels are kept open.

Electronic ticket machines, security systems, and monitoring equipment are only a few of the electronic gadgets and systems that are installed in railway stations and control rooms. These procedures can be severely disrupted by power outages, which puts passengers' safety and comfort at risk. These vital components receive dependable power backup from UPS systems, which guarantees continuous operation and raises the general effectiveness and security of railroad services. To guarantee passenger comfort and safety, train operations—which include onboard equipment for lighting, air conditioning, and passenger information—need a steady power supply. Power outages can lead to various problems, such as discomfort from inadequate air conditioning and lights to safety risks from malfunctioning emergency systems. Passengers can travel in safety and comfort knowing that critical onboard systems are kept operational during power outages thanks to UPS systems.

The proper operation of **railway maintenance equipment** also depends on continuous power. In order to guarantee the efficient and secure functioning of the railway network, these instruments are used to examine and maintain rails, trains, and other railway equipment. Power outages can jeopardize safety and cause maintenance tasks to be delayed. In order to assist the timely and effective maintenance of railway infrastructure, UPS systems supply the essential power backup to keep diagnostic and maintenance equipment operating. Advanced control systems used in contemporary railway operations, like centralized traffic control and automated train control, depend on constant electricity to regulate train movements and guarantee operational effectiveness. These control systems are susceptible to disruptions from power outages, which could result in delays and even safety risks. These sophisticated control systems have a dependable power supply thanks to UPS systems, which guarantee their continued operation in the event of a power outage. This contributes to the overall dependability of the railway network by maintaining the effectiveness and safety of train operations.

3.1.5 Oil & Gas

Uninterruptible Power Supply (UPS) systems are essential for preserving operational integrity and safety in the oil and gas sector. These systems guarantee that vital machinery and processes continue to operate in the event of a power outage, which can be brought on by inclement weather, malfunctioning machinery, or other interruptions. In order to eliminate expensive downtime and other safety risks, UPS systems offer a dependable power source that enables continuous tracking and oversight of activities.

Drilling activities, whether onshore or offshore, are a significant use of UPS in the oil and gas industry. Drilling rigs need a steady power source in order to run their safety features, control systems, and drilling apparatus. Drilling operations may be suspended by a power outage, which could result in large losses and delays. Drilling activities may continue and remain safe because UPS systems make sure that vital equipment continues to function even in the event of power shortages or variations.

UPS systems are crucial to the efficient operation of communication networks, safety devices, and control systems in **refining and processing facilities**. Power disruptions can have a serious negative operational and financial impact on refineries, which transform crude oil into a variety of products. UPS systems ensure that the refinery runs safely and effectively even during power outages by supplying backup power to Emergency Shutdown Systems (ESD), Distributed Control Systems (DCS), and Programmable Logic Controllers (PLC).

In order to oversee operations across large, frequently unreachable areas, the oil and gas sector also significantly rely on **remote monitoring and automation systems**. These systems, which include automated controls, communication devices, and sensors, depend on a constant power source to operate properly. These remote monitoring stations receive the backup power they require from UPS systems, which guarantees continuous data gathering and communication—essential for preserving operational safety and efficiency.

The Oil and Gas industry's **pipeline operations** also profit immensely from UPS systems. Long-distance oil and gas transportation is facilitated via pipelines, and power outages can have an impact on the functionality of pumps, control valves, and monitoring apparatus. UPS systems guarantee that these vital parts continue to function in the event of a power outage, averting possible spills, leaks, or pipeline interruptions that can have detrimental effects on the environment and the economy.

Offshore platforms rely significantly on UPS systems to keep critical equipment operating because of their harsh climatic conditions and distant locations. For the safety systems, processing, and drilling on these platforms, a reliable power source is necessary. By guaranteeing that vital functions may continue without interruption, UPS systems offer dependable power backup, protecting the platform and its users.

UPS systems facilitate a number of operations in the **exploration** and **production** sector, including as the acquisition of seismic data, well logging, and transmission of data in real time. A constant power source is necessary for these operations in order to guarantee precise data gathering and analysis. Resource extraction is made more productive and efficient when UPS systems supply the backup power required to keep exploration and production going uninterrupted.

In general, UPS systems are essential to the oil and gas sector because they guarantee the continued operation of crucial machinery and processes even in the event of a power outage. They support pipeline operations, remote monitoring, drilling, and refining, among other uses, by preserving operational continuity, safety, and efficiency.

3.1.6 Power

Uninterruptible Power Supply (UPS) systems are essential for maintaining the dependability and continuity of operations in the power generation and distribution industry. During power outages, **control and monitoring systems** in power plants—whether they be nuclear, coal, gas, hydro, or renewable energy facilities—rely on UPS systems to remain operational. These technologies are essential for safeguarding delicate equipment, avoiding operational delays, and guaranteeing plant workers' safety. UPS systems give control systems instant backup power, enabling equipment to be shut down in a controlled manner and averting catastrophic failures.

Substations are a key location for UPS systems in the power industry. Because substations are essential components of the power distribution network, any interference with their operation has the potential to cause extensive blackouts. Substations with UPS systems guarantee that critical monitoring and control equipment continues to function in the event of a power outage. This allows operators to promptly identify and fix problems, reducing downtime and preserving grid stability. Substations cannot work properly without relay systems, circuit breakers, and communication equipment operating continuously. UPS systems supply the backup power required to make this happen.

UPS systems are also crucial to **distribution and transmission control centers**. These centers control how energy is distributed throughout the electrical grid, making decisions in real time to maintain grid stability, balance supply and demand, and handle crises. UPS systems make sure control centers stay up and running in the event of a power outage, which enables operators to stay in touch with field units and efficiently plan responses. These control centers' potential power losses could result in long outages, blackouts, and delayed reactions. Consequently, the total resilience of the electrical grid depends on the dependability of UPS systems.

UPS systems are also advantageous for renewable energy projects, including solar power plants and wind farms. These facilities frequently function in isolated areas and are vulnerable to erratic weather patterns that may have an impact on the production of electricity. UPS systems ensure that data collection and communication with **grid operators** continue unhindered by providing backup power to monitoring and control systems. This is especially crucial for preserving the dependability and efficiency of renewable energy sources because they require real-time monitoring and modifications in order to maximize power output and integrate them into the larger grid.

UPS systems are crucial for **microgrids and distributed energy resources** (DERs), in addition to large-scale power generation and distribution. Localized power networks known as microgrids can function either separately or in tandem with the larger grid. Microgrids with UPS systems guarantee the constant functioning of vital parts such control units, energy storage systems, and inverters. Maintaining power quality and stability during the shift between grid-connected and islanded modes is particularly critical. Microgrids become more resilient and reliable when UPS systems are integrated with them, which makes them a good option for off-grid and remote applications.

UPS systems are also necessary for industrial facilities that rely on their own power generation capabilities, such as cogeneration plants. These facilities produce thermal energy and electricity on-site, offering a dependable and effective energy source for industrial operations. During power outages, UPS systems make sure that safety gear, communication networks, and control systems continue to function.

3.1.7 Aviation

In the aviation sector, Uninterruptible Power Supply (UPS) systems are essential for guaranteeing the uninterrupted functioning of vital systems. UPS systems are essential to the constant power supply of **radar systems**, **communication networks**, and **navigational aids in air traffic control towers**. Any interference with these systems could pose serious risks to aircraft safety and coordination inside the airspace. UPS systems guarantee that air traffic controllers can continue to safely and effectively oversee flights even in the event of a power outage by offering dependable power backup. Additionally essential to airport operations are UPS systems, which support a number of crucial systems like **ticketing, luggage handling, and security screening**. Airports depend on a wide range of electronic devices to run efficiently, so a power outage can result in serious delays, disruptions to operations, and security hazards. UPS systems support the upkeep of these systems' operational integrity by guaranteeing a steady supply of power, enabling the safe and efficient processing of passengers.

In order to ensure the safety and security of travelers, employees, and airport infrastructure, UPS systems in airport security enable the uninterrupted operation of **surveillance cameras, access control systems**, and other security measures. Power outages have the potential to jeopardize security operations and expose networks to attacks and breaches. Airport security is ensured by UPS systems, which supply the essential power backup required to maintain these security systems running constantly.

The utilization of UPS systems is advantageous to airline operations centers as well, since these centers oversee **crew scheduling**, **flight operations, and real-time aircraft monitoring**. For the effective management of airline operations, these centers' data and communication technologies are essential.

UPS systems are essential to the operation of **diagnostic equipment and maintenance management systems** in aviation repair facilities. These facilities perform routine aircraft inspections and repairs, necessitating the accurate and constant operation of numerous electronic instruments and systems. A power loss may cause schedules for maintenance to be disrupted, repairs to be delayed, and possibly even the safety of aircraft. UPS systems offer the essential power backup to guarantee uninterrupted maintenance operations. UPS systems are also beneficial to aircraft communication and entertainment systems. These devices improve the traveling experience for passengers by offering connectivity and entertainment while in flight. The uninterrupted functioning of these systems depends on a steady power supply, and any outage can make passengers unhappy.

Lastly, UPS systems are essential to the aviation industry's adherence to legal and regulatory regulations. Strict requirements for operational continuity and safety are mandated by regulatory organizations. Crucial to these standards is guaranteeing dependable power backup for vital systems. Aviation entities can strengthen their operational reliability and safety standards, comply with regulatory requirements, and avoid penalties by putting UPS systems into place.

3.1.8 Manufacturing & Process

Uninterruptible Power Supply (UPS) systems are essential for preserving operational continuity and safeguarding vital equipment in the manufacturing and process industries. **Production lines and machinery** are among the key applications of UPS in this industry. Production procedures frequently rely on complex equipment and automated systems that are susceptible to power variations. Production can be interrupted by an abrupt drop in voltage or power, which could cause expensive delays and equipment damage. UPS systems make sure that the machinery keeps running smoothly, avoiding disruptions in the production process and protecting the machinery and output. Process control systems represent a substantial additional use for UPS in the manufacturing industry. For these systems to work, which track and manage different parts of the production process, there needs to be a steady and reliable power source.

In order to sustain product quality and compliance with industry standards, UPS systems supply backup power to these control systems, guaranteeing that operations run smoothly and processes stay stable. UPS units are essential for safeguarding **sensitive data and IT infrastructure** in manufacturing facilities, in addition to process control systems. IT systems are integrated into a lot of contemporary manufacturing processes for data collecting, monitoring, and analysis. UPS systems guarantee that essential IT components continue to function in the case of a power outage, protecting data and enabling the continuous gathering and examination of vital production data. Based on precise and up-to-date data, this aids in decision-making and manufacturing process optimization.

UPS systems are very vital in the field of safety and emergency systems. Safety features including **ventilation systems**, **emergency lights,** and **fire alarms** are frequently found in manufacturing facilities and are crucial for both the building's and its occupants' protection. These safety measures need to continue working in the event of a power outage in order to guarantee worker safety and the ability to handle any problems. These safety systems receive the backup power they require from UPS systems, which guarantees their proper operation in the event of an emergency or a power outage. Moreover, delicate instruments and equipment utilized in production operations are safeguarded by UPS systems. A steady power source is necessary for the precise **operation of analytical and precision instruments**, which are used in many manufacturing processes. Power fluctuations or outages can affect the performance and accuracy of these instruments, leading to potential errors and production issues. UPS systems safeguard these critical instruments by providing a reliable power source and protecting them from electrical disturbances.

Backup power for energy-intensive manufacturing operations is also supported by UPS systems. Certain manufacturing processes require a lot of energy, thus even a short power outage can have a big effect on output. Energy-intensive

procedures can continue uninterrupted thanks to UPS systems' smooth backup power transition. This is especially crucial for sectors with lengthy production cycles where it can be expensive and time-consuming to restart operations. By supplying steady and dependable power, assisting in the prevention of downtime, lowering maintenance costs, and improving the general performance of production systems, UPS systems improve the overall efficiency and dependability of manufacturing operations.

3.1.9 Logistics

Uninterruptible Power Supply (UPS) systems are essential for preserving efficiency and operational continuity across a range of industry operations in the logistics sector. **Warehouse management** is one of the main uses for UPS systems in logistics. They shield complex management systems and vital inventory from power fluctuations and outages, guaranteeing that order processing, inventory management, and other warehouse operations continue unhindered.

Transportation management systems (TMS) are a significant additional use for UPS systems. Logistics firms depend on TMS for fleet management, shipment monitoring, and route optimization. UPS systems make sure these platforms run smoothly even in the event of a power outage, avoiding delays and preserving precise shipment tracking and management.

The communication networks of logistics organizations also depend on UPS systems. **Coordinating activities** between many divisions, suppliers, and customers requires effective communication. In order to keep communication lines open and functioning during power outages, UPS systems supply backup power for communication devices including phones, radios, and network systems. This helps to minimize communication disruptions and preserves the seamless running of logistics processes.

UPS systems also assist with **security** and **surveillance** for logistics operations. To improve security, a lot of logistics facilities use alarm systems, access control systems, and CCTV cameras. These systems need constant electricity to operate properly and defend against possible attacks; UPS systems make sure that security precautions don't falter in the event of a power outage. UPS systems are essential for logistics firms that use automated sorting and handling systems. Conveyor belts and robotic sorters are two examples of automated systems that depend on a steady power supply to function properly. Any interruption in this supply can result in delays, damaged items, and higher operating expenses. UPS systems protect these automated procedures, guaranteeing uninterrupted sorting and handling and maintaining the effectiveness of logistics operations.

UPS systems safeguard logistics organizations' **IT infrastructure** as well, including computers and data storage that handle vital information about shipments, inventories, and customers. In the event of a power outage, UPS systems make sure that these IT assets continue to function, preventing data loss and facilitating a smooth data recovery process—both of which are essential for preserving correct records and bolstering the general effectiveness of logistics operations.

Finally, during power outages, UPS systems support business continuity. Logistics firms frequently work nonstop, so any interruption can have a big effect on both operations and finances. In order to satisfy customers and keep a competitive edge in the logistics sector, logistics companies need to be able to avoid disruptions, maintain service levels, and ensure smooth operations even during unplanned power outages. This is what UPS systems do for them.

3.1.10 Security & Safety Systems

Uninterruptible Power Supply (UPS) systems play a crucial role in the Security & Safety Systems industry by guaranteeing the uninterrupted and dependable functioning of a range of safety and security systems, such as **access control mechanisms, alarm systems, and surveillance cameras**. These systems are essential for preserving security and

keeping an eye on surroundings, and a UPS makes sure they keep working even in the event of power disruptions or variations, offering unbroken security and observation. A UPS ensures that vital components for surveillance systems, such as closed-circuit television (CCTV) cameras, keep working continuously. Video footage from surveillance systems frequently needs to be continuously recorded, thus any power outage could cause gaps in the security monitoring. A UPS keeps cameras running by supplying backup power, which is essential for recording and preserving events in real time.

A UPS system is essential to the operation of **alarm systems**, including intrusion detection and fire alarms, in the event of a power outage. These systems are intended to notify users of potential safety risks or security breaches; nevertheless, they may become inoperative in the event of a power outage. Alarm systems can continue to function as intended, even in the event that the primary power source is unavailable, thanks to the power backup that a UPS provides. A constant power source is also crucial to access control systems, which regulate and keep an eye on access to restricted locations. These devices, which include biometric scanners, card readers, and electronic locks, all depend on steady power to operate properly.

Systems for **detecting and suppressing fires** are another essential element that gains from UPS support. In order to detect smoke or fire and initiate suppression mechanisms, these systems need to be functioning at all times. Sprinklers, fire alarms, and other fire safety equipment get power backup from a UPS, which makes sure that these systems can still react quickly to crises in the event of a power outage. For safety and emergency lighting during blackouts, safety and emergency lighting systems are essential in big commercial buildings and industrial settings. These systems include lights for hallways, emergency exits, and other important lighting fixtures. During power outages, a UPS makes sure that these lights stay on, directing people out of the building safely and averting mishaps or injuries. A UPS makes sure that communications equipment utilized in security operations, like intercoms and emergency communication networks, continue to function even in the event of a power outage. Coordinating responses to safety emergencies and security incidents requires effective communication. A UPS keeps these communication systems operational by supplying backup power, which promotes efficient coordination and reaction.

A UPS is essential for preserving overall system integrity in the context of integrated security systems, which incorporate several safety and security aspects into a single platform. These integrated systems frequently combine components for **communication, access control, alarms, and surveillance**. A UPS guarantees that, in the event of a power outage, every element of the integrated system will continue to operate as a whole, offering uninterrupted protection and safety coverage.

3.1.11 Corporate and Commercial Offices

Uninterruptible Power Supply (UPS) systems are essential for sustaining continuous business operations in corporate and commercial buildings. For everyday operations, offices mostly rely on technology and electronic systems, such as **computers, servers, communication networks, and data storage**. By supplying backup power during blackouts, UPS systems guard these vital parts from damage, loss of data, and interruptions in service.

This guarantees that company operations stay uninterrupted even in the event of a power outage. In business settings, UPS systems are also essential for maintaining the functionality of communication networks. **Email servers, phone systems, and internal communication networks** are essential for businesses to support daily employee interactions and teamwork. Any outage of electricity has the potential to cause communication disruptions, which could hinder productivity and even cause important business procedures to be delayed. By guaranteeing the continuous operation of various communication systems, a UPS preserves uninterrupted connectivity and productivity.

Sensitive electronic equipment is shielded from power fluctuations and surges by UPS systems. Frequent voltage dips and spikes in business settings can harm peripheral electronics like printers and computers. UPS systems assist in preventing this kind of damage by offering a steady power supply and controlling voltage levels, increasing the life of

office equipment and lowering the likelihood of expensive repairs or replacements. Upgrading corporate offices' security and surveillance systems also requires the installation of UPS systems. Alarm systems, access control systems, and security cameras are essential for protecting properties and guaranteeing the security of personnel and property. The office's security integrity is maintained by these security measures continuing to function despite power outages thanks to a dependable power backup provided by a UPS system.

The uninterrupted operation of vital corporate applications and procedures is supported by UPS systems. Power is necessary for **financial transactions, client data management**, and other critical company operations in order to guarantee timeliness and accuracy. UPS systems give these apps the backup power they need to remain operational, enabling companies to stay out of trouble and continue offering a high standard of service. The robustness and dependability of corporate IT infrastructure are enhanced by the presence of UPS systems. Recovering promptly from power-related disruptions is essential for preserving operational efficiency and competitiveness in today's fast-paced corporate climate. Businesses may preserve their IT investments, increase operational dependability, and guarantee that office operations run smoothly even in the event of power outages by investing in UPS systems.

3.1.12 PSUs and Government

Uninterruptible power supply (UPS) systems are necessary for preserving operational continuity and safeguarding critical operations in government and public sector undertakings (PSUs). These industries generally manage significant activities and essential services where electricity dependability is essential.

In order to maintain service during power fluctuations and outages, UPS systems are utilized in a variety of government buildings and PSU operations. UPS systems are essential for **government data centers**, which handle enormous volumes of sensitive data and vital infrastructure. They maintain ongoing government services including tax collection, public records management, and **e-governance platforms** by ensuring constant power to prevent data loss and system outages. UPS systems are essential to the running of public sector businesses in the energy, transportation, and utility sectors. In power plants and grid control centers, UPS systems stabilize control systems and communication networks, preventing disruptions in energy distribution and operational efficiency. Similarly, in transportation hubs and logistics centers, UPS systems maintain the functionality of ticketing systems, surveillance, and communication networks.

UPS systems are also essential to government organizations that provide **emergency services and public safety**, including police departments, fire departments, and disaster management centers. For these facilities to react to crises in a timely and efficient manner, they must run constantly. Public safety operations are improved by UPS systems' dependable power backup, which keeps data management programs, emergency response systems, and communication equipment operational during blackouts. Furthermore, for efficient everyday operations, UPS systems are essential in government buildings such as legislative assembly, administrative offices, and courts. These structures frequently contain vital operational and communication systems that require continuous electricity to support judicial, legislative, and administrative procedures. UPS systems shield governance and administration from interruptions brought on by power outages.

UPS systems safeguard financial transactions and data integrity in the public sector financial sector, which includes government-run banks and financial organizations. UPS systems contribute to preserving public confidence and operational effectiveness by averting disruptions brought on by power outages. In order for public sector financial institutions to continue operating, they provide support for the delivery of services like **banking transactions, financial record administration, and customer service**. Additionally, UPS systems assist government-affiliated research and education facilities by safeguarding vital research data, administrative frameworks, and educational materials. Online learning environments, data gathering processes, and ongoing research can all be hampered by power outages. UPS systems work to guard against these disruptions and maintain the flow of learning and research activities.

3.1.13 Defense

Uninterruptible Power Supply (UPS) systems play a crucial role in the defense industry by guaranteeing the uninterrupted functioning of critical systems and infrastructure. **Modern technology, including command and control centers, surveillance tools, and communications systems**, is essential to military operations. These systems all require a steady and dependable power source. In order to preserve efficacy and security, UPS systems offer vital backup, guaranteeing that these systems continue to function during power fluctuations or outages.

Systems for communications are especially important in the defense industry. For the purpose of **coordinating operations, transmitting intelligence, and formulating strategic decisions, military operations require instantaneous, secure communication links**. In the event of a power outage, UPS systems make sure these communication networks continue to operate, averting communication failures that can jeopardize missions and employee safety.

UPS systems are also necessary for **monitoring and surveillance systems**. Defense installations frequently monitor borders, bases, and sensitive areas with the use of cutting-edge equipment including radars, cameras, and sensors. For these systems to identify and react to possible threats, they must run constantly. UPS systems supply the backup power required to keep surveillance equipment running around-the-clock, enabling continuous watchfulness and prompt reactions to security lapses or threats.

Various electronics systems, such as computers, servers, and communication devices, are necessary for command and control centers, which are places where important decisions and strategic planning take place. In order to keep these systems operating continuously and prevent power outages from interfering with command and control tasks, UPS devices are essential. Maintaining the integrity of the command and carrying out its execution depend on this continuous operation.

In the defense industry, UPS systems are also utilized to support **disaster recovery and emergency response** activities. Defense agencies are required to maintain operational preparedness and send out fast response teams in the case of emergencies, including natural catastrophes. In order to facilitate quick and efficient responses to emergencies and lessen the impact of disasters on defense operations, UPS systems make sure that emergency response equipment, such as communication and navigation tools, stays operational during power outages. Critical infrastructure, including environmental controls, security systems, and lighting, is supported by UPS systems in military bases and facilities. Power outages can seriously jeopardize people's and property's security and safety. UPS systems provide reliable backup power for essential infrastructure, ensuring that lighting, security alarms, and environmental controls remain operational, thereby maintaining the safety and well-being of personnel.

Lastly, UPS systems are critical to the defense industry's research and development efforts. **Research facilities and specialized labs** are frequently used to create and test cutting edge defense breakthroughs and technology. UPS systems prevent critical research equipment and data from being damaged by power outages, enabling continuous analysis and testing. This guarantees the uninterrupted continuation of vital research and development endeavors, hence propelling progress in defense technologies and capabilities.

3.1.14 Petrol Pumps

Uninterruptible Power Supply (UPS) systems are necessary in the gas pump industry to guarantee continuous operations and uphold service dependability. **Fuel dispensers and payment systems** are two examples of vital equipment for which UPS systems at gas pumps are used as backup power sources. For these systems to function properly, there must be a steady and dependable power source because any disruption could cause service outages and even result in lost revenue. During power outages, UPS systems make sure fuel dispensers stay functional, enabling gas pumps to keep servicing customers without any disruptions.

Point-of-sale (POS) terminals and other electronic payment systems depend on UPS systems to continue operating. Electronic payment systems are frequently used at gas stations to handle transactions fast and securely. These systems can be interfered with by a power outage, which could result in transaction delays and even financial losses. In order to maintain payment systems operating and guarantee that clients may continue to pay for fuel and services without interruption, UPS systems provide a backup power supply.

Additionally, the **security and monitoring systems** at petrol pumps are powered by UPS systems. Alarms, access control systems, and security cameras are essential for ensuring security and thwarting theft. In order to maintain the safety of the premises during a power loss, these systems need to continue working. In order to maintain the functionality of security and surveillance systems and guard against theft and security breaches, UPS systems supply the backup power required.

Updating lighting systems is another crucial use for UPS systems in gas pumps. For safety and visibility, particularly at night or in low light, proper lighting is crucial. UPS systems make sure that lights stay on during blackouts, which makes the workplace safer for employees and consumers alike. They also lower the risk of accidents and uphold general safety.

Additionally, UPS systems facilitate the operation of communication systems at gas stations. **Radios and intercom systems** are examples of communication technology that is essential for managing staff communication and coordinating operations. These systems may become vulnerable after a power outage, which could result in unsafe operations. In the event of unplanned power outages, UPS systems provide uninterrupted and effective operation of communication systems by supplying backup power.

3.1.15 Schools and Educational Institutions

In order to guarantee the continuous operation of vital electronic devices and preserve a favorable learning environment, Uninterruptible Power Supply (UPS) systems are crucial in schools and other educational facilities. Power outages can cause **instructional activities** to stop, **administrative procedures** to come to a stop, and the operation of necessary equipment to be compromised. In order to minimize disruptions and preserve the flow of teaching, UPS systems offer a dependable backup power source that guarantees the ongoing operation of computers, projectors, and other educational devices.

UPS systems are essential in **computer labs** to safeguard computers and other electronic equipment against surges and power outages. In the modern classroom, where computers are used for assignments, research, and learning activities, these labs are essential. Unexpected power outages can cause system breakdowns, data loss, and disruptions to student work. By offering backup power that enables users to safely save work and shut down equipment, UPS systems help to avert these problems and safeguard priceless educational resources as well as student progress.

UPS systems are very helpful in classrooms with **electronic whiteboards, projectors, and audio-visual aids**. These tools improve education by adding interactivity and engagement to the classroom. During power outages, a UPS makes sure that these gadgets continue to function, enabling teachers to continue teaching courses. This is particularly crucial during exam or instructionally key times.

Educational institutions' administrative offices also depend on UPS systems to maintain business continuity. These offices are in charge of crucial duties like **organizing staff activities, processing applications,** and keeping track of student records. The institution's overall effectiveness may suffer from delays in administrative tasks brought on by a power outage in certain locations. In order to provide important services, administrative staff can continue working uninterrupted thanks to backup power provided by UPS systems.

UPS systems are essential for preserving access to **online databases and catalog systems** in libraries, where academic staff and students use digital resources and carry out research. Power outages in libraries can prevent users

from accessing these essential resources, which can hinder study and research efforts. UPS systems guarantee that library services are available at all times, supporting the institution's academic needs by offering a dependable power supply.

UPS systems are also beneficial to facilities management, especially when it comes to keeping **security and surveillance equipment** operational. To maintain safety and security, schools and other educational institutions need to have their grounds constantly inspected. Surveillance cameras, alarm systems, and other security equipment depend on UPS systems for backup power, which keeps them functional during power outages and keeps personnel and students safe.

UPS systems are necessary to prevent disturbances during activities like exams, seminars, and conferences held in educational institutions. These activities frequently depend on a variety of **technical equipment, such as computer systems, microphones, and projectors**. During these occasions, a power loss can result in serious delays and inconveniences.

3.1.16 Network Hubs and Mobile Towers

Uninterruptible Power Supply (UPS) systems are essential for sustaining uninterrupted operations and guaranteeing dependable communication services in network hubs and mobile towers. Network hubs are essential locations for routing and **data distribution**, and they need continuous power to control information flow between different networks. Any interruption to the power supply may result in network outages, which could impact customer and business connectivity. In the case of an interruption, UPS systems instantly supply backup power to maintain network hub functionality.

Reliable power sources are also necessary for mobile towers to keep mobile networks connected. Through the sending and receiving of signals to and from mobile devices, these towers enable communication. Users' ability to make calls, send messages, and access the internet may be negatively impacted by a widespread loss of service caused by a mobile tower power outage. **Mobile towers** are kept operational during power outages using UPS systems, which minimizes user interference and permits continuous communication.

UPS systems shield **network hubs and mobile towers** from power surges and electrical disruptions in addition to offering backup power. Power quality fluctuations have the potential to harm delicate electronic equipment, necessitating expensive repairs and downtime. Surge protection and voltage control features integrated into UPS systems defend against these problems and extend the life and dependability of the equipment.

The number of network hubs and mobile towers has expanded due to the growing demand for data and mobile connection. There is an increasing requirement for **dependable power solutions** as these facilities grow. In order to maintain this growing infrastructure and guarantee that every hub and tower runs smoothly, UPS systems are crucial. These facilities' expanding power needs can be flexiblely accommodated thanks to the scalability of UPS systems. In distant and off-grid settings where steady power sources may be scarce, UPS systems are extremely important. When traditional infrastructure is weak, mobile towers in underserved or rural locations sometimes rely on UPS systems to maintain uninterrupted operation despite unstable power grids.

3.1.17 Small Offices, Shops and MSMEs

Under micro, small, and medium companies (MSMEs), as well as small offices, Uninterruptible Power Supply (UPS) systems are essential for **preserving data security** and ensuring uninterrupted business operations. For day-to-day operations, these organizations frequently rely significantly on technology, such as point-of-sale (POS) systems, customer databases, and digital communication tools. Businesses may continue operating without interruption and avoid possible financial losses from downtime when a UPS guarantees that these vital systems continue to work during power outages.

UPS systems offer crucial backup power for **point-of-sale terminals** and **computerized cash registers** in small retail stores and offices. These systems are essential for handling inventory and processing transactions. During busy business hours, a power outage can lead to lost revenue, irate customers, and operational delays. By using a UPS, businesses can maintain their sales operations, keep their register systems active, and ensure a smooth customer experience even during electrical disturbances.

Data security is a major problem for MSMEs, since they frequently have lesser IT budgets and fewer staff. Because UPS systems give computers and servers backup power, they are essential to protecting sensitive company data. This keeps sensitive information like customer and operational data safe from corruption and loss from unplanned power outages, enabling organizations to preserve the accuracy of their financial records. Reduction of recovery time and the possibility of data loss are reduced when systems can be appropriately shut down and work saved during a power outage.

UPS systems are frequently used by small offices to maintain their **network equipment**, which includes **modems**, **switches, and routers**. Maintaining productivity and client communication during power outages requires a UPS to guarantee internet connectivity and communication services stay functional. A dependable UPS system is essential for companies that depend on continuous connectivity, such those who provide online assistance or remote services, in order to prevent service interruptions and guarantee steady operation.

UPS systems support **security systems**, including as alarm systems and surveillance cameras, in retail settings. Preserving the safety of the facilities and safeguarding inventory depend heavily on these security procedures. These systems receive backup power from a UPS, which guarantees their continued operation in the event of a power loss. This reduces the risk of theft and improves security in general.

Compact and effective UPS systems are beneficial for MSMEs, who sometimes have limited space and finances. Space-constrained small offices and shops can benefit greatly from the energy-efficient and space-saving design of modern UPS systems. These systems are a sensible option for companies with modest infrastructure since they provide dependable power protection without taking up a lot of floor area.

UPS systems provide a **temporary power source** during **brownouts or blackouts**, which helps with business continuity planning. This relieves pressure on firms to put emergency plans in place and execute backup power sources or emergency procedures, for example. Maintaining the functionality of critical systems gives organizations the time they need to resolve power outages and seamlessly return to normal operations. For small businesses, shops, and MSMEs, UPS systems are essential because they provide vital assistance in guaranteeing security, preserving data, and preserving operational continuity.

3.1.18 Malls, Theaters and Retail

Systems for supplying power without interruption are essential to the **uninterrupted functioning of theaters, shopping centers**, and other businesses. Constant electricity is necessary for both operational effectiveness and customer happiness in these busy settings. UPS systems protect a number of vital services for malls, such as security systems, escalators, elevators, and lighting. A UPS makes sure these services continue to function during a power loss, avoiding interruptions that can cause inconvenience to customers or pose a risk to their safety. Furthermore, **complex heating, ventilation, and air conditioning (HVAC) systems** are frequently used in malls. For the comfort of customers and to safeguard delicate goods from temperature changes, HVAC systems depend on backup power from a UPS to maintain ideal temperatures and air quality even in the event of a power outage.

UPS systems are useful for retail establishments in malls because they guarantee the continued operation of **digital payment gateways and point-of-sale (POS) systems**. A UPS supplies the energy required to maintain the operation of payment terminals, inventory management systems, and cash registers in the case of a power outage. In doing so, revenue losses are avoided, transactions are made possible, and financial stability and high standards of customer care

are upheld. Large crowds are drawn to performances and screenings at theaters, which likewise largely depend on UPS systems. During power outages, these systems make guarantee that essential parts like projection equipment, sound systems, and lighting continue to function. In order to preserve the caliber and continuity of performances, a UPS offers dependable backup in the event of disturbances that can negatively impact the audience's experience.

UPS systems are also necessary for retail locations, theaters, and mall security systems. For proper operation, **access control, alarm, and surveillance cameras** require constant power. A UPS makes sure that these security precautions continue to function during blackouts, safeguarding both consumers and employees from theft and damage. Sustaining a safe workplace and preventing security breaches require maintaining security coverage.

UPS systems are essential for the dependability of the communication systems in shopping centers and movie theaters, in addition to ensuring operational continuity. In order to guarantee efficient communication during **emergencies, public address systems**, **intercoms, and emergency notification systems** must continue to function. These communication devices are powered by backup power from a UPS, which guarantees uninterrupted transmission of vital alerts and announcements—an essential function for handling emergencies and upholding law and order.

UPS systems are especially advantageous for retail companies that use cutting-edge technology for **digital marketing**, **CRM, and inventory management**. These systems enable technology platforms that maintain inventories, drive sales, and interact with customers through digital channels to run continuously. Maintaining business continuity and supporting retail operations' efficiency is facilitated by making sure these systems continue to function during power outages. The general dependability of operations in theaters, shopping centers, and other venues is improved by the presence of a UPS system.

3.1.19 Healthcare and Hospitals

Because they continuously supply power for necessary activities and equipment, Uninterruptible Power Supply (UPS) systems are critical to the healthcare and hospital industries. Hospitals and other healthcare institutions need continuous power to keep up **vital operations and life-saving services**. By preventing power outages from interfering with medical procedures, patient care, or other essential services, a UPS safeguards patient safety and the accuracy of medical data.

The support of life-sustaining medical equipment is one of the main uses of UPS systems in the healthcare industry. For proper operation, devices including **dialysis machines, ventilators, and infusion pumps** require a steady power source. Any outage of power can compromise patient safety and make it more difficult to continue therapy. These devices receive backup power from UPS systems, which guarantees their continued operation in the event of a power outage and protects patient safety.

The upkeep of **electronic health records (EHR) systems**, which house vital patient data like test results, treatment plans, and medical histories, depends on UPS systems as well. A sudden loss of power could cause data to be lost or corrupted, which could have detrimental effects on patient care. In order to maintain continuity of care and data integrity, UPS systems make sure that EHR systems continue to function and that data is stored during power outages.

UPS systems are essential for the operation of **hospital communication systems** in addition to **sustaining EHR and medical equipment**. Coordinating internal operations, emergency responses, and patient care all depend on effective communication. In order to maintain the availability of phone lines, intercoms, and communication networks during blackouts, UPS systems supply backup power to these systems.

UPS systems are also necessary for **hospital lighting systems**, including as emergency and surgical illumination. During a power outage, immediate lighting availability is crucial to preserving a safe atmosphere and carrying out surgeries or other important procedures. UPS systems minimize disruption and guarantee patient and healthcare provider safety by supplying the backup power required to maintain illumination functionality.

Additionally, UPS systems are crucial for **hospital HVAC system maintenance**. For the safe storage of pharmaceuticals, vaccines, and other delicate items that need particular environmental conditions, temperature control is crucial. In the event of a power outage, a UPS system makes sure HVAC systems continue to function, safeguarding these vital resources and avoiding spoiling or damage.

Hospital security systems, such as access control, alarm, and surveillance camera systems, are also supported by UPS systems. To safeguard patients, employees, and facilities in healthcare environments, security is essential. In order to keep security systems functional and effective during power outages and preserve patient safety and security, UPS systems supply backup power to security systems.

Within healthcare facilities, UPS systems are often used for **administrative and support tasks**. These technologies facilitate vital administrative tasks that are necessary for the facility's efficient administration, including scheduling, billing, and other non-medical procedures. UPS guarantees that administrative tasks are carried out without interruption by supplying backup power to these systems, which enhances overall operational efficacy and efficiency.

3.1.20 Data Center

Uninterruptible Power Supply (UPS) systems are necessary in data centers to guarantee dependability and continuous operation. These facilities are essential for supporting a range of applications, including business resource planning and **cloud computing**, as well as for **managing and storing massive volumes of data**. In order to preserve data integrity and service accessibility during electrical outages, UPS systems are made to deliver rapid backup power.

In data centers, UPS systems play a crucial role in providing power interruption protection. Operations can be disrupted by even brief power outages or fluctuations, which may result in data loss and system outage. UPS systems offer a rapid changeover to battery power, enabling data centers to carry on with uninterrupted operations and avoiding interruptions to vital services. They also **guard against power fluctuations** and **surges** for **delicate electrical equipment**. Surprising power spikes or drops can cause damage to expensive servers and networking equipment housed in data centers. These parts are protected from electrical disruptions by UPS units with integrated surge protection, which increases their operating life and lowers the need for expensive repairs or replacements.

Additionally essential to preserving data integrity and avoiding data corruption are UPS systems. A UPS guarantees that all data transfers are carried out correctly and supplies sufficient power for safe system shutdowns in the event of a power outage. By doing this**, data loss or corruption** that can result from systems shutting down suddenly owing to an unexpected power failure is avoided. UPS systems provide redundancy and scalability for high-density computing settings found in data centers. Data centers can expand their power backup capacity as needed by scalably configuring modern UPS solutions thanks to their modular design. This adaptability is essential for meeting rising power requirements and maintaining a steady supply of electricity.

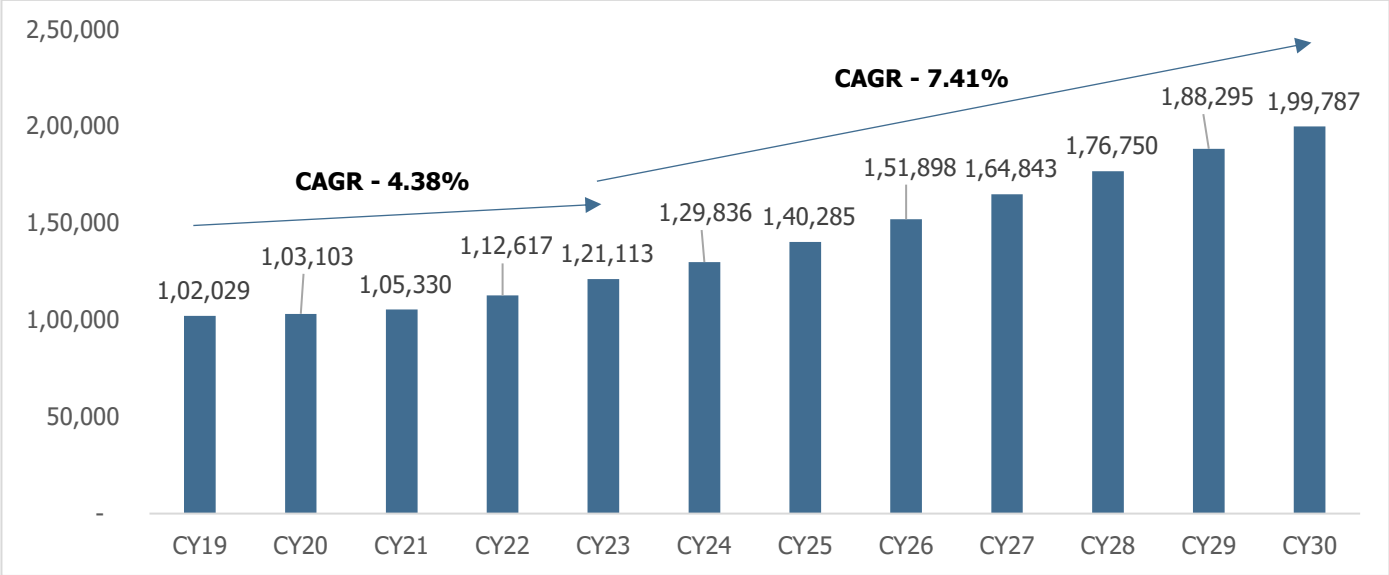
Disaster recovery plans make use of UPS systems, which is another crucial application. UPS systems are frequently a part of larger disaster recovery plans used by data centers to guarantee company continuity. UPS systems enable data centers' operations during unforeseen occurrences like natural catastrophes or severe weather by offering dependable power backup, which speeds up the recovery process and reduces downtime.

Data centers can further reduce their energy use by using UPS systems. **Energy-saving features** are built into many contemporary UPS units, lowering power usage and increasing overall efficiency. This is especially crucial for data centers, where controlling energy expenses is a major issue. UPS systems provide dependable power backup while assisting data centers in meeting their energy saving targets through power usage optimization. The efficiency of UPS systems is further increased by their interaction with other data center infrastructure management technologies. Modern UPS systems have **remote monitoring and management capabilities** that let users keep an eye on performance, identify problems, and carry out preventative maintenance. Maintaining UPS dependability and making sure they're prepared to deliver backup power when needed depend on this skill. The selection of UPS systems can have an effect

on total operating costs; the risk of downtime and related expenses, such as lost income and unhappy customers, can be decreased by investing in dependable, high-quality solutions.

3.1.20.1 Global UPS in Data Center Market Size (INR Millions)

Chart 32: Market Size of UPS in Data Center (INR Millions)



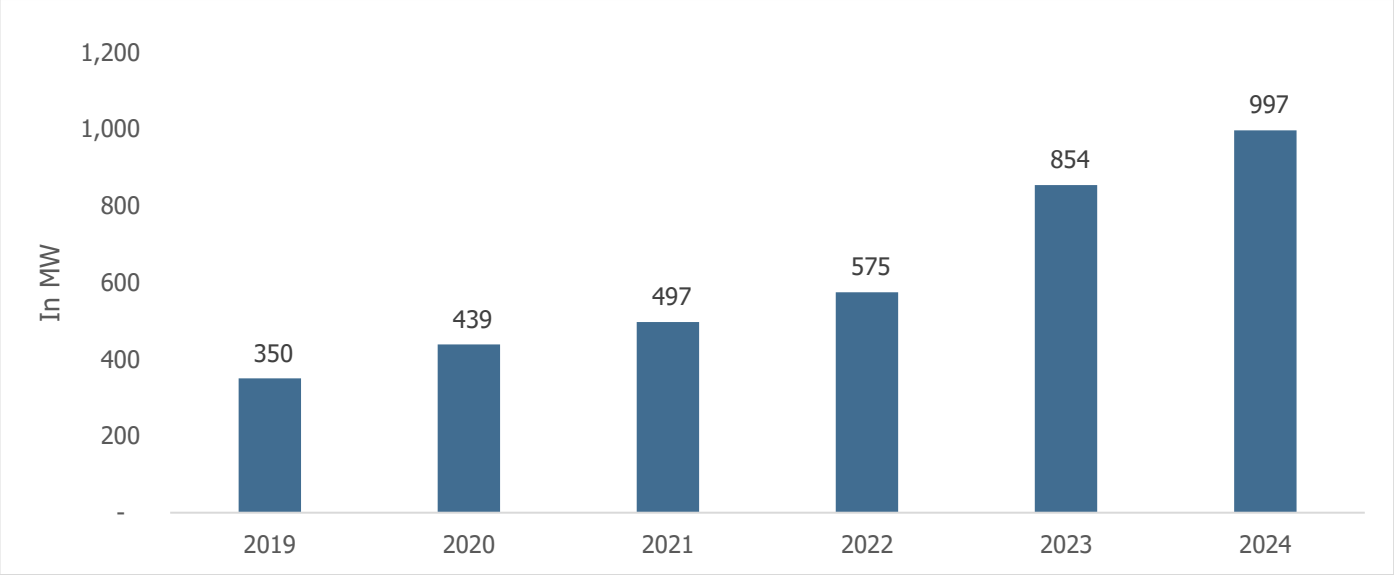
Source: Techsciresearch

The Global UPS in Data Center Market was valued at INR 1,21,112.68 million in CY23 and is expected to reach INR 1,99,787.02 million by CY30, with a CAGR of 7.41% during the forecast period. This growth is driven by the increasing construction of data centers, the proliferation of cloud computing, and the rising demand for reliable power solutions. UPS systems are essential for maintaining a continuous power supply and protecting sensitive IT infrastructure from power disruptions that can cause significant data loss and operational downtime.

Market growth is fueled by the expanding adoption of data center services across industries such as finance, healthcare, and e-commerce, which require uninterrupted power for critical operations. Additionally, the growing trend of digital transformation and the Internet of Things (IoT) further increases the demand for advanced UPS systems capable of supporting high-density power environments. Technological advancements in UPS systems, including modular designs and lithium-ion batteries, are improving efficiency and reducing operational costs. However, challenges such as high initial investment costs and the need for regular maintenance may impact market growth.

3.1.20.2 India Data Center Capacity (2019-2024)

Chart 33: Data Center Capacity (In India)



Source: Techsciresearch

The capacity of data centers in India increased from 350 MW in 2019 to 997 MW in 2024. Several factors, such as the quickening pace of digital transformation, rising data consumption, encouraging government regulations, and huge investments from both local and foreign companies, are driving this enormous rise. The exponential growth in data usage is a major factor in this increase. The demand for data processing and storage has expanded significantly as a result of the growing usage of smartphones, higher internet penetration, and the explosion of digital services. The increasing data traffic is a result of many activities like video streaming, online gaming, cloud computing, and the expanding use of Internet of Things (IoT) devices. As a result, data center infrastructure needs to be expanded.

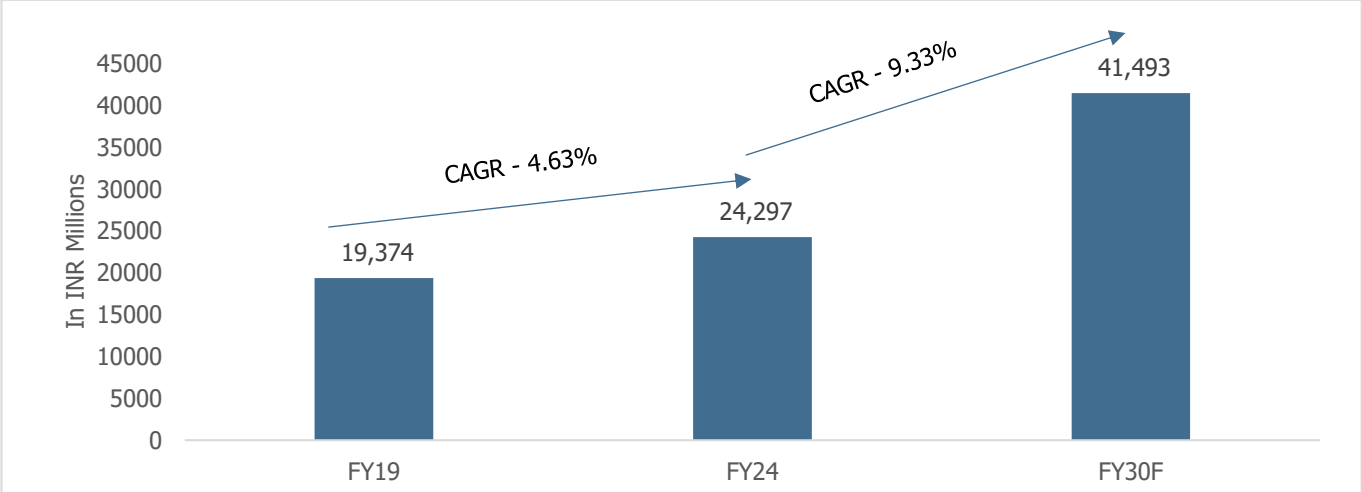
The expansion of the data center industry in India has been greatly aided by government initiatives. The National e-Governance Plan and the Digital India campaign are two examples of initiatives that seek to improve internet connection and online infrastructure nationally. The need for local data centers has also been fueled by the government's emphasis on data localization, which mandates that data created in India be maintained domestically.

In the data center industry, environmental sustainability is likewise becoming more and more significant. In an effort to lessen their carbon impact, businesses are investing more and more in green data centers that run on renewable energy. For instance, Yotta Infrastructure has erected the largest Tier IV data center in Asia in Navi Mumbai. This facility is built to run solely on renewable energy.

3.2 Historical Revenue Trends of the UPS Market

3.2.1 IT

Chart 34: UPS market revenue trend – IT sector

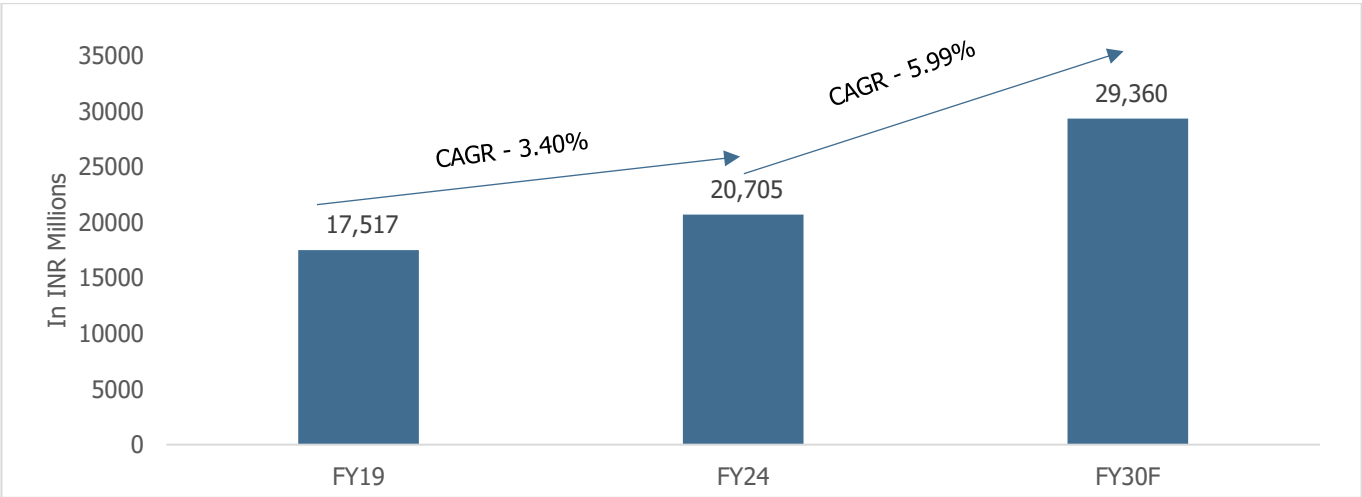


Source: TechSci Research, CareEdge Research

In FY24, UPS's revenue from IT industry was Rs. 24,297 Millions which is expected to increase to Rs. 41,493 Millions by FY30 at a CAGR of 9.33%. This growth is expected to be driven by increasing data centers demand, rising needs for continuous operations, and heightened focus on system reliability and disaster recovery. As businesses demand higher uptime and data security, the need for robust UPS systems to prevent disruptions and data loss grows. Additionally, the rise of remote work and IoT will further accelerate this demand.

3.2.2 OEM

Chart 35: UPS market revenue trend – OEM sector

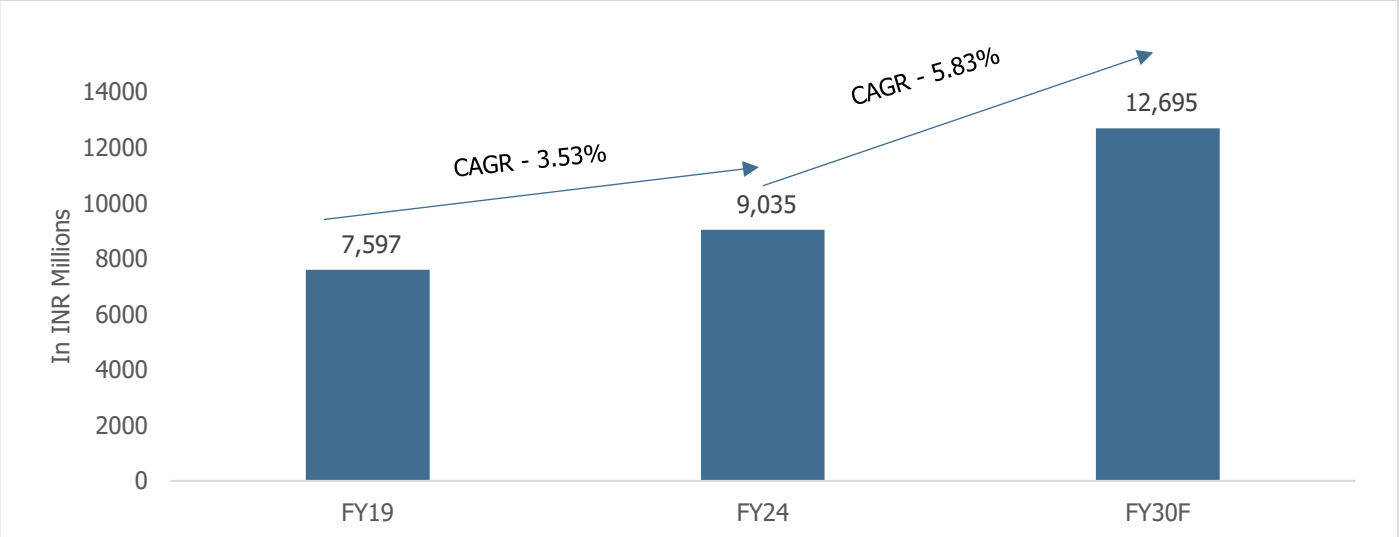


Source: TechSci Research, CareEdge Research

In FY24, UPS's revenue from OEM industry was Rs. 20,705 Millions which is expected to increase to Rs. 29,360 Millions by FY30 at a CAGR of 5.99%. This future growth will be driven by increasing demand for reliable power solutions, the rise of automation and IoT technologies, and the need to protect sensitive equipment from power disruptions. Additionally, as industries adopt more digital and smart technologies, the reliance on UPS systems for continuous operations will become critical.

3.2.3 BFSI

Chart 36: UPS market revenue trend – BFSI sector

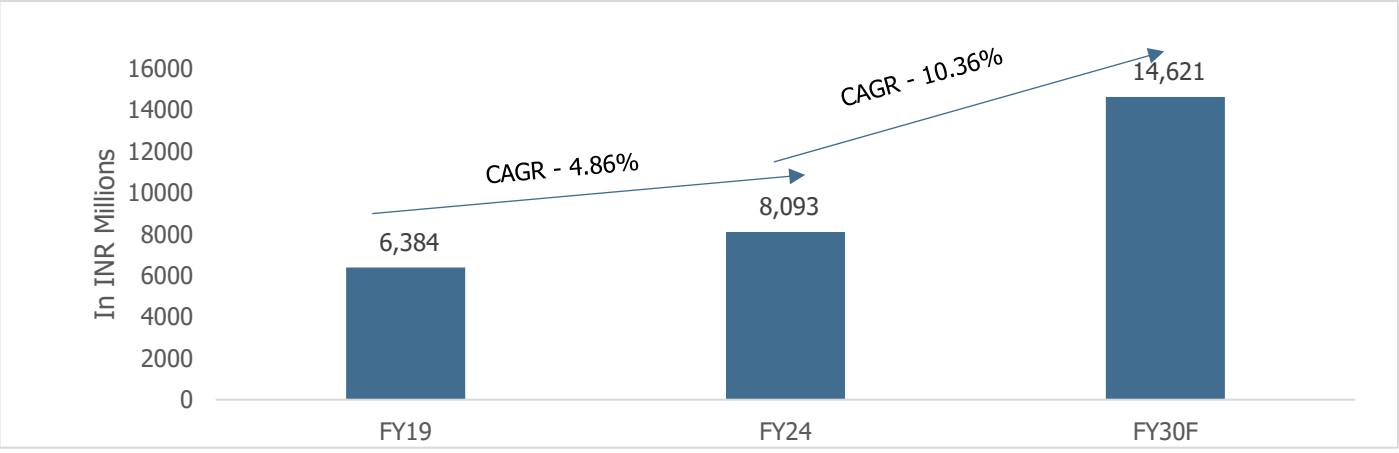


Source: TechSci Research, CareEdge Research

In FY24, UPS's revenue from BFSI industry was Rs. 9,035 Millions which is expected to increase to Rs. 12,695 Millions by FY30 at a CAGR of 5.83%. This positive growth is expected to be impacted by the critical need for uninterrupted operations and data integrity. Financial institutions require constant power to maintain real-time transactions, safeguard sensitive data, and ensure operational continuity. UPS systems will help to prevent downtime, protect against data loss, and support compliance with stringent regulatory standards.

3.2.4 Healthcare

Chart 37: UPS market revenue trend – Healthcare sector

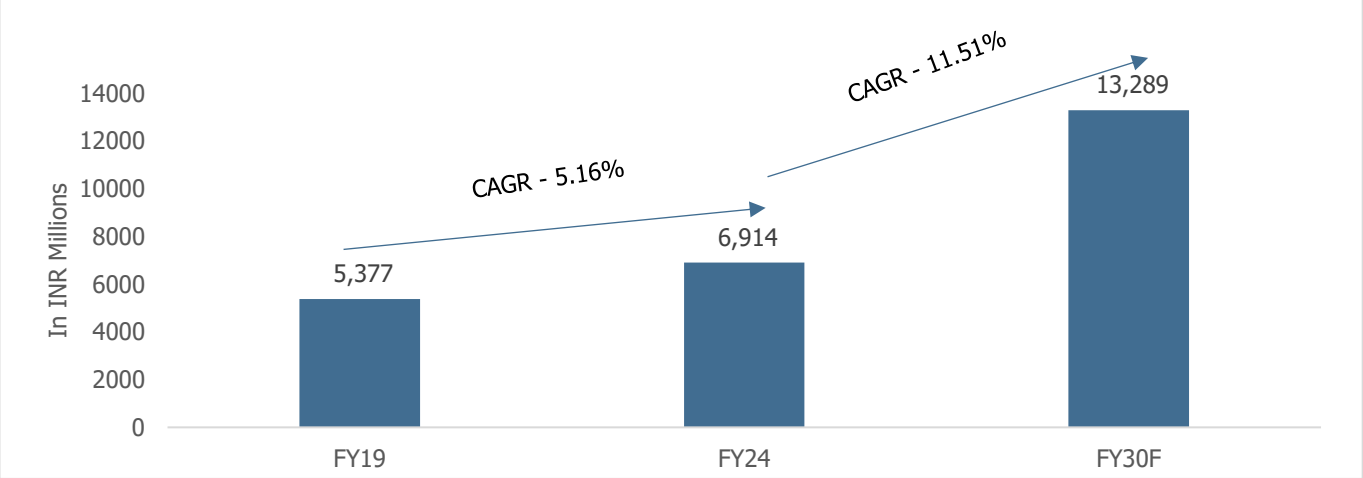


Source: TechSci Research, CareEdge Research

In FY24, UPS's revenue from Healthcare industry was Rs. 8,093 Millions which is expected to increase to Rs. 14,621 Millions by FY30 at a CAGR of 10.36%. Growth of UPS industry in the healthcare sector will be driven by the increasing reliance on advanced medical equipment, the need for continuous patient care, the rise in telemedicine, and the adoption of electronic health records. Additionally, growing concerns about power outages affecting critical healthcare services will prompt investments in reliable UPS systems.

3.2.5 Railway

Chart 38: UPS market revenue trend – Railway sector

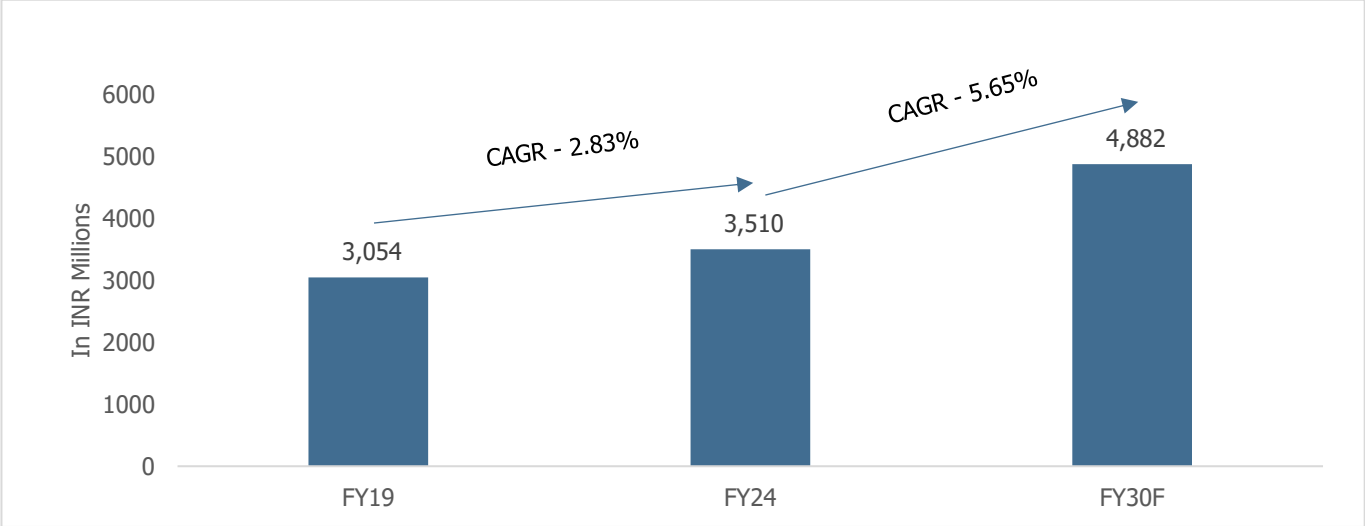


Source: TechSci Research, CareEdge Research

In FY24, UPS's revenue from Railway industry was Rs. 6,914 Millions which is expected to increase to Rs. 13,289 Millions by FY30 at a CAGR of 11.51%. UPS usage is expected to see a growth in the railway sector, mainly driven by increasing electrification of rail networks, rising demand for reliable power supply for signaling and communication systems, and the need for continuous operations in remote areas. Additionally, the push for energy efficiency and integration of renewable energy sources will further boost the demand for advanced UPS systems.

3.2.6 Oil & Gas

Chart 39: UPS market revenue trend – Oil & Gas sector

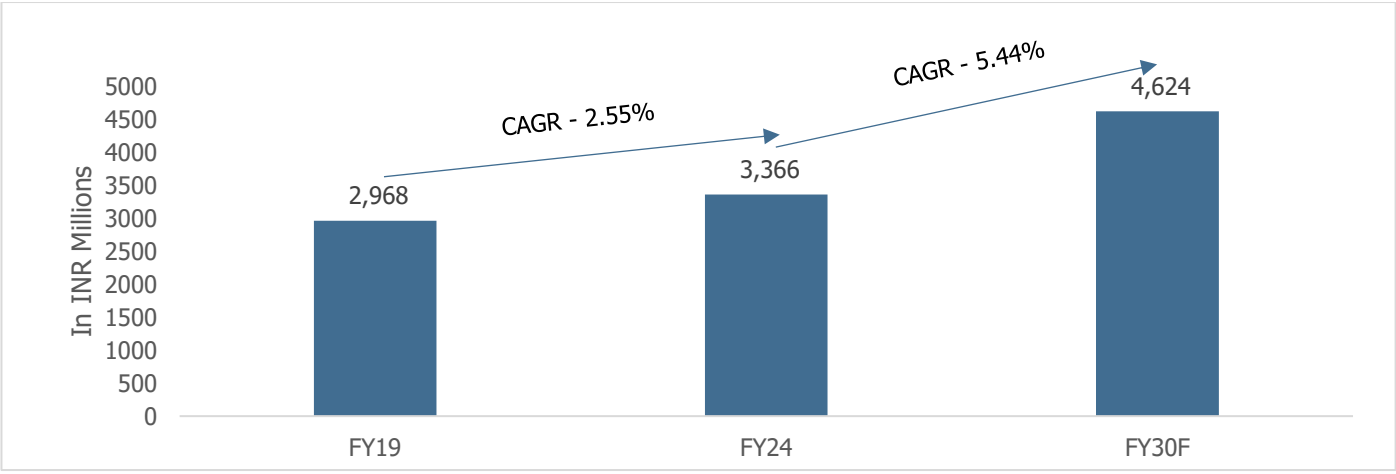


Source: TechSci Research, CareEdge Research

In FY24, UPS's revenue from Oil & Gas industry was around Rs. 3,510 Millions which is expected to increase to Rs. 4,882 Millions by FY30 at a CAGR of 5.65%. The growth of UPS in the oil and gas sector will be guided by the increasing automation of critical processes, the rising need for reliable energy to prevent costly downtimes, and the sector's expansion into remote, challenging environments. As operations become more complex, ensuring continuous power will be essential to maintaining safety, productivity, and regulatory compliance.

3.2.7 Power

Chart 40: UPS market revenue trend – Power sector

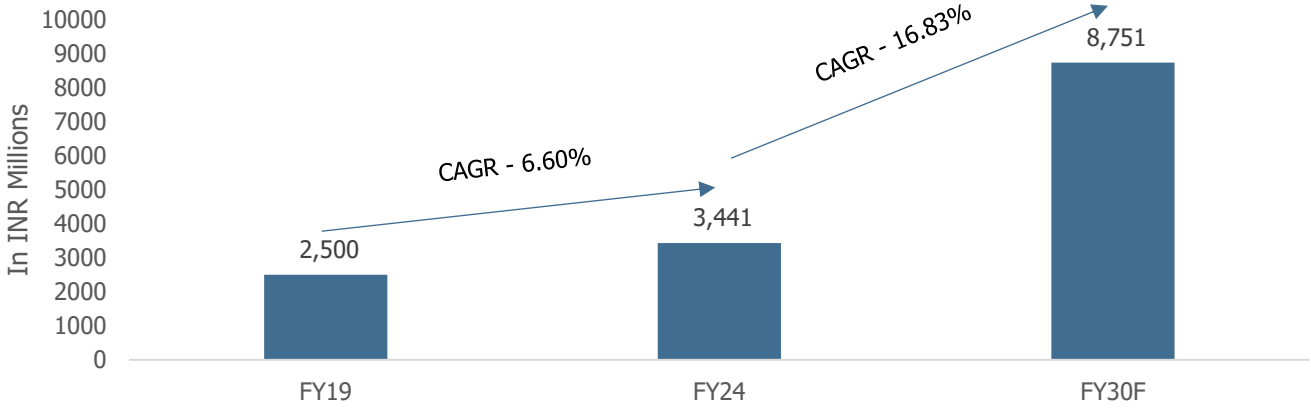


Source: TechSci Research, CareEdge Research

In FY24, UPS's revenue from Power industry was Rs. 3,366 Millions which is expected to increase to Rs. 4,624 Millions by FY30 at a CAGR of 5.44%. This growth will be driven by increasing demand for reliable electricity due to technological advancements, the rise of smart grids, renewable energy integration, and the need for energy security. Investments in infrastructure, battery storage, and grid modernization, along with government policies promoting sustainable energy, will further contribute to this growth.

3.2.8 Solar

Chart 41: UPS market revenue trend – Solar sector



Source: TechSci Research, CareEdge Research

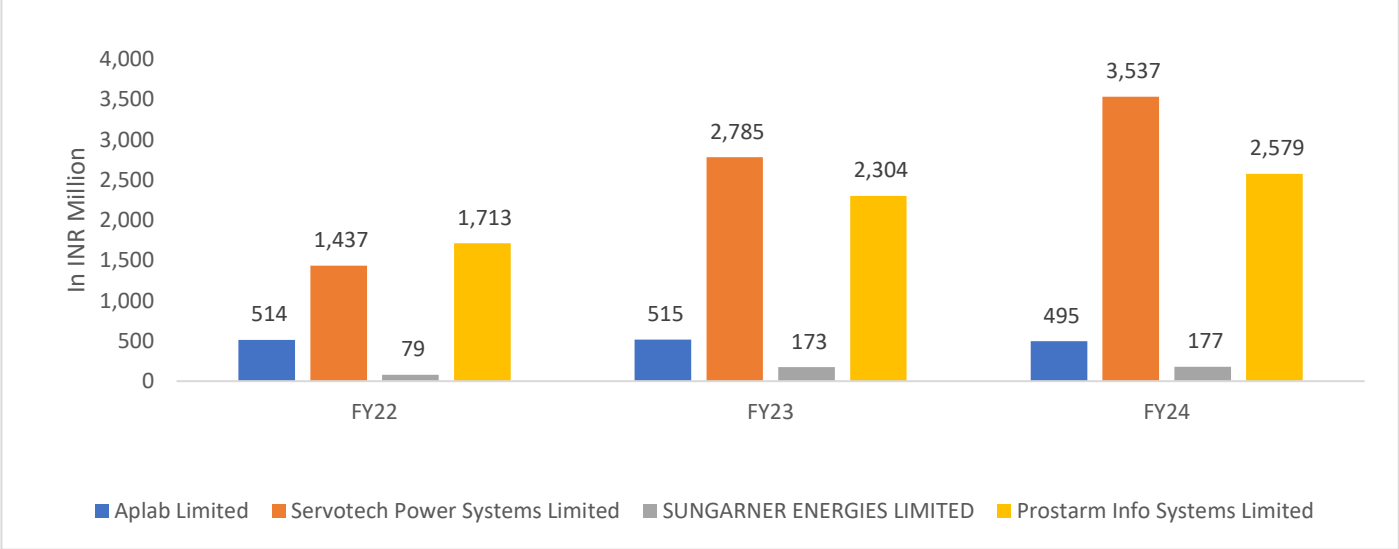
In FY24, UPS's revenue from OEM industry was Rs. 3,441 Millions which is expected to increase to Rs. 8,751 Millions by FY30 at a CAGR of 16.83%. Future growth of UPS in the solar sector is expected to be driven by advancements in energy storage technologies, declining costs of solar panels and batteries, and increasing demand for sustainable energy. Government incentives and policies supporting renewable energy adoption, along with rising concerns over grid reliability and environmental impact, is expected to further contribute to the expansion of solar-powered UPS systems.

4 Competitive Landscape

4.1 Peer benchmarking of ProstarM Info Systems Limited

Name of the Company	Business Overview
ProstarM Info Systems Limited	ProstarM Info Systems Ltd. is an Indian company specializing in power electronics solutions, offering reliable and affordable products to businesses across various sectors. With a registered office in Pune, a corporate office in Mumbai, and regional sales offices in 20 states, the company has a strong nationwide presence. Over 16 years, ProstarM has built a reputation for delivering dependable Uninterruptible Power Supply (UPS) systems that ensure continuous power availability in critical sectors like banking, finance, and healthcare.
Aplab Limited	Aplab has been a global player for nearly fifty years, offering a diverse range of electronic products that adhere to international safety and reliability standards such as UL and VDE. The company operates through multiple divisions: Test and Measurement Instruments, Power Conversion & Controls, UPS Systems, and Banking & Retail Automation. Listed on the BSE, Aplab has sales and support offices in over 50 cities across India. Its products meet EMI-EMC requirements and are CE marked, supported by rigorous in-house R&D. Aplab serves various sectors, including education, defence, avionics, telecom, banking, retail, and manufacturing.
Servotech Power Systems Limited	Servotech Power System Ltd is an NSE-listed company. The company business involves innovation with high-end solar products and efficient EV chargers. They have developed ultra-fast DC and home AC chargers, and also have achieved installing over 2,400 EV chargers in partnership with major oil marketing companies to advance India's electric mobility. Committed to the 'Make in India' initiative, they focus on domestic manufacturing. They have over two decades of experience.
Sungarner Energies Limited	SunGarner Energies Ltd is a manufacturer of power products and solar solutions since 2015. In 2017, the company established its first solar inverter manufacturing unit in Greater Noida, India. Since then, SunGarner has expanded into energy storage and solar panels. The company has successfully completed over 100 large solar grid-tied projects, ranging from 50 kWp to 2 MWp, both in India and internationally. SunGarner's inverters have been supplied to 26 states in India, from Leh to Tamil Nadu, within just six years. Additionally, SunGarner exports to seven countries worldwide.

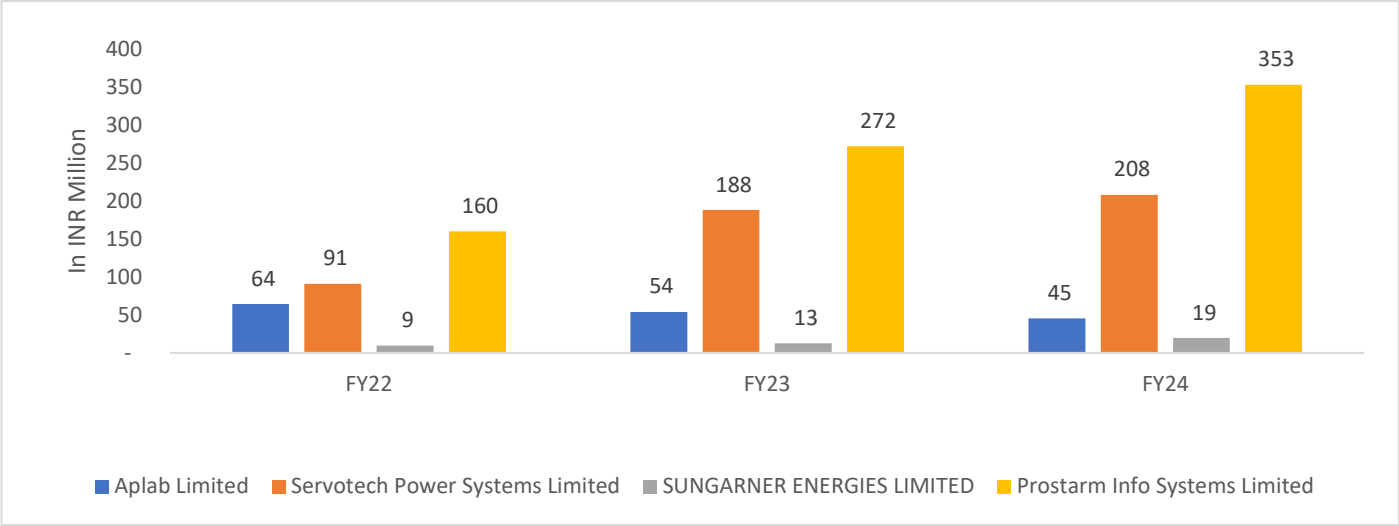
Chart 42: Comparison of Revenue from Operations (In INR Million)



Source: Annual reports

ProstarM reported Rs. 2,579 million in Revenue from Operations for FY24, ranking it second in the peer group after Servotech Power Systems Limited's Rs. 3,537 million. On a year-on-year basis, ProstarM achieved an 11.9% growth in revenue.

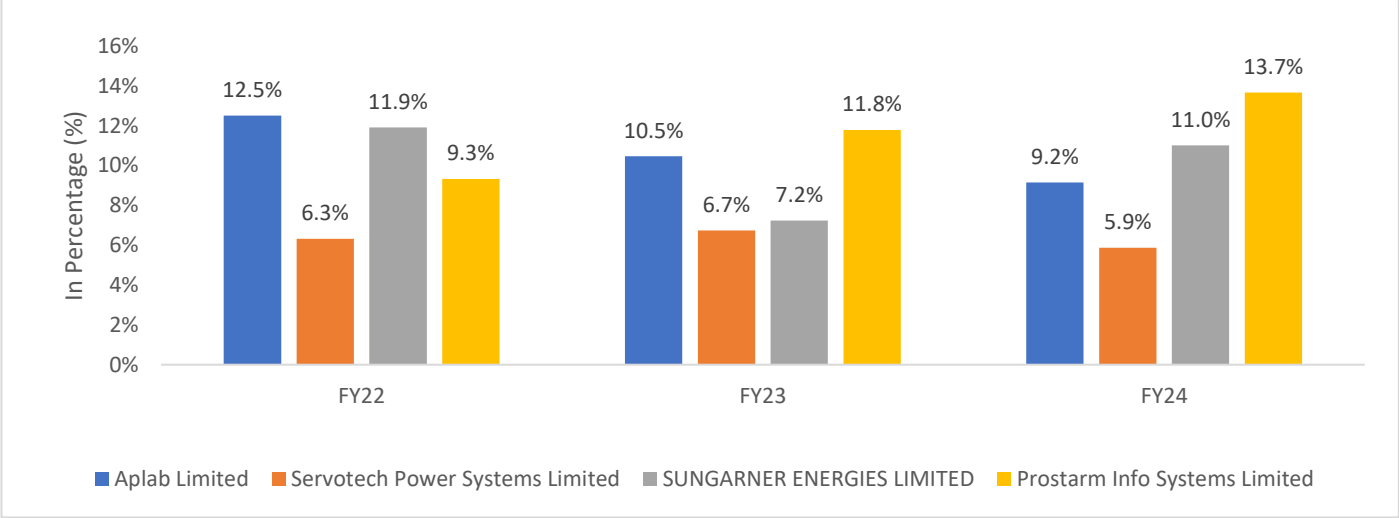
Chart 43: Comparison of EBITDA (In INR Million)



Source: Annual reports

In terms of EBITDA, ProstarM reported the highest figure at Rs. 353 million in FY24. On a year-over-year basis, the company recorded an impressive 29.8% growth in EBITDA.

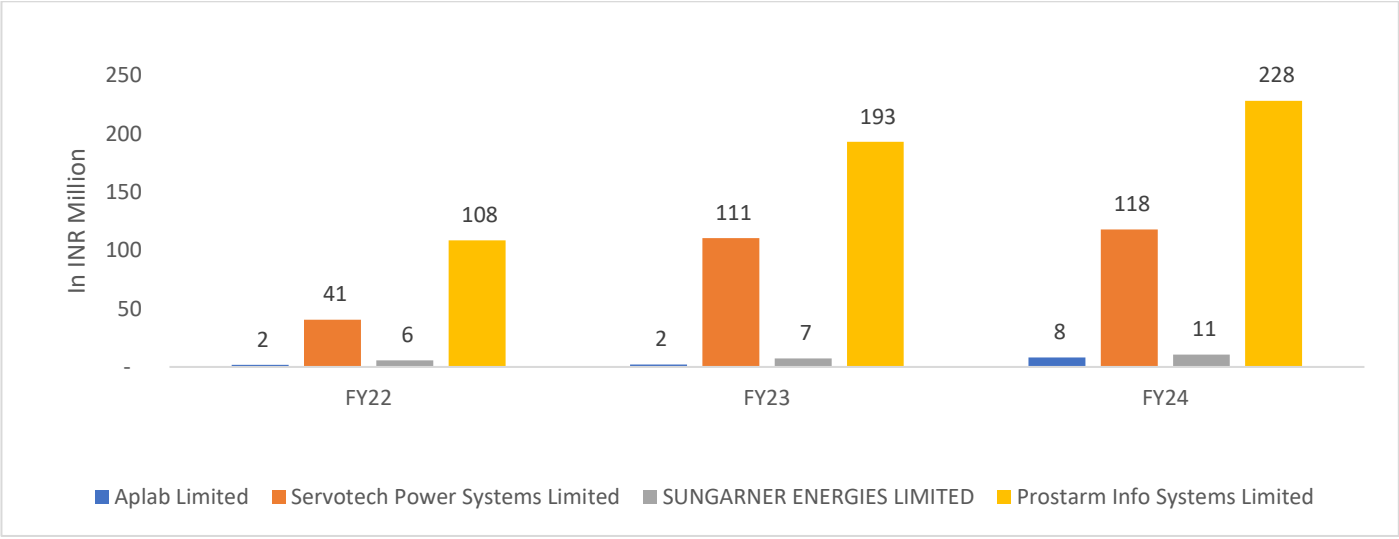
Chart 44: Comparison of EBITDA Margin (In %)



Source: Annual reports

In FY24, ProstarM recorded 13.7% EBITDA margin, the highest among the peer set. Unlike other peer companies, ProstarM's EBITDA margin has consistently increased over the past three years.

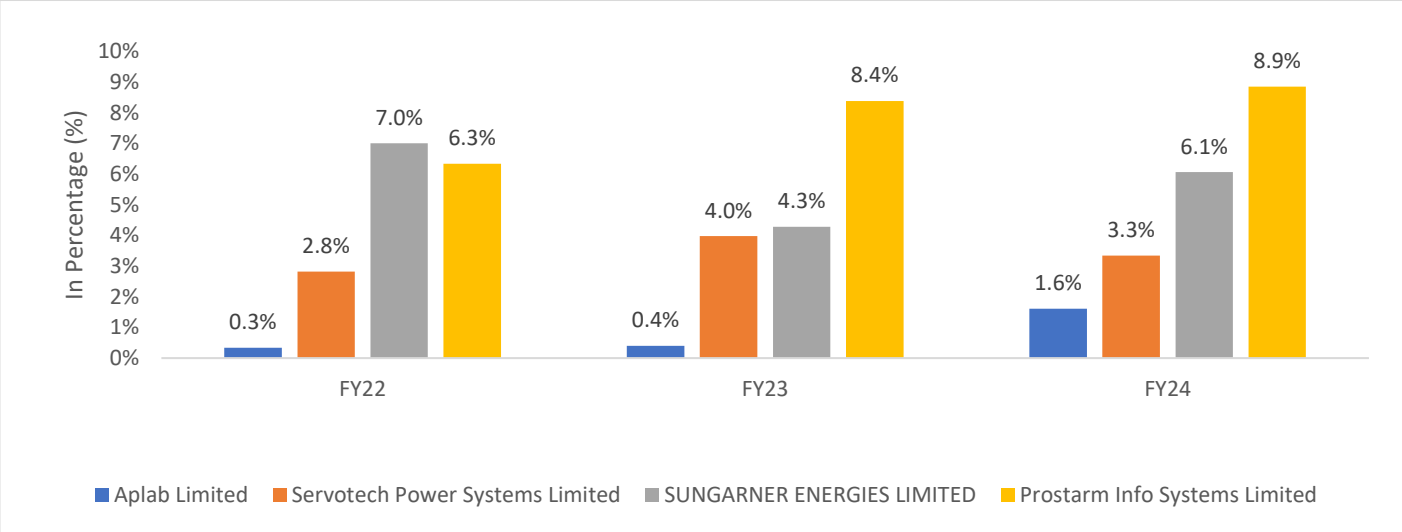
Chart 45: Comparison of PAT (In INR Million)



Source: Annual reports

ProstarM reported the highest PAT margin among its peers at 8.9% in FY24, significantly exceeding the peer average of 5.0%. The company's PAT for the year stood at Rs. 228 million.

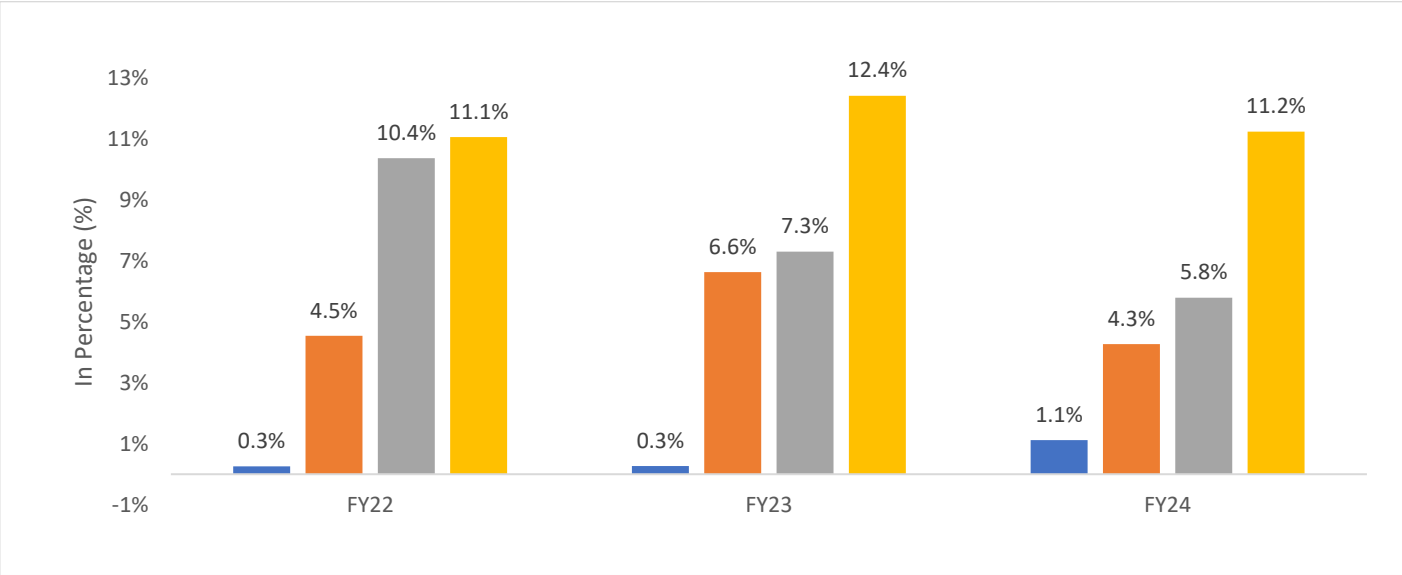
Chart 46: Comparison of PAT Margin (In %)



Source: Annual reports

Since last 2 years, Prostarm's PAT margin has been the highest among the peer set.

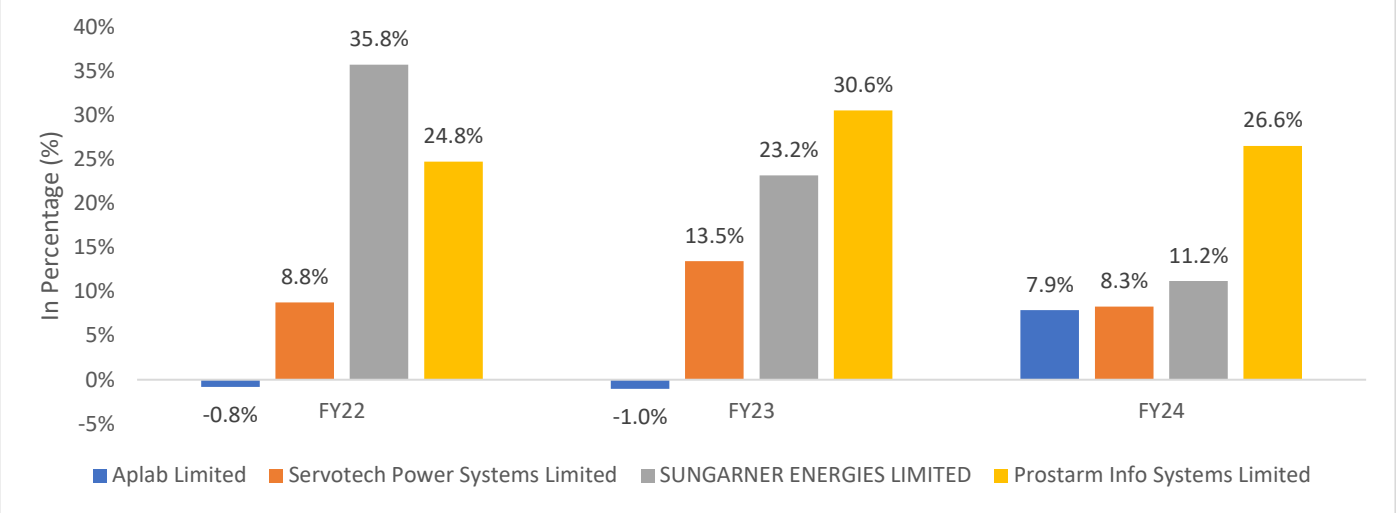
Chart 47: Comparison of ROA (In %)



Source: Annual reports

Comparing the Return on Asset, ProstarM achieved the highest ROA in FY24 at 11.2%, which is higher than the peer average of 5.6%.

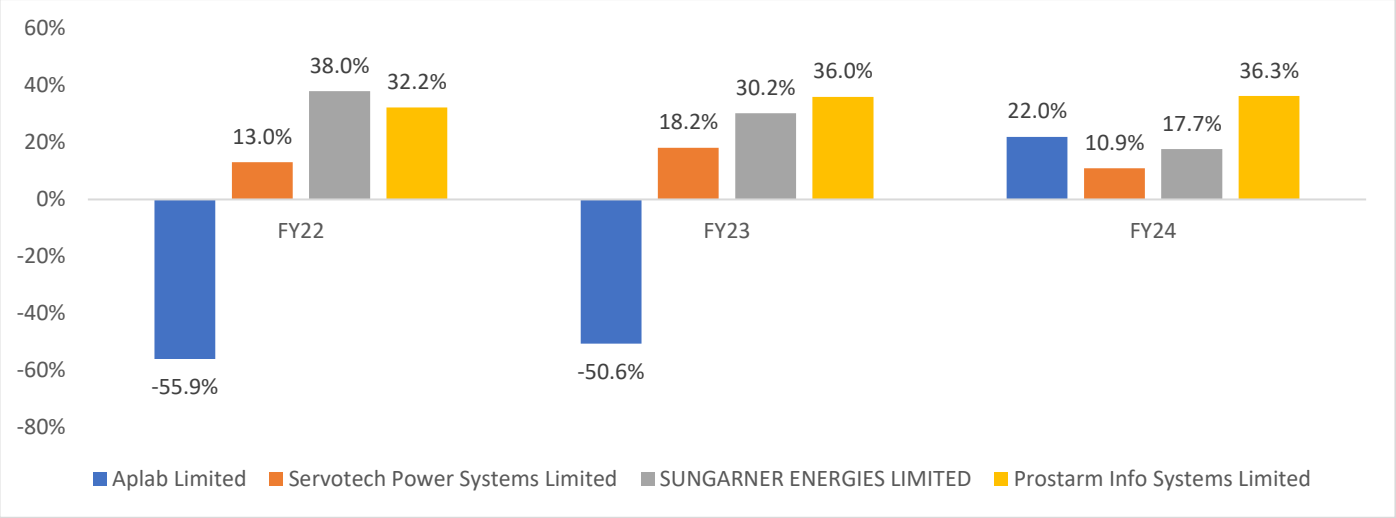
Chart 48: Comparison of ROE (In %)



Source: Annual reports

Similarly, comparing the Return on Equity, ProstarM achieved the highest ROE in FY24 at 26.6%, which is higher than the peer average of 13.5%.

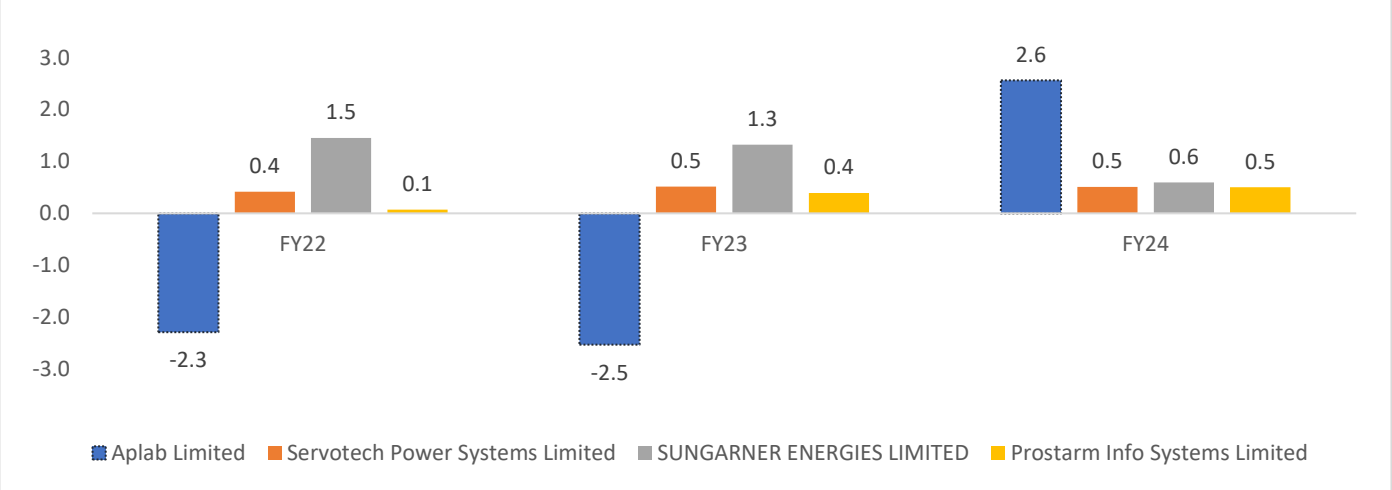
Chart 49: Comparison of ROCE (In %)



Source: Annual reports

Comparing the Return on Capital Employed, ProstarM achieved the highest ROCE in FY24 at 36.3%, which is higher than the peer average of 21.7%.

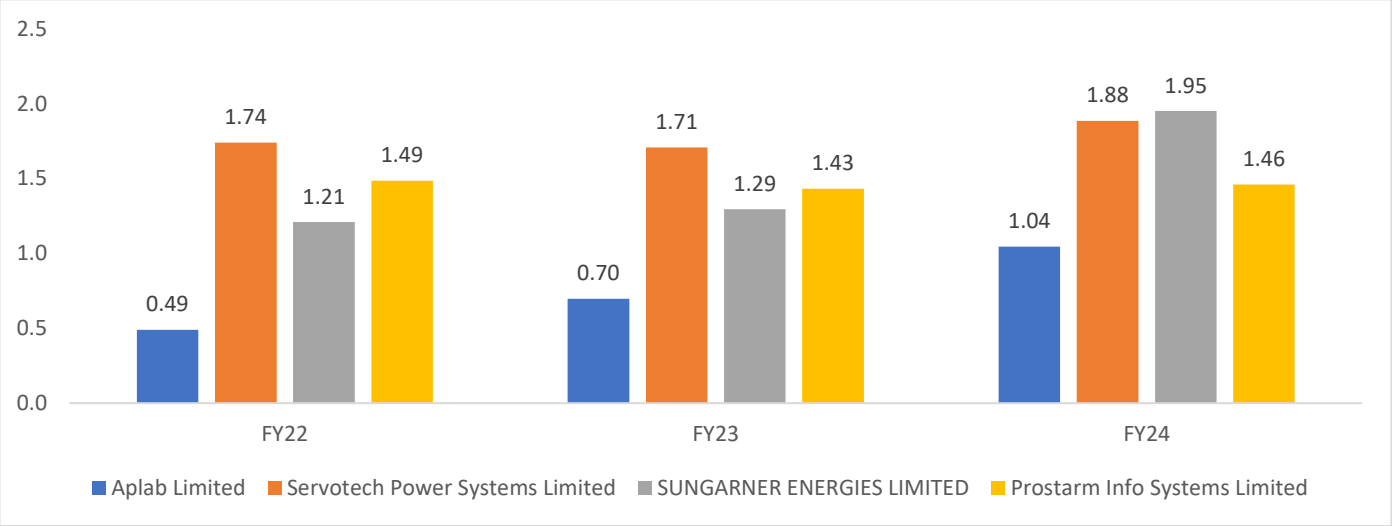
Chart 50: Comparison of D:E Ratio (In Times)



Source: Annual reports

In FY24, ProstarM's Debt-to-Equity Ratio was 0.50x.

Chart 51: Comparison of Current Ratio (In Times)



In FY24, ProstarM's Current Ratio was 1.46x, which is below the peer average of 1.58x.

4.2 Key Global players in the storage and power backup solution industry

Name	Headquarter	Revenue	Employee strength	Product/Service segments	Brand/ Product names
Hitachi Ltd	Japan	USD 69.1 Billion (2023)	300,000+	1) IT 2) Green Energy 3) Construction machinery 4) Metals 5) Mobility, etc	Wind and Solar power energy, power generation system, digital solution, etc.
Schneider Electric SE	France	Euro 36 Billion (2023)	150,000+	1) Critical Power 2) Solar & Energy storage 3) MV Distribution & Grid automation 4) Industrial/Building Automation, etc	UPS, power conditioning, Circuit breakers, switches, solar off-grid and back-up, etc.
Mitsubishi Electric Corporation	Japan	Yen 5,257.9 Billion (FY24)	149,000+	1) Transmission & Distribution 2) Power generation 3) Medium and Low voltage switchgear & systems 4) Power information & communication technology 5) Nuclear systems	High voltage switchgear, Step-up/Three and single-phase/gas insulated transfromers, HVDC, Flexible AC Transmission System, etc
ABB Ltd	Switzerland	USD 32.2 Billion (2023)	100,000+	1) Electrification 2) Industrial Automation 3) Motion 4) Robotics and Discrete Automation	UPS, Power conditioning, power distribution, UPS selector, digital solutions, Power Converters and Controllers, high power rectifiers, Distributed Control Systems, etc
EATON Corporation PLC	Ireland	USD 23.2 Billion (2023)	94,000+	Backup power, UPS, surge & IT power distribution: 1) UPS 2) Network connectivity 3) Power Management software 4) Surge protection, etc	**Backup power, UPS, surge & IT power distribution** - UPS for Lithium-ion batteries, PC, workstations, data centre, network & server, Intelligent power software, RTU/X-slot Relay card, connectivity products, UPS companion, ATS rack PDU, Visual

Name	Headquarter	Revenue	Employee strength	Product/Service segments	Brand/ Product names
					power manager, SmartEdge enclosure system, etc **Brands**- Electrical Americas and Electrical Global, Aerospace, Vehicle, eMobility and Hydraulics
Emerson Electric Co	USA	USD 17.5 Billion (Sep'2024 ended fiscal)	67,000+	1) Power supply/conditioning and Transformers 2) Control & safety system 3) Industrial & factory automation 4) Professional tools and vacuum 5) Regulators & Valves, etc 6) Asset performance management	Brands - SolaHD, Aventics, Bettis, AMS, AspenTech, DeltaV, Movicon, Ovation, and many more
Delta Electronics Inc	Taiwan	NT 401.2 Billion (2023)	11,800+	1) Industrial Automation solutions 2) Building Automation solutions 3) Data center solution 4) Telecom Energy solution 5) Smart Energy solutions 6) EV Charging solutions	Residential/Commercial rooftop PV, Utility solar power plant, energy management, EV charging management, utility & grid support, converter transformer, planar transformer, line filters, reactors, etc

Name	Headquarter	Revenue	Employee strength	Product/Service segments	Brand/ Product names
Riello Elettronica SpA	Italy	Euro 420 Million (2023)	1,277	Power - 1) UPS- The product range includes single-phase and three-phase UPS with a power from 400 VA to 6.4 MVA, ideal for both domestic environments and for offices, large industrial plants, data centers. 2) Transfer system - "Intelligent" Transfer and Switching Systems to ensure continuous and reliable power distributions. 3) Software and connectivity - Wide range of UPS Monitoring software characterized by simplicity and intuitiveness, guarantee and reliability, highly customizable. 4) Reillo Solar Tech - This includes Photovoltaic Inverters Apart from Power, the company is also into Automation, Safety & Security and Real Estate.	UPS Online, CPS, Transfer systems, interactive line, software and connectivity. **Brands**- Solar Tech, Cardin, AVS Electronics and Gamma Systems

5 Threats & Challenges faced by the industry

Renewable power storage solutions encompass a range of technologies, including Lithium-Ion batteries, stabilizers, solar energy solutions in EPC, solar hybrid inverters, lift inverters, battery chargers, transformers, and other related systems.

1. **High Initial Costs**: The upfront investment needed for purchasing and installing renewable power storage solutions and other battery systems can be substantial, especially for advanced models with higher capacity and features. Also, despite falling prices, the high upfront costs of solar inverter systems and solar power installations remain a barrier, particularly for small and medium-sized enterprises and residential customers.

2. **Competition from Conventional Power**: Traditional energy sources, such as coal and thermal power, are still relatively cheaper in some areas, limiting the uptake of renewable technologies like solar inverters.

3. **Maintenance Requirements**: Regular maintenance is crucial for ensuring the reliability of renewable power storage solutions and other battery systems. However, it can be costly and time-consuming, and neglecting maintenance can lead to system failures. Similarly, solar panels require routine cleaning, as dust accumulation can obstruct sunlight, limiting their energy generation capabilities. Without regular maintenance, the panels' efficiency drops, impacting their ability to produce electricity effectively and diminishing the returns on solar energy investments.

4. **Battery Lifespan and Degradation**: The batteries in renewable power storage solutions systems have a limited lifespan and can degrade over time, reducing the system's effectiveness. Replacing batteries incurs ongoing costs and can also lead to downtime.

5. **Environmental Factors**: Renewable power storage solutions and battery systems are sensitive to environmental conditions such as temperature, humidity, and dust. Adverse conditions can cause overheating, reduced efficiency, or equipment failure.

6. **Power Capacity Limitations**: Renewable power storage solutions and battery systems have a limited power capacity, which may not suffice for all connected devices or extended outages. Overloading the system can result in failures and insufficient backup power.

7. **Technological Obsolescence**: As technology progresses, older renewable power storage solution systems may become obsolete, lacking the efficiency and features found in newer models, potentially causing compatibility issues with modern devices. Additionally, India’s outdated and underdeveloped grid infrastructure in many areas poses challenges for integrating solar power efficiently, particularly for hybrid and grid-tied inverters. The growing demand for high-efficiency, smart transformers requires substantial investment in R&D. Companies slow to adopt new technologies risk losing market share. Furthermore, integrating renewable energy into the grid remains a complex task, and the inadequacy of the existing grid infrastructure delays necessary transformer upgrades and installations.

8. **Security Vulnerabilities**: As renewable power storage solution systems become more connected and integrated with other networked devices, they may be vulnerable to cybersecurity threats, including hacking and unauthorized access.

9. **Energy Efficiency Concerns**: While renewable power storage solution systems are essential for backup power, they can be less energy-efficient, leading to higher operational costs, particularly in large-scale applications like data centers.

10. **Disposal and Environmental Impact**: The disposal of renewable power storage solution batteries and other components presents environmental challenges, as they often contain hazardous materials requiring proper handling and recycling.

11. **Supply Chain Disruptions**: The availability of components and replacement parts for renewable power storage solution systems can be affected by supply chain issues, causing delays in repairs and maintenance. Also, India still relies on imports for many key components for solar inverters and transformer components, which can create supply chain disruptions and price fluctuations due to geopolitical tensions or trade restrictions. Supply chain disruptions for transformers can arise from raw material shortages, logistics challenges, labor issues, and geopolitical factors. These issues can lead to project delays and increased costs in the market.

12. **Policy Uncertainty and Regulatory Hurdles**: Inconsistent government policies and shifting regulations can create uncertainty for manufacturers and consumers, hindering long-term investment in solar energy solutions. Also, frequent changes in government policies and stringent environmental regulations create compliance challenges for manufacturers of transformers.

6 Abbreviations

WEO	World Economic Outlook
GDP	Gross Domestic Product
RBI	Reserve Bank of India
GVA	Gross Value Added
GFCF	Gross Fixed Capital Formation
PLI	Production-linked Incentive
IIP	Index of Industrial Production
CPI	Consumer price index
SDF	Standing deposit facility
LAF	Liquidity adjustment facility
MSF	Marginal standing facility
GNDI	Gross National Disposable Income
PFCE	Private Final Consumption Expenditure
IMD	India Meteorological Department
ESS	Energy Storage Systems
UPS	Uninterruptible Power Supply
OEM	Original equipment manufacturer

BESS	Battery energy storage system
FAME	Faster Adoption and Manufacturing of Hybrid & EV
GWh	Gigawatt-hour
EPC	Engineering, Procurement, and Construction
KUSUM	Kisan Urja Suraksha evam Utthaan Mahabhiyan
NTPC-REL	NTPC Renewable Energy Ltd
GUVNL	Gujarat Urja Vikas Nigam Limited
SPPD	Solar Power Park Developer
RUVITL	Rajasthan Urja Vikas and IT Services Limited
PPP	Public-private partnerships
ICF	Integral Coach Factory
LHB	Linke-Hofmann-Busch
PMGDISHA	Pradhan Mantri Gramin Digital Saksharta Abhiyan
PMKVY	Pradhan Mantri Kaushal Vikas Yojana
NRP	National Rail Plan
CCTV	Closed-circuit television
MSME	Micro, Small & Medium Enterprises
EHR	Electronic health records
UL	Underwriters Laboratories
VDE	Verband der Elektrotechnik
EMI	Electromagnetic Interference
EMC	Electromagnetic Compatibility

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