CareEdge ANALYTICS & ADVISORY

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Industry Research Report on Infrastructure and Utilities Sectors

20 June 2025

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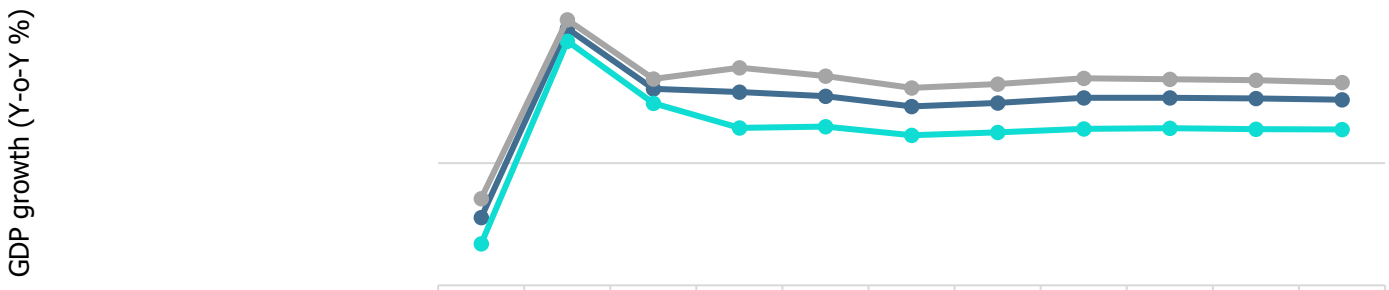
1. Economic Outlook

1.1. Global Economy

Global growth, which reached 3.5% in CY23, stabilized at 3.3% for CY24 and projected to decrease at 2.8% for CY25. Global trade is expected to be disrupted by new US tariffs and counter measures from trading partners, leading to historically high tariff rates and negatively impacting economic growth projections. The global landscape is expected to change as countries rethink their priorities and policies in response to these new developments. Central banks priority will be to adjust policies, while smart fiscal planning and reforms are key to handling debt and reducing global inequalities.

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



	CY20	CY21	CY22	CY23	CY24	CY25P	CY26P	CY27P	CY28P	CY29P	CY30P
World	-2.7%	6.6%	3.6%	3.5%	3.3%	2.8%	3.0%	3.2%	3.2%	3.2%	3.1%
Advanced Economies	-4.0%	6.0%	2.9%	1.7%	1.8%	1.4%	1.5%	1.7%	1.7%	1.7%	1.7%
Emerging Market and Developing Economies	-1.7%	7.0%	4.1%	4.7%	4.3%	3.7%	3.9%	4.2%	4.1%	4.1%	4.0%

Source: IMF – World Economic Outlook, April 2025; Notes: P-Projection, E-Estimated

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

	Real GDP (Y-o-Y change in %)										
	CY20	CY21	CY22	CY23	CY24	CY25P	CY26P	CY27P	CY28P	CY29P	CY30P
India	-5.8	9.7	7.6	9.2	6.5	6.2	6.3	6.5	6.5	6.5	6.5
China	2.3	8.6	3.1	5.4	5.0	4.0	4.0	4.2	4.1	3.7	3.4
Indonesia	-2.1	3.7	5.3	5.0	5.0	4.7	4.7	4.9	5.0	5.1	5.1
Saudi Arabia	-3.6	5.1	7.5	-0.8	1.3	3.0	3.7	3.6	3.2	3.2	3.3
Brazil	-3.3	4.8	3.0	3.2	3.4	2.0	2.0	2.2	2.3	2.4	2.5
Euro Area	-6.0	6.3	3.5	0.4	0.9	0.8	1.2	1.3	1.3	1.2	1.1
United States	-2.2	6.1	2.5	2.9	2.8	1.8	1.7	2.0	2.1	2.1	2.1

Source: IMF- World Economic Outlook Database (April 2025)

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

Advanced Economies Group

Advanced economies, growth stood at 1.8% in CY24 and is projected to decline to 1.4% in CY25 with a marginal increase to 1.5% in CY26. The CY25 forecast revised down by 0.5 percentage points compared to the January 2025 WEO Update.

The **United States** growth is projected to ease to 1.8% in CY25, lower than the January 2025 forecast by 1 percent point. The revision reflects factors such as policy uncertainty, ongoing trade dynamics, and a slower pace of consumption demand. In CY26, growth is expected to remain moderate at 1.7%, influenced by trade measures and steady private consumption.

The **Euro Area's** growth is anticipated to ease slightly to 0.8% in CY25 due to the uncertainties in the trade tariffs and with a modest recovery in CY26 to 1.2% which is supported by consumption demand.

Emerging Market and Developing Economies Group

Emerging market and developing economies are forecasted to drop to 3.7% in CY25 and rise to 3.9% in CY26, with a continued momentum till CY30. The economic forecast for emerging and developing Asian countries is expected to decline to 4.5% in CY25 and increase to 4.6% in CY26.

China's GDP growth for CY25 has been revised down to 4.0% from 4.6%, reflecting the impact of newly implemented tariffs. The implied tariffs also offset the stronger momentum and planned fiscal expansion that took place from late CY24. The CY26 forecast is also lowered to 4.0% from 4.5%, due to ongoing trade policy uncertainty and the continued effect of tariffs. In contrast, **India's** growth remains stable, with anticipated rates of 6.2% in CY25 and 6.3% in CY26. This growth is mainly supported by private consumption.

The **Indonesian** economy is expected to register growth of 4.7% in CY25 and CY26, however, an important concern for Indonesia is the trade fragmentation. **Saudi Arabia's** growth in CY25 is projected to have the growth rate to 3.0% on account of the extension of oil production cuts taking place in the country. Going forward, GDP is expected to grow at 3.7% in CY26. On the other hand, **Brazil's** growth is projected to be 2.0% in CY25 and CY26 due to the anticipated tightening of the labour market and ongoing restrictive monetary policy, growth is expected to slow down.

Despite the turmoil in the last 2-3 years, India bears good tidings to become a USD 5 trillion economy by CY27-CY28. According to the IMF dataset on Gross Domestic Product (GDP) at current prices, the nominal GDP projected to be at USD 4.2 trillion for CY25 and is projected to reach USD 5.1 trillion by CY27 and USD 6.8 trillion by CY30. India's expected GDP growth rate for coming years is almost double compared to the world economy. The Indian economy shows resilience amid global inflation, supported by a stable financial sector, strong service exports, and robust investment driven by government spending and high-income consumer consumption, positioning it for better growth than other economies.

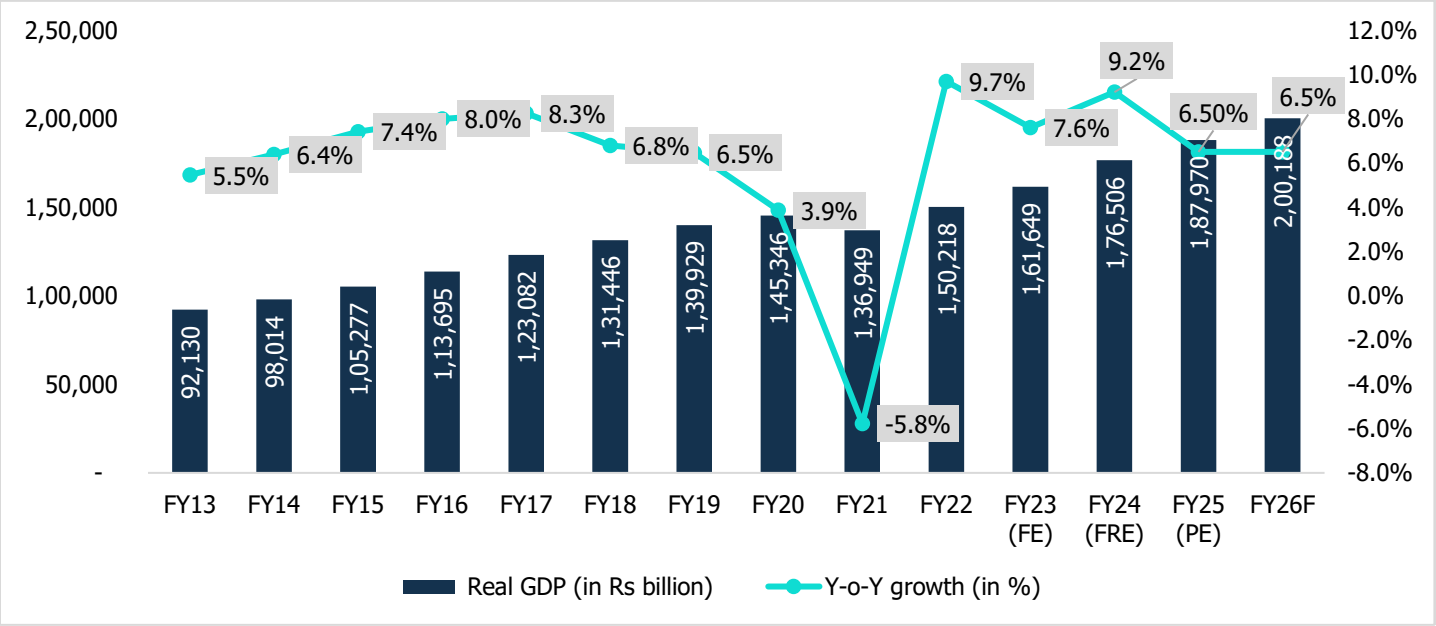
Besides, India stands out as the fastest-growing economy among the major economies. The country is expected to grow at a range of 6.2%-6.5% in the period of CY25-CY30, outshining China's growth rate. By CY27, the Indian economy is estimated to emerge as the third-largest economy globally, hopping over Japan and Germany. Currently, it is the third largest economy globally in terms of Purchasing Power Parity (PPP) with a ~7.9% share in the global economy, with China on the top followed by the United States.

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



Source: MOSPI, Reserve Bank of India;
Note: FE – Final Estimates, FRE- First Revised Estimates, PE – Provisional Estimates, F - Forecasted

India's real GDP grew by 9.2% in FY24 (Rs. 176,506 billion) which is the highest in the previous 12 years (excluding FY22 being 9.7% on account of end of pandemic) and is estimated to grow by 6.5% in FY25 (Rs. 187,970 billion), driven by double digit growth particularly in the Manufacturing sector, Construction sector and Financial, Real Estate & Professional Services. This growth is also led by private consumption increasing by 7.6% and government spending increasing by 3.8% Y-o-Y. Real GDP growth is projected at 6.5% in FY26 as well, driven by strong rural demand, improving employment, and robust business activity.

GDP Growth Outlook (April 2025)

The RBI projects real GDP growth at 6.5% for 2025–26, driven by strong private consumption, steady investment, and resilient rural and urban demand. A favourable monsoon, robust services sector, and improving corporate balance sheets support this outlook.

- Rural demand remains firm, aided by resilient agricultural activity, while the service sector is expected to drive a recovery in urban consumption. On the supply side, the outlook for agriculture remains positive, backed by an above-normal south-west monsoon forecast and resilient allied activities. The services sector is also expected to maintain strong performance.

- Investment activity is gaining traction, strengthened by higher capacity utilisation, improved corporate and financial sector balance sheets, and strong government capital expenditure. While uncertainty around trade policy continues to weigh on merchandise exports, the finalisation of the FTA with the United Kingdom and progress with other economies are expected to support trade growth.

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

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

FY26P (complete year)	Q1FY26P	Q2FY26P	Q3FY26P	Q4FY26P
6.5%	6.5%	6.7%	6.6%	6.3%

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

1.2.2. Gross Value Added (GVA)

Gross Value Added (GVA) is the measure of the value of goods and services produced in an economy. GVA gives a picture of the supply side whereas GDP represents consumption.

India's recovery in FY25 was powered by a broad-based rebound across sectors.

Industry and Services sector leading the recovery charge

- The gap between GDP and GVA growth stood at 0.1 percentage point in FY25, with GDP growing at 6.5% and GVA at 6.4%, as per MoSPI's provisional estimates released in May 2025.

- The agriculture and allied sector grew by 4.6% y-o-y in FY25, accelerating from 2.7% in FY24. The sector contributed significantly to overall growth, aided by a favourable monsoon, improved kharif and rabi output, and resilient allied activities. Its estimated value added stood at approximately Rs 24.7 trillion, reflecting its continued 14.4% share in total real GVA.

- The **industrial sector** output in FY25 grew by 5.9%, owing to decline in manufacturing activities. India's industrial sector experienced robust growth in FY24 supported by positive business sentiment, falling commodity prices, and government policies like production-linked incentives. The sector grew by 9.5% on y-o-y basis, reaching Rs. 48.9 trillion for FY24. This growth was driven mainly by sales growth in manufacturing companies, construction, and utility services. Construction grew at the highest rate of 9.4% as compared to a growth rate of 10.4% in previous year.

- The services sector grew at **6.4% y-o-y** in FY25, down from **8.6%** in FY24. Strong gains in public administration (8.9%) and financial services (7.2%), along with steady trade and transport growth (5.8%), helped the sector contribute around **Rs 94.4 trillion.**

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

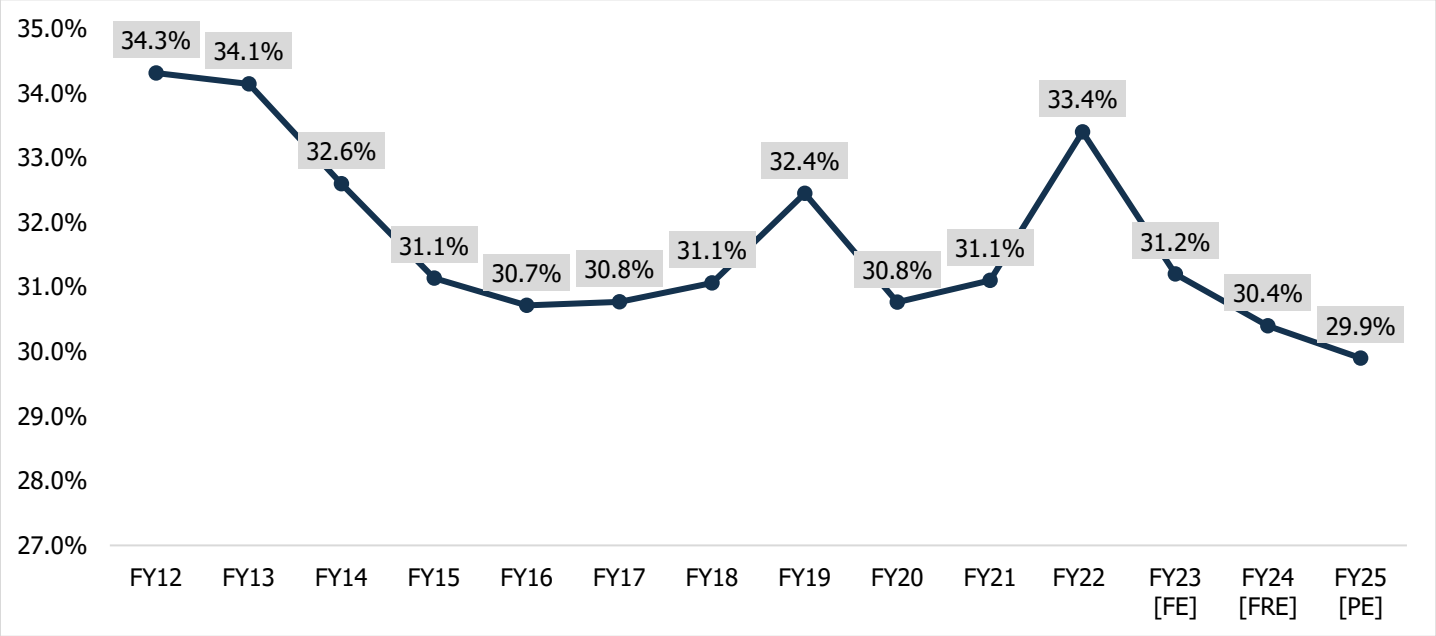
At constant Prices	FY19	FY20	FY21	FY22	FY23 (FE)	FY24 (FRE)	FY25 (PE)
Agriculture, Forestry & Fishing	**2.1**	**6.2**	**4.1**	**3.5**	**5.1**	**2.7**	**4.6**
Industry	**5.3**	**-1.4**	**-0.9**	**11.6**	**2.0**	**10.8**	**5.9**
Mining & Quarrying	-0.9	-3.0	-8.6	7.1	2.8	3.2	2.7
Manufacturing	5.4	-3.0	2.9	11.1	-3.0	12.3	4.5
Electricity, Gas, Water Supply & Other Utility Services	7.9	2.3	-4.3	9.9	11.5	8.6	5.9
Construction	6.5	1.6	-5.7	14.8	10.0	10.4	9.4
Services	**7.2**	**6.4**	**-8.2**	**8.8**	**11.3**	**9.0**	**7.2**
Trade, Hotels, Transport, Communication & Broadcasting	7.2	6.0	-19.7	13.8	14.4	7.5	6.1
Financial, Real Estate & Professional Services	7.0	6.8	2.1	4.7	10.7	10.3	7.2
Public Administration, Defence and Other Services	7.5	6.6	-7.6	9.7	8.2	8.8	8.9
GVA at Basic Price	**5.8**	**3.9**	**-4.2**	**8.8**	**7.4**	**8.6**	**6.4**

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

1.2.3. Investment Trend in Infrastructure

Gross Fixed Capital Formation (GFCF) is a measure of net increase in physical assets. In FY23, the ratio of investment (GFCF) to GDP remained flat, as compared to FY22 which was at 33.4%. The growth stabilized at 30.4% in FY24 before falling to 29.9% in FY25. The moderation reflects cautious capital spending by both government and private corporations, which has persistently lagged overall GDP growth.

Chart 3: Gross Fixed Capital Formation (GFCF) as % of GDP (At constant prices)



Source: MOSPI; Note: FE – Final Estimates, FRE- First Revised Estimates, PE- Provision Estimates

Overall, the support of public investment in infrastructure is likely to gain traction due to initiatives such as Atmanirbhar Bharat, Make in India, and Production-linked Incentive (PLI) scheme announced across various sectors.

1.2.4. Industrial Growth

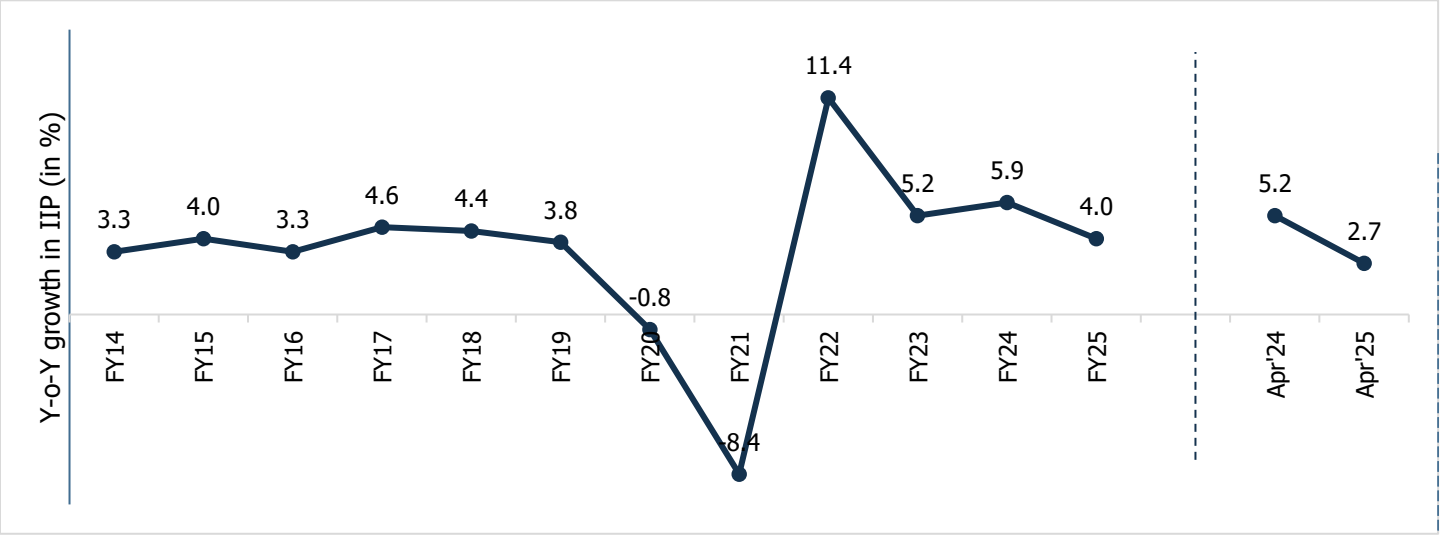
The Index of Industrial Production (IIP) is an index to track manufacturing activity in an economy. During FY23, the industrial output recorded a growth of 5.2% y-o-y supported by a favourable base and a rebound in economic activities. During FY24, the industrial output recorded a growth of 5.9% y-o-y supported by growth in manufacturing and power generation sectors.

The Quick Estimates of the Index of Industrial Production (IIP) for April 2025 show a growth of 2.7%, compared to 5.2% in April 2024. The year-on-year growth moderation reflects subdued performance across key segments, largely due to a contraction in consumer non-durables, infrastructure industries, intermediate goods, capital goods, and primary goods.

In April 2025, industrial growth was supported by Manufacturing (3.4%) and Electricity (1.1%), while the Mining sector contracted by 0.2%. Within the manufacturing sector, industry groups such as pharmaceuticals, motor vehicles, and beverages recorded notable growth. Specifically, the electrical equipment and fabricated metal products segments contributed positively Use-based indices highlighted slower growth across Primary Goods, Capital Goods, and Intermediate Goods. Capital Goods, however, stood out with a strong 20.3% rise, suggesting continued investment momentum.

Manufacturing output grew by 3.4%, contributing significantly to overall industrial growth. This was primarily driven by strong performance in segments such as pharmaceuticals, motor vehicles, beverages, and electrical equipment.

Chart 4: Y-o-Y growth in IIP (in %)

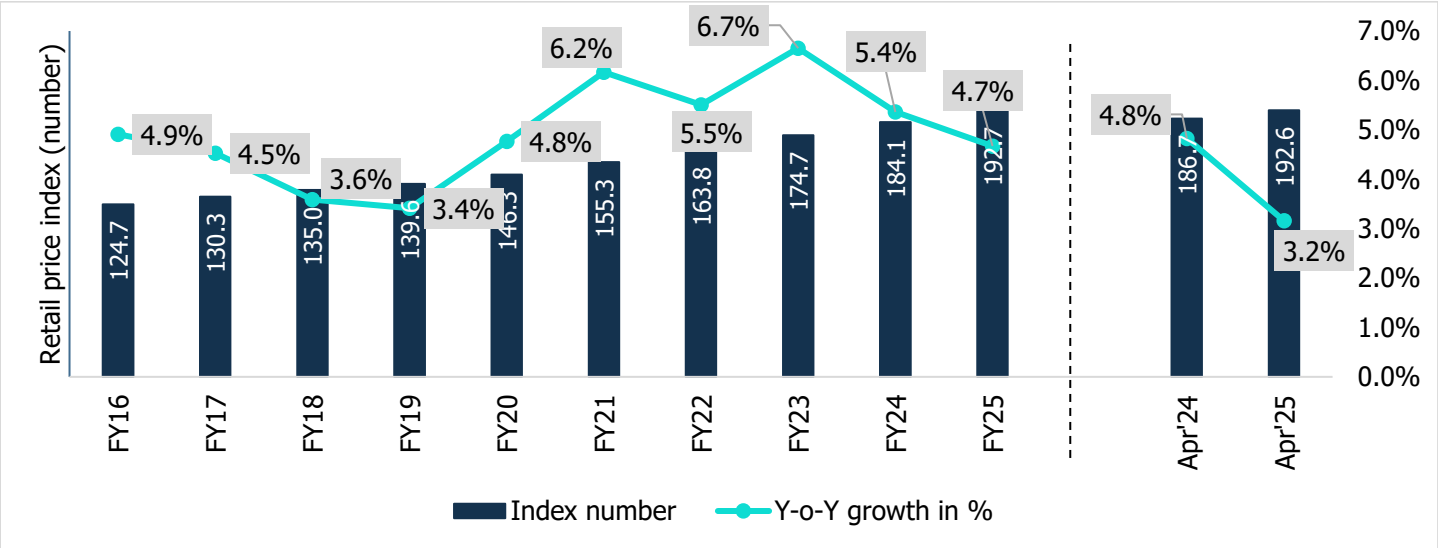


Source: MOSPI

1.2.5. Consumer Price Index

India's consumer price index (CPI) tracks retail price inflation in the economy. During FY23, CPI remained elevated at an average of 6.7%, above the RBI's tolerance level. In FY24, the Consumer Price Index (CPI) showed fluctuations, starting with a moderation to 4.3% in May 2023, followed by a spike to 7.4% in July 2023 due to rising food prices. The CPI (general) and food inflation in April 2025 over April 2024 (3.2%, provisional) witnessed lowest Y-o-Y inflation since July 2019. The moderation was driven by decline of price inflation in Vegetables, Pulses, Fruits, Meat and fish, Personal care and effects and Cereals.

Chart 5: Retail Price Inflation in terms of index and Y-o-Y Growth in % (Base: 2011-12=100)

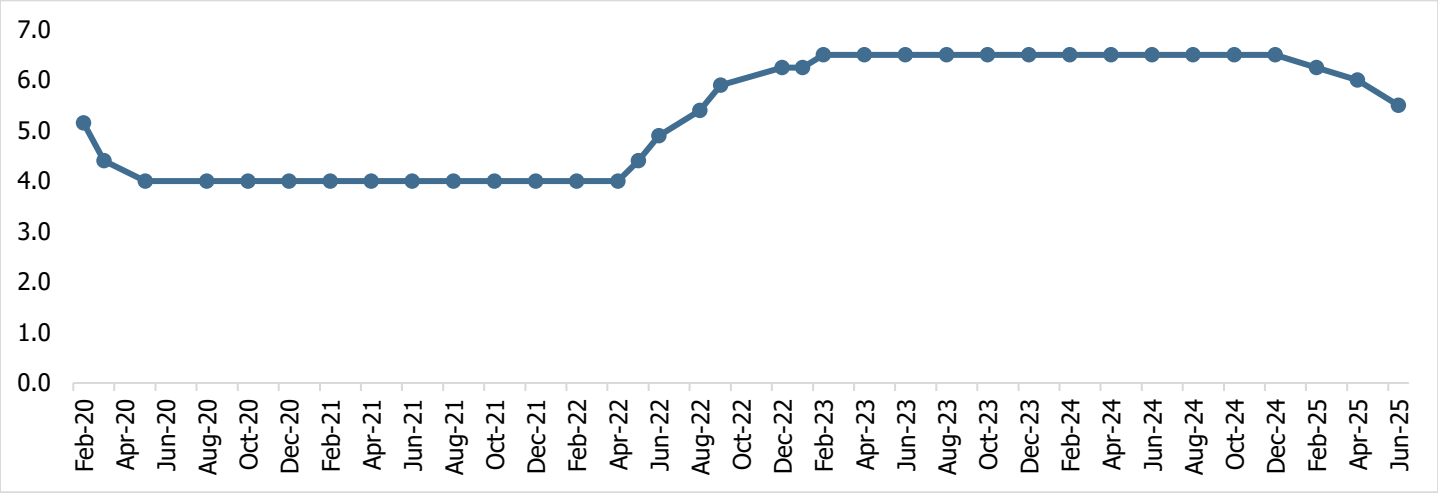


Source: MOSPI

The CPI is primarily factored in by RBI while preparing their bi-monthly monetary policy. At the bi-monthly meeting held in June 2025, RBI projected inflation at 3.7% for FY26 with inflation during Q1FY26 at 2.9%, Q2FY26 at 3.4% and Q3FY26 at 3.9% and Q4FY26 4.4%.

Considering the current inflation situation, RBI has cut the repo rate to 5.5% in the June 2025 meeting of the Monetary Policy Committee.

Chart 6: RBI historical Repo Rate



Source: RBI

Further, the central bank shifted its policy stance from 'accommodative' to 'neutral'. With a decline in food inflation, the headline inflation moderated to a six-year low to 3.2% in April 2025.

The economic growth outlook for India is expected to maintain momentum, supported by private consumption and continued growth in fixed capital formation. The uncertainty regarding the global outlook has reduced given the temporary tariff stay and optimism with trade negotiations. However, global growth and trade has been revised downward due to weakened sentiments and lower growth prospects.

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

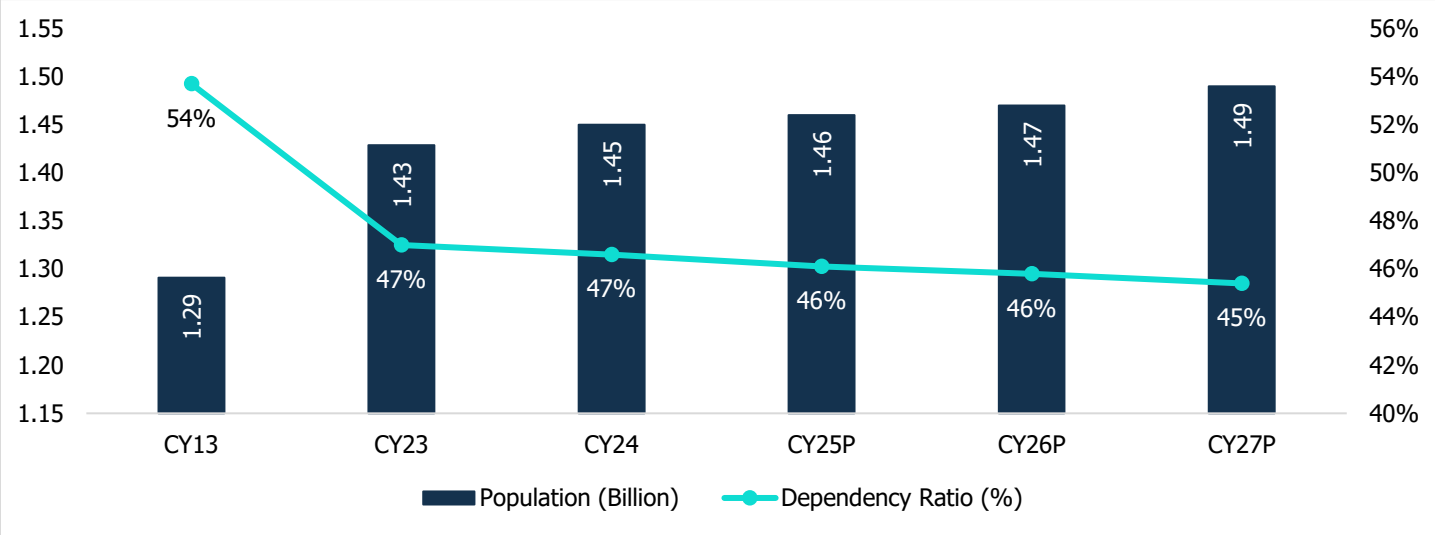
1.2.6. Overview on Key Demographic Parameters

- **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 CY24 surpassed 1.45 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. Declining dependency means the country has an improving share of working-age population generating income, which is a good sign for the economy. It was as high as 54% in CY13, which has reduced to 47% in CY23. However, this ratio is expected to rise again to 54% by CY36, driven by an increase in the elderly population as life expectancy improves.

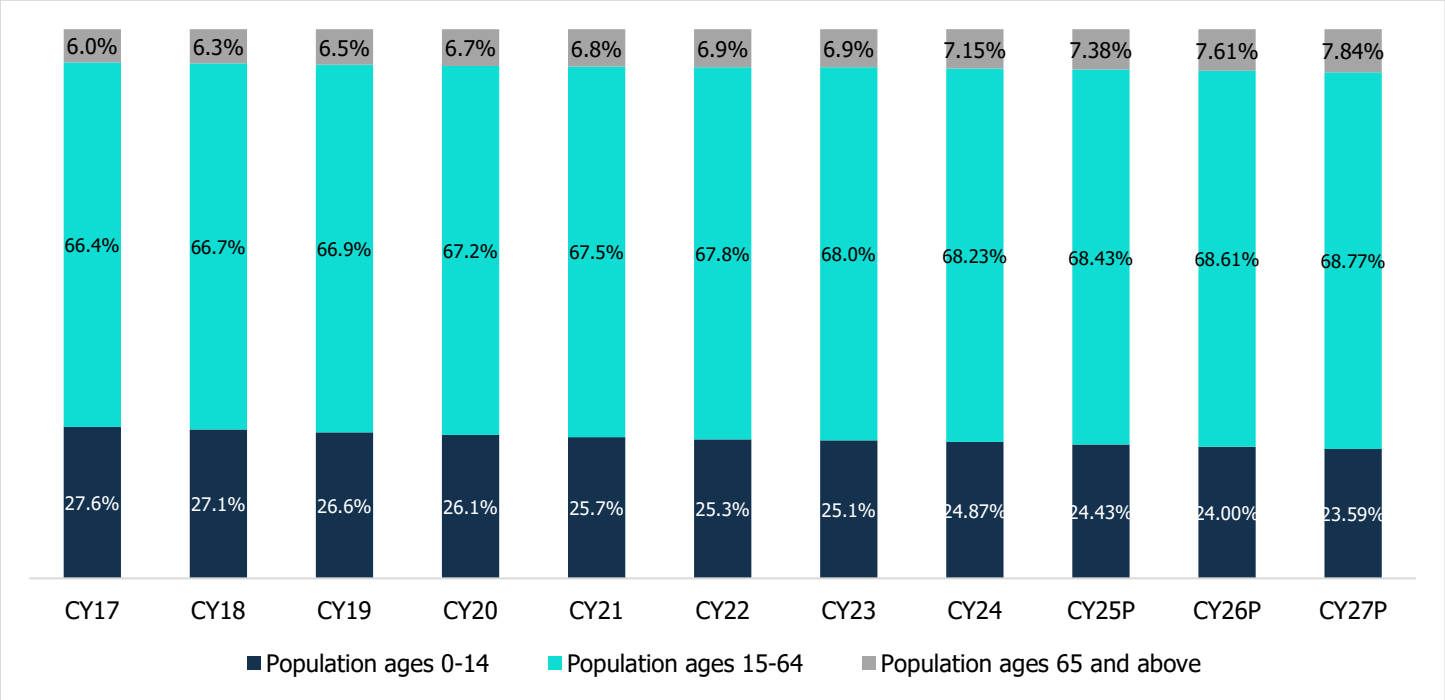
Chart 7: Trend in Population growth vis-à-vis dependency ratio in India (in Billion)



Source: World Bank Database, MOSPI; Note: P- Projected

Despite a projected rise in the dependency ratio to 54% by CY36, India's young and growing workforce, especially in newly urbanised towns, will continue to drive income growth and consumer demand. This presents strong opportunities for sectors like consumer electronics, transportation, and railways. Rising employment, urbanisation, and government investment in rural development and digital infrastructure will further boost demand, while increased tech adoption supports long-term consumption growth across both urban and rural markets.

Chart 8: Age-Wise Break Up of Indian population (% of working-age population)

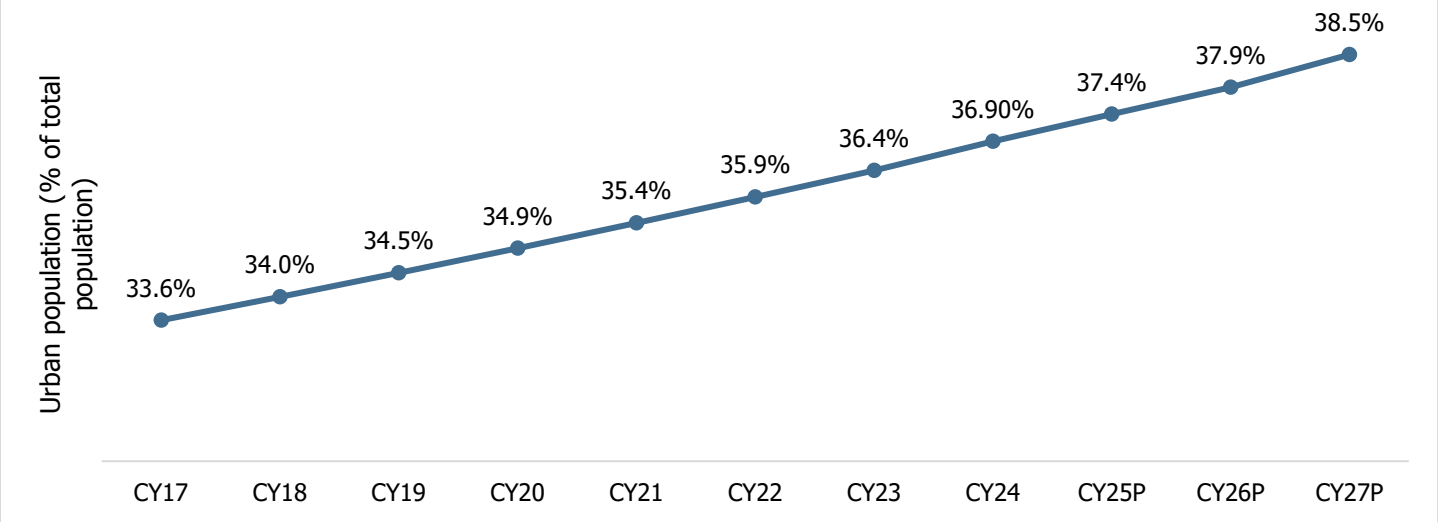


Source: World Bank Database

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 CY13 to 519.5 million (36.4% of total population) in the year CY23. India is undergoing a significant urban transformation, with the urban population projected to rise to 40% by CY36. This shift is driven by factors such as improved living standards, increased employment opportunities in urban areas, and government

initiatives aimed at urban development. This rapid urbanisation might necessitate substantial investments in infrastructure, housing, and transportation.

Chart 9: Urbanization Trend in India



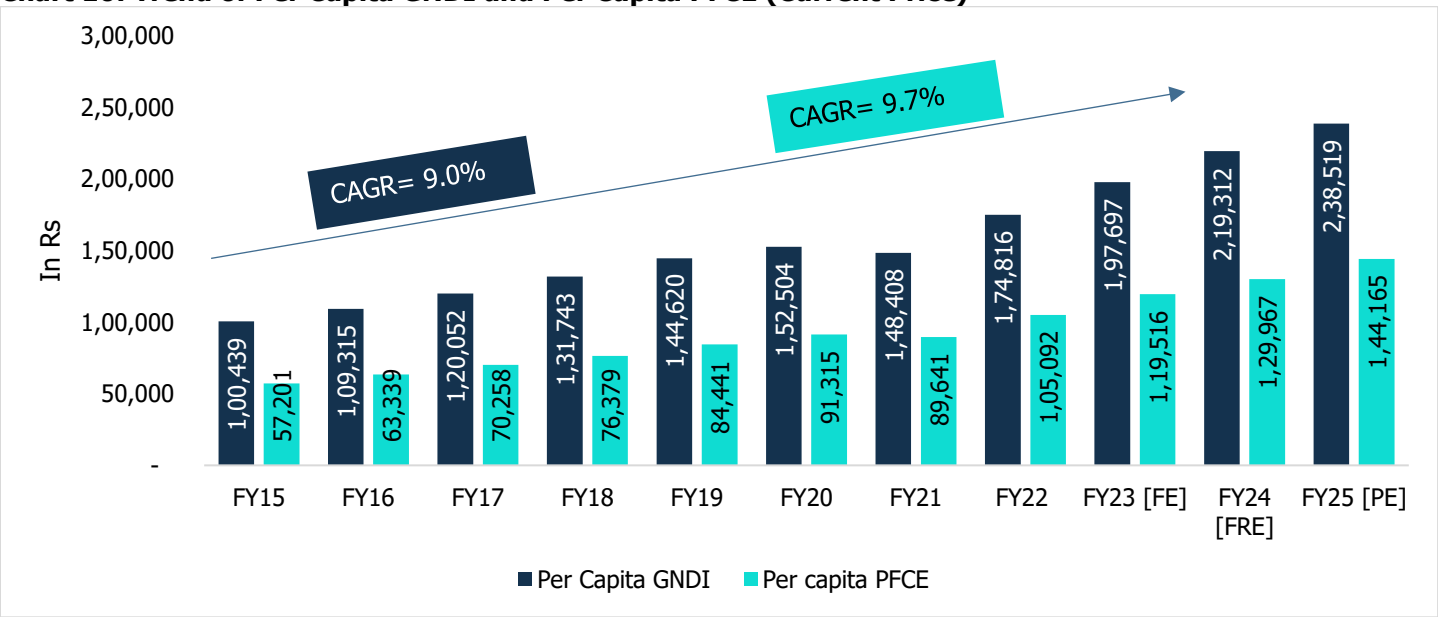
Source: World Bank Database

- **Increasing Disposable Income and Consumer Spending**

Gross National Disposable Income (GNDI) is a measure of the income available to the nation for final consumption and gross savings. Between the period FY15 to FY25, per capita GNDI at current prices registered a CAGR of 9.0%. More disposable income drives more consumption, thereby driving economic growth.

With increase in disposable income, there has been a gradual change in consumer spending behaviour as well. Per capita Private Final Consumption Expenditure (PFCE) which is measure of consumer spending has also showcased significant growth from FY15 to FY25 at a CAGR of 9.7%.

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



Source: MOSPI; Note: FRE – First Revised Estimates, FE – Final Estimate, SAE-Second Advance Estimate

1.2.7. 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 6.2% GDP growth in CY25 (FY26 according to the fiscal year), compared to the global projection of 3.3%. Key drivers include strong domestic demand, government capital expenditure and moderating inflation.

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.

The impact of U.S. tariffs on India's export trade is anticipated to be minimal. The key sectors which will have a potential impact are engineering goods, electronics, gems and jewellery, pharmaceuticals, textiles, and automobiles, among others. The affected sectors represent a small fraction of India's total exports, with key industries such as steel industry affected by the 25% tariffs although the impact is expected to be minimal given the volume of goods exported is less, and textiles are potentially benefiting from reduced competition.

India's relatively lower tariff structure enhances its attractiveness as a trade partner, and ongoing negotiations with the U.S., along with efforts to diversify export markets, including the EU and ASEAN, are likely to mitigate potential adverse effects. As India progressively positions itself as a competitive manufacturing hub, particularly in textiles, pharmaceuticals, electronics, and auto components, it remains more competitive than countries like China, Taiwan, Bangladesh, and Vietnam. This strengthens India's position as a viable alternative in global trade, particularly in sectors where it holds a comparative advantage. India's expanding manufacturing capacity, coupled with its skilled workforce, makes it an appealing investment destination for global companies. Sectors such as electronics and textiles, including the relocation of Apple's iPhone production, are likely to attract greater U.S. interest as businesses seek lower-tariff alternatives.

On February 13, 2025, Prime Minister Narendra Modi and President Donald Trump discussed enhancing the U.S.-India trade relationship, with a target to increase bilateral trade from USD 200 billion to USD 500 billion by 2030. Negotiations for a multi-sector bilateral trade agreement (BTA) are expected to commence later this year, focusing on trade fairness, national security, and job creation.

Thus, while U.S. tariffs may have a limited impact on India's exports, ongoing trade negotiations and India's competitive manufacturing advantage position it well for continued growth in global trade.

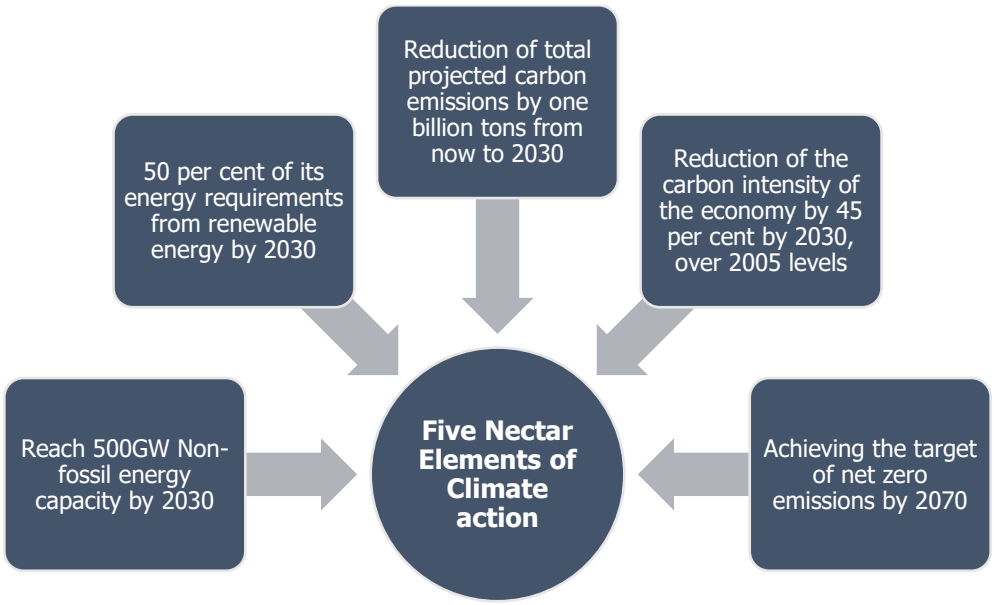
2. Green Hydrogen

2.1. Introduction

Hydrogen demand is increasing globally due to its potential to support the transition to a low-carbon economy. It is seen as a versatile energy carrier and a key element in reducing greenhouse gas emissions. According to International Energy Agency (IEA)'s Global Hydrogen Review 2024, the demand for global hydrogen reached more than 97 million tonnes in 2023 and reach almost 100 million tonnes in 2024. The primary consumers of hydrogen are the industrial sectors, particularly oil refining, ammonia production for fertilizers, and methanol production. The hydrogen demand is expected to grow to around 150 million metric tons by 2030, according to IEA.

The Government of India has presented the following five nectar elements (Panchamrit) of India's climate action during COP 26 summit:

Chart 11: Five Nectar Elements



Hydrogen is becoming increasingly vital for achieving decarbonization, particularly in hard-to-abate sectors such as steel, fertilizers, refining, and shipping. This has led to a growing global momentum for deploying clean hydrogen-based projects, with the investment pipeline exceeding $500 billion by mid-2021, according to the Hydrogen Council. Over 40 countries have established or are in the process of establishing national strategies or roadmaps for hydrogen adoption. The surge in commodity price volatility, especially in the past three years due to the pandemic and the recent Russia-Ukraine war, has heightened the urgency for major economies to reduce fossil fuel dependence, prompting governments to incentivize hydrogen adoption.

2.2. Production and Colours of Hydrogen

Hydrogen can be produced through various methods, each associated with different colours based on the production technique and its environmental impact. Here are the main types-

Table 4: Types of Hydrogen based on colour

Colour	Production	Cost	Environmental Impact
Grey Hydrogen	Produced from natural gas or methane through a process called steam methane reforming (SMR).	USD 1-2.5 per kg	Significant carbon dioxide emissions are released during production.
Blue Hydrogen	Also produced from natural gas, but the carbon emissions are captured and stored (carbon capture and storage, CCS).	USD 3-4 per kg	Lower emissions compared to grey hydrogen due to CCS, but still relies on fossil fuels.
Green Hydrogen	Produced by electrolysis of water using renewable energy sources such as wind, solar, or hydropower	USD 4-6 per kg	Virtually zero emissions, making it the most environmentally friendly option.
Black/Brown Hydrogen	Produced from coal through gasification	USD 1-2 per kg	High carbon dioxide emissions and significant environmental impact.
Pink Hydrogen	Produced by electrolysis using nuclear energy.	NA	Low emissions, dependent on the nuclear energy source.
Turquoise Hydrogen	Produced by methane pyrolysis, which splits methane into hydrogen and solid carbon	NA	Lower emissions than grey hydrogen if the process is powered by renewable energy
Yellow Hydrogen	Produced by electrolysis using grid electricity, which may come from a mix of renewable and non-renewable sources.	USD 4-7 per kg	Emissions depend on the energy mix of the grid
White Hydrogen	Naturally occurring hydrogen found in underground deposits	NA	Not yet commercially exploited, so the environmental impact is unknown

Source: IEA, CareEdge Research

Blue Hydrogen vs Green Hydrogen

The choice between blue and green hydrogen involves weighing various factors, including environmental impact, production costs, and scalability as outlined below.

Table 5: Blue Hydrogen vs Green Hydrogen

Blue Hydrogen	Green Hydrogen
Production: Blue hydrogen is produced from natural gas through a process called steam methane reforming (SMR) or autothermal reforming (ATR), combined with carbon capture and storage (CCS) to capture the CO_2 emissions generated during production	**Production:** Green hydrogen is produced by electrolysing water using electricity generated from renewable sources such as wind, solar, or hydroelectric power
Lower Emissions than Grey Hydrogen: By capturing and storing CO_2, blue hydrogen significantly reduces emissions as compared to grey hydrogen, which does not capture CO_2.	**Zero Emissions:** The production process is virtually emission-free if powered by 100% renewable energy.

Blue Hydrogen	Green Hydrogen
Cost-Effective: Currently, blue hydrogen is less expensive than green hydrogen due to lower production costs and established natural gas infrastructure.	**High Cost:** Currently, green hydrogen production is more expensive than blue hydrogen due to the high costs of renewable energy and electrolyser technology.
Dependence on Fossil Fuels: Continued reliance on natural gas conflicts with long-term goals of complete decarbonization	**Sustainability:** Aligns with global goals for renewable energy adoption and complete decarbonization.

The choice between blue and green hydrogen depends on current priorities and resources:

Short-Term Strategy: Blue hydrogen may be more practical in the short term due to lower costs and the ability to utilise existing infrastructure, making it a suitable option for reducing emissions while scaling up renewable capacity.

Long-Term Goal: Green hydrogen is ideal for achieving a fully sustainable and carbon-free energy system but necessitates significant investment and the development of renewable energy infrastructure and technology.

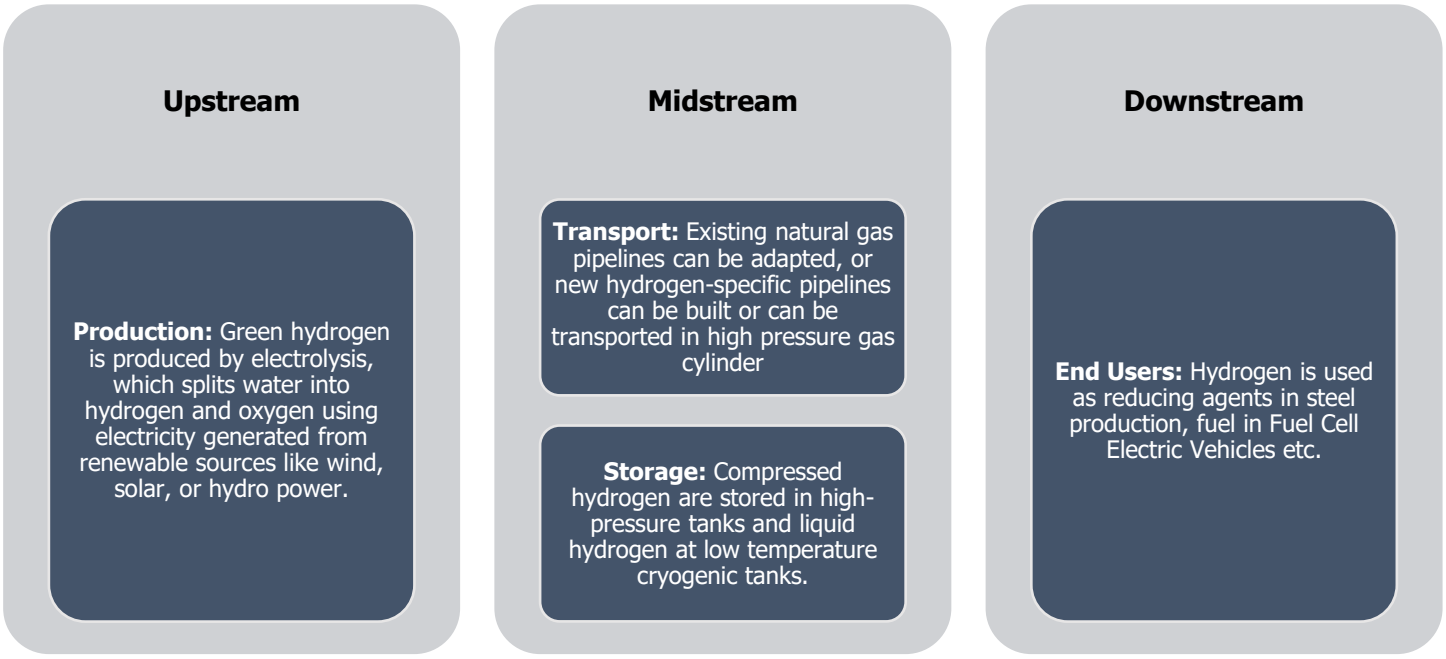
Ultimately, both forms of hydrogen have roles to play in the transition to a sustainable energy future, with blue hydrogen serving as a transitional solution and green hydrogen as the goal for decarbonization.

While India has opportunities across various industries for carbon capture, it holds a significant competitive advantage in green hydrogen due to the substantial progress it has made in renewable energy over recent years. This progress, combined with the availability of capital, land resources, and an extensive grid system, positions India as an ideal candidate for a swift transition to green hydrogen. Among its regions, Gujarat and Rajasthan benefit from some of the highest solar radiation levels, potentially making them among the lowest-cost green hydrogen production areas.

2.3. Green Hydrogen Value-Chain Development

The green hydrogen value chain includes all activities and processes involved in producing, processing, and distributing green hydrogen. It begins with generating renewable energy (such as solar or wind power), the electrolysis process that splits water into hydrogen and oxygen, and extends to the storage, transportation, and end-use applications of the produced hydrogen.

Chart 12: Green Hydrogen Value Chain



2.4. Upstream- The production of hydrogen

Although hydrogen is the lightest and most abundant element in the universe, it is rarely present in nature in its elemental form and always must be extracted from other hydrogen-containing compounds. It also means that how well hydrogen contributes decarbonisation depends on how clean and green the method of production is.

Hydrogen is mostly produced predominantly from fossil fuels. According to IEA, only 0.1% of the hydrogen being produced comes from electrolysis. There are majorly four types of electrolysers - Alkaline, Polymer electrolyte membranes, anion exchange membrane and solid oxides.

- **Alkaline -** The alkaline method of electrolysis or alkaline water electrolysis (AWE), efficiently produces hydrogen using a mature and widely adopted technology. This process uses an alkaline electrolyte, typically potassium hydroxide (KOH) or sodium hydroxide (NaOH), to conduct electricity between two electrodes—an anode and a cathode. During electrolysis, water splits into hydrogen and oxygen gases. At the cathode, water molecules gain electrons (reduction) to produce hydrogen gas and hydroxide ions, while at the anode, hydroxide ions lose electrons (oxidation) to form oxygen gas and water. This well-understood reaction ensures efficiency and makes the method ideal for large-scale hydrogen production.

A key advantage of alkaline electrolysis is its ability to operate at lower current densities and moderate temperatures (typically between 60-80°C), which contributes to its reliability and longevity. Additionally, the materials used for electrodes in AWE, such as nickel, are relatively inexpensive compared to those required for other electrolysis methods like proton exchange membrane (PEM) electrolysis. However, AWE has certain limitations, including lower current densities and slower

start-up times compared to PEM electrolysis. These limitations can affect its efficiency and scalability, particularly in dynamic energy markets driven by intermittent renewable sources.

- **Polymer electrolyte membranes-** Polymer electrolyte membrane (PEM) electrolysis is a cutting-edge method utilized in the process of splitting water molecules into hydrogen and oxygen gases. This innovative technique employs a solid polymer electrolyte membrane as a separator between the anode and cathode compartments, facilitating the selective transport of ions while preventing the mixing of gases. The PEM serves as a conductive medium for protons, allowing them to migrate from the anode to the cathode, where they combine with electrons to form hydrogen gas. Meanwhile, oxygen gas is produced at the anode through the oxidation of water molecules. PEM electrolysis offers several advantages over traditional methods, including higher efficiency, lower operating temperatures, and increased safety due to the elimination of liquid electrolytes. Additionally, PEM electrolysers are compact, modular, and suitable for decentralized hydrogen production, making them a promising technology for advancing the transition to a sustainable energy future.

- **Anion exchange membrane-** The anion exchange membrane (AEM) method of electrolysis is an advanced technique used to split water into hydrogen and oxygen gases. In this process, the AEM, which is a polymer-based membrane containing positively charged functional groups, allows the selective transport of anions (typically hydroxide ions, OH^-) from the cathode to the anode. At the cathode, water is reduced to produce hydrogen gas and hydroxide ions. The hydroxide ions then migrate through the AEM to the anode, where they are oxidized to produce oxygen gas and water. This method is particularly advantageous because it operates under alkaline conditions, thereby reducing the reliance on expensive noble metal catalysts typically required in acidic environments. Additionally, the AEM method can utilize less costly materials for both electrodes and the membrane, making it a promising approach for cost-effective and efficient hydrogen production — a critical component in advancing sustainable energy systems**.**

- **Solid oxides**- The solid oxide method of electrolysis is an advanced technique primarily used for the efficient and environmentally friendly extraction of metals, such as aluminium and magnesium, from their ores. In this process, a solid oxide electrolyte, typically composed of zirconia stabilized with yttria, is utilized at high temperatures (usually around 800-1000°C). The solid oxide electrolyte facilitates the conduction of oxygen ions, enabling the electrolytic separation of the desired metal from its oxide form. This method offers several advantages, including lower energy consumption compared to traditional smelting processes, reduced greenhouse gas emissions, and the ability to produce high-purity metals. Furthermore, the solid oxide electrolysis method is gaining attention for its potential applications in energy storage and conversion, particularly in the development of efficient fuel cells and electrolysers.

Table 6: Specifications of different type of Electrolysis

Features	AEM	PEM	Solid Oxides
Electrolyte	KOH/NaOH	Solid Polymer Electrolyte	Yttria-stabilized Zirconia (YSZ)
Electrode (H_2 side)	Nickel- coated perforated stainless steel	Iridium Oxide	Ni/YSZ
Electrode (O_2 side)	Nickel- coated perforated stainless steel	Platinum Carbon	Perovskites
Temperature (Celsius)	40-90	20-100	600-900
Voltage(V)	1.8-2.4	1.8-2.2	0.7-1.5
Pressure (Bar)	<30	<30	<10
Production (Nm^3/h)	10	5	5
Output H_2 pressure (bar)	10	35	10 (after PSA)
Gas purity (%)	>99.5%	>99.995	NA
Stack Energy Consumption (kWh/Nm^3)	4.2-5.9	4.2-5.5	>3
System Efficiency (% LHV)	55-60	55-70	74-81

Features	AEM	PEM	Solid Oxides
Lifetime of stack/h	55-120	60-100	Aug-20
Degradation (%/a)	0.25-1.5	0.5-2.5	Mar-50
Maintenance cost (% of investment/year)	2-3	3-5	NA
Capita Cost (EUR/kW)	880-1650	1540-2550	>2000
Technical Sophistication	Omnipresent Commercialization	Commercialization	Exploration and development phase

Source: Industry Sources, CareEdge Research

Table 7: List of Electrolyser Manufacturers

Players	Headquarters	Types
Nel Hydrogen	Norway	PEM, Alkaline
ITM Power	United Kingdom	PEM
Siemens Energy	Germany	PEM
Cummins Inc. (including its subsidiary Hydrogenics)	United States	PEM, Alkaline
McPhy Energy	France	PEM, Alkaline
Toshiba Energy Systems & Solutions Corporation	Japan	PEM
Linde (including its subsidiary ITM Linde Electrolysis GmbH)	Germany	PEM
Enapter	Germany	AEM
Plug Power	United States	PEM
Thyssenkrupp Uhde Chlorine Engineers	Germany	Alkaline
Sunfire	Germany	Solid Oxide, Alkaline
H2B2 Electrolysis Technologies	Spain	PEM, Alkaline
Proton OnSite (a subsidiary of Nel Hydrogen)	United States	PEM
Asahi Kasei Corporation	Japan	Alkaline
Kawasaki Heavy Industries	Japan	PEM
Green Hydrogen Systems	Denmark	PEM
Giner ELX (a subsidiary of Plug Power)	United States	PEM
Siemens Gamesa	Spain	PEM
Idroenergy	Italy	PEM, Alkaline
Elogen	France	PEM

Source: Industry Sources, CareEdge Resource

2.5. Midstream

- **Transport**

Hydrogen can be transported in three main ways, depending on the distance, volume, and state of the hydrogen:

➢ **Pipelines -** Pipelines are typically the most economical method for transporting hydrogen over longer distances. Building pipelines generally requires certainty in volume and demand to justify the investment. Existing natural gas pipelines can be repurposed if they meet the technical criteria to reduce the risk of embrittlement. This repurposing also allows for blending hydrogen within existing natural gas networks, which can accelerate demand creation.

➢ **Trucks -** Trucks are used to transport hydrogen in smaller volumes, both in gaseous and liquid forms, for local distribution and longer journeys.

➢ **Tanker ships -**Tanker ships are utilized for transporting larger volumes over long distances, primarily moving liquid hydrogen (LH2), Liquid Organic Hydrogen Carriers (LOHCs), and ammonia. Shipping hydrogen is currently expensive due to the added costs of conversion (liquefaction or chemical conversion) and the necessary structural design to mitigate the risk of embrittlement.

- **Storage**

Hydrogen has three main avenues for storage, each with its own use cases and challenges:

➢ **Storage Tanks -**

Storage tanks offer one of the most straightforward and often most cost-effective solutions for storing and transporting hydrogen, typically in the form of compressed or cryo-compressed gas. However, storing compressed hydrogen presents a challenge due to its low energy density, necessitating containers that are approximately three times larger than those used for methane and ten times larger than those required for petrol. This significantly increases material costs.

Liquefying hydrogen enhances its energy density, thereby improving storage efficiency, but this method incurs considerable energy expenditure, consuming up to 30% of the hydrogen's energy content, in contrast to the 4%–7% energy loss associated with compression.

➢ **Chemical storage** - Forms of compounds such as liquefied organic hydrogen carriers (LOHCs) like methanol and toluene, and hydrides such as ammonia (NH3), is not gaining prominence due to the high energy cost of liquefaction and the material inefficiencies of compression. Each mode of chemical storage has its own uses and hurdles, including energy conversion costs and chemical characteristics that require careful handling.

➢ **Natural underground Storage -** Natural Underground storage in salt caverns and salt domes offers large volume, low-cost, natural storage options, but local availability can be a challenge.

2.6. Downstream

Green hydrogen, produced using renewable energy sources, has a variety of end-user sectors. Each sector leverages green hydrogen for its unique advantages, promoting sustainability and reducing carbon emissions. Here are the key end-user sectors in detail:

- **Industrial Sector**

➢ **Ammonia Production**: Green hydrogen is essential to produce green ammonia, which is a crucial component in fertilizers. Traditional ammonia production relies on natural gas, but green hydrogen can eliminate carbon emissions from this process.

➢ **Refineries:** Hydrogen is used to remove sulphur from fuels during the refining process. Green hydrogen can replace the conventional hydrogen derived from fossil fuels, thereby reducing the carbon footprint of refineries.

➢ **Steel Manufacturing:** The steel industry uses hydrogen to reduce iron ore to iron. Green hydrogen can replace carbon-intensive coke, significantly lowering CO2 emissions from steel production.

➢ **Chemical Industry:** Many chemical processes require hydrogen as a feedstock. Using green hydrogen can reduce the environmental impact of producing chemicals like methanol and other hydrocarbons.

- **Transportation Sector**

➢ **Fuel Cell Electric Vehicles (FCEVs):** Green hydrogen powers fuel cells in electric vehicles, producing only water as a by-product. This technology is especially beneficial for heavy-duty vehicles such as buses, trucks, and trains, which require longer ranges and shorter refuelling times compared to battery electric vehicles.

➢ **Aviation:** Hydrogen can be used either directly in fuel cells or as a feedstock for synthetic aviation fuels, offering a path to decarbonize air travel.

➢ **Shipping:** Green hydrogen and its derivatives, like ammonia, can serve as clean fuels for maritime transport, helping to reduce the significant emissions from the shipping industry.

- **Power Generation and Storage**

➢ **Grid Balancing:** Green hydrogen can be used to store excess renewable energy, such as wind or solar power, by converting it into hydrogen through electrolysis. This hydrogen can then be converted back into electricity during periods of high demand or low renewable energy generation.

➢ **Remote Power Supply:** In off-grid or remote areas, green hydrogen can provide a stable and clean power supply, reducing reliance on diesel generators.

- **Residential and Commercial Heating**

➢ **Heating Systems:** Green hydrogen can be blended with natural gas or used directly in hydrogen boilers and fuel cells for heating buildings, offering a low-carbon alternative to conventional heating fuels.

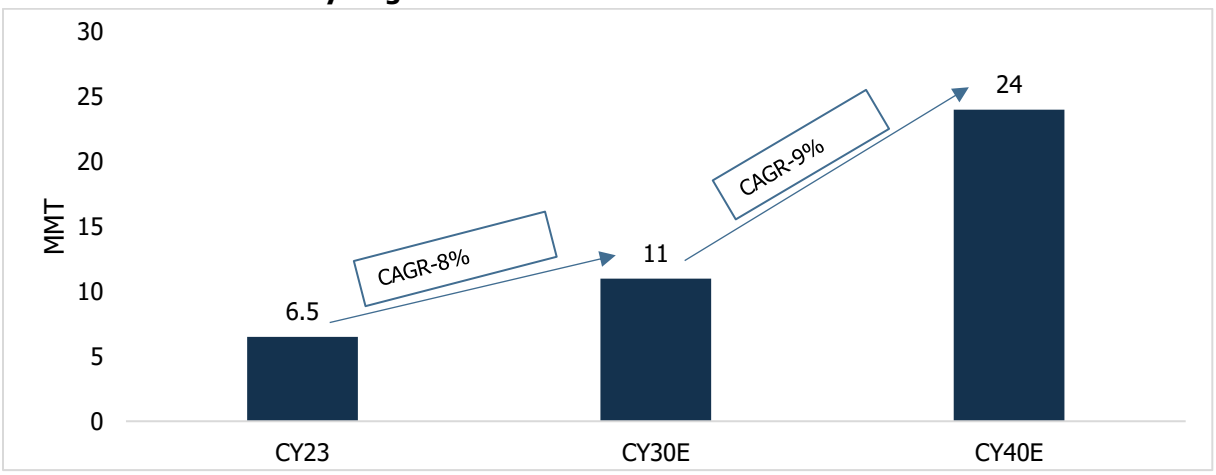
➢ **Combined Heat and Power (CHP):** Fuel cells using green hydrogen can provide both electricity and heat, improving energy efficiency for residential and commercial buildings.

2.7. Domestic Sector Demand

India's domestic demand for hydrogen is growing rapidly, driven by the nation's commitment to decarbonization and energy security. The Indian government's focus on green hydrogen, produced using renewable energy sources, aims to reduce reliance on fossil fuels and significantly lower greenhouse gas emissions. Additionally, emerging applications in transportation—especially in fuel cell vehicles, and power generation are further fuelling the demand for hydrogen.

As India sets ambitious targets for renewable energy adoption, the focus on developing a robust hydrogen economy is becoming more pronounced, with significant investments in infrastructure, research, and development to support the production, storage, and distribution of hydrogen. This growing demand is poised to transform the energy landscape, contributing to a sustainable and resilient future for the country. Current H2 demand in India is 6.5 MTPA, driven by captive consumption of refineries (3.1 MTPA), fertilizer & ammonia (2.1MTPA), concentrated in western region.

Chart 13: Demand for Hydrogen in India

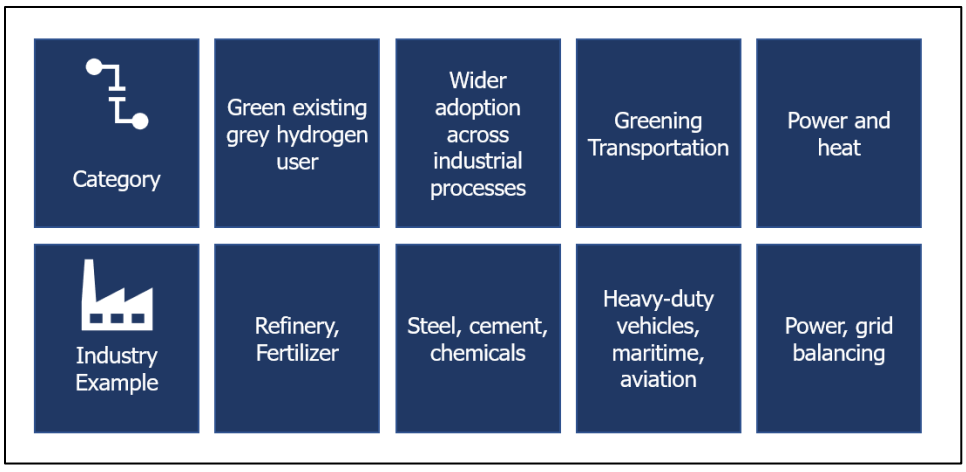


Source: PIB, MNRE

Demand from various categories

The demand for hydrogen can potentially grow at a CAGR of 8% from 2023 to reach 11 MMT and further at a CAGR of 9% to reach 24 MMT by 2040. While steel and heavy-duty trucking will be the long-term demand drivers, in the near term, demand will likely be driven by the more mature markets in industrial feedstock—ammonia and refining.

Chart 14: Demand for various Categories



- **Fertilizers**

India is an agrarian nation, where over half of the population relies on agriculture for their livelihood. The country is the world's largest producer of spices, pulses, milk, tea, cashew nuts, and jute, and the second-largest producer of wheat, rice, fruits and vegetables, sugarcane, cotton, and oilseeds. Agriculture continues to be a strong contributor to the economy, and the persistent demand for fertilisers is expected to be bolstered by an increased Minimum Support Price (MSP) for kharif and rabi crops in the 2023–24 marketing season. Furthermore, the government's ongoing provision of upfront fertiliser subsidies—including those for urea and nutrient-based fertilisers—totalling Rs 1.64 lakh crore, is likely to support momentum in both the fertiliser industry and the broader agricultural sector. However, this allocation represents a reduction of nearly 25% compared to the previous year, largely due to a decline in global fertiliser prices. Fertiliser prices, which surged in FY22, have since declined, driven by muted global demand and an increase in exports from China. Indian farmers are exercising caution in their purchases, anticipating a further price drop amid a high likelihood of El Niño, which could impact cropping patterns and overall demand. Collectively, these dynamics are likely to limit sales volume in the fertiliser industry in the near term.

Ammonia, a compound consisting of nitrogen and hydrogen, is widely used in the chemical especially in the production of fertilizers sector. Currently, most of the hydrogen feedstock for ammonia production is derived from natural gas. This can be replaced by renewable-based electrolysis to produce green ammonia. Ammonia's applications include:

➢ **Ammonia-derived fertilizers:** Ammonia is predominantly used in the manufacturing of nitrogen-based fertilizers (such as urea) and other complex fertilizers like diammonium phosphate (DAP). The demand for nitrogenous fertilizers is expected to grow at a CAGR of 3% over the next decade, driven by the rising population and increasing demand for food.

➢ **Ammonia as fertilizer:** While ammonia is mainly used as feedstock for other fertilizers, it can also be directly applied to soil, either in anhydrous form or as aqua-ammonia (ammonia dissolved in water). Anhydrous ammonia is readily available and can be easily applied to soil, but it requires careful consideration regarding its transportation and storage. Aqua-ammonia, on the other hand, is relatively safer than the anhydrous form and can be applied more easily since it is not injected as deeply into the soil.

- **Steel**

Hydrogen demand for the steel industry hinges on technology competitiveness and fuel availability. Steel is primarily produced through three main processes:

➢ **Blast furnace –** basic oxygen furnace (BF – BOF), which uses coking coal for the reduction of iron ore.

➢ **Direct reduced iron** – electric arc furnace/induction furnace (DRI – EAF/IF), which can achieve reduction using either natural gas or coal on pelletized iron ore.

➢ EAF/IF with scrap steel, where scrap or recycled steel is directly heated via electricity to form steel.

The DRI process presents a potential role for hydrogen to replace fossil fuels, particularly natural gas. The demand for hydrogen in the steel sector is driven by several factors including the need for cleaner and more sustainable production methods. In traditional steelmaking processes such as the blast furnace-basic oxygen furnace (BF-BOF) route, coking coal is used for the reduction of iron ore. However, there is increasing interest in exploring alternative methods such as direct reduced iron-electric arc furnace/induction furnace (DRI-EAF/IF), which can utilize hydrogen as a replacement for fossil fuels like natural gas.

This shift towards hydrogen usage in steel production is motivated by the industry's commitment to reducing carbon emissions and achieving greater energy efficiency. As a result, the demand for hydrogen in the steel sector is expected to grow as technologies evolve and environmental regulations become more stringent.

- **Refining**

Hydrogen is essential to the petroleum refining industry and is primarily used for desulphurisation of products. Hydrogen demand depends on two factors:

- Demand of petroleum products, which is bound to increase considerably if efficiency measures and low/zero-carbon alternatives are not adopted.

- Stringent policy actions on limiting the sulphur content from petroleum products—the more stringent the standards, the higher the requirement of hydrogen in desulphurisation.

The demand for hydrogen in the refining sector is driven by its crucial role in various refining processes. Hydrogen is extensively used in refining to remove impurities from crude oil and other feedstocks, such as sulphur and nitrogen compounds, through processes like hydrocracking, hydrotreating, and hydrodesulfurization. These processes help improve the quality of refined petroleum products, such as gasoline, diesel, and jet fuel, by reducing sulphur content and enhancing their environmental performance. Additionally, hydrogen is utilized in processes like catalytic reforming to upgrade low-value hydrocarbons into high-value products like aromatics and olefins. As environmental regulations become more stringent and the demand for cleaner fuels rises, the demand for hydrogen in the refining sector is expected to increase further.

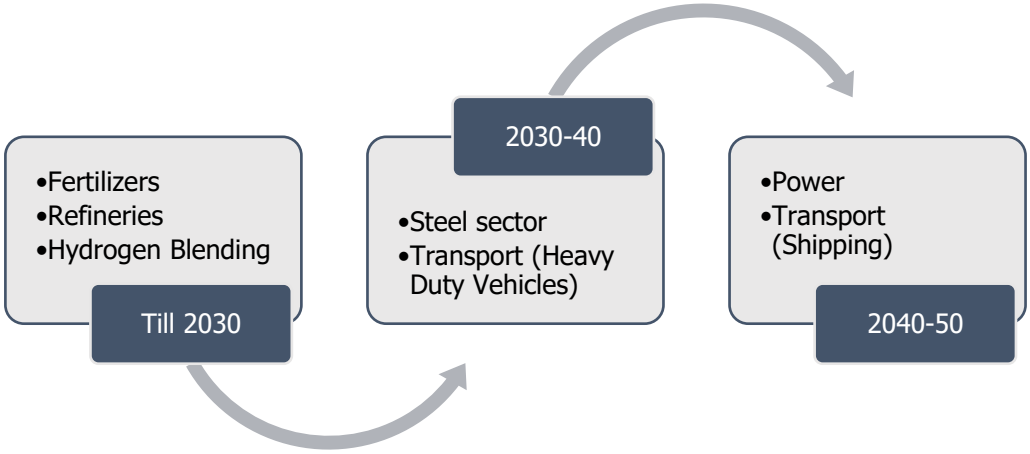
- **Other Sectors**

Industries such as transportation and power generation are increasingly exploring hydrogen as a clean energy source. In transportation, hydrogen fuel cells are being developed as an alternative to traditional fossil fuel engines, offering zero-emission solutions for vehicles. Additionally, hydrogen is utilized in chemical processes to produce ammonia, methanol, and other industrial chemicals.

Refineries are also adopting hydrogen for desulfurization and hydrocracking processes to meet stringent environmental regulations. Furthermore, hydrogen fuel cells are being integrated into power generation systems, providing reliable and efficient energy storage solutions for grid stability and renewable energy integration. As the global transition towards sustainable energy accelerates, the demand for hydrogen across diverse sectors is expected to continue growing.

Hydrogen's role as a fuel for the transport sector can extend beyond road transport to shipping and aviation. Shipping and aviation sectors use heavy fuel oil and jet fuel respectively. Moreover, there are very few alternatives to decarbonize these sectors, and they are less readily available and more expensive than conventional fuels. Hence, hydrogen or hydrogen-based compounds such as ammonia or methanol can play a big role in decarbonizing shipping and aviation.

Chart 15: Projected Timeline for adoption of green Hydrogen by various end-user segment



2.8. Review and expectations of policy announcements

With the increasing net-zero emission targets set by countries and companies, and hydrogen's potential to decarbonize hard-to-abate sectors, hydrogen is gaining renewed momentum globally. At least 43 countries have established or are in the process of establishing strategies or roadmaps for a hydrogen economy. Most government-related R&D funding for hydrogen is concentrated in Europe, the United States, Japan, and China.

Table 8: Key features of global hydrogen strategies

Region	Current Hydrogen Demand	Policy Target Demand	Capital Allocated (US$)	Focused Hydrogen Source	Demand Focus			Export/ Import Focus	Strategy
					Industry	Transport	Others		
European Union		6 GW capacity by 2024; 40 GW by 2030; 10 MMTPA green H2 by 2030	609 billion	Low Carbon - Blue / Green	1. Chemical feedstock 2. Refining	1. Medium and Heavy Duty 2. Buses 3. Rail			Market Development, Direct Investments, regulatory measures, Financial Mechanism
Chile	58.5 ktpa	5 GW/a (2025) 25 GW/a (2030)	50 million	Green	1. Chemical feedstock 2. Refining	1. Medium and Heavy Duty 2. Buses	1. Heating	Export	Hydrogen Price target, regulatory mechanism, market development
United States	10 MMTPA		> 15 billion	Low Carbon - Blue / Green / Others	1. Refining 2. Others	1. Passenger Vehicle 2. Medium and Heavy Duty 3. Buses 4. Aviation	1. Heating 2. Power 3. Energy storage		R&D, Hydrogen Price Target, Direct Investments, regulatory measures, Financial Mechanism
Australia	650 ktpa		278 million (annual support)/ yr	Clean - Blue / Green	1. Chemical feedstock	1. Medium and Heavy Duty 2. Buses	1. Heating	Export	R&D, Market Development, Hydrogen Price Target, Direct Investments, regulatory measures, Financial Mechanism
United Kingdom	0.7 MMTPA	5 GW/a electrolysis capacity by 2030	2 billion	Blue / Green	1. Chemical feedstock 2. Iron and Steel	1. Medium and Heavy Duty 2. Buses 3. Rail 4. Aviation 5. Shipping	1. Heating 2. Power	Export	R&D, Market Development, Hydrogen Price Target, Direct Investments, regulatory measures, International Strategy, Financial Mechanism

Region	Current Hydrogen Demand	Policy Target Demand	Capital Allocated (US$)	Focused Hydrogen Source	Demand Focus			Export/ Import Focus	Strategy
					Industry	Transport	Others		
South Korea	220 ktpa	3.9 MMTPA by 2030 and 27 MMTPA by 2050	653 million /yr	Grey / Blue / Green		1. Passenger Vehicle 2. Medium and Heavy Duty 3. Buses	1. Power	Import	R&D, Market Development, Hydrogen Price Target, Direct Investments, regulatory measures, International Strategy, Financial Mechanism
Japan	2 MMTPA	3 MMTPA by 2030 and 20 MMTPA by 2050 (5-30 by 2050)	935 million /yr	Blue		1. Passenger Vehicle	1. Heating 2. Power	Import	R&D, Market Development, Hydrogen Price Target, Direct Investments, regulatory measures, International Strategy, Financial Mechanism

Source: NITI AAYOG

2.9. Incentive Schemes for Green Hydrogen Production and Electrolyser manufacturing

- **PLI Scheme -** MNRE announced PLI schemes covering two critical area that are Green Hydrogen production and manufacturing of electrolysers in India. An initial budgetary outlay of Rs 19,744 crores were approved for the National Green Hydrogen Mission. The budget allocated for the National Green Hydrogen Mission in FY26 is Rs 600 crores, a 100% rise over previous budget of Rs 300 crores in FY25. These incentives are to be provided for the duration of three years starting from the date of commencement of Green Hydrogen production. Beneficiaries are to be selected through competitive process wherein applicants quoting minimum fiscal incentive would be given preference.

- **Strategic Interventions for Green Hydrogen Transition (SIGHT) programme -** The Ministry of New and Renewable Energy (MNRE) has released new guidelines and incentives to encourage the adoption of green hydrogen as part of the National Green Hydrogen Mission. As part of this initiative, the Strategic Interventions for Green Hydrogen Transition (SIGHT) program has been allocated a total outlay of Rs 17,490 crore which includes Rs 4,440 crores to support the domestic manufacturing of electrolysers and Rs 13,050 crores to produce green hydrogen. These incentives aim to drive down cost and facilitate rapid growth in the sector.

Implemented under Mode-2B, a framework devised by the MNRE for the SIGHT program, this strategy involves aggregating demand and inviting bids for green hydrogen and its derivatives at competitive prices through a transparent selection process. Tranche I of Mode 2B offers a bidding capacity of 200,000 million tonnes per annum.

The execution of the scheme will be overseen by agencies designated by the Ministry of Petroleum and Natural Gas (MoPNG), primarily oil and gas companies, with guidance from the Centre for High Technology (CHT).

2.10. India's Hydrogen Policy

The National Green Hydrogen Mission was approved by the Government of India in January 2023, with an objective to make India a global hub for production, usage and export of green hydrogen and its derivatives and approved an outlay of Rs 190 billion to help achieve an annual production target of 5 MMT by 2030 for facilitating the net-zero target. The mission is also expected to generate Rs 8 trillion in total investments by 2030 and around 50 MMT per annum of CO_2 emissions are expected to be averted.

The policy provides the following:

i. Green Hydrogen / Ammonia manufacturers can procure renewable power from the power exchange or establish renewable energy capacity themselves or through developers anywhere.
ii. Open access will be granted within 15 days of receiving the application.
iii. The Green Hydrogen / Ammonia manufacturers can bank their unconsumed renewable power with the Distribution Company for up to 30 days and retrieve it when needed.
iv. Distribution licensees can procure and supply renewable energy to Green Hydrogen/Ammonia manufacturers within their states at concessional prices, covering only procurement costs, wheeling charges, and a small margin determined by the State Commission.
v. Waiver of inter-state transmission charges for a period of 25 years will be allowed to the manufacturers of Green Hydrogen and Green Ammonia for the projects commissioned before 30th June 2025.
vi. The manufacturers of Green Hydrogen / Ammonia and the renewable energy plant shall be given connectivity to the grid on priority basis to avoid any procedural delays.
vii. The benefit of Renewable Purchase Obligation (RPO) will be granted incentive to the hydrogen/Ammonia manufacturer and the Distribution licensee for consumption of renewable power.
viii. To ensure ease of doing business a single portal for carrying out all the activities including statutory clearances in a time bound manner will be set up by MNRE.
ix. Connectivity, at the generation end and the Green Hydrogen / Green Ammonia manufacturing end, to the ISTS for Renewable Energy capacity set up for the purpose of manufacturing Green Hydrogen / Green Ammonia shall be granted on priority.
x. Green Hydrogen/Ammonia manufacturers can set up bunkers near ports for storing Green Ammonia for export or shipping use. Respective Port Authorities will provide land for storage at applicable charges.

The mission defines green hydrogen as the hydrogen produced using renewable energy, including but not limited to production through electrolysis or conversion of biomass.

When green hydrogen is produced through electrolysis, the non-biogenic greenhouse gas emissions arising from water treatment, electrolysis, gas purification and drying and compression of hydrogen shall not be greater than 2 kilogram of carbon di-oxide equivalent per kilogram of hydrogen (kg CO_2 eq./kg hydrogen), taken as an average over last 12-month period.

For green hydrogen produced through conversion of biomass, the non-biogenic greenhouse gas emissions arising from biomass processing, heat/steam generation, conversion of biomass to hydrogen, gas purification and drying and compression of hydrogen shall not be greater than 2 kilogram of carbon dioxide equivalent per kilogram of hydrogen (kg CO_2 eq./kg hydrogen) taken as an average over last 12-month period.

The mission is proposed to be implemented in phased manner since the sector is at nascent stage and rapidly evolving.

Table 9: Phases under Green Hydrogen Mission

Phase	Timeline	Activities to be undertaken
Phase I	2022-23 to 2025-26	Focus on creating demand while enabling adequate supply by increasing the domestic electrolyser manufacturing capacity
Phase II	2026-27 to 2029-30	Build on the foundational activities and undertake green hydrogen initiatives in new sectors.

The pilot projects of the mission include outlay of Rs 4.55 billion up to FY30 for low carbon steel projects, Rs 4.96 billion up to FY26 for mobility pilot projects, Rs 1.15 billion up to FY26 for shipping pilot projects and other target areas including decentralized energy applications, hydrogen production from biomass, hydrogen storage technologies, etc.

Under the Green Hydrogen Mission, the sub schemes are Strategic Interventions for Green Hydrogen Transition Programme and Green Hydrogen Hubs where, states and regions capable of supporting large scale production and/or utilization of hydrogen will be identified and developed as hubs,

The Strategic Interventions for Green Hydrogen Transition (SIGHT) program is a major financial measure under the Green Hydrogen Mission with an outlay of Rs 174.90 billion. The programme has two distinct financial initiative mechanisms to support domestic manufacturing of electrolyser and production of green hydrogen with an aim to enable rapid scale-up, technology development and cost reduction.

In 2024, under the SIGHT program contracts for electrolysers manufacturing with a total capacity of 1,500 MW per annum were awarded to eight companies, while ten companies were selected under the SIGHT scheme for Green Hydrogen Production with a combined capacity of approximately 4 lakh tonnes per annum.

2.11. Renewable Energy Demand – Green Hydrogen

As of FY25, the renewable energy sources had a combined installed capacity of 209.44 GW in India.

Under National Green Hydrogen Mission, the government has targeted to establish 5 million tonnes of annual green hydrogen production capacity by 2030. The government has made substantial progress and have awarded tender for incentives to support green hydrogen production of total of 4,12,00 tonnes per annum. Additionally, tenders have been awarded for the establishment of electrolyser manufacturing capacity amounting to 1,500 MW per annum, further bolstering India's capacity to produce green hydrogen at scale.

Green Hydrogen demand in India is estimated to grow up to 2 MMTPA by 2030 which will call for investments up to USD 60 Billion.

However, given the favourable regulatory policies and aggressive announcements by the players, hydrogen production by 2030 may surpass the target, which presents significant upside risks to the renewable capacity requirements.

2.12. Key Announcements in Green Hydrogen Sector in India

The green hydrogen sector in India is witnessing significant momentum with substantial investments, strategic collaborations, and supportive government policies. These initiatives are expected to position India as a global leader in green hydrogen production and play a crucial role in the country's transition to a sustainable energy future.

In FY25, incentives worth Rs 2,220 crore were awarded for 1,500 MW per annum of electrolyser manufacturing, and Rs 2,239 crore was allocated for 4.5 Lac TPA of Green Hydrogen production. Under the National Green Hydrogen Mission, seven pilot projects were funded with Rs 454 crore for decarbonizing the steel sector.

Production plans for Green Hydrogen

- Major oil companies like IOCL, HPCL, BPCL, GAIL, MRPL, NRL are advancing green hydrogen production in line with the national green hydrogen mission.
- BPCL is collaborating with BARC for a facility by 2025.
- MRPL is preparing for site with 3.5 MW initially, scalable up to 18 MW.
- HPCL is ordering Electrolysers and setting up facility in Visakhapatnam.
- GAIL is installing a large PEM Electrolyser in Madhya Pradesh.
- NRL is planning a 5 KTPA facility by 2030 and floated a tender for a 20 MW AWE or PEM technology.
- IOCL partners with ReNew power for renewable energy initiatives.
- All these companies will have a cumulative production of 831.10 KTA which is 0.8311 MMT green hydrogen.

Table 10: Production plans

Organizations	Project Sites	Green Hydrogen Capacity by 2030 (KTA)
IOCL (Indian Oil Corporation)	IOCL Refineries	350.00
HPCL (Hindustan Petroleum)	Visakh Refinery & Barmer Refinery (Cumulative)	29.10
BPCL (Bharat Petroleum)	Bina/Kochi/Mumbai	28.00
GAIL (Gas Authority of India Limited)	H2 Blending in City Gas Distribution Network	45.00
MRPL (Mangalore Refinery and Petrochemicals Limited)	MRPL, Mangalore	5.00
NRL (Numaligarh Refinery Limited)	Numaligarh, Assam	9.00
ONGC (Oil and Natural Gas Corporation)	Mangalore/Gujrat	360.00
CPCL (Chennai Petroleum Corporation Limited)	Manali, Chennai	5.00
	TOTAL	**831.10**

Source: Ministry of Oil & Natural Gas

Other Announcements-

- Reliance Industries commits a substantial $10 billion investment towards green hydrogen production, aiming for a 1 GW facility in Jamnagar, Gujarat operational by 2025. They have secured subsidies for manufacturing 0.30 GW electrolyser. If they manufacture at least 1 GW till 2030 per year, their total manufactured electrolyser capacity will reach 6 GW.
- In 2021, Ohmium inaugurated India's first electrolyser giga-factory, with an initial capacity of 0.50 GW and plans to scale up to 2 GW by 2025. They have also received subsidy to manufacture 0.137 GW electrolyser. If they continue to manufacture at least 2 GW till 2030, their cumulative manufacturing will amount to 15.62 GW.
- Other companies including, Advait Infratech LTD, L&T Electrolysers limited, Matrix gas & renewables limited, Homihydrogen Private limited, Adani New Industries Limited have also been granted subsidies for manufacturing electrolysers in capacities ranging from 0.063 GW to 0.30 GW, with a cumulative of 0.76 GW. Considering they at least manufacture 0.76 GW per year from 2026 till 2030 their cumulative will be around 3.815 GW.
- NTPC, India's largest power utility, announced several green hydrogen projects, including the country's first green hydrogen mobility project in Leh and a pilot project for blending green hydrogen with natural gas in Gujarat.
- Indian Oil Corporation announced plans to build green hydrogen plants at its refineries as part of a broader strategy to achieve net-zero carbon emissions. IOC is also exploring partnerships and collaborations for green hydrogen production and usage.
- JSW Steel, one of India's leading steel producers, announced plans to use green hydrogen for steel production as part of its strategy to reduce carbon emissions and transition to more sustainable manufacturing processes.

2.13. Strategic Tie-ups

JSW-Fortescue

- Under the agreement, **Fortescue** Future Industries (FFI) and JSW Energy will collaborate and conduct scoping work on potential projects relating to the production of green hydrogen and explore opportunities to utilize it for green steel making, hydrogen mobility, green ammonia and other mutually agreed industrial applications in India.

HMEL-NTPC Green Energy

- To realize green energy and green hydrogen objectives and the GOI's efforts towards energy transition, a Memorandum of Understanding (MoU) signed between NTPC Green Energy Limited (NGEL) and HPCL Mittal Energy Limited (HMEL)
- The MoU envisages to collaborate in the field of Renewable Energy through sourcing of 250 MW RE-RTC (Round-The-Clock) power to meet the requirement of HMEL and exploring opportunities in the Green Hydrogen business & its derivatives (Green Ammonia & Green Methanol)

Greenko-John Cockerill

- Development initiatives for Green Hydrogen Electrolysers in the Indian sub-continent, hastening a domestic green supply chain. This agreement will accelerate the deployment of the green hydrogen ecosystem in India and will enable to build a gigawatt electrolyser manufacturing plant, expandable to a multi gigawatt scale, to serve the local market.
- John Cockerill-Greenko collaborates for a 1 GW facility, supported by a 0.30 GW subsidy, aiming to meet India's 30 GW market by 2030.

Reliance Industries- Steisdal

- Steisdal is involved in developing and commercializing several technologies to combat the climate crisis. The new technology for HydroGen Electrolysers has the potential to significantly reduce costs compared to current technologies, paving the way for rapid decarbonization and the commercialization of affordable Green Hydrogen – a key enabler in achieving India's green energy transition.
- As a part of the agreement Reliance New Energy Solar Limited (RNESL) and Steisdal will collaborate to develop and implement climate change technologies which include offshore wind energy, long duration energy storage and generation fuel cells for conversion of hydrogen to electricity for mobile and static electricity generation.

Greenzo Energy – EODev

- Greenzo Energy India Limited (GEIL) has entered into a partnership with France based EODev (Energy Observer Developments) to introduce GEH2 hydrogen fuel cell power generators in India and Nepal.
- The project aims to replace diesel-based systems and reduce dependency on fossil fuels.

ONGC – NTPC

- NTPC Green Energy Ltd., a subsidiary of NTPC and ONGC Green Energy Ltd., a subsidiary of ONGC, have established a joint venture with equal ownership (50:50).
- Their collaboration focuses on renewable and emerging energy initiatives, including green hydrogen, green ammonia, sustainable aviation fuel (SAF), green methanol, and other clean energy solutions. This partnership supports India's commitment to a greener and more sustainable future.

2.14. Hydrogen projects

Table 11: Status of Green Hydrogen Projects in India

Status	Total Project Capacity (Tonnes H2 P.A.)	Total Electrolyser Capacity (MW)
Announced	1,11,85,841.80	33,234.76
Planned	90,007.30	300.05
Under Construction	9,334.50	63.60
Commissioned	2,221.78	14.56
Active	370.00	2.40
Decommissioned	-	149.00
Total	**1,12,87,775.38**	**33,764.37**

Source: MNRE

There has been significant advancement in hydrogen production and electrolyser capacity. The total of green hydrogen production capacity across all project stages is 112.88 million tonnes per annum.
The capacity of announced projects stands at 111.86 million tonnes per annum. These includes major players like RIL, L&T, Adani, Greenko, Avaada, NTPC, Welspun and Ocior.

This growth is supported by strong electrolyser capacity of 33,234.8 MW. In addition, planned projects account for 90,007.3 tonnes of green hydrogen production with an electrolyser capacity of 300.1 MW.

NTPC-Bloom Energy

- NTPC has awarded project of 'Standalone Fuel-Cell based 50 kW Micro-grid Pilot project with hydrogen production using electrolyser' to M/s Bloom Energy India Pvt Ltd., Bangalore at NTPC Simhadri (Andhra Pradesh).
- The hydrogen would be produced using the advanced 240 kW Solid Oxide Electrolyser by taking input power from the nearby Floating Solar project.
- They aim to produce 5 million metric tons of green hydrogen annually by 2030.

NTPC Green Energy Limited (NGEL)

- In 2024, NTPC Green signed MoU with the Government of Maharashtra to develop Green Hydrogen and its derivatives of up to 1 MTPA. This is a part of Green Investment Plan of Government of Maharashtra, aiming for an estimated investment of Rs 80,000 crore over the next five years. NTPC aims at building up a RE capacity of 60 GW by 2032.

Reliance Industries- Nel Hydrogen Electrolyser ASA

- Reliance Industries has entered into a technology licensing agreement with Nel Hydrogen Electrolyser ASA, a wholly owned subsidiary of Nel ASA to manufacture alkaline electrolysers for captive global purposes. RIL aims to transition from grey/blue hydrogen to green hydrogen by 2025.

GAIL- Cummins

- In a strategic alliance, Cummins, a global power solutions provider, is set to provide advanced technology in collaboration with Tecnimont Private Limited (TCMPL), the Indian subsidiary of Maire Tecnimont Group, to construct one of India's largest proton exchange membranes (PEM) electrolysers for GAIL at Vijaipur, in Madhya Pradesh, India.
- Cummins will leverage its proprietary PEM electrolysis technology, renowned for being one of the most advanced and efficient methods available today, to manufacture electrolysers specifically for the GAIL project. The use of PEM electrolysis is significant because it offers high efficiency and rapid response times, making it particularly suitable for integrating with renewable energy sources such as solar and wind power.
- The project is anticipated to produce 4.3 tonnes of green hydrogen per day, which equates to approximately 10 MW of electrical power input. GAIL and Cummins have signed MoU on hydrogen and energy transition technologies. In April

2024, the company has commissioned their 10 MW green hydrogen unit at its Madhya Pradesh plant. This substantial production capacity contributes to India's green hydrogen landscape, aiding in the country's broader decarbonization efforts.

L&T and Hydrogen Pro

- L&T and Norway based leading Electrolyser technology company HydrogenPro signed MoU to tap the emerging Green Hydrogen market. These companies will jointly work towards setting up a joint venture in India for Gigawatt scale manufacturing of Alkaline Water Electrolysers.
- The factory will produce electrolysers of upto 4 MW and has approved an investment of ~Rs 500 crore and will be setup in the Hazira district of Gujarat.

2.15. Hydrogen Policy - State Updates

India has been making significant strides in its hydrogen policy at the state level, with notable updates from Uttar Pradesh and Gujarat.

Uttar Pradesh:

The Uttar Pradesh government recently approved its Green Hydrogen Policy. This policy aims to establish a robust green hydrogen ecosystem in the state, targeting an annual production capacity of 1 million metric tonnes by 2028. Key incentives include financial support for start-ups and the establishment of incubators. The government is offering substantial financial incentives, including

1. **Land and water resources incentives-** This incentive will be applicable for green hydrogen/ ammonia production, consumption or other elements such as storage or transportation including 100% exemption for payment of land tax, stamp duty and 50% exemption from industrial water consumption charges.

2. **Infrastructure incentives-** Infrastructure for green hydrogen/ammonia production including components such as electrolysers, new consumption units and components for production, storage, and transportation. The policy shall provide the following infrastructure incentives: 30% one-time grant support for technology acquisition subject to a maximum of Rs 5 crores for R&D centres and industries and Capex subsidy applied for electrolyser with minimum capacity of 50 MW.

3. **Operational Incentives-** The policy shall provide the following incentives to reduce the operating cost further and make green hydrogen/ammonia more competitive. This includes 100% reimbursement of State's Goods and Services Tax (SGST) for green hydrogen/ammonia production and an additional subsidy of INR 3,500 per tonne of urea will be applicable for every tonne of green urea produced in the state beyond the 10 percent blending share in total production.

Gujarat:

The state aims to leverage its industrial ecosystem to become a major hub for green hydrogen production. The policy includes provisions for significant land allocations, with 1.99 lakh hectares already allotted on the Kutch-Banaskantha border to major players like Reliance and Adani. These investments, amounting to around Rs 10 trillion, are expected to support an annual production of three million tonnes of green hydrogen. Companies are required to meet half of their production capacity within five years and full capacity within eight years to benefit from the policy's incentives.

The state government has targeted to produce 3 MMTPA of green hydrogen by 2030. The policy is expected to initiate after Lok Sabha elections while the pilot project is underway in collaboration between Gujarat State Petroleum Corporation and Gujarat Power Corporation Ltd for a hydrogen blending project.

Kerala:

Kerala has been making significant strides in advancing its green hydrogen policy as part of its broader efforts to achieve net zero emissions by 2050 and transition to 100% renewable energy by 2040. The state has recently launched the Kerala Green Hydrogen Mission, which is central to these decarbonization efforts.

One of the major initiatives is the development of a green hydrogen hub in Kochi.

In collaboration with the India Hydrogen Alliance (IH2A), this project aims to establish a facility with a capacity of 60 tonnes per day using a 150 MW electrolyser.

Additionally, the Kerala government is partnering with the Agency for New and Renewable Energy Research and Technology (ANERT) and the Green Hydrogen Organisation (GH2) to implement supportive policies and create a regulatory framework for green hydrogen production and use. This includes developing standards and certification processes, attracting investment, and building the necessary skills within the state.

The state's budget has allocated substantial funds, amounting to Rs 200 crores, to support these green hydrogen initiatives, with plans for additional hubs in Thiruvananthapuram and other locations. This also includes setting up hydrogen fuelling stations and exploring low-carbon hydrogen production in collaboration with major industry players such as Indian Oil Corporation Limited and Bharat Petroleum Corporation Limited.

Andhra Pradesh:

The Government of Andhra Pradesh has launched the 'Green Hydrogen/Green Ammonia Policy – 2023', in line with the India's goal to achieve Net Zero target by 2070, the state continues to play a significant role in the renewable energy sector and providing multiple incentives for the growth in the sector.

According to the policy documents the state's hydrogen demand stands at approximately 0.47 MTPA, and future requirement is expected to rise based on the growth of the downstream industries. The New and Renewable Energy Development Corporation of Andhra Pradesh Ltd ((NREDCAP) has been designated as the Nodal agency for implementing the policy and will be responsible to conduct various functions such as registration of production projects, approvals of plants, development of production parks, facilitate water allocation and co-ordinate with MNRE and other agencies.

The objectives of this Policy are to target Green Hydrogen production up to the capacity of 0.5 MTPA or Green Ammonia production up to the capacity of 2.0 MTPA in the next five years. The policy also aims to support the development of eco-system for Green Hydrogen/Green Ammonia production, attract investments, provide employment and improve the economy of the State. And lastly to make Andhra Pradesh the preferred destination for production and export of Green Hydrogen/Green Ammonia.

3. Solar PV Module

India is projected to become the world's third-largest energy consumer by 2030, surpassing the European Union and accounting for nearly a quarter of the global energy demand growth from 2019 to 2040. Relying solely on conventional energy sources to meet this demand will lead to higher import costs and increased emissions. To address this, India signed the Paris Agreement in 2016, committing to reduce the emissions intensity of its GDP by 45% by 2030. In 2021, India announced its decarbonization targets, referred to as the "Panchamrit," outlined by Prime Minister Narendra Modi during his address at the COP 26 summit. These targets include achieving net-zero emissions by 2070, ensuring that renewable power constitutes more than 50% of total power consumption by 2030, reducing carbon intensity by 45% by 2030 (compared to 2005 levels), increasing non-fossil fuel capacity to 500 GW by 2030, and cutting India's carbon emissions by one billion tonnes by 2030. Additionally, at the COP 27 summit, India submitted its long-term low emission development strategy to the United Nations Framework Convention on Climate Change, highlighting the crucial roles of hydrogen, electric vehicles, and ethanol in achieving decarbonization.

As of March 2025, renewable energy sources had a combined installed capacity of 209.44 GW in India. The solar tariffs in India are now competitive and have achieved grid parity due to technological improvements, economy of scale and reduction in solar cells/module prices. There has been a steep decrease in solar tariffs in India from Rs. 6.2 kWh in FY15 to Rs. 2.55 in FY24. In FY24, tariffs slightly declined to an average of Rs 2.55 per kWh, reflecting supply chain stabilization and improvements in domestic manufacturing, though they remained above historic lows due to ongoing input cost pressures and import duties.

3.1. Assessment of Key Policies and Incentive mechanisms

- **Production Linked Incentive (PLI) Scheme:**

The government introduced the Production Linked Incentive (PLI) Scheme to promote local manufacturing in the country. Of the 13 sectors for which PLI has been approved, 'High Efficiency Solar PV Modules' has also been included with Ministry of New and Renewable Energy (MNRE) as the designated ministry.

MNRE has appointed India Renewable Energy Development Agency Limited (IREDA) as the implementing agency for the PLI Scheme 'National Programme on High Efficiency Solar PV Modules' Tranche-1. The financial outlay for PLI for 'High Efficiency Solar PV Modules' Tranche-1 over a five-year period is Rs.45 billion. Under Tranche-1 of the PLI scheme, a total integrated capacity of 8,737 MW was allocated.

The government has further allocated a total capacity of 39,600 MW of domestic Solar PV module manufacturing across 11 companies as beneficiaries under the PLI Scheme for High Efficiency Solar PV Modules (Tranche-II), with a total outlay of Rs. 140 billion. Manufacturing capacity totalling 7,400 MW is expected to become operational by October 2024, 16,800 MW capacity by April 2025 and the balance of 15,400 MW capacity by April 2026.

The Tranche-II is expected to bring in an investment of Rs 930 billion. The PLI scheme is expected to add 48 GW of domestic Solar Module manufacturing capacity in the next 3 years. Apart from this, the government is projected to focus on fostering a conducive environment to increase domestic production and improve the local supply chain.

In FY25, under the Production Linked Incentive (PLI) Scheme for High-Efficiency Solar PV Modules, investments of Rs 41,000 crore have fuelled the sector's expansion, creating employment for 11,650 jobs.

Solar Manufacturing Zones:

Power Sector plays a very important role in the economic and industrial growth of India. However, India is reliant on imports to meet the growing domestic demand of renewable power equipment. The target of 450 GW of renewable energy capacity by 2030 presents a tremendous opportunity to create skilled jobs, technology transfer and contribution to 'Make in India' campaign and reduce import reliance.

Hence, Ministry of New and Renewable Energy (MNRE) along with Ministry of Power (MoP) have proposed a scheme for establishing three Manufacturing Zones out of which two Brownfield Manufacturing Zones are already in development and one greenfield Manufacturing zone in coastal area.

The proposed funding under the scheme is Rs 10 billion for the two brownfield manufacturing zones and one greenfield manufacturing zone which is kept flexible for supporting common infrastructure and testing facility with a ceiling of Rs 4 Billion in the manufacturing zones. The duration of the scheme is 5 years from the period of FY23 to FY27.

The purpose of the initiative is -

(a) To establish a manufacturing facility utilizing cutting-edge, clean, and energy-efficient technology to reduce reliance on imported equipment, critical components, and spares required for the power sector and renewable energy equipment.

(b) To support the 'Make in India' and 'Atmanirbhar Bharat' initiatives and aiming to position India as a global leader in the power and renewable energy equipment manufacturing sector.

(c) To encourage indigenization through domestic manufacturing of currently imported items.

(d) To facilitate the creation of an exclusive Manufacturing Zone in the country by ensuring hassle-free land allocation and clearances, and by providing state-of-the-art Clean Technology Fund (CTF) and Climate Investment Funds (CIF), thereby significantly reducing manufacturing costs and making the domestic industry competitive and self-reliant in the production of power and renewable energy equipment.

Approved Models and Manufacturers of Solar Photovoltaic Modules

The Approved List of Models and Manufacturers (ALMM) mandate[1] introduced in 2021 to boost the domestic manufacturing, has led to disruption in the completion of the solar projects. The intention behind the ALMM mandate was to reduce the import of solar equipment from China.

Accordingly, the Ministry of New and Renewable Energy (MNRE) issued "Approved Models and Manufacturers of Solar Photovoltaic Modules (Requirement for Compulsory Registration) Order, 2019". The ALMM Order specifies that the ALMM shall include LIST-I, which details models and manufacturers of Solar PV Modules, and LIST-II, which details models and manufacturers of Solar PV Cells. The first ALMM List for solar PV modules was released on March,2021.

Only the models and manufacturers listed in ALMM List-I (for solar PV modules) are eligible for use in Government Projects, Government-assisted Projects, Projects under Government Schemes & Programmes, Open Access, and Net-Metering Projects installed in the country. This includes projects set up for the sale of electricity to the Government under the Guidelines issued by the Central Government under section 63 of the Electricity Act, 2003, and its amendments.

However, starting March 2023, the ALMM order has been suspended for one financial year, i.e., FY24. Consequently, projects commissioned by March 2024 will be exempt from the requirement to procure solar PV modules from the ALMM. This ban was reinstated effective 1st April 2024, and an updated List-I was published.

The Ministry of New and Renewable Energy has released List-II of the ALMM, which will take effect from 1st June 2026. This update reflects the growing solar manufacturing capacity in the country and the expected rise in solar cell production.

The Ministry of New and Renewable Energy has directed that only such models of Solar PV Module and Manufactures will be enlisted under ALMM, which will comply with the BIS Standards and have the following minimum efficiency as on April, 2024 -

[1] ALMM mandate consists of a list of manufacturers who are eligible to manufacture solar cell and module types which are Bureau of Indian Standard certified.

Category	Application/Use	Minimum Module Efficiency requirement for crystalline-Silicon technology based Solar PV Modules	Minimum Module Efficiency requirement for Gadmium Telluride Thin Film technology based Solar PV Modules
Category I	Utility / Grid Scale Power Plants	20%	19%
Category II	Rooftop and Solar Pumping	19.5%	18.5%
Category II	Solar Lighting	19%	18%

Source: Ministry of New and Renewable Energy (MNRE)

3.2. Rooftop Solar (RTS) projects and DCR

Domestic Content Requirement (DCR):

Under few current schemes of the MNRE, namely Central Public Sector Undertaking (CPSU) Scheme Phase-II, PM-KUSUM Component B and Grid-connected Rooftop Solar Programme Phase-II, wherein government subsidy is given, it has been mandated to source solar PV cells and modules from domestic sources.

Rooftop Solar Programme

The Ministry of New and Renewable Energy (MNRE) launched the Rooftop Solar Programme Phase I in December 2015 in which incentives and subsidies were provided for residential, institutional and social sectors. The Phase-II was launched in February,2019 with the objective of achieving 40 GW of rooftop solar (RTS). The programme aims to install 4,000 MW of RTS capacity in the residential sector by providing Central Financial Assistance (CFA). According to MNRE, as of March 2024, the installed capacity under the programme in the residential sector stood at approximately 3,045 MW.

For general category states, the CFA is Rs 14,588/kW for the first 3 kW of RTS capacity and Rs 7,294/kW for RTS capacity beyond 3 kW and up to 10 kW.

For special category states (including the North-eastern states, Sikkim, Uttarakhand, Himachal Pradesh, the UT of Jammu & Kashmir, Ladakh, Lakshadweep, and the Andaman & Nicobar Islands), the admissible CFA is Rs 17,662/kW for the first 3 kW of RTS capacity and Rs. 8,831/kW for RTS capacity beyond 3 kW and up to 10 kW.

Resident Welfare Associations/Group Housing Societies (RWA/GHS) are also eligible for CFA for RTS installation in common facilities, up to a maximum of 500 kW capacity. The CFA for RWA/GHS is Rs 7,294/kW in general category states and Rs 8,831/kW in special category states.

The details of the installed capacity State/UT-wise under the Grid Connected Solar Rooftop Programme are as below:

Table 12: State/UT-wise Rooftop Solar capacity installed under PM-Surya Ghar Yojna (Solar Rooftop) and Total solar power installed capacity (May'25)

S.N.	State/UT	PM-Surya Ghar Yojna (Solar Rooftop)	Total Installed Capacity Solar Power
1	Andaman & Nicobar	5.30	30.62
2	Andhra Pradesh	339.70	5434.38
3	Arunachal Pradesh	6.68	14.85
4	Assam	95.30	230.74
5	Bihar	111.00	328.34
6	Chandigarh	71.70	78.85
7	Chhattisgarh	107.40	1398.50

S.N.	State/UT	PM-Surya Ghar Yojna (Solar Rooftop)	Total Installed Capacity Solar Power
8	DNH and DD	83.60	97.90
9	Goa	54.90	58.34
10	Gujarat	5534.60	20093.26
11	Haryana	859.50	2107.82
12	Himachal Pradesh	24.63	217.22
13	J&K	42.20	74.49
14	Jharkhand	93.04	199.87
15	Karnataka	710.10	9876.57
16	Kerala	1375.50	1723.64
17	Ladakh	1.80	7.80
18	Lakshadweep	0.00	4.97
19	Madhya Pradesh	572.50	5265.37
20	Maharashtra	3592.90	11827.63
21	Manipur	7.11	13.79
22	Meghalaya	0.21	4.28
23	Mizoram	2.00	30.39
24	Nagaland	1.00	3.17
25	NCT of Delhi	323.20	334.50
26	Odisha	84.90	701.74
27	Puducherry	66.30	67.51
28	Punjab	453.80	1421.43
29	Rajasthan	1591.80	29546.70
30	Sikkim	5.12	7.56
31	Tamil Nadu	1003.30	10433.27
32	Telangana	472.90	4842.10
33	Tripura	4.80	21.24
34	Uttarakhand	273.71	593.07
35	Uttar Pradesh	329.90	3376.74
36	West Bengal	67.13	320.62
	Total	**18369.53**	**110789.27**

Source: MNRE

The Financial outlay of the Phase-II Rooftop Solar (RTS) programme is Rs 118.14 Bn, which includes Rs 66 Bn of CFA and Rs 49.85 Bn of incentives to the Distribution Companies. The Programme has been extended till 31.03.2026 without change in the financial outlay initially approved for the Programme.

PM-Surya Ghar: Muft Bijli Yojana

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

The scheme includes:

Central Financial Assistance (CFA) for Residential Rooftop Solar

- The scheme offers a CFA of 60% of the system cost for 2 kW systems and 40% of the additional system cost for systems between 2 to 3 kW capacity. The CFA is capped at 3 kW. At current benchmark prices, this translates to a Rs 30,000 subsidy for a 1 kW system, Rs 60,000 for 2 kW systems, and Rs 78,000 for 3 kW systems or higher.

- Households can apply for the subsidy through the National Portal and select a suitable vendor for installing rooftop solar. The National Portal will provide relevant information such as appropriate system sizes, a benefits calculator, vendor ratings, etc., to assist households in their decision-making process.
- Households can access collateral-free low-interest loan products at around 7% for installing residential RTS systems up to 3 kW.

Features of the Scheme

- A Model Solar Village will be developed in each district to serve as a role model for the adoption of rooftop solar in rural areas.
- Urban Local Bodies and Panchayati Raj Institutions will also benefit from incentives to promote RTS installations in their areas.
- The scheme includes a component for payment security for renewable energy service company (RESCO) based models and a fund for innovative projects in RTS.

Outcome and Impact

- The scheme will enable households to save on electricity bills and earn additional income through the sale of surplus power to DISCOMs. A 3-kW system can generate more than 300 units per month on average for a household.
- The scheme is expected to add 30 GW of solar capacity through residential rooftop solar, generate 1000 BUs of electricity, and reduce 720 million tonnes of CO2 equivalent emissions over the 25-year lifetime of the rooftop systems.
- It is estimated that the scheme will create around 17 lakh direct jobs in manufacturing, logistics, supply chain, sales, installation, O&M, and other services.

State-wise Progress

Table 13: Top 5 states with highest number of beneficiary households under PM Surya Ghar: Muft Bijli Yojana (as of Jan 2025)

States	% of household benefiting
Gujarat	41.5%
Maharashtra	22.8%
Uttar Pradesh	8.7%
Kerala	7.7%
Rajasthan	3.1%
Others	16.2%
Total	100.0%

Source: Press Information Bureau

There has been tremendous progress in the various states in terms of the number of households being benefiting from the rooftop solar initiative under the PM Surya Ghar Muft Bijli Yojana, Gujarat is leading the way followed by Maharashtra and Uttar Pradesh. Among the top players are the Union Territory of Chandigarh, Daman and Diu who have achieved 100% of their rooftop solar target in adopting clean energy. In FY25, Rs 5,437.20 crore has been disbursed as central finance assistance to 6.98 lakh beneficiaries under the scheme.

Custom Duty

To protect the domestic solar manufacturing industry from a surge in imports of solar cells and modules, the government of India levied a safeguard import duty of 25% to import of subject goods from China PR and Malaysia, two major exporters to India. The main objective behind this was to create a more level playing field for domestic manufacturers.

However, even with the safeguard duty in place, solar developers in India continue to largely source their modules from China due to lower costs. To tackle this situation the government replaced the safeguard duty on solar cells and modules and imposed a Basic Customs Duty (BCD) as follows:

1. 40% BCD to be levied on imported solar modules from April 2022 was reduced to 20% effective February 2025.

2. 25% BCD to be levied on imported solar cells from April 2022 was reduced to 20% effective February 2025.

Although is anticipated to achieve the desired outcome of establishing price parity between Indian solar modules and their imported equivalents, India still relies heavily on China for cells and other upstream components. It is believed that the BCD along with the Production Linked Incentive (PLI) Scheme will drive additional domestic manufacturing.

Export Incentives

India has exported solar panels worth USD 1.15 billion in FY25. The exports have increased by ~11.77% from FY23 to FY25 with USA, UAE and South Africa being the major importer. This is expected to increase as the world is transitioning to renewable sources of energy. The domestic manufacturing of solar modules is expected to rise with government's PLI scheme Phase-II of Rs 195 billion, hence encouraging exports in future.

Special Economic Zones ACT, 2005

The primary goals of the SEZ Scheme include stimulating economic activity, enhancing export capabilities, attracting investments, fostering job creation, and advancing infrastructure development. SEZs, marked as duty-free zones beyond India's customs jurisdiction, facilitate authorized operations without the need for import licenses. Manufacturing or service ventures are permitted within SEZs, providing units with the freedom to subcontract and benefiting from simplified customs procedures that exempt them from regular cargo inspections. Solar component manufacturing facilities situated within a Special Economic Zone (SEZ) are regulated by the SEZ Act and are eligible to receive incentives and subsidies.

3.3. Pradhan Mantri Kisan Urja Suraksha evam Utthaan Mahabhiyan Scheme 2019 (PM-KUSUM)

The Government of India initiated the Pradhan Mantri Kisan Urja Suraksha evam Utthaan Mahabhiyan (KUSUM) Yojana in March 2019. Its objective is to increase farmers income while offering options for irrigation and reducing diesel dependency in the agricultural sector.

The primary goal of PM KUSUM is to ensure energy security for farmers in India, while fulfilling India's commitment to increase the proportion of installed electric power capacity from non-fossil-fuel sources to 40% by 2030, as part of its Intended Nationally Determined Contributions (INDCs). The scheme aims to increase solar capacity by 30,800 MW, with a total central financial support of Rs 344.22 billion.

The scheme comprises three main features:

Components, Targets & Criteria	Financial Assistance available
The Scheme is demand-driven and open to all farmers across the country, following the scheme guidelines. **Component A:** Establishment of 10,000 MW of decentralized ground/stilt-mounted solar power plants on barren, fallow, pasture, marshy, or cultivable land of farmers. These plants can be set up by individual farmers, Solar Power Developers, Cooperatives, Panchayats, and Farmers Producer Organizations. **Component B:** Installation of 14 lakh stand-alone solar pumps in off-grid areas.	Procurement Based Incentive (PBI) to DISCOMs is set at 40 Paise/kWh or Rs 6.60 lakhs/MW/year, whichever is lower, for purchasing solar or other renewable power under this scheme. This PBI is provided to DISCOMs for a period of five years from the plant's Commercial Operation Date, totalling Rs. 33 lakh per MW over the period. **For Component-B and Individual Pump Solarization under Component-C:** A Central Financial Assistance (CFA) of 30% of the benchmark cost issued by MNRE or the tender-discovered prices, whichever is lower, is provided. However, for the

Component C: Solarization of 35 lakh grid-connected agriculture pumps through (i) individual pump solarization and (ii) feeder level solarization. Beneficiaries under Component B and Component C can include individual farmers, Water User Associations, Primary Agriculture Credit Societies, and communities/cluster-based irrigation systems.	North-eastern States, including Sikkim, Jammu & Kashmir, Ladakh, Himachal Pradesh, Uttarakhand, Lakshadweep, and A&N Islands, a CFA of 50% is provided. Additionally, the respective state/UT must contribute at least 30% financial support. The remaining cost is to be covered by the beneficiary. Component B and Component C (IPS) of the PM KUSUM scheme can also be implemented without the state's 30% share. In this case, the Central Financial Assistance will remain at 30%, and the farmer will bear the remaining 70%. For agricultural feeder solarization, a CFA of Rs 1.05 crore per MW is provided. There is no mandatory requirement for financial support from the participating state/UT. Feeder solarization can be implemented in CAPEX or RESCO mode.

Table 14: Progress under PM-KUSUM (March 2025)

S. No.	State	Component-A (MW)		Component-B (Nos)		Component-C (Nos)		
		Sanctioned	Installed	Sanctioned	Installed	Sanctioned (IPS)	Sanctioned (FLS)	Installed
1	Andaman & Nicobar Islands	0	0	34	0	436	0	0
2	Andhra Pradesh	0	0	0	0	0	1,00,000	0
3	Arunachal Pradesh	0	0	700	434	0	0	0
4	Assam	2	0	4,000	0	0	0	0
5	Chhattisgarh	30	4	0	0	0	0	0
6	Bihar	0	0	0	0	0	70,000	0
7	Gujarat	0	0	18,212	9,349	0	7,25,000	91,976
8	Goa	50	0	900	100	0	11,000	700
9	Haryana	158	6.65	1,97,655	1,49,717	0	12,899	0
10	Himachal Pradesh	100	25.95	1,270	785	0	0	0
11	Jammu & Kashmir	0	0	5,000	2,228	0	0	0
12	Jharkhand	0	0	42,985	31,509	0	0	0
13	Karnataka	0	0	41,360	1,895	0	7,66,588	5,066
14	Kerala	0	0	8	8	39,448	25,387	8,999
15	Ladakh	0	0	1,400	0	0	0	0
16	Madhya Pradesh	1,790	48.63	59,400	7,325	0	4,45,000	7,417
17	Maharashtra	260	6	5,05,000	3,36,289	0	7,75,000	1,13,640
18	Manipur	0	0	1,150	78	0	0	0
19	Meghalaya	0	0	3,035	98	0	0	0
20	Mizoram	0	0	1,700	40	0	0	0
21	Nagaland	0	0	265	65	0	0	0

22	Odisha	40	0	16,441	5,666	0	10,000	0
23	Puducherry	0	0	0	0	0	0	0
24	Punjab	0	0	33,000	12,952	186	95,000	0
25	Rajasthan	6,550	338.75	1,62,914	96,731	6,418	4,00,000	20,108
26	Tamil Nadu	14	1	5,200	4,187	5,000	6,000	0
27	Telangana	1,000	0	0	0	28,000	0	0
28	Tripura	5	0	10,895	4,072	3,600	0	50
29	Uttar Pradesh	1	0	1,10,948	61,181	12,000	1,29,000	2,000
30	Uttarakhand	0	0	5,685	866	200	0	0
31	West Bengal	0	0	0	0	20	0	20

Source: Press Information Bureau, Sansad answer

3.4. Broad overview of market and competition assessment

With renewable energy usage gaining momentum across the world, there was a significant surge in global manufacturing capacity for solar PV modules in CY23, nearly reaching 510 GW, with China contributing nearly 440 GW. The extensive capacity additions or announcements in recent years have fuelled substantial output growth, outpacing demand, primarily due to government support for renewables. This support includes clean energy penetration mandates, taxation incentives, subsidized tariffs for renewables, and government-led renewable project allocations, driving growth in the segment.

While the increase in renewable capacity in Europe, the United States and Brazil hit all-time highs, China's acceleration was extraordinary. In CY23, China commissioned solar PV as the entire world in CY22, while its wind additions also grew by 66% year-on-year. Globally, solar PV alone accounted for three-quarters of renewable capacity additions worldwide. Solar PV capacity additions are expected to grow at fast pace through CY28 in United States, the European Union, India and Brazil.

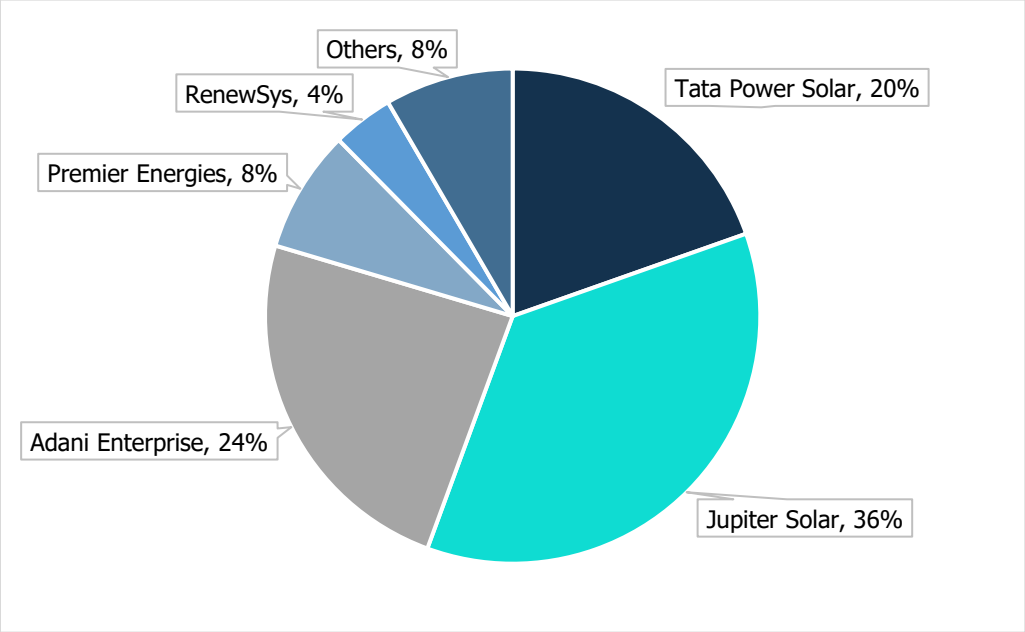
In CY23, spot prices for solar PV modules dropped by nearly 50% year-on-year, with manufacturing capacity tripling compared to 2021 levels. The current manufacturing capacity under construction suggests that the global supply of solar PV will reach 1,100 GW by the end of CY24, according to International Energy Agency (IEA).

While developing domestic PV manufacturing will enhance supply security and provide economic benefits to local communities, replacing imports with more expensive production in the United States, India, and the European Union will raise the overall cost of PV deployment in these markets.

As on March 2024, India has a total installed renewable energy capacity of 190.57 GW, with solar energy constituting ~40% of this capacity. The estimated solar energy potential in India stands at an impressive 748 GW. As March 2024, India had achieved a cumulative solar power capacity of 81.8 GW. The country receives an abundance of solar energy, with around 5,000 trillion kWh per year incident over its land area, with most regions receiving 4-7 kWh per square meter per day. According to the National Institute of Solar Energy (NISE), the country's installed capacity for solar PV module manufacturing stands at approximately 50 GW. In India, progressive policy enhancements addressing auction participation, financing, and distributed solar PV challenges are yielding faster renewable power growth through CY28.

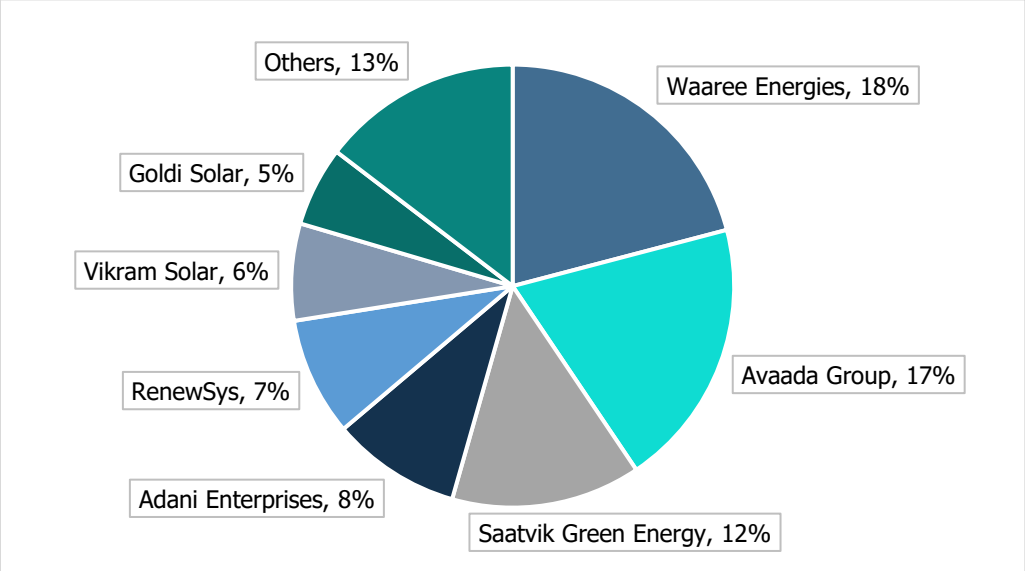
As on April 2025, India has achieved a cumulative solar power capacity of 107.95 GW, exceeding a major milestone by exceeding 100 GW of installed solar capacity. The capacity addition has increased from 15 GW in FY24 to 21 GW in FY25, a 38% increase in capacity addition. The solar module production capacity doubled from 38 GW in March 2024 to 74 GW in March 2025, while solar PV cell manufacturing tripled, rising from 9 GW to 25 GW. The country's first ingot-wafer manufacturing facility (2 GW) commenced operations in March 2024 by Adani Enterprises.

Chart 16: Market share of Indian PV cell manufacturers (FY25)



Source: Company Websites

Chart 17:Market share of Indian PV module Manufacturers (FY25)



Source: Company Website

More than 50% of the market share is held by the top four PV module manufacturers. As of FY25, India's annual solar module production capacity stood at ~70 GW. Technology plays a pivotal role, with the global module manufacturing industry offering mono-PERC and bifacial capability modules, while emerging technologies like TOPCON and HJT are being explored worldwide.

Adani Enterprises launched the first 1.2 GW cell-to-module integrated manufacturing unit in India in 2017, which was expanded to 4 GW, making it the largest integrated capacity as of March 2023. The entity manufactures mono-PERC and n-type bifacial cells.

Table 15: Overview of major domestic players in the market

Parameter	Vikram Solar	Waaree Energies	Adani Enterprises	Premier Energies	RenewSys India	Tata Power Solar	Emmvee Photovoltaic	Alpex Solar	Goldi Solar
Number of manufacturing factories	One each in West Bengal and Tamil Nadu	Four in Gujarat	One in Gujarat	Two in Telangana	One each in Karnataka, Telangana, and Maharashtra	Two in Karnataka	Two in Karnataka	One in Uttar Pradesh	One in Gujarat
Experience in PV module manufacturing	13 years	34 years	7 years	30 years	10 years	35 years	18 years	10 years	14 years
Enlisted capacity as per ALMM list (April 2024)	4,855 MW	21,679 MW	1,942 MW	3,646 MW	4,585 MW	671 MW	1,866 MW	423 MW	396 MW
Market share as a percentage of total enlisted capacity (as per ALMM)	6.3%	28.3%	2.5%	4.8%	6.0%	0.9%	2.4%	0.5%	0.5%
Products and services	Integrated Solar energy solutions provider with a presence in solar PV modules, EPC services, and O&M services	Solar PV modules, inverters, batteries, EPC services, rooftop solutions, O&M services, solar home appliances, and solar water pumps	Solar PV cells and modules, EPC services, O&M services	Solar PV cells and modules, EPC services, O&M services, water pumps, power	Solar PV modules and cells, encapsulants, back sheets	Solar PV cells and modules, EPC services, O&M services, and water pumps	Solar PV cells and modules, EPC services, rooftop solutions, O&M services, and solar water heater solutions	Solar PV modules, EPC services, Solar Water Pumps	Solar modules, EPC services, Solar Water Pumps
Technology	mono PERC, bifacial & monofacial and smart and polycrystalline PV modules	Multicrystalline, Monocrystalline and TopCon technology, mono-PERC, bifacial, flexible modules, BIPV	Multi-crystalline, mono-PERC, and bifacial modules	Poly-crystalline and mono-crystalline Si cells, mono-PERC, poly-crystalline PV modules	Mono/multi-PERC, bifacial, half-cut and full cell modules	Mono-PERC cells, mono-PERC half-cut modules	Mono-PERC, poly-crystalline modules, bifacial modules, half-cut cell modules	Mono-crystalline, poly-crystalline PV modules, bifacial modules	Mono-crystalline, poly-crystalline PV modules

Source: Company websites, MNRE ALMM June 2025

3.5. Overview of Solar PV Value Chain

The installed capacity for the solar power has increased sharply in the last decade to 107.95 GW as of April 2025. However, the domestic production of solar modules faces challenges due to high cost of raw material as compared to the import cost of raw material from the global counterparts. While the domestic companies have begun manufacturing across various levels of the value chain, the import dependence still persists. The global Solar PV module depends majorly on China for cost effective components like Polysilicon, ingots, wafers and cells.

Chart 18: Solar PV Value Chain

Component	Polysilicon	Wafers	Cells	Modules
Global Capacity (GW)	1000-1100	850-900	1200-1250	1100-1150
China's Share in Global Manufacturing Capacity	93%	94-96%	88%	82-84%
India's Capacity (GW)	0	4	20	35
India's import dependency	100%	99-100%	80-90%	75-85%

The solar photovoltaic (PV) value chain in India encompasses a series of stages from raw material acquisition to the installation and maintenance of solar power systems. This chain begins with the manufacturing of silicon wafers, which are the fundamental building blocks for solar cells. India has been focusing on increasing domestic production of polysilicon, the primary material for wafers, to reduce dependency on imports.

Next in the chain is the production of solar cells, where the silicon wafers are processed into cells that can convert sunlight into electricity. India hosts several manufacturers that produce these cells, although the country still imports a significant portion to meet its growing demand.

After cell production the solar modules are assembles, where multiple cells are combined into a single panel. This stage has seen substantial growth in India, with numerous companies setting up manufacturing facilities to cater to both domestic and international markets. The Indian government has been promoting this sector through various incentives and schemes like the Production Linked Incentive (PLI) scheme to boost local manufacturing.

Once the modules are assembled, they are distributed and installed in various settings, including residential rooftops, commercial establishments, and large-scale solar farms. This installation phase involves a network of distributors, installers, and service providers who ensure that the systems are properly set up and operational.

The value chain is completed with the operation and maintenance (O&M) services, ensuring that the solar PV systems continue to function efficiently throughout their lifespan. India's O&M sector has been evolving to include advanced monitoring and predictive maintenance technologies to maximize energy yield and system longevity.

Overall, the solar PV value chain in India is rapidly developing, supported by strong policy frameworks and a growing emphasis on self-reliance and sustainability in the renewable energy sector.

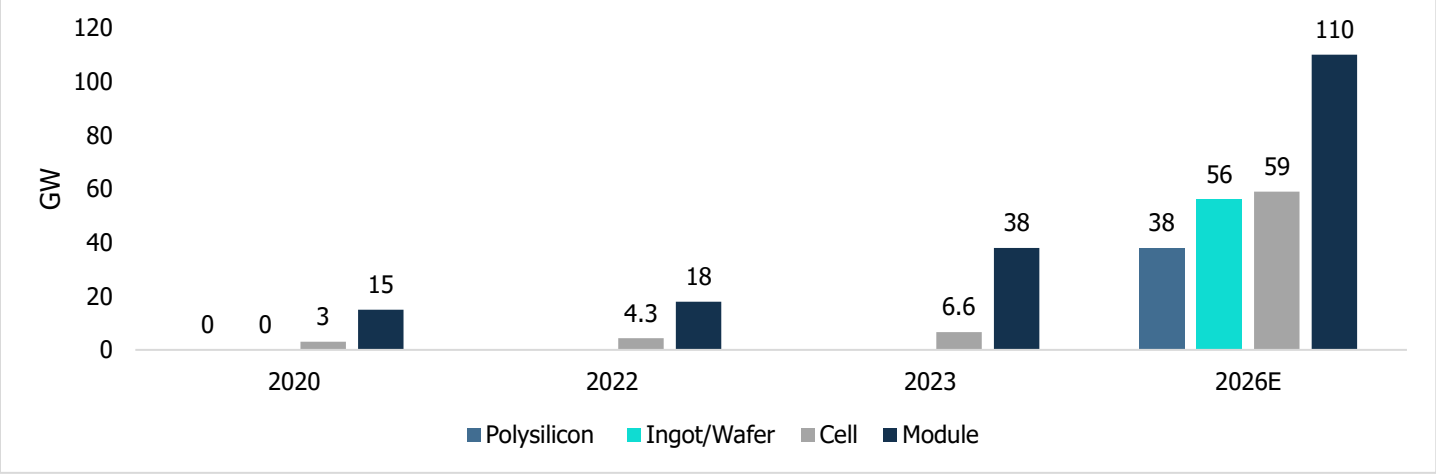
3.6. Assessment of Domestic and Export Market Potential

Like the U.S. and Europe, India has historically been a net importer of PV products but is now working towards self-sufficiency and reducing its reliance on China. Therefore, global market trends are expected to shape the future of PV manufacturing in India.

The PV manufacturing sector in India is experiencing significant transformation, both in terms of scale and quality. Looking ahead, the development of current trends in the sector is likely to evolve into further opportunities.

India's PV module manufacturing capacity has more than doubled from 18GW in 2022 to around 38GW in 2023 to 74 GW in 2025 and the PV cell manufacturing capacity tripled from 9 GW in 2024 to 25 GW in 2025. This growth in domestic manufacturers' capacities will continue for the next two to three years.

Chart 19: Growth of Domestic Photovoltaic Manufacturing Capacity in India



Source: Institute for Energy Economics and Financial Analysis
Note: E stands for Estimates

With such a large expansion of PV manufacturing capabilities, domestic modules in the market is expected to become self-sufficient in the coming few years. Indian manufacturers will then have the potential to meet domestic demand and cater to the export market.

Imports and Exports

Important components such as solar cells, modules, and inverters are largely imported by Indian solar sector. The government has taken several efforts to boost indigenous industry, including raising import duties. The present installed solar PV Cells manufacturing capacity in India is around 3 GW/year and around 10 GW/year in case of Solar PV Modules capacity. The government has issued the scheme guidelines for implementation of the Production Linked Incentive Scheme on National Programme on High Efficiency Solar PV Modules.

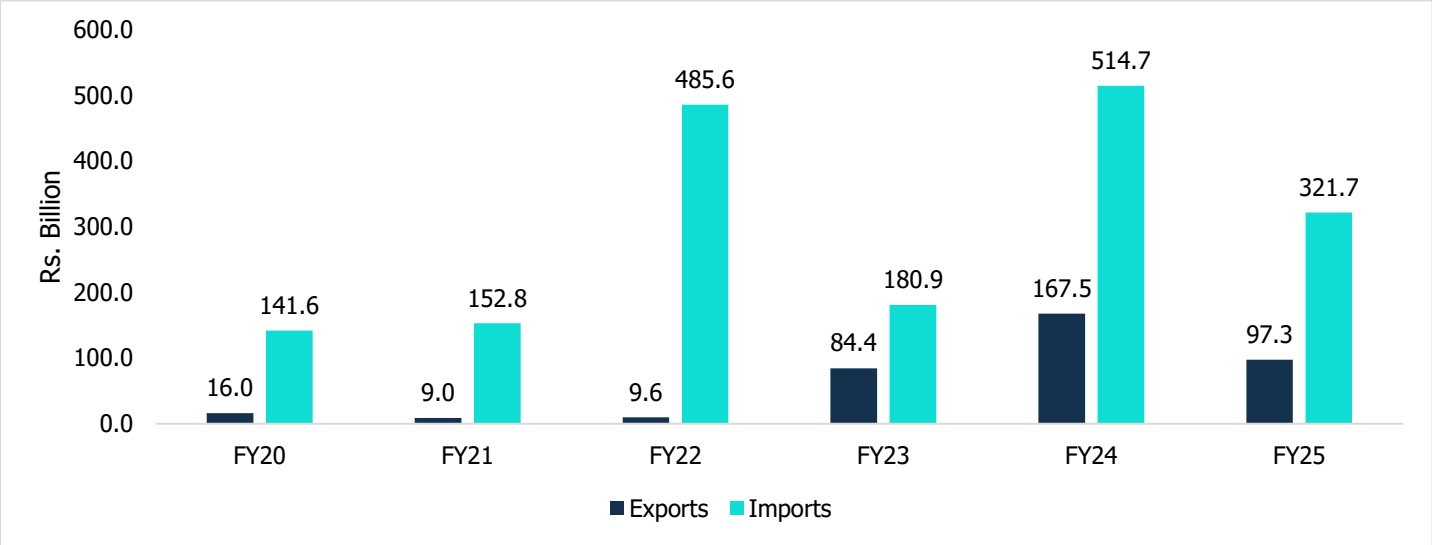
In FY22, solar cells and modules exports have increased by 9% as compared to FY21, whereas the imports have increased by 218% during the same period. The growth in imports has been significant because of imposition of BCD[2] as

[2] Basic Custom Duty (BCD) was imposed from effect on April 1,2022 according to which custom duty of 25% on import of solar PV cells and 40% on import of solar PV modules has been implemented. This was done to improve the indigenous manufacturing of solar panels and modules.

manufacturers tried to stock up on their raw material inventory. The imports reduced by 11% in FY23 (9 months) y-o-y while the exports declined by 84% in the same period after the BCD was imposed.

Indian solar power producers are still dependent on imports of solar modules mainly from China which accounts for about 90% of the total imports, followed by Hong Kong and Malaysia, assessed based on the value of imports.

Chart 20: Import and Export of Solar Cells and Modules



Source: Ministry of Commerce and Industry, CareEdge Research

India is well positioned by way of its geographical location and abundance of resources to become global hub for solar cells manufacturing. However, China's strong position and low-cost manufacturing base poses a challenge for domestic manufacturers to achieve self-reliance in solar energy sector.

All major PV importers globally are actively adopting a "China+1" strategy to protect their PV procurements from potential supply chain shocks that can arise due to the concentration of manufacturing in a single country. Additionally, for some countries like the U.S., geopolitical issues also influence decisions regarding solar imports.

India, with the second-largest module manufacturing capacity globally and ambitious expansion plans, is emerging as a viable alternative to China for PV needs. Leading GW-scale manufacturers in India are witnessing substantial interest and demand from international markets for their high-quality, high-wattage module lines. As a result, they are dedicating approximately 20–25% of their production capacity to exports. However, this focus on exports could lead to short-term shortages of high-quality modules in the domestic market. Moreover, Indian manufacturers must remain mindful of the potential risk of declining overseas demand in the future, as key export markets like the U.S. and Europe ramp up their PV manufacturing capabilities and move toward self-sufficiency.

3.7. Risks to PV Manufacturing

- **Lack of Domestic Solar Equipment Manufacturing**

Although India has made significant strides towards achieving self-sufficiency in solar PV manufacturing through capacity addition, the machinery for this comes almost entirely through imports, mainly from China. Thus, in the event of breakdowns or process fine-tuning, there is overreliance on spare parts/assistance from the PV machinery supplier located outside India.

- **Market Volatility**

PV manufacturing relies on a complex global supply chain. Fluctuations in demand, pricing, and government policies can lead to market volatility. Uncertainty in subsidies, tariffs, or incentives can affect investment decisions and long-term

planning for manufacturers. Any adverse movement in exchange rates will impact the rupee and push the raw material prices up.

- **Technological Obsolescence**

Rapid advancements in PV technology can render existing manufacturing processes and equipment obsolete. Manufacturers need to continually invest in research and development to stay competitive and adapt to evolving industry standards. As all the Solar PV manufacturing country spends on R&D, there is chances that to have improved cell/module efficiency or module design in the manufacturing process.

- **Competitive Pressures**

Global competition from established manufacturers and emerging players can exert pressure on margins and market share. Price wars and aggressive marketing strategies may impact profitability and sustainability for PV manufacturers. Foreign players, particularly from Asia including China, Malaysia, Taiwan, and Korea, maintain a competitive edge over domestic manufacturers. This advantage stems from their considerably larger scale of module manufacturing, resulting in substantial economies of scale. Furthermore, government backing, combined with the backward integration efforts undertaken by foreign players throughout the solar module manufacturing supply chain, starting from the polysilicon stage, enhances their competitiveness.

- **Regulatory Changes**

Changes in environmental regulations, trade policies, or quality standards can impact PV manufacturing operations. Compliance with evolving regulations may require additional investments in equipment, processes, or certifications. In India, Basic Customs Duty (BCD) was imposed from on April 1, 2022, wherein the custom duty of 25% on the import of solar PV cells and 40% on import of solar PV modules has been implemented. This was done to improve the indigenous manufacturing of solar panels and modules.

- **Financial Risks**

PV manufacturing involves significant capital investments in equipment, infrastructure, and research. Economic downturns, currency fluctuations, or changes in financing options can pose financial risks to manufacturers, affecting their ability to expand or remain solvent.

- **Grid Integration**

While the government has planned grid integration in line with renewable capacity additions, any delays in grid integration due to land acquisition, project execution delays, etc. For the additional solar capacity will impact the offtake of the projects.

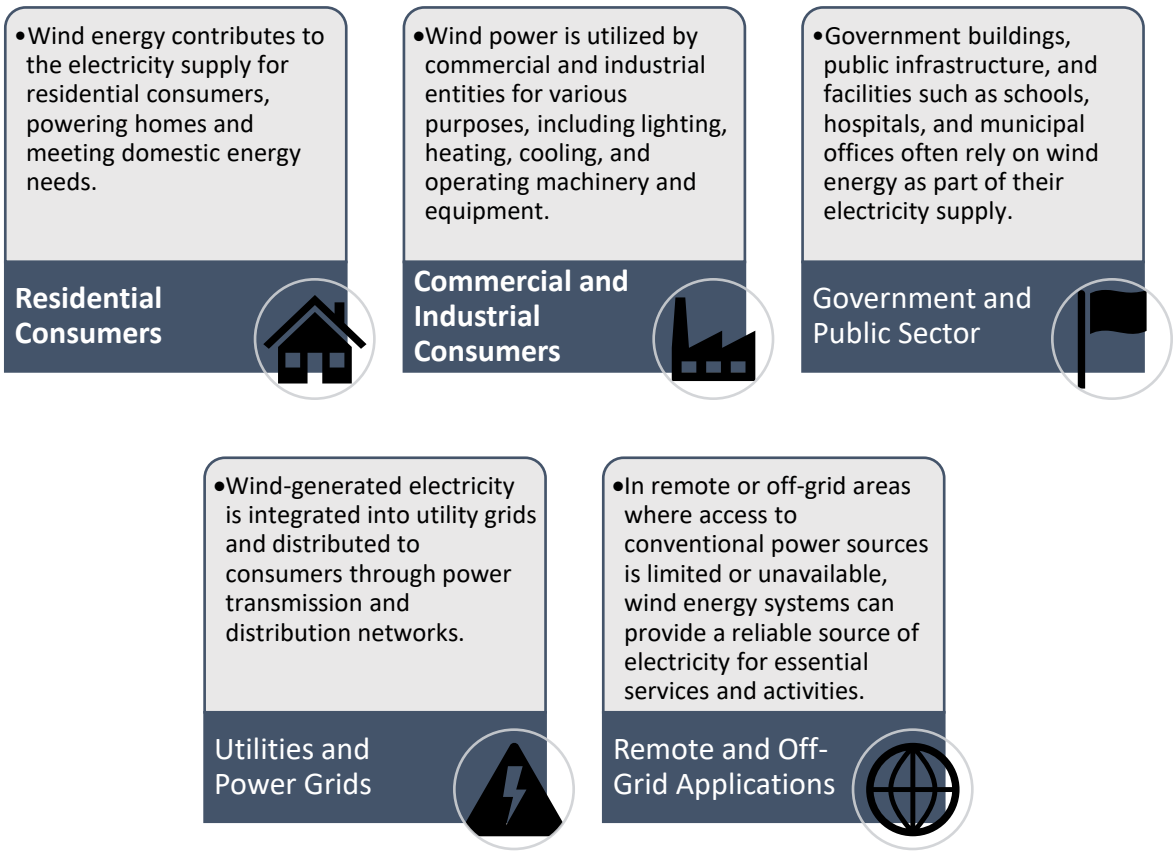
- **Not Availability Round the Clock**

Solar energy is intermittent in nature and is available only for certain hours during the day. Intensity of solar energy is also seasonal. Therefore, the power generated from solar energy is not available round the clock due to the seasonal nature and variations.

4. Wind Manufacturing Sector

4.1. Demand from end-use segment

The demand for wind energy from end-use segments is driven by factors such as environmental considerations, government policies and incentives, technological advancements, and the cost competitiveness of wind power compared to other sources of power. The wind power demand from various end users is depicted below:



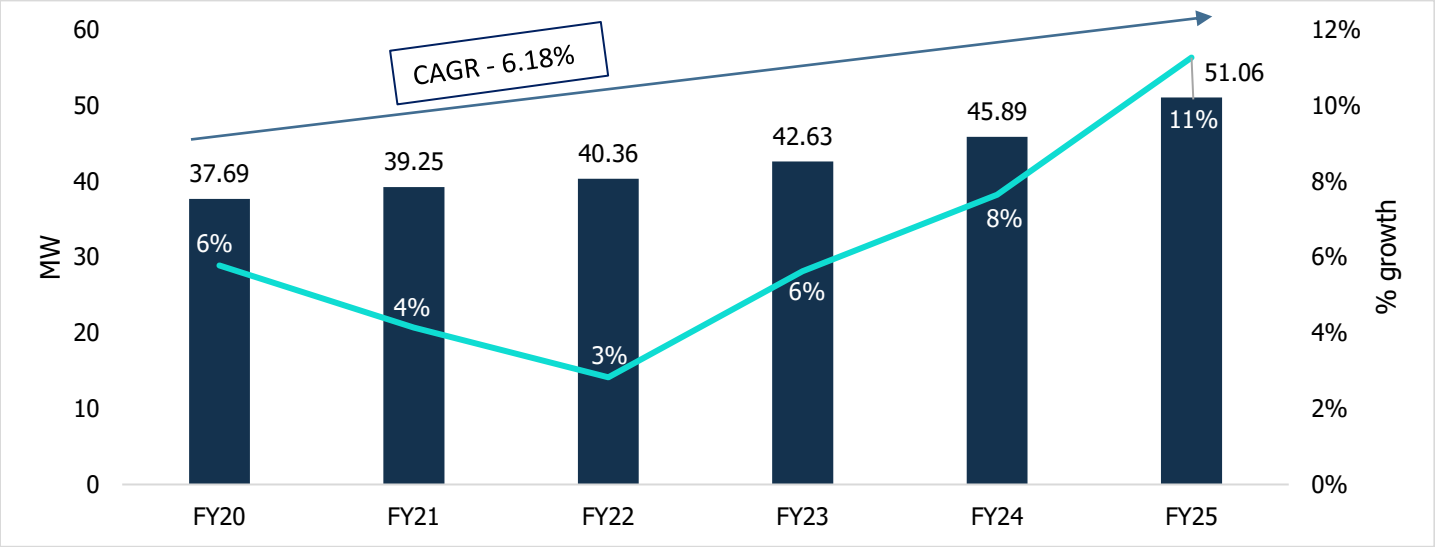
As renewable energy goals and targets are established globally and domestically, the demand for wind energy is expected to continue growing, leading to further deployment of wind turbines and capacity expansion in the wind power industry.

4.1.1. Review of Wind energy capacity additions in India

India's power generation sources range from conventional sources such as coal, lignite, natural gas, oil, nuclear and hydro power to viable unconventional sources such as wind, solar, agricultural and household waste.

With a total installed capacity of 51.06 GW as on FY25, India currently ranks fourth in the world in terms of installed capacity of wind power. The wind power industry's growth has resulted in a robust ecosystem, project operating capabilities, and a domestic manufacturing base of around 10,000 megawatts per year, as per the Ministry of New and Renewable Energy (MNRE).

Chart 21: Wind Power Installed Capacity



Source: CEA

Wind is an intermittent and site-specific resource of energy, and therefore, an extensive wind resource assessment is essential for the selection of potential sites. The government, through the National Institute of Wind Energy (NIWE), has installed over 800 wind-monitoring stations in India and issued wind potential maps at 50m, 80m, 100m, and 120m above the ground level. The recent assessment indicates a gross wind power potential of 302 GW in the country at 100 meters and 696 GW at 120 meters above ground level. Most of this potential exists in seven windy states.

Table 16: Wind Power Potential at 100 meters, 120 meters and 150 meters above ground level

States	Potential at 100 m (GW)	Potential at 120 m (GW)	Potential at 150 m (GW)
Andhra Pradesh	44.23	74.90	123.3
Gujarat	84.43	142.56	180.8
Karnataka	55.86	124.15	169.3
Madhya Pradesh	10.48	15.40	55.4
Maharashtra	45.39	98.21	173.9
Rajasthan	18.77	127.75	284.2
Tamil Nadu	33.80	68.75	95.1
Telangana	NA	24.83	54.7
Total (8 Windy States)	**292.96**	**676.55**	**1136.70**
Other States	9.28	18.95	27.1
All India Total	**302.24**	**695.50**	**1163.80**

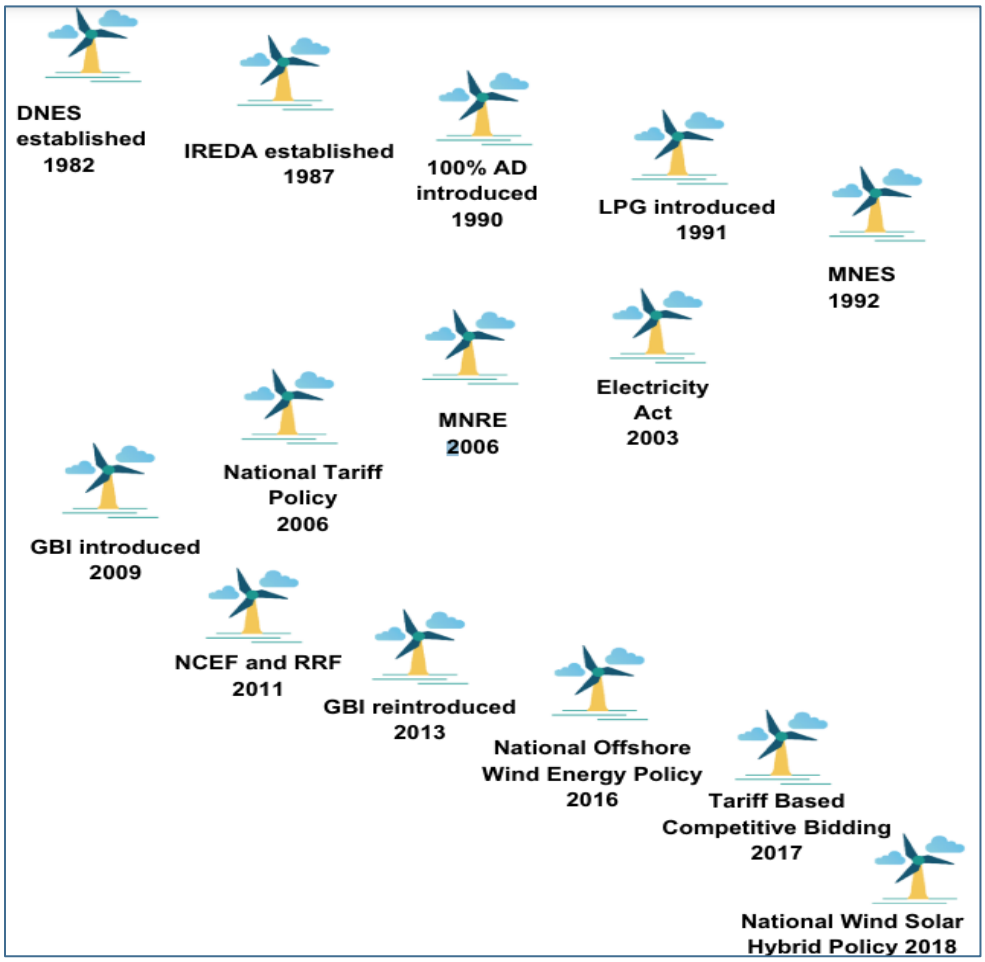
Source: Annual Report 2023-24, MNRE, CareEdge Research

Offshore Wind Energy

India has a coastline of about 7,600 km surrounded by seawater on three sides and has tremendous power generation potential from offshore wind energy.

As per MNRE and based on the early analysis of satellite data and data from other sources, eight zones in Gujarat and Tamil Nadu have been identified as possible offshore wind energy exploitation zones. The potential for offshore wind energy is estimated to be 174 GW (technical resources) across fixed bottom and floating potential mainly off the coast of Gujarat and Tamil Nadu.

4.1.2. Evolution of Wind Power in India



The evolution of wind power in India has been a significant aspect of the country's renewable energy journey. Here's an overview of the key stages and developments:

Early Development (1980s-1990s): The Indian wind energy sector saw its beginnings in the 1980s with the establishment of the first few wind farms primarily in coastal regions. During this period, the focus was on identifying suitable locations for wind turbines and installing early-generation wind turbines with relatively low capacity.

Policy Support (2000s): The Indian government introduced policy measures to promote renewable energy, including wind power. The Electricity Act of 2003 and the National Electricity Policy laid the foundation for renewable energy integration into the power sector. Additionally, state-level policies and incentives, such as feed-in tariffs and renewable purchase obligations (RPOs), incentivized wind power development.

Rapid Expansion (2000s-2010s): The 2000s witnessed a significant expansion of wind power capacity in India. Technological advancements led to the deployment of larger and more efficient wind turbines, increasing the capacity factor of wind farms. Several states, particularly Tamil Nadu, Maharashtra, Gujarat, Karnataka, and Rajasthan, emerged as leading wind power producers.

Grid Integration Challenges (2010s): As wind power capacity grew, grid integration became a critical challenge. Variability and intermittency of wind resources necessitated grid upgrades, energy storage solutions, and better forecasting techniques to ensure grid stability and reliability.

Policy Reforms and Targets (2010s-2020s): The Indian government set ambitious renewable energy targets, including capacity addition targets for wind power. The National Action Plan on Climate Change aimed to achieve 175 GW of renewable energy capacity by 2022, with a significant portion allocated to wind power. Various policy reforms, auctions, and competitive bidding processes were introduced to promote cost-effective wind power deployment.

Technological Advancements and Offshore Wind Potential: In recent years, there has been a focus on technological advancements, including taller wind turbines, advanced control systems, and predictive maintenance techniques, to enhance the efficiency and reliability of wind power plants. Additionally, India has begun exploring the potential for offshore wind power development along its extensive coastline.

Overall, the evolution of wind power in India reflects a transition from nascent development to rapid expansion, driven by supportive policies, technological advancements, and growing awareness of the need for clean and sustainable energy sources.

4.2. Modes of Wind Project Operations

In India, wind projects typically operate on various modes to optimize their performance and efficiency. Here are the key modes of wind project operations:

1. **Grid-Connected Operation:** The most common mode of operation for wind projects in India is grid-connected operation. In this mode, electricity generated by the wind turbines is fed into the grid for distribution and consumption. Wind farms are typically located in regions with favourable wind conditions, and the electricity generated is transmitted to nearby substations through dedicated transmission lines.

2. **On-Grid Operation with Power Purchase Agreements (PPAs):** Many wind projects in India operate under power purchase agreements (PPAs) with utilities or power distribution companies. These agreements stipulate the terms of electricity purchase, including the tariff rate, duration, and quantity of power to be supplied. Wind project developers enter into PPAs to ensure revenue certainty and project viability over the long term.

3. **Merchant Power Sales:** Some wind projects in India operate on a merchant basis, selling electricity directly into the wholesale power market without long-term PPAs. In this mode, project revenues are determined by prevailing market prices, which can fluctuate based on demand-supply dynamics, fuel prices, and other factors. Merchant power sales entail higher market risk but may offer opportunities for higher revenue in favourable market conditions.

4. **Captive Consumption:** In certain cases, industries or commercial establishments may set up wind projects for captive consumption of electricity. These projects are designed to meet the internal energy needs of the organization, reducing dependence on the grid and providing cost savings over the long term. Captive wind projects require adequate land availability and regulatory approvals for interconnection and operation.

5. **Hybrid Operation with Solar PV:** With the increasing deployment of solar photovoltaic (PV) projects in India, hybrid wind-solar projects have emerged as a viable option for renewable energy generation. Wind-solar hybrid projects combine the complementary characteristics of wind and solar resources to enhance overall energy generation and grid integration. These projects may operate in grid-connected or off-grid modes, depending on local conditions and project requirements.

6. **Off-Grid Operation**: In remote or off-grid areas where grid connectivity is limited or unreliable, wind projects may operate in off-grid mode, supplying electricity to local communities, industrial facilities, or remote installations such as telecom towers or rural electrification projects. Off-grid wind projects may incorporate energy storage systems to ensure reliable power supply during periods of low wind or high demand.

4.2.1. Outlook of Wind power capacity additions in India

Offshore Wind and Solar-Wind Hybrid projects to gain pace going forward

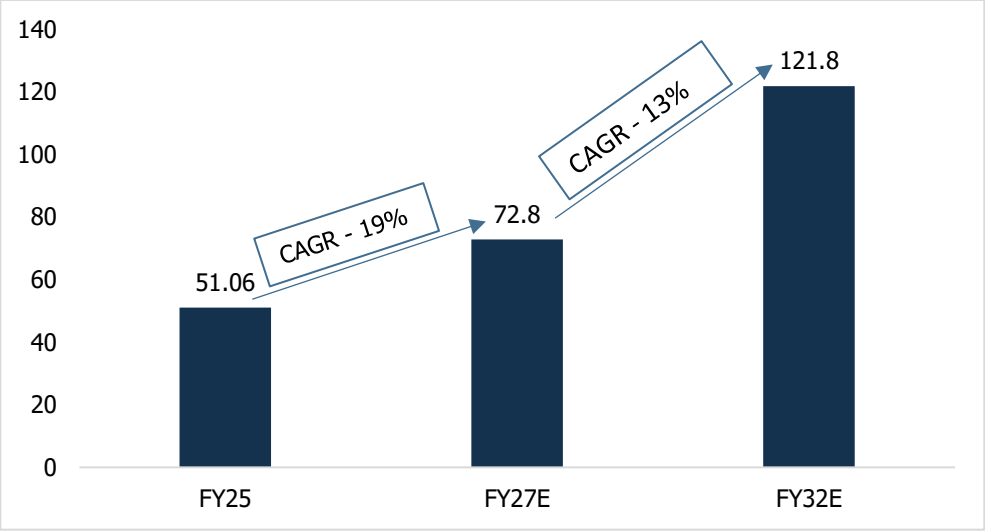
India's electricity demand is expected to grow at a CAGR of ~7% until 2032, driven by factors such as the push for 'Make in India', rapid urbanization, and economic growth. Wind capacity additions have slowed down in the recent past due to challenges in pricing, grid availability, scarce availability of windy sites, land availability, and payment delays. While the cost competitiveness of wind continues to be better as compared to the conventional power and the government is pushing capacity additions through wind-solar hybrids, storage, and round-the-clock supply, constraints on availability of land and transmission infrastructure are likely to continue to impact the near-term capacity additions. Also, the declaration by government of ultra-mega power parks for wind might alter the wind deployment strategy in the future.

India's wind power accounts for 10% of the country's total installed capacity and 25% of its total renewable power capacity. India ranks fourth in the world in terms of installed wind capacity. The government is preparing to annually allocate approximately 10 GW of wind projects. These initiatives are directed toward achieving the ambitious goal of reaching 500 GW in renewable capacity by 2030. India aspires to meet nearly half of its electricity requirements through renewable energy sources by 2030.

Furthermore, India has strong wind potential, estimated at around 302 GW at 100m and approximately 695 GW at 120m. This wind potential is concentrated in the top seven windy states: Andhra Pradesh, Gujarat, Karnataka, Madhya Pradesh, Maharashtra, Rajasthan, and Tamil Nadu.

As per the National Electricity Plan Vol-1 (March 2023), 72.8 GW of installed wind power capacity is expected to be achieved by FY27 and 121.8 GW by FY32.

Chart 22: Wind Power capacity addition projections



Source: National Electricity Plan Vol-1 (March 2023), CareEdge Research

Over the medium term, wind capacity additions are expected to be driven by capacity additions in wind-solar hybrids and offshore wind projects. Apart from favourable project economics, hybrid projects play a key role in round the clock generation of renewables. In addition, the change in policy from the reverse auction and the increasing renewable purchase obligations (RPO) are some of the positive steps to rejuvenate the wind sector that has been stagnant for several years.

Further, India has set a target of 500 GW of non-fossil fuel installed capacity and fulfil 50% of its energy requirements by renewable sources by 2030. India expects to create 30 GW of offshore wind electricity by 2030. However, development has been slow due to a lack of developed port infrastructure and transmission infrastructure and higher expenses of placing turbines in the sea. India currently has no offshore wind energy plants in operation.

Key innovations such as wind solar hybrid and offshore wind farms, ultra-mega renewable energy parks, repowering, and round-the-clock supply are expected to be the key drivers for wind capacity additions.

The Ministry of New and Renewable Energy Wind Energy Division issued a revised guideline for installation of prototype wind turbines as of May 2012 and amended the same in Sept 2012 and on June 2016, these are applicable for all wind turbines manufacturers in India. A wind turbine prototype is a full-scale test model used to assess efficiency and performance before mass deployment. It converts wind energy into electricity using large aerodynamic blades. Among the other players Adani Enterprises has installed India's largest wind turbine prototype of 5.2 MW at Mundra SEZ plant followed by Envision Wind Power Technologies at 3.3 MW.

4.3. Wind Manufacturing Market

Traditionally, thermal power has been the preferred source of power. However, a strong government focus on renewable energy and lower tariffs (due to lower capital costs, domestic manufacturing, and improved efficiency) has aided the expansion of renewable energy capacity. The installed capacity of renewable energy has grown from 125 GW in FY23 to 172 GW in FY25 growing at a CAGR of 17.30% in the same period.

Table 17: Installed Capacity of Companies in India

Companies	Factories	Installed Capacity (MW)-2025
Suzlon Energy Ltd	Daman, Padubiri (KA), Puducherry	15100
Siemens Gamesa Renewable Energy Ltd	Mamandur (TN)	925
Envision Energy Ltd	Pune (MH)	653.4
InoxWind Ltd	Bhuj (GJ), Uan (HP), Barwani (MP)	1,600
Vestas India Ltd	Chennai (TN)	3,000

Companies	Factories	Installed Capacity (MW)-2025
General Electric	Pune (MH)	5,000
Senvion India Ltd	Baramati (MH)	1000

Source: Industry Sources

4.3.1. Impact of technological improvements in wind energy capacity additions

In 2023, an estimated 96% of newly installed, utility-scale solar PV and onshore wind capacity had lower generation costs than new coal and natural gas plants. In addition, three-quarters of new wind and solar PV plants offered cheaper power than existing fossil fuel facilities. Wind and solar PV systems will become more cost-competitive during the forecast period. Despite the increasing contribution needs for flexibility and reliability to integrate various renewables, the overall competitiveness of onshore wind and solar PV changes only slightly by 2028 in Europe, China, India and the United States.

Technological improvements have had a significant impact on the capacity additions and overall growth of wind energy globally, including in India. Here are some key impacts:

Increased Efficiency: Technological advancements, such as improvements in turbine design, blade aerodynamics, and drivetrain efficiency, have led to higher energy capture rates and increased overall efficiency of wind turbines. This increased efficiency allows for higher capacity factors, meaning more electricity can be generated from the same installed capacity.

Cost Reduction: Advances in wind turbine technology, manufacturing processes, and supply chain management have resulted in significant cost reductions for wind energy projects. Lower equipment costs, coupled with economies of scale and streamlined installation processes, have made wind energy more competitive with conventional sources of electricity generation.

Higher Hub Heights and Rotor Diameters: Modern wind turbines are taller with larger rotor diameters compared to earlier models. This allows them to access higher and more consistent wind speeds at elevated hub heights, leading to increased energy production. The use of longer blades and taller towers has become feasible due to advancements in materials, manufacturing techniques, and construction methods.

Integration of Digital Technologies: The integration of digital technologies, such as advanced sensors, data analytics, and predictive maintenance algorithms, has enabled better monitoring, control, and optimization of wind turbines and wind farms. Real-time data analytics and condition monitoring systems help optimize turbine performance, minimize downtime, and reduce maintenance costs.

Offshore Wind Development: Technological advancements have also facilitated the growth of offshore wind energy, particularly in regions with favourable marine conditions. Offshore wind turbines are subjected to harsher environmental conditions compared to onshore turbines, requiring specialized designs and engineering solutions. Advances in offshore foundation designs, installation methods, and grid connections have made offshore wind more economically viable and scalable.

Hybrid and Integrated Solutions: Technological innovations have enabled the development of hybrid renewable energy systems that integrate wind power with other renewable energy sources such as solar PV and energy storage. Hybrid systems can provide more reliable and stable power output by complementing the intermittency of wind and solar resources.

Overall, technological improvements have been instrumental in driving the growth and maturation of the wind energy sector, allowing for higher capacity additions, improved performance, and increased competitiveness. Continued innovation and research efforts are expected to further enhance the efficiency, reliability, and cost-effectiveness of wind energy in the years to come.

Wind energy technology innovations can reduce the cost of energy, increase the pace of installation and enable growing access to clean wind energy. These innovations include:

- **Blades of increased length:** Longer blades significantly enhance energy capture per turbine. Innovations like segmenting blades can facilitate easier transportation, thereby reducing installation costs.

- **Heightened towers:** Stronger winds are found at higher hub heights, beyond the range of typical turbines today. An average height increase of 17 meters provides the necessary clearance for longer blades to access these high-altitude winds.

- **Low-specific-power turbines:** These turbines feature larger rotor sizes relative to generator size. With bigger rotors capturing more wind, they transfer increased energy to the generator, thus augmenting wind power availability.

- **Innovative tower manufacturing:** Novel manufacturing methods such as spiral welding and 3D printing enable the on-site construction of wind turbine towers, leading to cost reductions and overcoming transportation limitations.

- **Climbing cranes:** As wind turbine heights rise, specialized cranes can facilitate more efficient turbine installation and component replacements (including gearboxes, generators, and blades). This approach may lower costs compared to conventional cranes due to reduced rental expenses and the avoidance of disassembly, reassembly, and relocation.

- **Wake steering:** Plant operators can use controls to tilt or adjust the direction of wind turbines and alter generator speed, thereby redirecting individual turbines to avoid affecting downstream turbines. This technique can potentially boost annual energy production gains by 1%–2%.

5. Data Centres

5.1. Changing Digital Landscape in India

India's progress in Digital Transformation is fuelled by major technological advances and government initiatives. The Indian economy is greatly benefitted by the IT and Start-up sectors, which also foster innovation in a variety of other industries. Millions of people now have greater access to various financial services, better efficiency and transparency mainly supported by digital applications in the financial sector. According to Ministry of Electronics and Information Technology, India is expected to become a $1 trillion digital economy by FY29. According to NASSCOM, Indian SaaS ecosystem stood at over $5 billion in FY22 and is expected to reach $13-15 billion by FY25. New business models are emerging within the SaaS landscape, leading to further diversification and potential growth opportunities. The pureplay SaaS industry has the potential for revenue grow of 6x by FY25, supported by push from government and MSMEs to drive digital transformation through SaaS solutions, strong funding pipeline and focus on enhancing SaaS skillsets.

The pandemic has increased demand for cloud services globally, contributing to the acceleration of digital transformation across industries. Additionally, people now rely heavily on the internet for both work and leisure. India has been a desirable location for investment in Data Centres because of growing digital infrastructure, increasing technology penetration and regulatory push.

Table 18: Major DC investment deals in CY24

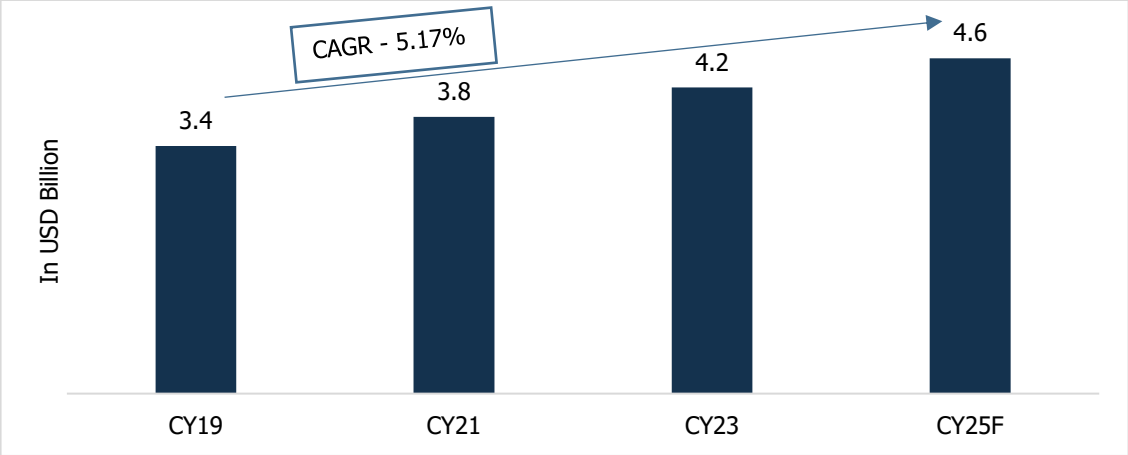
Investor	Investment (USD Million)
Adani	4,000
STT GDC	3,200
Amazon Web Services	2000
Colt DCS and RMZ	1700
CapitaLand	1150
CtrlS	1000
Sify	1100
Princeton Digital Group	1000
Equinix	65

Source: Industry reports, CareEdge Research

5.2. India – a data centre hub

The investments in data centres in India is estimated to reach USD 5 billion by 2025, indicating a CAGR of 5% between 2019-2025, which is 2x faster than the global average. With respect to development as well as operating expenses, India enjoys a significant cost advantage over developed nations.

Chart 23: Trend in Indian Data Centre Market Investment (USD Billion)



Source: NASSCOM, CareEdge Research

5.3. Power Capacity Addition to Support Digital Revolution for the future

The digital revolution is driving an unprecedented increase in data generation, processing, and storage needs, which in turn is pushing the data centre industry to expand its power capacity significantly.

1. Increased Power Capacity

Data centres are rapidly increasing their power capacity to keep up with the growing demand. The companies are investing in new facilities with higher power capacities to meet future needs, while the existing data centres are upgrading their infrastructure to support higher power densities and capacities. This often includes enhanced cooling systems, power distribution units, and backup power solutions.

2. Energy Efficiency and Sustainability

Power cost accounts for 65% of the total operating cost of data centre. Data Centres are increasingly powered by renewable energy like solar, wind and hydroelectric power. Giant companies have committed to having carbon neutrality and are investing heavily in renewable energy projects. Green Data Centres have emerged as a result of stakeholders' demand for sustainable business practices and lower carbon footprint.

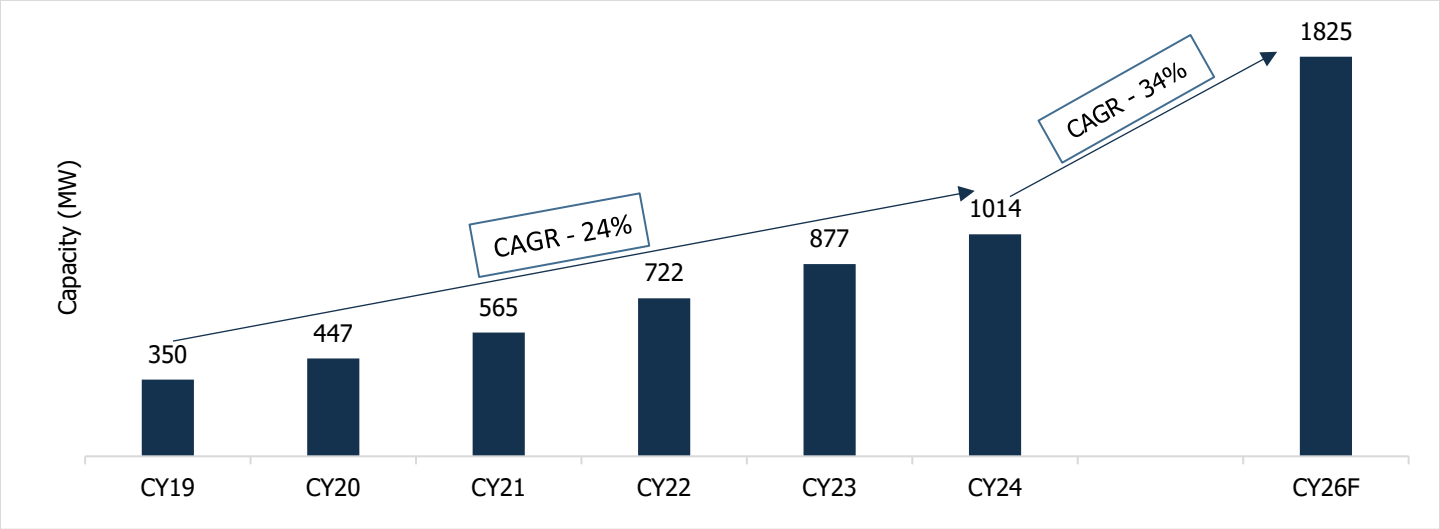
3. Geographical Distribution and Edge Computing

Regions with favourable climate, land availability and renewable energy resources are particularly attractive for companies to build data centres. Edge Data centres are smaller, localized data centres at the edge of the network, which reduces latency and bandwidth usage by processing data closer to where it is generated.

5.4. Review and Outlook of the data centre industry in India in Capacity terms (CY19 to CY26)

India's first commercial data centre was established in 2000. Initially, the industry's growth was sluggish, with total capacity reaching only 122 MW by 2010, an average increase of just 12 MW per year. However, from 2010 onwards, the sector experienced a significant acceleration, tripling its capacity by 2020, with an average annual increase of 32 MW. This rapid growth was spurred by the dot-com boom, broadband policy, and the introduction of 2G and 3G networks. The most substantial growth occurred following the launch of JIO, a new telecommunications provider offering extensive network coverage at affordable prices, and the implementation of the Unified Payment Interface (UPI) in 2016.

Chart 24: Data Centre Capacity in India



Source: CareEdge Research, Industry Reports

The industry witnessed annual capacity addition of 100MW-150 MW during the period of CY20-CY24 to reach total capacity of 1,014 MW by end of CY24. The growth in the data centre industry was complemented by increasing utilization, which increased from 82% in 2019 to 93% in CY23.

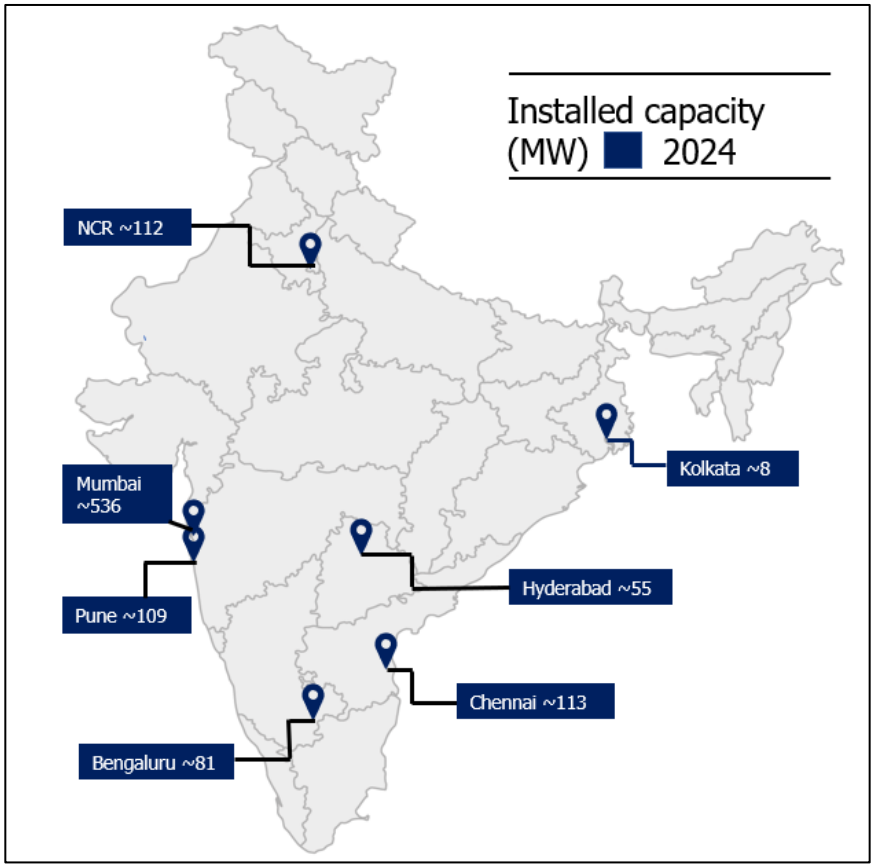
The industry has entered a growth phase and CareEdge Research estimates that capacity is expected to double to about 1,900 MW by 26. The growth plans have also created substantial investment prospects and CareEdge Research estimates a capex of Rs.50,000 crore in this space until over the next three years till CY26.

5.5. Current Installed Capacity (MW) in selected key cities in India

Mumbai – major data centre hub in India

In India, data centres are flourishing in key cities like Mumbai, Chennai, Bengaluru, Hyderabad, Pune, and Delhi. Mumbai contributes to more than 50% of the total installed capacity. As the capacity is expanding, Mumbai and Chennai will need real estate space to support the increasing demand, while Hyderabad and NCR are emerging Data Centres cities, so they will require both real estate as well as investments to support the existing supply.

Chart 25: Current Installed Capacity in Key Cities



Source: CareEdge Research

Mumbai, a large data centre hub with a capacity of 536 MW, is situated on India's west coast and benefits from excellent fibre connection via multiple submarine cables, which facilitates effective data transfer. The city is home to most of the India's banking and financial institution headquarters which are top contributor to data centre demand. Furthermore, the city benefits from availability of reliable power, cable landing stations, telecom hub, and no significant natural hazards.

Chennai, with a data centre capacity of 113 MW, is rapidly emerging as a key data centre hub in India. The city's appeal is enhanced by the state data centre policy, which provides financial incentives such as tax benefits and power subsidies, as well as the presence of undersea cables and a surplus power supply. The demand for data centres in Chennai is primarily driven by IT firms and the BFSI sector.

Bengaluru has a data centre capacity of 81 MW, with continuous demand fuelled by the technology, fintech, and e-commerce industries. The state's data centre policy aims to position Karnataka as the preferred location for data centres, offering incentives such as capital and land subsidies, tax exemptions, and tariff reductions, thus creating a conducive business climate. Moreover, Bengaluru's location in an area with low vulnerability to natural disasters and low seismic risk is expected to drive further demand. Future growth is anticipated from the rising needs of generative AI and start-ups.

With 112 MW of capacity, investments in Delhi NCR are largely driven by government policies. The city witnessed large-scale investments in the recent past with the anticipated demand from government digital initiatives. The city also has good fibre connectivity, proximity to customers, availability of skilled workforce.

Pune, an upcoming IT hub preferred by MNCs. The demand is driven by digital transformation initiatives by government, improvement in terrestrial network connectivity. The installed capacity is 109 MW.

Hyderabad, which is the headquarters of global cloud providers, hosts 55 MW of capacity. Tax incentives introduced by the government to attract hyperscale data centres, are boosting investments in the city.

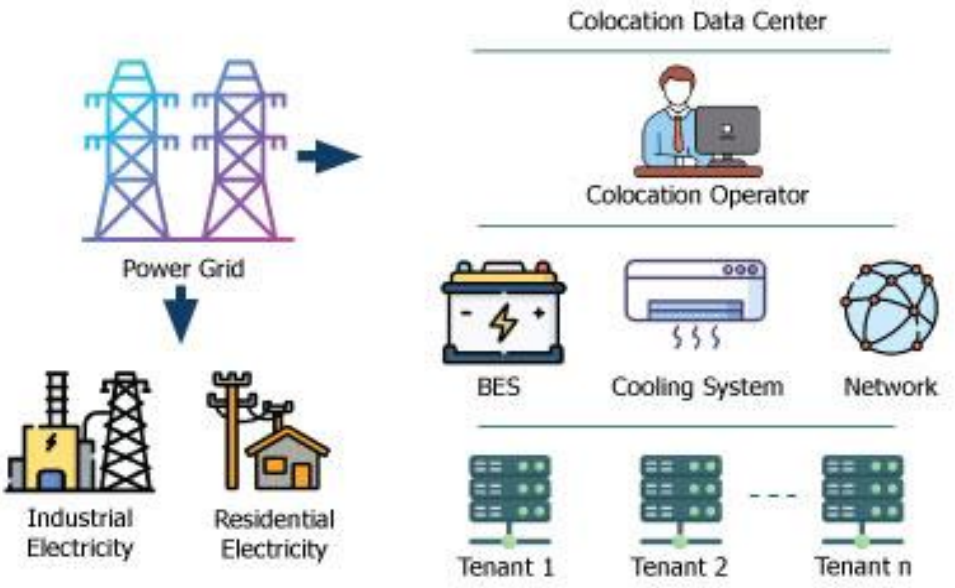
5.6. Qualitative Overview of Key business Models in the Data Centre industry in India

Table 19: Key Business Models

Business Models		
Captive	**Co- location**	**Hosting**
Description		
Captive data centres are privately owned and operated by a single organization to meet its internal data processing and storage needs.	Co-location facilities lease space, power, and cooling to multiple customers, who install and manage their own IT hardware within the data centre.	Hosting data centres provide comprehensive IT services, including space, power, and fully managed IT infrastructure. These services can include web hosting, application hosting, and managed cloud services.
Key Features		
➢ Dedicated Resources ➢ Customization ➢ High Security ➢ Significant Investment	➢ Shared Infrastructure ➢ Scalability ➢ Cost Efficiency ➢ Flexibility	➢ Managed Services ➢ Subscription based ➢ Technical Expertise ➢ Resilient
Advantages		
➢ Complete control over the data centre environment and infrastructure. ➢ Tailored Security Protocol Infrastructure can be optimized for the organization's specific applications and workloads.	➢ Lower capital and operational expenses as compared to owning a data centre. ➢ Access to high-availability infrastructure and redundant systems provided by the co-location provider.	➢ Comprehensive IT management allowing businesses to focus on their core activities. ➢ Easily scalable solutions to accommodate growth and changing demands. Subscription models provide predictable and manageable costs.
Challenges		
➢ High Costs ➢ Resource Intensity ➢ Scalability Issues	➢ Dependency on Provider ➢ High Initial Setup Cost ➢ Shared Environment	➢ Less Direct Control ➢ Dependency on hosting providers services and pricing Security Concerns

Source: CareEdge Research

5.7. Co-location – A widely used business model



The co-location business model in the data centre industry involves data centre providers offering space, power, cooling, and security infrastructure to companies that bring their own IT hardware and expertise. This model allows businesses to rent space within a data centre facility, enabling them to benefit from the data centre's infrastructure without the need to build and maintain their own data centre. Co-location services are popular among businesses looking for a cost-effective and scalable solution to meet their data storage and processing needs.

This model allows organizations to retain ownership and control over their server hardware while benefiting from the professional hosting environment and services provided by the colocation facility.

Co-location is favoured for its scalability, security, compliance with regulatory requirements, and the ability to focus on core business operations while the provider manages the infrastructure.

Customers are charged based on the space they occupy and the power they consume, similar to renting an apartment and paying rent and utility bills. This model is advantageous for businesses that require reliable data centre services but prefer not to invest in building and managing their own data centre infrastructure.

The co-location business model is widely adopted in the data centre industry, with a significant percentage of data centre service providers worldwide operating in the co-location space. In India, new entrants in the data centre market have adopted the co-location business model, reflecting its popularity and effectiveness in meeting the diverse needs of businesses for data storage, processing, and management.

5.8. Key growth drivers and trends for data centre industry in India

1. Increasing Internet Users

The internet user penetration rate in India is the lowest amongst the countries such as China, the USA, and the European Union. However, India has the highest mobile data consumption as compared to these other nations.

In terms of data centre capacity per million internet users, India lags significantly behind other major economies. In India, the data centre capacity per million users is just 1 MW. In contrast, China has a much higher capacity of 4 MW per million users. Furthermore, the data centre capacity per million internet users in the USA and the European Union is even greater than China's, and substantially higher than India's.

As per Department of Telecom, there were 970.16 million internet subscribers in India as on 31st December 2024 and internet per 100 persons stood at 68.86, the rising number of internet users and online transactions in India is fuelling the demand for robust data centre infrastructure to support digital services and e-commerce platforms.

2. Technological Advancements

Technological advancements include cloud computing, Internet of things (IoT), Artificial Intelligence (AI) and Big Data Analytics. Technological advancements play a pivotal role in shaping the data centre industry, driving the need for advanced solutions to meet the evolving demands of businesses and organizations.

Data centres play a crucial role in supporting cloud services by providing the necessary infrastructure to host cloud-based applications and store vast amounts of data securely.

Data centres equipped with IoT capabilities can process and analyse data from interconnected devices, enabling businesses to derive valuable insights for decision-making and operational efficiency.

Data centres with high-performance computing capabilities are essential for running AI algorithms efficiently. These data centres provide the computational power and storage capacity required to train AI models, process complex algorithms, and deliver real-time AI-driven insights across various industries, from healthcare to finance.

Data centres equipped with advanced analytics capabilities can process, analyse, and visualize big data to uncover patterns, trends, and correlations that drive business decisions. By leveraging big data analytics within data centres, organizations can optimize operations, enhance customer experiences, and gain a competitive edge in the market.

3. 5G Roll-Out

There is a notable surge in demand for computation and storage capacity in data centres due to the deployment of 5G networks. Massive numbers of connected devices are supported by 5G networks, producing enormous volumes of data that must be handled and stored. Data centres are moving toward a cloud-native design built on virtualization and containerization technologies to effectively serve 5G networks. Disaggregating hardware and software facilitate flexibility, scalability, and compatibility among several vendors.

The deployment of 5G networks is driving a significant increase in the demand for data centres with enhanced computing capabilities, low latency, cloud-native architecture, and advanced automation and orchestration capabilities. This trend is shaping the evolution of the data centre industry to support the growing demands of 5G networks and the applications they enable.

5.9. Government Policies and digitalization are leading growth drivers for data centres

India is in the process of transitioning towards an advanced market economy, where technology is expected to play a pivotal role in this transformation. The digital revolution is accelerating economic growth and resulting in a significant amount of data generation. This surge in digitalization, propelled by the expansion of online commerce, financial technology platforms, internet-based video streaming, and gaming services, is predicted to raise the number of internet users and enhance internet penetration (proportion of the population using the internet) from approximately 87% by FY29.

The adoption of technologies such as 5G, IoT, and Artificial Intelligence is also anticipated to substantially increase the demand for data and consequently for data centres. Collectively, these factors are projected to triple data consumption in India.

Considering the growing significance of this industry, the Central Government has taken steps to entice capital and facilitate the expansion of data centres. The data centre market is projected to expand from $4.5 billion in 2023 to $11.6 billion by 2032," according to the Economic Survey 2024-25, which was tabled in the Parliament on January 31, 2025. The state of the infrastructure makes it simpler to obtain institutional credit, obtain long-term financing at favourable rates, and present refinancing options.

State governments have also started offering incentives in this approach, such as single window clearing, power subsidies, stamp duty exemptions, and property tax refunds. The drive from regulations for data localization would also lead to an increase in DC capacity.

The Government's Digital India initiative, which aims to transform India into a digitally empowered society and knowledge economy, has led to the creation of sizeable data centres and cloud infrastructure. The Indian government's focus on data localization and data protection policies requires businesses to store and process certain types of data within the country's borders, which promotes the establishment of data centres in India and creates opportunities for data centre providers to offer compliant solutions.

As part of strengthening India's digital infrastructure, the government has focused on expanding and modernising its data centre ecosystem. The National Informatics Centre (NIC) has established advanced National Data Centres (NDCs) in Delhi, Pune, Bhubaneswar, and Hyderabad to support the growing demand for cloud computing, data storage, and AI/ML applications. These centres provide secure and scalable cloud services to central ministries, state governments, and PSUs, along with disaster recovery and hosting support.

Current infrastructure includes approximately 100PB of storage—comprising All Flash, Object, and Unified Storage—and around 5,000 servers deployed for cloud workloads. A new Tier-III NDC with a capacity of 200 racks (expandable to 400) is under development in Guwahati, Assam.

To specifically serve the Northeastern region, the NDC–Northeast Region (NDC-NER) was inaugurated in September 2020. This initiative aims to bridge the regional digital divide and enhance public service delivery through reliable, high-performance data infrastructure.

Draft Rules under the Digital Personal Data Protection Act (DPDP) 2023

In 2025, India's Ministry of Electronics and Information Technology introduced a new draft, the Digital Personal Data Protection Rule which seeks to operationalize the Digital Personal Data Protection Act, 2023 (DPDP Act). These rules aim to protect citizens rights while supporting innovation and the growth of the digital economy.

The rules require data centres and other data handlers (Data Fiduciaries) to provide clear information about how personal data is used, take consent from users, and allow users to erase their data if they choose. Citizens can also appoint digital nominees and raise complaints through simple online systems.

The rules follow a "digital by design" approach, with digital processes for consent, complaint handling, and the working of the Data Protection Board. This ensures faster service, more transparency, and better protection of personal data stored and processed in data centres

5.10. Cable landing stations & government initiatives – Maharashtra over other states

The cable landing stations in India serve as crucial gateways for international internet connectivity, enabling the transmission of data through submarine cables. These stations play a vital role in facilitating global communication and data exchange. In India, various operators own and operate cable landing stations across key cities like Mumbai, Chennai, Cochin, Tuticorin, and Trivandrum, where Mumbai and Chennai have the maximum number of cable landing stations. These stations are essential for connecting India to the global internet infrastructure, supporting high-speed data transmission and communication services. The presence of multiple cable landing stations reflects India's strategic position in the global telecommunications network, enhancing connectivity and enabling seamless data exchange on an international scale.

Submarine cables are vital digital communication infrastructure of today's fast-paced global economy and are the lifelines of any country's communication grid, empowering its business and economic operations. Telecom Regulatory Authority of India (TRAI) has issued the recommendations on 'Licensing Framework and Regulatory Mechanism for Submarine Cable Landing in India'.

India is an important part of the global submarine cable network. The country has about 17 international subsea cables connected through 14 landing stations located in cities such as Mumbai, Chennai, Cochin, Tuticorin, and Trivandrum. By the end of 2022, these cables had a total lit capacity of 138.606 Tbps and an activated capacity of 111.111 Tbps.

5.11. Data Security – Key concern for the industry

Data Privacy

Data privacy in data centres requires a comprehensive approach that combines robust cybersecurity practices, physical security measures, and adherence to data protection regulations. Any breach in data privacy can have severe financial implications, potentially costing millions. By prioritizing data privacy and implementing effective risk mitigation strategies, data centres can uphold the confidentiality and security of the data they manage, thereby safeguarding their clients' sensitive information and maintaining trust in their services.

Power Management

Ensuring continuous and reliable power supply is essential to maintain uninterrupted operations. Proper planning involves assessing the power requirements of IT infrastructure and cooling systems to ensure they are adequately supported during normal operations and in the event of power outages.

Effective power management strategies include implementing power backup solutions, conducting detailed load analysis, employing energy-efficient hardware, virtualization technologies, and power management tools to optimize power consumption, reduce energy costs, and enhance operational efficiency. Regularly monitoring power usage, conducting energy audits, and performing preventive maintenance on power infrastructure to identify potential issues, optimize performance, and ensure system reliability.

Capacity Planning

Data centres must be operated at a targeted capacity in order to provide the best possible performance. Tools for managing the infrastructure of data centres are an effective means of doing the same. Systems for managing the infrastructure of data centres can determine the needs for cooling, storage, and processing power.

Adani's Positioning

Adani Enterprises Limited is a part of the Adani group, which is among India's top business houses. Adani Enterprises commenced data centre business in 2020. The company entered into a joint venture with EdgeConneX, an American data centre firm with over a decade of experience serving global technology leaders. This partnership, named Adani ConneX, aims to build reliable data centre networks powered by renewable energy to cater to the rapidly growing demand in this sector. Adani ConneX has plans to develop data centres across several key cities in India, including Chennai, Noida, Navi Mumbai, Hyderabad, Vizag, Pune, Kolkata, and Bengaluru. The first data centre facility was successfully commissioned in Chennai in October 2022.

The Adani group brings expertise in executing large-scale projects, along with unique full-stack capabilities in power generation, transmission, and distribution, including renewable energy sources. EdgeConneX, on the other hand, contributes its specialized expertise in operating and designing over 50 data centres across more than 30 markets globally. This strategic alliance combines the strengths of both partners, positioning Adani ConneX to attract reputed clientele, seeking reliable and sustainable data centre solutions to support their growing digital infrastructure needs.

5.12. Competitive Profile

1. NXTRA Data Limited

Nxtra Data, incorporated in 2013, is a fully owned subsidiary of Bharti Airtel headquartered in Gurugram. They have 10 operational data centres across 7 locations: Noida, Manesar, Mumbai, Pune, Bhubaneshwar, Bangalore, and Chennai. They provide colocation, managed services, and cloud services in India. They specialize in designing, building, and operating the largest network of hyperscale, core, and edge data centres in India to ensure maximum reliability, extensive reach, flexible power configurations, and a carrier-dense ecosystem for an unparalleled customer experience.

With 12 large data centres, 120 edge data centres, the company has over 40,000+ racks. They also have upcoming projects in 6 cities, incorporating 32,000 racks with over 200 MW of power. The company has more than 45% of its data centers in Chennai, Pune and Mumbai, with Chennai having major share. The company is planning to open new data centers in Hyderabad and Kolkata.

Table 20: Financial Parameter (Rs. in Crore)

NXTRA DATA LIMITED	FY21	FY22	FY23	FY24
REVENUE FROM OPERATIONS	1109.1	1333.3	1601.1	1826.6
EBITDA	442.80	361.15	355.55	730.20
PAT	178.8	238.4	220.1	231.8
Total Debt	440	234.3	350	810.1
Net Worth	284.118	523.1	2532.3	2768.6
EBITDA MARGIN (%)	39.92%	27.09%	22.21%	39.98%
EBIT	265.50	336.60	321.90	351.20
CAPITAL EMPLOYED	1371.22	2445.62	2996.17	3533.20
ROCE (%)	19.36%	13.76%	10.74%	9.94%
DEBT to EBITDA	0.99	0.65	0.98	1.11
INTANGIBLE ASSETS	58.30	49.40	46.70	49.80
TANGIBLE NET WORTH	225.82	473.70	2485.60	2718.80
DEBT to Tangible Net Worth	1.95	0.49	0.14	0.30
Finance Cost	24.1	22.90	25.90	34.90
Interest Coverage (times)	11.02	14.70	12.43	10.06

Source: Company Report

2. CtrlS Data Centre Limited

CtrlS Data Centre Limited was founded in 2007 and incorporated its first data centre in Hyderabad in 2008. They have data centres across six locations: Mumbai, Chennai, Hyderabad, Noida, Bangalore, and Kolkata. Their service portfolio includes hyperscale, colocation, work area recovery, and managed services. They specialize in building colocation facilities with rack space, caged racks, dedicated server halls/floors, and dedicated buildings.

With 8 data centres, company has over 13,500+ racks, and approximately 120 MW of power, they have established a presence across India, with more than 70% of data centers located in Mumbai. The company is planning to open new data centers in Chennai and Kolkata.

Table 21: Financial Parameter (Rs. in Crore)

CTRLs DATACENTRES LIMITED	FY21	FY22	FY23	FY24
REVENUE FROM OPERATIONS	780.2	932.9	1121.3	1339
EBITDA	463.2	541.7	630.3	651.9
PAT	234.4	286.4	289.8	209.6
Total Debt	438.5	581.6	977.9	1671.8
Net Worth	656.9	943.9	1235.3	1448
EBITDA MARGIN (%)	59.37%	58.07%	56.21%	48.69%
EBIT	364.40	435.20	474.80	438.40
CAPITAL EMPLOYED	1157.80	1669.50	2761.90	4090.90
ROCE (%)	31.47%	26.07%	17.19%	10.72%
DEBT to EBITDA	0.95	1.07	1.55	2.56
INTANGIBLE ASSETS	2.20	0.80	12.60	13.00
TANGIBLE NET WORTH	654.70	943.10	1222.70	1435.00
DEBT to Tangible Net Worth	0.67	0.62	0.80	1.17
Finance Cost	50.1	49.10	86.70	153.90
Interest Coverage (times)	7.27	8.86	5.48	2.85

Source: Company Report

3. STT Global Data Centres India Private Limited

STT GDC India, a majority-owned subsidiary of ST Telemedia Global Data Centre's. The company has been designing, constructing, and overseeing data centres in India since 2005. With a nationwide presence, STT GDC India delivers over 160 MW of critical IT load through its 18 operational facilities spread across eight major cities. These purpose-built, scalable, and secure data centre facilities are highly interconnected and carrier-neutral, providing enterprises with the ideal infrastructure for their digital operations. The company has more than 65% of its data centers in Chennai, Pune and Bengaluru, with Chennai and Pune having majority share.

Table 22: Financial Parameter (Rs. in Crore)

STT GLOBAL DATA CENTRES	FY21	FY22	FY23
REVENUE FROM OPERATIONS	1,175.04	1,454.75	1,823.45
EBITDA	375.09	781.79	866.73
PAT	(69)	153.69	164.01
Total Debt	1764.212	1906.8763	2136.1405
Net Worth	667.0307	1472.938	1985.2811
EBITDA MARGIN (%)	31.92%	53.74%	47.53%
EBIT	143.60	462.9	488.86
CAPITAL EMPLOYED	3607.31	4510.46	5899.02
ROCE (%)	3.98%	10.26%	8.29%
DEBT to EBITDA	4.70	2.44	2.46
INTANGIBLE ASSETS	52.31	6.38	4.32

STT GLOBAL DATA CENTRES	FY21	FY22	FY23
TANGIBLE NET WORTH	614.72	1466.56	1980.96
DEBT to Tangible Net Worth	2.87	1.30	1.08
Finance Cost	234.54	256.89	269.19
Interest Coverage (times)	0.61	1.80	1.82

Source: Company Report

Note: FY24 annual report available on MCA is corrupt

4. NTT Global Data Centers & Cloud Infrastructure India Private Limited

NTT Data commenced its operations in India in 2013, establishing a significant presence in the country. Their data centres are located across key Indian cities such as Mumbai, Bengaluru, Delhi NCR, and Chennai, offering data centre services. With a focus on providing hosting environment, NTT Data operates multiple data centres in the vicinity of Mumbai. Additionally, NTT Data maintains data centre facilities in Delhi, Bengaluru and Chennai.

NTT Data operates eight facilities across four cities, with Mumbai accounting for more than 80% of the share. Additionally, they have two upcoming facilities in Chennai and Noida.

Table 23: Financial Parameter (Rs. in Crore)

NTT GLOBAL DATA CENTERS & CLOUD INFRASTRUCTURE INDIA PRIVATE LIMITED	FY21	FY22	FY23	FY24
REVENUE FROM OPERATIONS	1210.13	1594.76	2258.29	2719.48
EBITDA	385.25	636.73	924.78	1069.88
PAT	51.01	167.52	173.72	38.18
Total Debt	1663.93	2539.33	5597.70	1641.38
Net Worth	1674.35	1842.06	2007.20	1998.32
EBITDA MARGIN (%)	31.84%	39.93%	40.95%	39.34%
EBIT	167.21	388.26	586.59	599.88
CAPITAL EMPLOYED	3058.61	3877.86	7601.34	8795.71
ROCE (%)	5.47%	10.01%	7.72%	6.82%
DEBT to EBITDA	4.32	3.99	6.05	1.53
INTANGIBLE ASSETS	7.08	155.53	167.07	
TANGIBLE NET WORTH	1667.28	1686.54	1840.13	1998.32
DEBT to Tangible Net Worth	1.00	1.51	3.04	0.82
Finance Cost	86.16	127.94	303.35	536.17
Interest Coverage (times)	1.94	3.03	1.93	1.12

Source: Company Report

5. Sify Infinit Spaces Limited

Sify is an IT and Digital Services company founded in 1995, with its headquarters located in India. The company's infrastructure includes 11 Data centres and the MPLS network. They also provide cloud-based business transformation solutions. They have presence across 6 Indian cities: Mumbai, Noida, Hyderabad, Bengaluru, Chennai and Kolkata.

Table 24 : Financial Parameter (Rs. in Crore)

SIFY INFINIT SPACES LIMITED	FY21	FY22	FY23	FY24
REVENUE FROM OPERATIONS	563	758	1,021	1,114
EBITDA	249.88	331.67	430.42	486.68
PAT	79	86	89	57
Total Debt	540.97	1139.02	1637.15	1890.05
Net Worth	583.6	669.21	1080.34	1881.2
EBITDA MARGIN (%)	44.39%	43.74%	42.14%	43.68%
EBIT	119.71	178.00	222.51	231.83
CAPITAL EMPLOYED	955.80	1542.63	2417.46	3521.33

SIFY INFINIT SPACES LIMITED	FY21	FY22	FY23	FY24
ROCE (%)	12.52%	11.54%	9.20%	6.58%
DEBT to EBITDA	2.16	3.43	3.80	3.88
INTANGIBLE ASSETS	33.64	36.30	50.43	77.59
TANGIBLE NET WORTH	549.96	632.91	1029.91	1880.90
DEBT to Tangible Net Worth	0.98	1.80	1.59	1.00
Finance Cost	47	55.12	103.29	153.94
Interest Coverage (times)	2.53	3.23	2.15	1.51

Source: Company Report

6. Roads

6.1. Review of road infrastructure in India

The road transport sector contributed 2.5% to GVA in FY21, after been in the range of 3.2%-3.1% from FY12 to FY20. Post the pandemic effect in FY21, the sector's growth rate has returned to pre-pandemic level of 3.2% of India's GDP in FY22. The road transport sector has grown on a CAGR of about 5.2% against the total CAGR growth of the GVA of about 6.5% during the period FY12-FY22.

Table 25: Gross Value Added at Constant (2011-12) Basic Prices

Year	FY12	FY13	FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22	FY23	FY24
Road Transport (Rs. Thousand Crore)	262.4	282.4	300.6	320.8	3431.2	362.3	396.4	417.5	418.9	345.1	461.2	446.3	452.2
% Share in total GVA	3.2%	3.3%	3.3%	3.3%	3.3%	3.2%	3.3%	3.3%	3.1%	2.5%	3.1%	3.0%	2.8%

Source: Ministry of Statistics and Programme Implementation, CareEdge Research

6.2. Total Road Network Length and Break-Up into National, State, and Rural Roads

India has the second-largest road network in the world, with about 63.45 lakh km as of FY24. This comprises national highways, expressways, state highways, major district roads, other district roads, and village roads. To accelerate the country's growth, the development of national highways has been the key focus area. On the other hand, state highways, district and rural roads continue to be a large part of the overall road network.

Table 26: Road Network of Past 5 Years (In Km)

Particulars	FY19	FY20	FY21	FY22	FY23	FY24
National Highways	1,32,500	1,32,500	1,36,440	1,40,995	1,44,955	1,46,195
State Highways	1,56,694	1,56,694	1,76,818	1,71,039	1,67,079	1,79,535
Other Roads	56,08,477	56,08,477	59,02,539	60,59,813	60,19,757	60,19,723
Total	**58,97,671**	**58,97,671**	**62,15,797**	**63,71,847**	**63,31,791**	**63,45,453**

Source: Ministry of Road Transport and Highways of India Annual Reports, CareEdge Research

Road transportation, the most common mode of transportation in India, accounts for about 87% of passenger traffic. Despite having a network of 1,46,195 km, Indian national highways account for only 2.1% of total road network and 40% of total road traffic. State highways and major district roads make up the country's secondary road transportation system, accounting for 60% of traffic and 98% of road length.

Table 27: Percentage Share in Total Road Length Across Various Categories

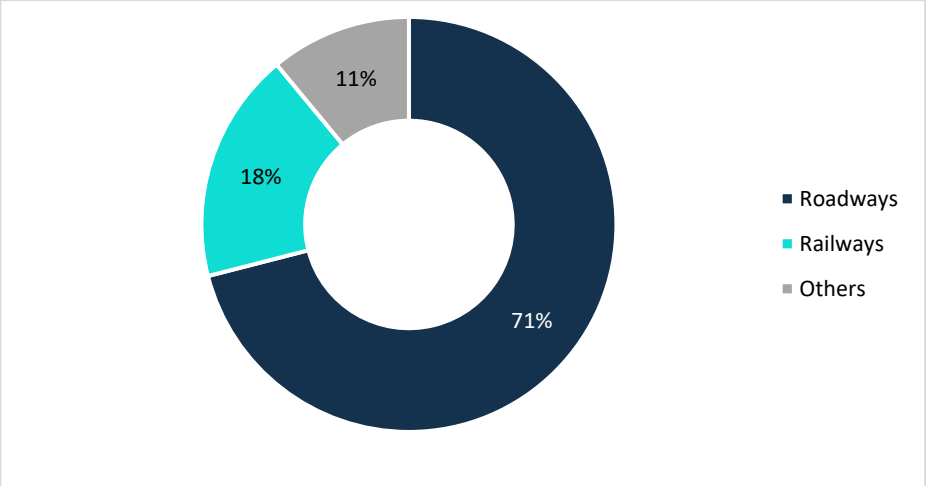
Year	National Highways	State Highways	District Roads	Rural Roads	Urban Roads	Project Roads
2020	2.1%	2.8%	9.7%	70.7%	8.6%	6.1%

Source: Ministry of Road Transport and Highways of India Annual Reports, CareEdge Research

Share of roads in Indian freight traffic

The Road Transport Sector represents approximately 87% of passenger movement and 60% of freight movement within the nation. Factors such as convenient accessibility, flexibility to cater to individual requirements, and cost-effectiveness contribute to the advantages of road transport. Railways sector contribute ~71% freight movement in India followed by Other transport like Airways and Waterways contributing ~11% of movement.

Chart 26: Freight Transport Movement in India



Source: CareEdge Research

6.3. Challenges faced by the Road Sector

Despite the government's continuous support by way of finance and amendments in the PPP model framework, few challenges persist for the sector

• **Delay in land acquisition and receipt of approvals for road construction:** Post Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act, 2003, many landowners demand higher compensation and refuse to hand over possession of their land. With the Act coming into effect, the cost of land has increased thereby increasing higher cash outflow from the government towards land acquisition. Furthermore, delay in land acquisition and receipt of approvals for road construction leads to substantial project cost and time overruns, thereby impacting the project viability.

• **Mismatches between Project Cashflows and Debt Repayment Tenure:** Revenue generation from large infrastructure projects is spread over 20-30 years whereas the loan for the same project is for 10-15 years. This misalignment creates cash flow mismatches during the initial operational years, before the project reaches stability. As a result, private developers are compelled to bridge the gap using their own financial resources.

• **Limited private sector participation in BOT projects due to past financial stress; however good participation seen in HAM projects awarded in past few years:** Due to failed BOT projects on account of lower than-estimated traffic volumes or delays in project completion due to approvals/ land acquisition, private players have come under financial stress due to significantly leveraged balance sheets in anticipation of high levels of project revenue growth. In contrast, the Hybrid Annuity Model (HAM) has witnessed stronger participation, as it offers reduced risk exposure and lower funding requirements. Under HAM, the National Highways Authority of India (NHAI) provides 40% of the project cost in ten instalments linked to project milestones. Of the remaining 60%, developers need to finance only 20–25%, with the balance raised through debt, thereby mitigating financial pressure.

• **Cautious bank lending approach to road sector, due to highly Stressed Loan Portfolio in the past:** With higher debt exposure to road project and many projects getting stuck or delayed resulted in loans turning into non-performing assets (NPAs), which had contracted the lending capacity of banks. With lower than anticipated revenues, the private players' debt servicing capacity has been impacted. o avoid corporate failure, many have opted for loan restructuring. While the first instance of restructuring does not affect asset classification, any subsequent restructuring triggers NPA recognition in the financial institution's books. Consequently, banks have become more selective and risk-averse in financing road sector projects.

• **Toll collection and willingness of users to pay toll:** The sector is susceptible to end user's willingness to pay toll, as there have been instances of people skipping toll payments, backed by regional groups or political parties. This in turn impacts the toll collection efficiency and revenues from the road projects, thereby adversely impacting the project cashflow position.

6.4. Institutional Framework for roads at the Central Level and for specific states

MoRTH, an apex ministry under the central government, is entrusted with the task of formulating and administering policies for road transport, national highways and transport research, in consultation with other central ministries/departments, state governments/UT administrations, organizations and individuals, with a view to increasing the mobility and efficiency of the road transport system in the country.

National Highways Authority of India (NHAI) is responsible for the development and maintenance of national highways. The **National Academy of Highway Engineers** (formerly National Institute of Training for Highway Engineers) is responsible for sharing of knowledge and pooling of experience on the entire range of subjects dealing with the construction and maintenance of roads, bridges, tunnels, and road transportation including technology, equipment, research, planning, finance, taxation, organization, and all connected policy issues. A wholly owned company of MoRTH, **National Highways and Infrastructure Development Corporation (NHIDCL)**, is responsible for promoting, surveying, establishing, designing, building, operating, maintaining, and upgradation of national highways and strategic roads including interconnecting roads in parts of the country which share international boundaries with neighbouring countries.

Maharashtra: Maharashtra's HAM model which was implemented earlier in 2017 at 40:60 split between government and concessionaire for 10,000 km which was further changed to construction of 6,000 km at the cost of Rs. 28,500 crores. In 2022 the ratio was changed to 30:70. The concessionaire has to raise 70% from the market which will be repaid by the state in 15 years.

Madhya Pradesh: Madhya Pradesh's HAM model, managed by the Madhya Pradesh Road Development Corporation Limited (MPRDC), involves 60% government funding during the construction period, similar to NHAI approach. The Asian Development Bank (ADB) signed a USD 175 million loan to improve connectivity up to 500 km of state highways and major district roads.

Karnataka: Karnataka's HAM model, managed by the Karnataka Road Development Corporation Limited (KRDCL) and Karnataka PWD is implemented from Karnataka State Highway Improvement Project, involves 60% government funding during the construction period, like Madhya Pradesh approach.

6.5. Overview of Recent Changes in the Model Concession Agreement for HAM Projects

- Bidder Eligibility criteria of NH projects under Hybrid Annuity Mode: The ministry has amended the Standard RFP document of HAM Mode to incorporate provisions relating to Threshold Technical capacity prescribed for similar work experience for EPC works related to Major Bridges and Tunnels. This will enable NHAI to procure concessionaires having appropriate experience in Major Bridges/ Tunnels for projects being executed under HAM mode.

- Changes have been made in the relevant clauses of the model RFP and MCA of the HAM project to allow the Lowest Quoted Bid Project Cost (BPC) as the basis for awarding the HAM Project and O&M cost to be fixed as in EPC projects. It was a much-needed demand of the industry as it will now bring out the winner immediately after the opening of financial bids in a transparent manner as in EPC mode of bidding. The earlier practice of making the award of the project in HAM after converting BPC and O&M quotes to NPV was not clear to many bidders.

- The Model Concession Agreement for BOT (Toll) projects have been amended to reduce the minimum ownership lock-in period from two years to one-year post-Commercial Operation Date (COD). This revision will enable construction companies to release their equity and reinvest the freed-up capital in new infrastructure projects, thereby enhancing liquidity and project participation.

Amendments to HAM-

Some of the major amendments To HAM after Model Concession Agreement (2020)-

- Back- ending of premium payment
- Redefinition of project milestones
- Interest on annuity payments linked to average one-year MCLR of top 5 scheduled commercial banks+1.25%
- 10 milestone payments each equal to 4% of the bid project cost
- Lenders receive first charge on all receivables
- Deemed termination of projects
- Maintenance obligations
- Toll fee notification

Table 28: Major Amendments in payments under HAM after Model Concession Agreement

<table>
<tr><th></th><th>Existing Clause</th><th>Proposed Clause</th></tr>
<tr><td>Maintenance during Construction Period</td><td>The concessionaire will be responsible to maintain the existing highway and ensure that the road is pothole free during the construction.</td><td>In case of extension of scheduled completion date, the concessionaire will be liable to maintain the project highway for the extended period and will be entitled to reimbursement.</td></tr>
<tr><td>Financial closure</td><td>The concessionaire shall achieve financial closure within 150 days from the date of agreement.</td><td>The concessionaire shall achieve financial closure for an amount not lower than either-
i. Total Project Cost or
ii. 10% less than (Estimated Project cost minus 40% of the bid project cost)</td></tr>
<tr><td>Payment during Construction Period</td><td>The payment milestone for the release of payment during construction period shall be as under-
<table>
<tr><th>Payment Milestone</th><th>Achievement</th></tr>
<tr><td>1st</td><td>10% physical progress</td></tr>
<tr><td>2nd</td><td>30% physical progress</td></tr>
<tr><td>3rd</td><td>50% physical progress</td></tr>
<tr><td>4th</td><td>75% physical progress</td></tr>
<tr><td>5th</td><td>90% physical progress</td></tr>
</table></td><td>The payment milestone for the release of payment during construction period shall be as under-
<table>
<tr><th>Payment Milestone</th><th>Achievement</th></tr>
<tr><td>1st</td><td>5% physical progress</td></tr>
<tr><td>2nd</td><td>10% physical progress</td></tr>
<tr><td>3rd</td><td>20% physical progress</td></tr>
<tr><td>4th</td><td>30% physical progress</td></tr>
<tr><td>5th</td><td>40% physical progress</td></tr>
<tr><td>6th</td><td>50% physical progress</td></tr>
<tr><td>7th</td><td>60% physical progress</td></tr>
<tr><td>8th</td><td>70% physical progress</td></tr>
<tr><td>9th</td><td>80% physical progress</td></tr>
<tr><td>10th</td><td>90% physical progress</td></tr>
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<table>
<tr><th></th><th>Existing Clause</th><th>Proposed Clause</th></tr>
<tr><td>Debt Due Payment</td><td>
<table>
<tr><th>Payment Milestone</th><th>Basic of calculation for termination payment</th></tr>
<tr><td>1st</td><td>90% debt due or 1.35% of bid project cost, whichever is lower</td></tr>
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<tr><th>Payment Milestone</th><th>Basic of calculation for termination payment</th></tr>
<tr><td>1st</td><td>90% debt due or 0.68% of bid project cost, whichever is lower</td></tr>
<tr><td>2nd</td><td>90% debt due or 1.35% of bid project cost, whichever is lower</td></tr>
<tr><td>3rd</td><td>90% debt due or 5.4% of bid project cost, whichever is lower</td></tr>
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</table>
</td></tr>
</table>

Source: Ministry of Road Transport and Highways of India

Amendments to BOT

MoRTH has issued several amendments in Build Operate Transfer (BOT) road projects in March 2024. The amendments are in following categories:

- Change in Ownership
- Performance Security
- Construction and Equity Support
- Buyback of projects by NHAI
- Terminal Payments

6.6. Policy framework for infrastructure sector

Government's Infrastructural Development Plans to Support Medium-Term Growth

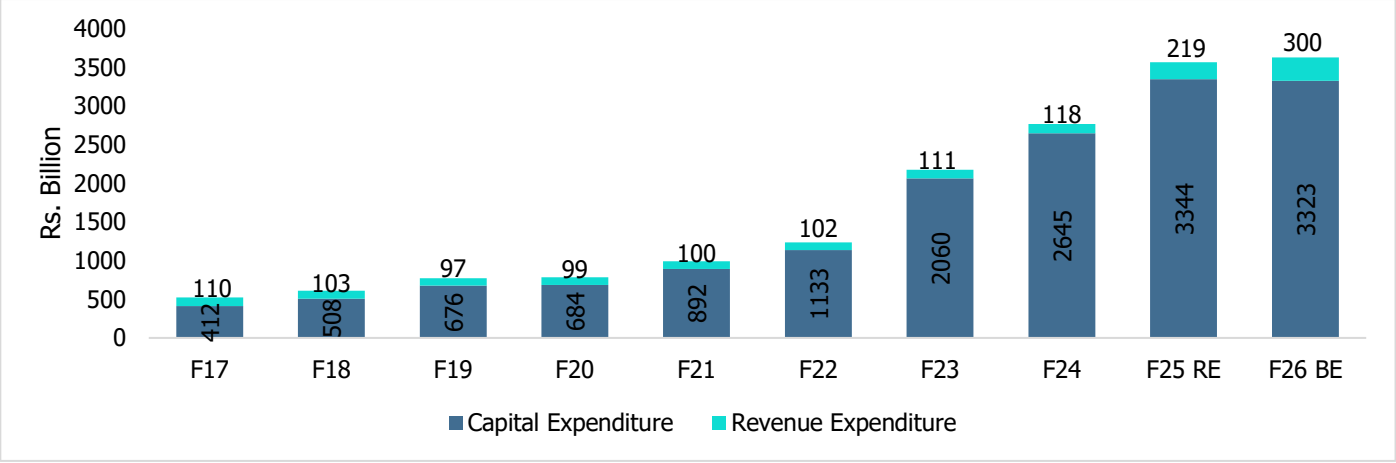
Road construction is amongst the critical sub-segments for infrastructure development, economic growth, and employment creation. Besides, the government is primarily focusing on infrastructure. For instance, in the Union budget 2025-26, the government budgeted to incur higher expenditure toward road construction. Wherein, the central government made the highest ever outlay of Rs 2873 billion (compared to the estimated expenditure of Rs 2805 billion for 2024-25).

Overall, the Union Budget for 2025-26 emphasized infrastructure development. The budget plan aims for multi-modal logistics facilities and connectivity systems under the PM Gati Shakti. For infra push, financial assistance of Rs 1,300 billion in interest-free loans for 50 years has been allocated to states from the Centre. This augurs well for the roads sector alongside the government's plans to generate employment opportunities.

This renewed infrastructure push is expected to significantly benefit the roads and highways sector, while also supporting the government's broader objective of job creation. The sustained emphasis on connectivity and logistics efficiency is aligned with the long-term vision of boosting economic competitiveness and fostering inclusive development across regions.

Moreover, Rs 111 trillion of investments have been projected in infrastructure projects for FY20-FY25 by the Task Force on National Infrastructure Pipeline (NIP), with ~18% of the targeted investment expected to be made in the road sector in India. Also, under the recently announced Asset Monetization Pipeline, around Rs 1,600 billion are to be raised through the monetisation of roads. As of FY24, the government has already raised approximately Rs. 1.2 trillion, achieving around 75% of the road sector target. FY25 alone, the Ministry of Road Transport and Highways (MoRTH) and NHAI aim to raise an additional Rs. 53,000–Rs. 60,000 crores through the monetization of 33 highway stretches covering about 2,750 km.

Chart 27: Budget Allocation for the Ministry of Road Transport and Highways



Source: Demand for Grants 2025-26
RE – Revised Estimates
BE – Budgeted Estimates

6.7. Overview of PPP Framework and Models in Operation

Connectivity has been the priority of the government and roads are the best and cheapest way of increasing last-mile connectivity. Construction of roads in every corner of the country by only government agencies is difficult as it will increase both time and cost. Accordingly, the government partnered with the private players under Public Private Partnership (PPP) to achieve complete connectivity by way of roads. Initially, PPP road projects broadly fell into one of the two categories of toll or annuity.

However, private sector participation began to decline post-2012 due to various issues including aggressive bidding, the over-leveraged balance sheet of developers, shortcomings in project preparation activities, and land acquisition issues. In response, the government introduced the Hybrid Annuity Model (HAM) to revitalise private investment. HAM aimed to ensure a balanced allocation of risk between the public and private sectors. Meanwhile, the monetisation of operational road assets has gained traction with the introduction of the Toll-Operate-Transfer (TOT) model. Additional asset monetisation avenues, such as Infrastructure Investment Trusts (InvITs) and the securitisation of toll revenues, have also been implemented to enhance private sector engagement and diversify funding sources.

PPP models

To boost private participation, the government has come up with various models including the PPP model.

- **Build Operate and Transfer (BOT) Toll Model**

This is a simple and conventional PPP model where the private partner is responsible for designing, building, operating (during the concession period), and transferring back the facility to the public sector. The role of the private sector partner is to bring the finance for the project and take the responsibility to construct and maintain it. In return, the public sector will allow it to collect revenue from the users by way of tolls. To increase the viability of projects, a capital grants up to a maximum of 40% is provided by NHAI.

- **BOT (Annuity) Model**

In the BOT (Annuity) mode, the private partner is responsible for building, operating, and transferring the road at the end of the agreement period to the public sector. The toll collection is however undertaken by the government agency and the payment is made on a semi-annual basis to the private players.

- **Hybrid Annuity Model (HAM)**

Due to subdued private participation in the bidding process, the government opted for an advanced version of the Hybrid Annuity Model (HAM) in FY2017. It was introduced when private players were piling on debt and banks were reluctant to provide additional loans as most of the projects were failing. Major BOT projects had proven to be a bad choice as the main assumption for the returns was traffic. If there was not enough traffic as assumed, the whole project would turn into a fund trap for private players.

The Hybrid Annuity Model (HAM) combines elements of both the BOT (Annuity) and EPC models, offering a balanced approach that protects the interests of both the government and private sector participants. Under this model, the government provides a grant amounting to 40% of the Bid Project Cost (BPC) during the construction phase, disbursed in five equal instalments based on the project's physical progress. The remaining 60% of the BPC is financed by the private entity through a combination of debt and equity. Unlike traditional annuity models, the government recovers its investment through toll collection, thereby generating long-term revenue from the project.
This model has been very successful as the burden of financing on private players has been reduced. In the first year of its implementation, projects worth Rs 280 billion were awarded by the NHAI of which 50% of the projects were under HAM. HAM has not only brought back private participation but has also safeguarded the banks as the funds disbursed to private players are backed by the government annuity payments, i.e., the traffic risk is taken care by the government, private players are only responsible for building the project and there is no role in road’s ownership, toll collection or maintenance.

- **Engineering, Procurement and Construction (EPC)**

In the EPC mode, the cost is completely borne by the public sector (government). The public sector invites bids for engineering knowledge from the private players. Procurement of raw materials and construction costs are met by the public player. The private sector's participation is limited to the provision of engineering expertise.

- **Service contract**

In this approach, the private promoter performs a particular operational or maintenance function for a fee over a specified period. In addition, there are modes such as TOT and Operate-Maintain-Transfer (OMT) for monetizing future toll earnings of completed projects.

- **Toll Collection**

In 2009, the concept of Toll collection emerged as a distinct business model similar to outsourcing. In this arrangement, the private parties are invited by the authority to collect tolls on highways built under EPC and BOT-annuity contracts. It is often used for projects which last less than a year.

The project is given to the private player with the highest bid and the contracting authority determines the user fee. During the concession time, the private player has the power to collect user fees.

- **OMT**

Under the OMT model, the private party is responsible for maintenance for a set period of time. The concept of OMT was established to ensure optimum quality and safety for road travellers. An OMT project includes a contract for the right to collect tolls as well as a contract for the stretch's management and maintenance. The OMT idea was established to ensure adequate quality and safety for travellers. An OMT project includes an agreement for the ability to collect tolls as well as a contract for the stretch's management and maintenance.

- **TOT**

Under the TOT model, the right of collection and appropriation of fees for selected operational NH projects constructed with public funds shall be assigned to developers for a pre-determined concession period in exchange for an upfront payment to NHAI. Such rights assignment shall be based on the toll income potential of the identified NH projects. The developer will be responsible for the operation and maintenance (O&M) of such projects until the concession period expires.

Table 29: Key Features

Type of Project	Development Risk	Financing Risk	Traffic Risk and accrual of toll fee collection	Award Criteria
BOT-HAM	Concessionaire	Concessionaire	Authority	Lowest project and O&M cost
EPC	Concessionaire	Authority	Authority	Lowest contract price
OMT	No to minimal development risk	Concessionaire	Concessionaire	Highest % of toll revenue share or highest premium per year
Tolling	No development risk	Concessionaire	Concessionaire	Highest revenue sharing bid
TOT	Authority in case of lane upgradation in the concession period	Concessionaire	Concessionaire	Highest upfront payment

Source: MORTH

6.8. Overview of National Highways Development Program (NHDP) and Bharatmala Pariyojana

The National Highway Development Program (NHDP) is a significant infrastructure initiative undertaken by the Government of India to upgrade and expand the country's road network. CCEA on 12th January, 2000 approved NHDP Phase-I - Four laning of 6,359 km. at a cost of Rs. 30,300 Cr, it aimed to improve connectivity and facilitate economic growth by enhancing road infrastructure across the nation. The NHDP encompasses various phases and components, each targeting different aspects of highway development, including expansion, modernization, and connectivity enhancement.

Bharatmala Pariyojana:

Bharatmala Pariyojana, India's one of the largest infrastructure programs was envisioned in 2017 to develop 34,800 km of National Highway corridors, connecting 580+ districts in the nation. The program signalled a paradigm shift to corridor approach of infrastructure development.

The overall network of the nation was reimagined through scientific studies including, Origin - Destination study of freight movement across 600 districts and crow-flight alignment for optimized route to reduce transit time. Bharatmala Pariyojana also ushered in a new age of technology driven highway development in the country through deployment of automatic traffic surveys and satellite mapping and imagery to identify upgradation requirements of corridors.

Bharatmala Pariyojana envisages 60% projects on Hybrid Annuity Mode, 10% projects on BOT(Toll) Mode and 30% projects on EPC mode respectively. Total aggregate length of 26,425 km with a total capital cost of Rs. 8,53,656crores have been approved and awarded till date under Bharatmala Pariyojana (including 6,758 km length of residual NHDP with a total capital cost of Rs. 1,51,991 crore).

Out of the total approved 26,425 km, EPC, HAM and BOT models account for 56%, 42% and 2% respectively.

Table 30: Appraisal and Award-Mode (till 31.12.2024)

Mode of Implementation	Length (km)	Awarded Total Capital Cost (Cr.)	Length (%)
EPC	14,748	4,06,024	55.81%
HAM	11,269	4,36,522	42.65%
BOT Toll	408	11,111	1.54%
Grand Total	**26,425**	**8,53,657**	**100%**

Source: MORTH, CareEdge Research

Note: The above total includes residual NHPD figures

Table 31: Bharatmala (Phase- I)

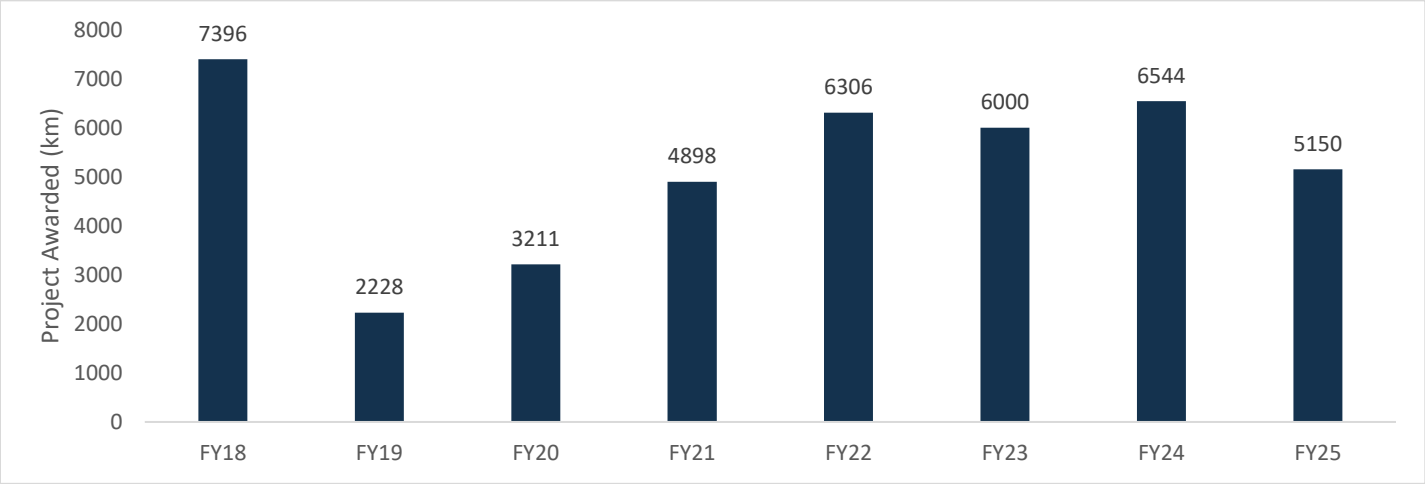
Components/ Scheme	Total Length in Km
Economic Corridors	8,737
Inter Corridors & Feeder Roads	2,889
National Corridor Efficiency Improvement	824
Border & International Road Connectivity	1,619
Coastal & Port Connectivity Roads	425
Expressways	2,422
Subtotal	**16,916**
Balance Road works under NHDP	6,758
Total	**23,674**

Source: MORTH, CareEdge Research

6.9. Review and Outlook on investments in national highways

The length of projects awarded by the National Highways Authority of India (NHAI) has increased over time, going from just 2,222 km in FY19 to 6,306 km in FY22. Even amidst the disruptions caused by the COVID-19 pandemic, FY21 saw a remarkable upswing, with the NHAI awarding 4,818 km of highway projects – the highest in three years at that time.

Chart 28: Projects Awarded by NHAI

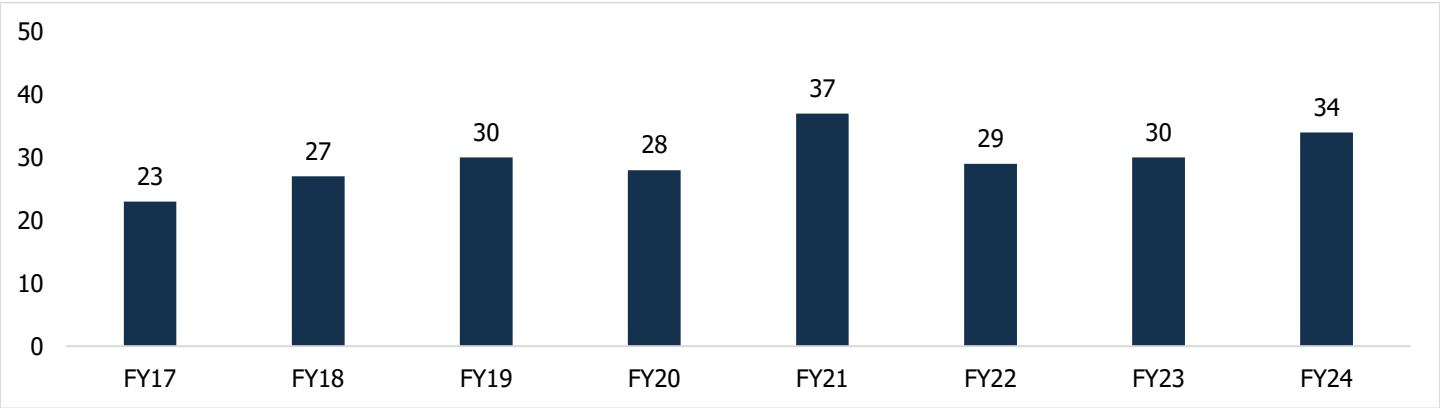


Source: NHAI Annual Reports, CareEdge Research

The NHAI awarded 6,306 km in FY22, demonstrating the increasing trend of awarding, while in FY23 it reached at around 6000 km and the awarding is expected to slow down and reach approx. 5000 km per year up to FY27. Since the cost of essential input materials, such as steel, bitumen, and cement, have been volatile, developers have been delaying the purchase of these supplies, which has prevented construction from moving forward much this year.

Strong execution of projects was witnessed in FY22, albeit lower than in FY21 as it was impacted by the reinforcement of lockdowns and extended monsoons. In FY23, construction activity picked up but was still lower than in FY21 on account of lower awarding activity than in FY22. The national highways project awarding activity witnessed a 21% decline in 11 months of FY25 due land acquisition issues, and execution delays. Road execution could be decline in next fiscal year. The lower execution is on account of lower awarding by the ministry in the past two years However, project execution is expected to continue its momentum in coming years on the back of various government initiatives such as Gati Shakti, Bharatmala Pariyojana, National Infrastructure Pipeline and change in the Model Concession Agreement (MCA) of the Hybrid Annual Model (HAM) of road project implementation.

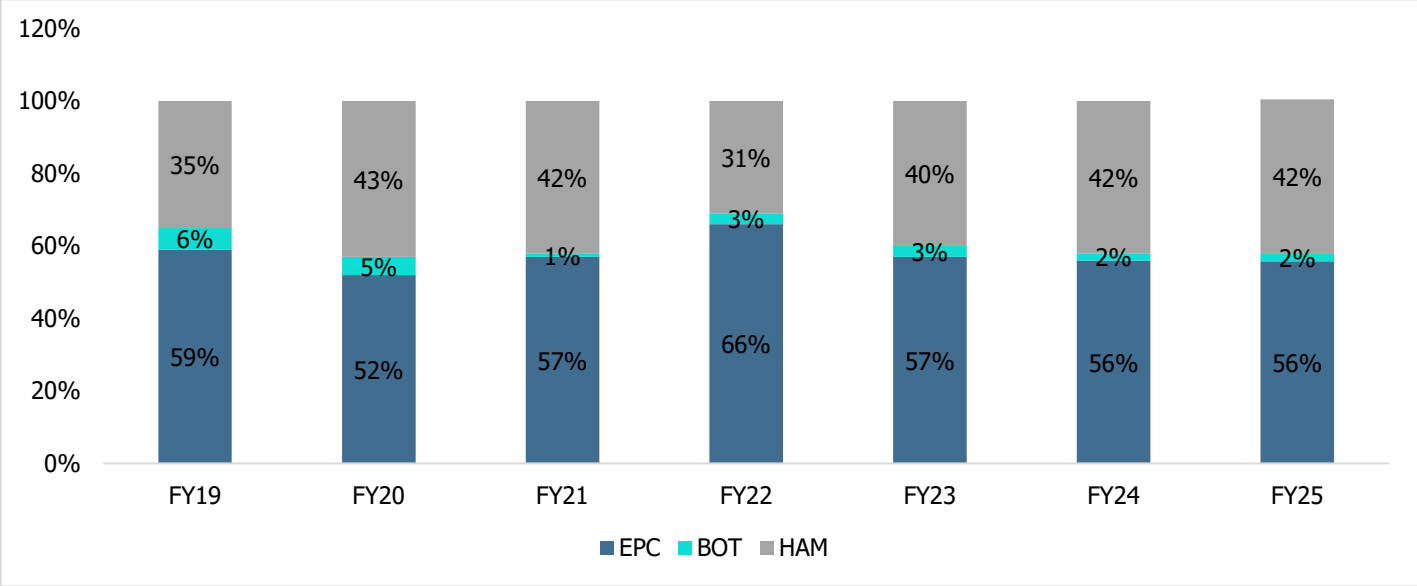
Chart 29: Pace of Construction (Km/Day)



Source: Ministry of Road Transport and Highways of India Annual Reports & CareEdge Research

According to Ministry of Road Transport & Highways, out of the total length approved, an aggregate length of 14,748 km has been approved on EPC mode, an aggregate length of 11,269km on HAM mode and an aggregate length of 408 km on BOT mode as on 31st December 2024.

Chart 30: Breakup of Capex Mix of NHAI



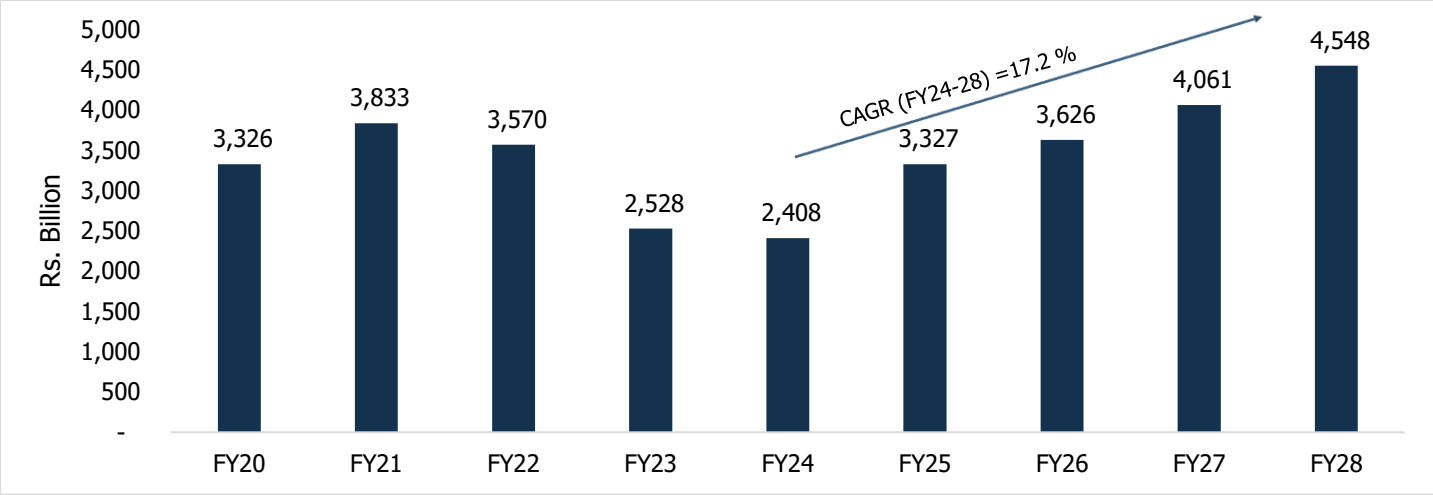
Source: NHAI Annual Reports, CareEdge Research

- **Hybrid Annuity Model (HAM) facilitates Private Participation in Highway Construction**

The awarding of national highway (NH) projects has experienced a slowdown, primarily due to reduced participation from private sector players. However, the government's increased emphasis on the Engineering, Procurement and Construction (EPC) and Hybrid Annuity Model (HAM) frameworks has helped revitalise project allocation. As a result, the pace of NH project awards witnessed a robust compound annual growth rate (CAGR) of 11.41% up to FY23 over the past four years (refer to the chart below).

Investments in the road sector are projected to grow at a CAGR of approximately 10–12% during the period FY25 to FY28. According to CareEdge Research, investments amounting to Rs. 18 trillion are anticipated between FY24 and FY28, primarily directed towards the development of national highways. Over this period, investment in national highways alone is expected to grow at a CAGR of around 17%.

Chart 31: Investments in Roads sector

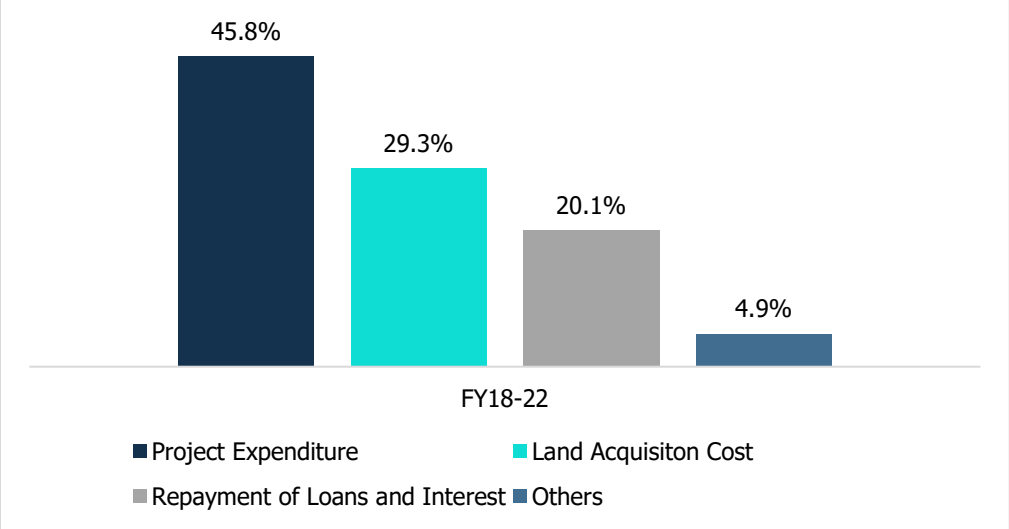


Source: Niti Aayog report on National Infrastructure Pipeline, CareEdge Research

6.10. Review and Outlook of NHAI funding

NHAI had an expenditure of Rs. 5.77 lakh crore from FY18 to FY22, wherein Projects expenditure stood at highest spending at 45.8% followed by Land Acquisition cost at 29.3% and 20.1% to Repayment of Loans and Interest Payment.

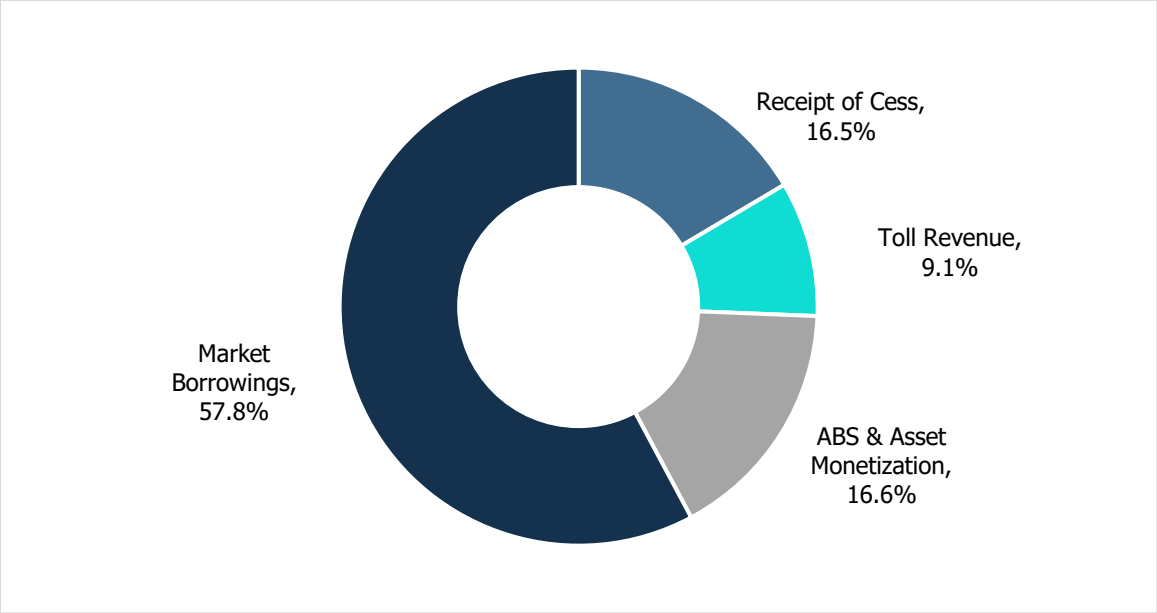
Chart 32: NHAI Application of Funds from FY18-FY22



Source: NHAI Annual Reports, CareEdge Research

NHAI source of funds has been Rs. 5.77 lakh crore from FY18 to FY22. The source of funds has been majorly supported by raising debt which contributes 57.8% of total sources of funds. The rest 42.8% has been sourced from Receipt of cess, Toll revenue, Additional budgetary support and Asset monetarisation at 16.5%, 9.1% and 16.6% respectively in the same period. The growing debt is in line with government's ambitious target of roads development.

Chart 33: NHAI Sources of Funds from FY18-FY22

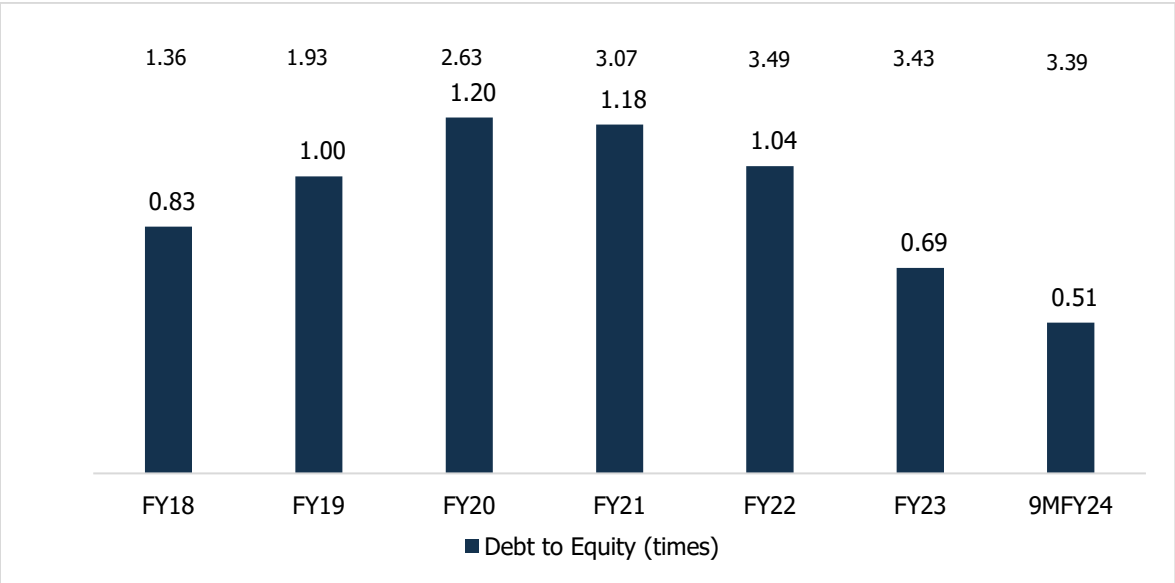


Source: NHAI Annual Reports, CareEdge Research
ABS: Additional Budgetary Support

With the growing focus on Roadways the market borrowings have been on a rise which peaked in FY20 and FY21. The debt has been increased from Rs. 1.4 lakh crore in FY18 to 3.4 lakh crore in 9MFY24. The borrowings were highest in FY22 at 3.5 lakh crore. The decline in Debt-to-Equity Ratio has been supported by government's capital infusion which has increased from Rs. 1.6 lakh crore in FY18 to Rs. 6.7 lakh crore in 9MFY24. Debt to Equity ratio has been consistently declining after FY21.

In light of high debt levels, NHAI is now focussing on reviving BOT model through recent amendments in the model concession agreement to encourage private sector participation in road development.

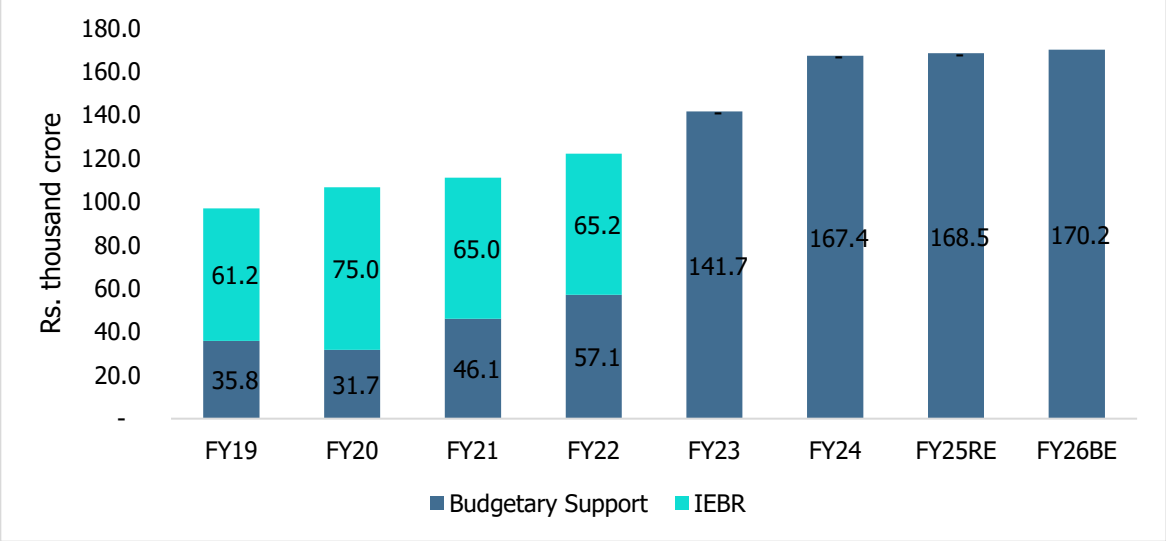
Chart 34: NHAI Borrowings



Source: NHAI Annual Reports, CareEdge Research
Note: The above figures are of Debt of NHAI in lakh crore

Government's increasing focus and budgetary support to NHAI has been rising since FY19. In FY26, Rs. 170.2thousand crores are expected budgeted support to NHAI.

Chart 35: Budgetary Support to NHAI



Source: Union Budget, CareEdge Research

The government is raising funds through the National Highways Infra Trust (NHAI InvIT), an infrastructure investment trust sponsored by the National Highway Authority of India (NHAI), to support the Government of India's National Monetization Pipeline. In its maiden round, NHAI InvIT raised Rs 8,011 crore with an initial portfolio of five operating toll roads. In the second round, NHAI InvIT secured over Rs 8,000 crore from high-quality foreign and Indian institutional investors. For InvIT Round-3, NHAI is monetizing national highway stretches totalling 889 kilometres with an enterprise value exceeding Rs 16,000 crore, marking the largest monetization by NHAI and one of the largest transactions in the history of Indian road sector.

Chart 36: NHAI Raising funds through TOT and InvITs

Asset Alloted Under TOT

- TOT 1 Macquarie Rs 9,681.5 crore
- TOT 3 Cube Highways Rs 5,011 crore
- TOT 5 Adani, DP Jain & Co Rs. 2,262 crore
- TOT 7 CDPQ Rs 6,267 crore
- TOT 9- NIIF Rs 3,144 crore
- TOT 11 Cube Highways Rs 2,156 crore
- TOT 12 IRB Infra Rs 4,428 crore
- TOT 13 IRB Infra Rs 1,683 crore
- TOT 14 Cube Highways Rs 7,701 crore
- TOT 16 Higway Infrastructure 6,661

Scrapped

- TOT 2 IECV Rs 5,362 crore
- TOT 4 IECV Rs 2,165 crore
- TOT 6
- TOT 8
- TOT 10

InvITs

- Rs. 17,738 crore rasied via InvITs in FY25
- NHAI InvITs rasied over Rs. 16,000 crore for 889 Km highway

Source: CareEdge Research

6.11. Key Growth Drivers for toll traffic at National Highways

- Infrastructure Development: The development of new roads, highways, bridges, and expressways increases connectivity between cities and regions, encouraging more vehicles to use toll roads as they offer better quality and faster travel compared to alternative routes.
- Economic Growth and Trade: National highways play a critical role in facilitating the movement of goods and people across the country. As India's economy expands and trade activity intensifies, the demand for efficient transportation solutions rises, leading to increased traffic volumes on national highways. These highways connect key industrial and commercial centres, ports, and economic zones. With the growth of industrial and commercial operations, there is a corresponding rise in the transportation of raw materials, finished products, and workforce, thereby increasing toll traffic on these routes.
- Government Policies and Investments: Government policies aimed at promoting infrastructure development, including highways, stimulate investment in road construction and maintenance. Public-private partnership (PPP) models for highway development and toll operation incentivize private sector participation, leading to the expansion of toll roads and increased toll traffic.
- Technological Advancements: The introduction of electronic toll collection (ETC) systems such as FASTag has enhanced toll collection efficiency, minimised congestion at toll plazas, and improved the overall travel experience for motorists. The convenience and time savings offered by electronic toll payments have encouraged more drivers to utilise national highways, thereby increasing toll road usage.
- Improved Connectivity and pick-up in tourism: Toll roads often offer better connectivity between major cities, tourist hubs, ports, and religious places. This enhanced connectivity attracts more traffic as businesses and individuals opt for faster and safer transportation options. National highways are often preferred for their better road quality, safety features, and faster travel times compared to state or district roads.

These factors collectively drive the growth of toll traffic at nation highways in India, making toll roads an essential component of the country's transportation infrastructure.

6.12. Competition Profile

Dilip Buildcon

Dilip Buildcon Limited (DBL) listed on Bombay Stock Exchange is infrastructure development company India. Dilip Buildcon undertakes road construction under EPC and HAM. The company primarily engages in the construction of roads, highways, bridges, irrigation projects, and mining infrastructure. It operates across various states in India and has executed projects for both government and private clients. The company has a presence across 19 states and 1 Union Territory and till date has executed over 100 EPC projects. As of fiscal 2025, it had Rs 113 billion in revenue and an order book to sales ratio of 1.3x.

KNR Constructions

Listed on the Bombay Stock Exchange and the National Stock Exchange. The company specializes in providing engineering, procurement, and construction (EPC) services, primarily focusing on the roads and highways, irrigation and urban water infrastructure management. Its order book is dominated by road projects (50.69%), followed by irrigation. The company is an established player in the south, especially in Andhra Pradesh, Karnataka, Kerala, Telangana, and Tamil Nadu. As of FY25, it had revenue of Rs 47 billion and an order book to sales ratio was 1.1x.

PNC Infratech

PNC Infratech Limited is a listed public limited Indian infrastructure investment, development, construction, operation, and management company. The company specializes in areas such as expressways, highways, bridges, flyovers, airport runways, water supply, industrial area development, and other related activities. It has expertise EPC projects in roads and highways. As of FY25, it had revenue of Rs 55 billion and an order book to sales ratio was 3.2x.

Ashok Buildcon

Ashoka Buildcon Limited established in 1993 the company is primarily involved in the construction of roads, highways, bridges, and other infrastructure projects. It operates across various states in India and has executed projects for both government and private clients. It develops and builds infrastructure facilities on design, build, finance, operate and transfer (DBFOT) basis in the highways sector, and on EPC basis in the highways and power sectors. As of FY25, it had revenue of Rs 100 billion and an order book to sales ratio was 1.5x.

Adani Enterprise

Adani Enterprises entered the business of road and highway construction in January 2018 and has bagged a portfolio of more than 5,000 lane km spread over 10 states. Adani Enterprises has a balanced portfolio of 14 projects comprising a mix of eight HAM projects, five BOT projects and one TOT project.

7. Water Industry

7.1. Overview of Wastewater Treatment Market

India is the world's most populous country with 1.43 billion people. Out of this, 64% of the population lives in rural areas and 36% are connected to the urban centres according to United Nations (2023). The metropolitan cities of the country are seeing major expansion because of economic expansions and reforms. This expansion in urban population is unsustainable without efficient planning of cities and provision of utility services especially clean and affordable water.

India has a challenge of serving 18% of the world population with 4% of the world's freshwater resources. Currently, India stores less than one-tenth of the annual rainfall and is designated to be a water stressed nation. Disproportionate use of water for agricultural use, excessive ground water pumping and deficient monsoon in the last couple of years make the demand-supply balance more critical.

It is expected that about 1,450 cubic kilometres of water will be required by 2050, of which ~75% will be used in agriculture, ~7% for drinking water, ~4% in industries, ~9% for energy generation and remaining by other industries. However, because of growing urbanization, the need for drinking water will take precedence over rural water requirements. Many cities are situated close to the riverbanks from where the fresh water is consumed and the waste water is disposed back into the river, thus causing contamination of the water source and irrigation water. This has raised serious challenges for urban wastewater management, planning and treatment.

According to the Central Pollution Control Board (CPCB), the estimated wastewater generation was almost 39,600 Million litres per day (MLD) in rural regions, while its estimated to be 72,368 MLD in urban regions for the year 2020-21. The estimated wastewater generation volume in the urban cities is almost double as compared to the rural regions because of the availability of more water for sanitation which has improved the standard of living.

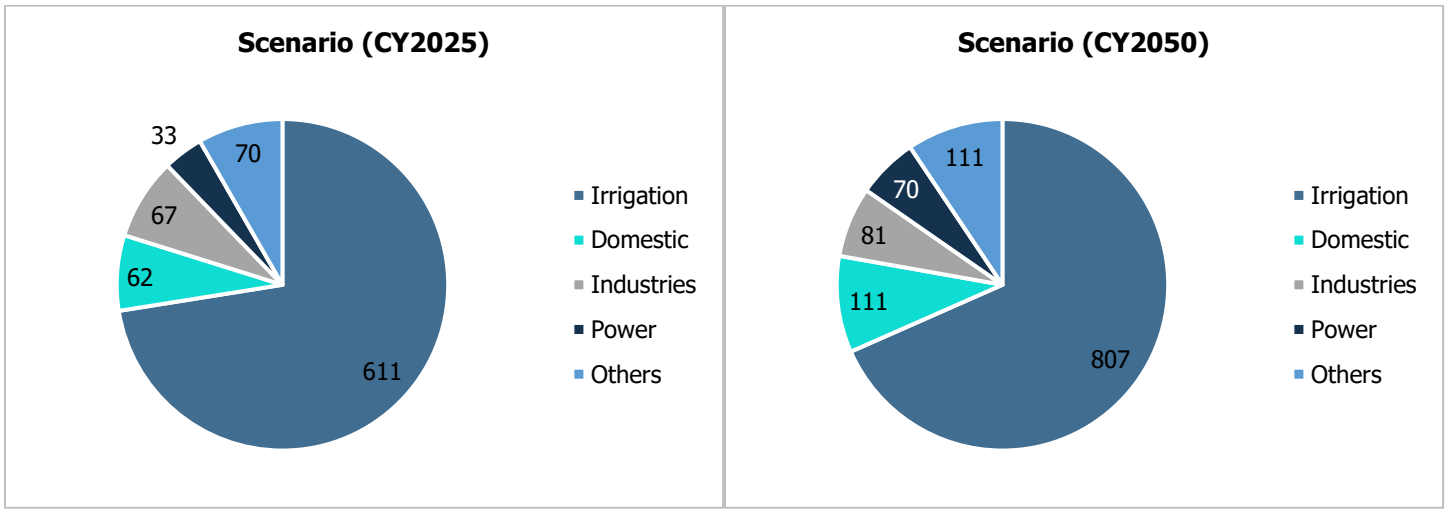
Water supply management

With increasing population in India, the need for water and its management is ever increasing. Water availability is projected to become a major concern in the future. In addition to that, the damage to water resources done by pollution is yet another concern. Releasing industrial waste, discharge of untreated or partly treated municipal wastewater through drains, discharge of industrial effluent, improper solid waste management, illegal ground water abstraction, encroachments in flood plains/ river banks, deforestation, improper water shade management and non-maintenance of e-flows and agriculture run off etc. are some of the major reasons for pollution of water bodies.

The Government of India (GoI) has come up with various schemes that emphasizes on water conservation and restoration. As a result, the number of polluted river stretches has reduced from 351 in 2018 to 311 in CY2022 and improvement in water quality has been observed in 180 out of 351 Polluted River Stretches (PRS) during the year 2018. As per a report by Ministry of Jal Shakti, assessment of water quality over the years discloses that in the year CY2015, 70% of rivers monitored were identified as polluted, whereas in the year CY2022 only 46% of rivers monitored are identified as polluted.

Market size for water requirement for different uses (in Billion Cubic Meters) in coming years:

Chart 37: Global: Market Size



Source: CareEdge Research

Providing clean drinking water is the main focus of the Government. Over the years, the drinking water quality has become a major concern in the rural areas.

Central Water Commission (CWC) periodically assesses country's overall water resources, and it has accorded water supply for drinking purpose as the topmost priority under water allocation.

To address the present and future food and water security concerns, the GoI has been implementing various schemes with focus on the following priority areas:

- Improving the overall water efficiency in irrigation and drinking water supply system
- Adoption of piped distribution system in place of open canal system to reduce the conveyance water loss
- Command area development by implementing more micro irrigation system and participatory irrigation management
- Dam safety, dam rehabilitation and performance improvement
- Repair, renovation and restoration of existing water bodies for irrigation, drinking water supply, cultural activities, etc.
- Improving the rural drinking water supply system and sanitation

Urban Waste Generation and Treatment

In India, the sewage generation in the urban region was 72,368 Million Litres per Day (MLD) for the year 2020-21, while the installed sewage treatment capacity is 31,841 MLD. The operational capacity is 26,869 MLD, which is very low than the load generation.

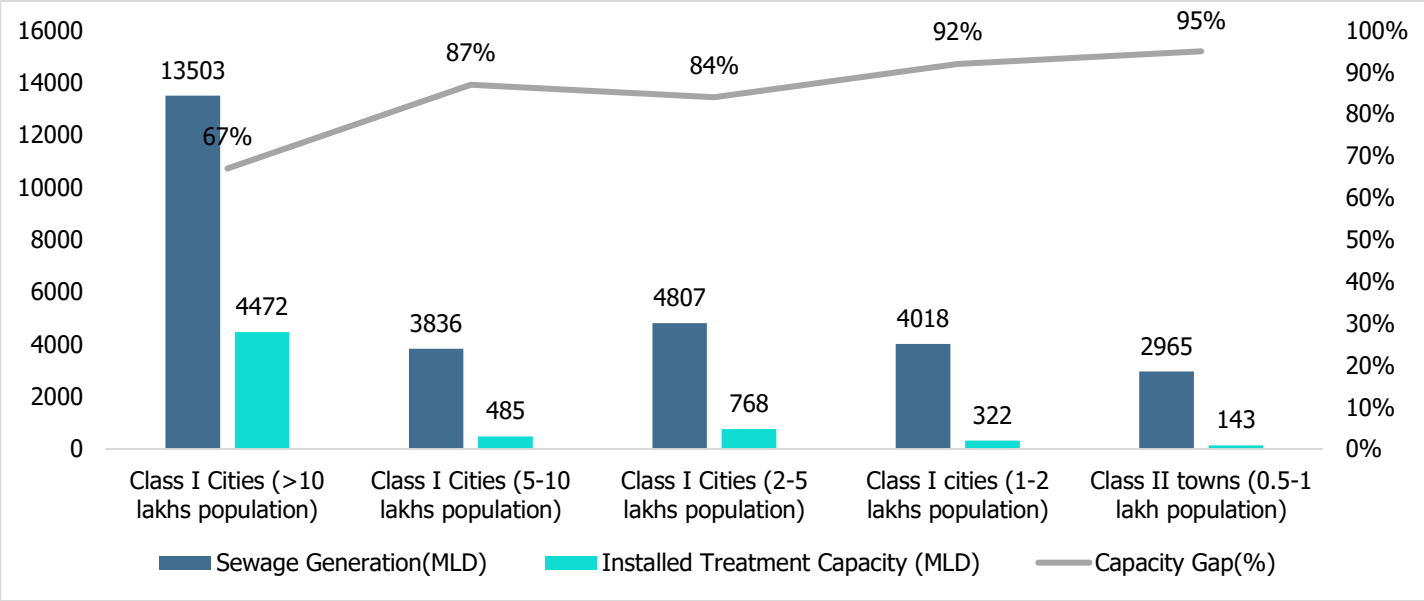
As of March 2025, according to the Ministry of Housing & Urban Affairs, a total of 11,186 MLD sewage treatment capacity has been created or approved under AMRUT and AMRUT 2.0, including 3,530 MLD for recycle and reuse.

As per a Niti Aayog report, as of August 2022, of the total sewage generation only 28% i.e. 20,236 MLD was treated which implies that 72% of the wastewater is left untreated and is disposed in the various water bodies like river, lakes or underground water.

Additionally, as per the CPCB (2021) in the city-scale assessments, the wastewater generation from Class I cities and Class II towns (as per the 2001 census) is estimated as 29,129 MLD, and under the assumption of a 30% decadal increase in urban population, it is expected to be 33,212 MLD at the current time.

Key performance Indicator for the water sewage sector:

Chart 38: Sewage generation and treatment capacities (MLD)



Source- Central Pollution Control Board, 2022

Note- Performance of 115 sewage treatment plants studied by Central Pollution Control Board

7.2. Key Trends & Drivers

- **Increase in schemes introduced by Government:** In recent times, there has been an increased number of schemes introduced by the Government towards improving water supply as well as water sewage infrastructure in India. Schemes like Jal Jeevan Mission (JJM), Jal Shakti, Atal Bhujal Yojana have been set up in the last 7 years. In FY25 Budget, the total budget outlay for Jal Jeevan Mission has been enhanced to Rs 67,000 Crore and the Mission stands extended until 2028.
- **Emergence of new sources of water**: Techniques like rain water harvesting, treated waste water are gaining momentum due to growing demand of water.
- **Focus on improving water efficiency:** A new initiative 'Support for Irrigation Modernization Program' to improve water efficiency, increase crop water productivity has been taken up by the Department of Water Resources.
- **Use of technology in water and waste water management**: Use of technology in various sectors is increasing day by day. Similarly, use of technology in water supply and waste water management is expected to increase for data collection, to keep a record of water treatment, sanction disposal and project mapping.
- **Increased private participation:** The participation of the private players who are providing water availability 24x7 is increasing. These players are setting up recycling facilities, sewage treatment plants to support increased supply of water.

Use of technologies and innovative waste water treatments play an important role in improving urban sanitation and enhancing water security. The usage of treated waste water is still an issue in India, despite the known benefits of waste water treatment and information about reuse technologies.

Key drivers for water supply management:

- **Mission on making water available to all**

The focus of the GoI's schemes in the past few years has been to make potable water available to all the households in India. The per capita water availability in India is decreasing with increasing population. As per a NITI Aayog report, India is facing water crisis with around 50% population experiencing high-to-extreme water shortage.

The Government has introduced schemes like 'Jal Jeevan Mission' to execute the mission of providing safe and adequate water to all.

- **Focus on improving water availability**

Based on the study of "Reassessment of Water Availability in India using Space Inputs" (CWC, 2019), the average annual per capita water availability for year 2021 and 2031 has been assessed as 1486 cubic meter and 1367 cubic meter respectively. The Government is coming up with measures to improve availability of water by building and maintaining natural resources of water. Below schemes have been set up by the GoI to tackle the declining availability of water:

- Atal Bhujal Yojana (Atal Jal): Sustainable groundwater management
- Jal Shakti Abhiyan: "Jal Shakti Abhiyan: Catch the Rain" focuses on creating Rainwater Harvesting Structures

The thrust areas for these schemes will be rain water harvesting, rejuvenation of water bodies.

On the other hand, the Department of Water Resources and other schemes aim to ensure maintenance and efficient use of water resources to match the continuously growing demand of water.

- **Rejuvenation of urban water bodies**

Water bodies in urban areas such as lakes, ponds, step-wells, and baolis have traditionally served the function of meeting water requirements of various needs like washing, agriculture or religious/cultural purposes. Surface water bodies and traditional water harvesting structures in numerous cities have either dried up, or disappeared due to encroachment, dumping of garbage, and entry of untreated sewage. These water bodies can store water and recharge ground water if revived thus helping in meeting the increased requirement of water.

Key drivers for waste water treatment:

- **Central Government policies push for waste water treatment and use**

Under the National Sanitation Policy, waste water treatment and reuse of water to enhance alternative water supplies and conservation is promoted. Initiatives like National Lake Conservation Plan, National Wetland Conservation Program are introduced to help identify lakes and wetlands across the country for undertaking conservation, waste water treatment, pollution abatement, education and awareness creation etc.

Central Government has also implemented National River Conservation Plan for abatement of pollution across stretches of various rivers and undertaking conservation plan, sewage systems construction, sewage treatment plant construction, electric crematoria and river front development.

Financial assistance for treatment plants installation are also provided to small scale industries. Apart from this, the Central Government has also issued directions for zero liquid discharge implementation.

- **Development plans to clean River Ganga and improve wastewater treatment and management**

The GoI has launched two flagship programs for cleaning River Ganga i.e., Ganga Action Plan (GAP) (1985) and Namami Gange Programme (2014). The Government has also initiated sectoral plans like Swachh Bharat Mission, AMRUT, Smart City initiatives etc. to improve unsewered and sewer sanitation. Under these initiatives, the State Government, municipal and private sector applicants are given grants and subsidies for the construction of sewage treatment plants and water treatment plants.

- **Agricultural water reuse**

Low quality water is not conventionally used in agricultural production. The two sources of non-conventional water (NCW) are – waste water used for domestic, municipal and industrial and saline water from underground, drainage or surface sources. But many countries are using the NCW sources for agricultural uses as the fresh water sources are limited. The NCW is primarily treated and blended with other water to produce the desired quality and quantity. In India, under Ganga Action Plan - I, the objective was to improve the water quality along with diversion and treatment of domestic sewage and industrial waste. If not properly treated the low-quality irrigation water might cause severe water and soil contamination. To tackle this, India needs water treatment plants with advanced technology and increased volume across the country.

- **Industrial water reuse**

The industrial water can be recycled and reused by processing the waste water. Various methods are used to perform this depending upon the quality of the waste water requirements, space constraints, and budget. Benefit of this, is reduction of fresh water cost and reduction in the water footprint. The operational and sustainability of the industries can also be improved with improved water treatment process and production capacity.

7.3. Risks & Challenges

Water Supply:

- **Regulatory challenges:**

Under water supply management, permits and finance are key elements for setting up the project. Different projects might need different permits along with financial sanctions which follow a regulatory process. The process can become time consuming due to delayed submissions, incomplete information, revised project plans. The unexpected changes could lead to extended timelines and delay the project timelines. Also, receiving funds required for implementation and execution of projects takes time, which leads to project execution delay.

- **Financial challenges:**

When the draft for a water supply project is presented, an estimated cost of the project is presented to the authorities as well. The project cost estimates for water supply project typically get revised as the design gets more specific or the design gets updated due to additions made in the project. Based on the draft design, the authorities sanction the budgeted amount which may get revised due to factors like inflation, change in material cost, economic changes or even inaccurate estimations. These unexpected changes lead to revised project cost which need approval from the authorities again or in some cases the additional construction cost may have to be borne by the construction company assigned.

- **Environmental challenges**

Climate change is affecting the environment in a major way. It is impacting rainfall patterns, causing floods and may also lead to long term decline in naturally available sources like groundwater storage. Groundwater availability is closely linked to food security as it has played a vital role in increasing agricultural production over the years. Groundwater contributes nearly 62% in irrigation, 85% in rural water supply and 50% in urban water supply. Even though Groundwater is replenishable but its availability is non-uniform as it is dependent on rainfall. The over exploited groundwater sources are a major challenge as it is a key water supply source for agriculture.

Waste water management:

- **Institutional Challenges**

The Urban Local Bodies (ULBs) are responsible for domestic waste water management and treatment. However, there is a lack of planning capacity and project implementation. According to the audit report of Comptroller and Audit General (CAG 2017), there was a shortage of man power in the municipalities for waste water collection, treatment and revenue collection which affected delivery of citizen services. It also exposed deficiencies in planning, financial management, implementation, and monitoring of various projects. Similarly, the CAG performance audit (2016) in the state of Jharkhand found that none of the sampled ULBs had a sewage network. In the absence of the same, around 175 MLD of untreated waste water is discharged into open drains polluting nearby water bodies.

The current institutional, legal and policy mechanisms for management and treatment of waste water and control of water pollution in the country is not sufficient to address the looming crisis.

- **Economic Challenges**

The gap between the sewage generation and present treatment capacity is very large in all the classes of cities and towns due to increasing population and urbanization in India. It is difficult for smaller cities and towns in finding necessary resources to set water treatment plants considering high capital expenditure and operation and maintenance cost. Community participation in operation and maintenance is suggested to improve the economic viability of Sewage Treatment Plants (STP). Private sector waste water treatment investments are difficult in India due to high capital investments and unpredictable revenue stream.

- **Technical Challenges**

There is an overdependence in India on older technologies for waste water treatment due to its high cost. This results in more repair work and less efficiencies of these plants. These limitations lead to poor performance of the plants and adulteration of sewage and water bodies. The conventional centralized waste water treatment plants are designed to remove only Nitrogen, Biological Oxygen Demand and Phosphorous but with rapid urbanization and changing type of contaminants, technologically advanced plants are needed to be setup to deal with them.

Apart from this the land requirement for STP plants is a big challenge. In urban areas land availability is a big issue due to limited land availability and high cost.

- **Social Challenges**

Social acceptance of treated waste water is a big challenge due to fear and disgust when it comes to reuse. Recycled water is unlikely to be used as drinking water when compared to its use in irrigation etc. The negative attitude towards this has also stemmed from concerns like health risk and aesthetic aspects like colour, odour, taste and cultural and religious background of consumers.

Identifying and obtaining of sites for plant setup is another challenge due to people not preferring to live near these plants. This is because of the reasons like health risks, aesthetic impacts and factors like land depreciation. Solutions like underground plant setup can help eliminate the above stated factors but involves a huge capital expenditure. Also, buffer zones are limited to solid wastes. Conventional systems in India suffers operational costs, management costs, demand of treated water and decentralized systems.

7.4. Government Policies & Regulations

Water supply

- **Jal Jeevan Mission - 'Har Ghar Jal'**

JJM is a Central Government initiative undertaken by Ministry of JAL SHAKTI. It aims to ensure piped water access to every household in India. The initiative was launched on 15th August 2019 by the Prime Minister of India.

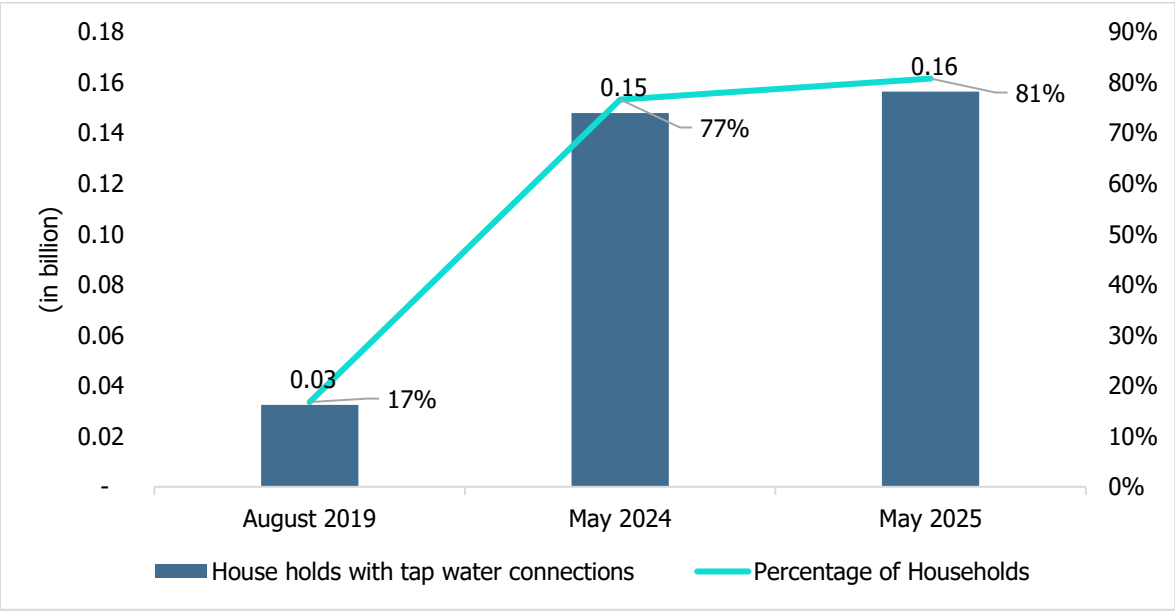
The program is implemented in partnership with States to assure tap water supply in adequate quantity, prescribed quality, adequate pressure, on a regular and long-term basis in all rural households and public institutions, which includes anganwadi, schools, ashramshalas, public/ community health centres, sub-centres, wellness centres, community centres, gram panchayat buildings, etc., by the year 2024.

Under JJM, 30% weightage was assigned for difficult terrains which inter alia include areas under Desert Development Programme (DDP) and Drought Prone Area Programme (DPAP) while allocating the fund, to prioritize the coverage in these areas. Further, provisions have been made in the operational guidelines for planning and implementation of bulk water transfer from long distances and regional water supply schemes for ensuring tap water supply in drought-prone & water-scarce areas/ areas with inadequate rainfall or dependable ground water sources. In addition, provisions have also been made for source recharging, viz. dedicated bore well recharge structures, rain water recharge, rejuvenation of existing water bodies, etc., in convergence with other schemes such as the Mahatma Gandhi National Rural Employment Guarantee Act 2005 (MGNREGA), Integrated Watershed Management Programme (IWMP), 15th Finance Commission tied grants to Rural Local Bodies (RLB)/ Panchayat Raj Institutions (PRI), State schemes, Corporate Social Responsibility funds, etc.

For villages in water-scarce areas, in order to save the precious fresh water, states are also being encouraged to plan new water supply scheme with dual piped water supply system, i.e. supply of fresh water in one and treated grey/ waste water in another pipe for non-potable/ gardening/ toilet flushing use. Moreover, the households in these areas are to be encouraged to use the faucet aerators that save a significant amount of water, in multiple taps that they may be using inside their house.

Functional Household tap connection under Jal Jeevan Mission:

Chart 39: Number of Households with tap water connection



Source: Jal Jeevan Mission, CareEdge Research

The total number of households in India as on May 2025 were 0.19 billion out of which over 0.16 billion households have received tap water connection as of May 2025.

Funds allocated for Jal Jeevan Mission:

The estimated cost of the mission is Rs. 3,600 Billion. The Central and State have a share of Rs. 2,080 Billion and Rs. 1,520 Billion, respectively of the total cost.

The 15th Finance Commission has identified water supply and sanitation as a national priority and allocated funds of Rs. 2,360 Billion to Rural Local Bodies/Panchayat Raj Institutions (RLBs/PRIs) for the period 2021-22 to 2025-26. Accordingly, 60% of the fund, i.e., Rs. 1,420 Billion provided as Tied Grants are meant to be utilized exclusively for the drinking water, rainwater harvesting and sanitation & maintenance of open-defecation free (ODF) village. This huge investment in rural areas across the country is accelerating economic activities and boosting the rural economy, as well as creating employment opportunities in villages. This is a progressive step to ensure that villages have potable water supply with improved sanitation for transforming the villages into 'Water Sanitation and Hygiene (WASH) enlightened ' villages.

In FY25, the GoI has released Rs. 218.25 Billion to 25 eligible States for the implementation of JJM. In FY25 Budget, the total budget outlay for Jal Jeevan Mission has been enhanced to Rs 670 Billion and the Mission stands extended until 2028.

The Central funds are released by the GoI based on the utilization of available Central funds and matching State share. For online monitoring, Integrated Management Information System (IMIS) and JJM–Dashboard have been put in place. Provision has also been made for transparent online financial management through Public Financial Management System (PFMS).

The details of Central funds allocated, funds drawn, and funds utilization reported in the year FY20, FY21, FY22, FY23, FY24 and FY25 under JJM is as below:

Table 32: Fund allocation for Jal Jeevan Mission: (in Rs. Billion)

Year	Opening balance	Funds allocated
FY20	24.36	111.39
FY21	64.47	230.33
FY22	48.25	923.08
FY23	195.10	1,007.89
FY24	235.89	1,329.36
FY25	112.12	699.26

Source: Department of Drinking Water and Sanitation

Status of tap water connections provided under JJM:

Households:

Table 33: State/UTs with 100% tap water connection (in Million):

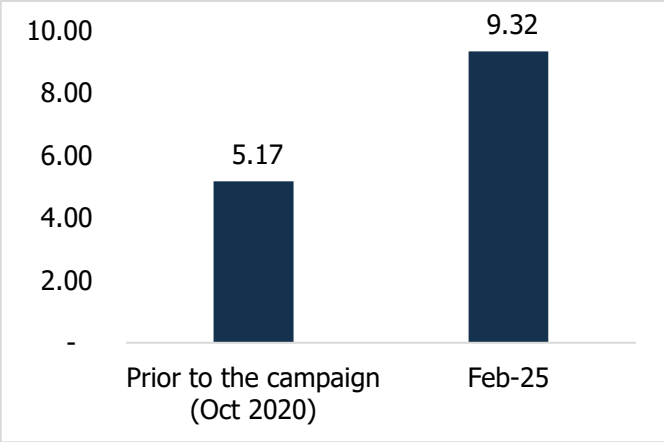
State/UT	Total Households	Households with Tap water supply	Households with Tap water supply %
Goa	0.26	0.26	100%
A&N Islands	0.06	0.06	100%
D&NH and D&D	0.09	0.09	100%
Haryana	3.04	3.04	100%
Telangana	5.40	5.40	100%
Puducherry	0.11	0.11	100%
Gujarat	9.12	9.12	100%

State/UT	Total Households	Households with Tap water supply	Households with Tap water supply %
Punjab	3.43	3.43	100%
Himachal Pradesh	1.71	1.71	100%
Arunachal Pradesh	0.23	0.23	100%
Mizoram	0.13	0.13	100%

Source: Jal Jeevan Mission, CareEdge Research

Schools:

Chart 40: Schools provided with tap water supply



Source: Jal Jeevan Mission, CareEdge Research

Table 34: Schools with 100% water supply:

State/UT	Total schools	Schools with tap water supply	Schools with tap water supply (%)
Andaman & Nicobar Islands	368	368	100%
Andhra Pradesh	41,227	41,227	100%
Dadra & Nagar Haveli and Daman & Diu	411	411	100%
Goa	1090	1090	100%
Haryana	12818	12818	100%
Himachal Pradesh	17251	17251	100%
Kerala	10877	10877	100%
Lakshadweep	33	33	100%
Mizoram	2371	2371	100%
Puducherry	390	390	100%
Sikkim	1027	1027	100%
Uttarakhand	19123	19123	100%

Source: Jal Jeevan Mission, CareEdge Research

- **Atal Bhujal Yojana**

Atal Bhujal Yojana was launched in 2019 to undertake community-led sustainable ground water management of the stressed areas identified. It was launched to strengthen institutional framework and monitoring ground water data and improve planning and implementation of the water management interventions.

It is a Scheme of the GOI aided by the World Bank with an outlay of Rs. 60 Billion. and is implemented to focus on community participation and sustain ground water level in identified water stressed areas during five-year duration. The

schemes currently are taken up in seven states of Haryana, Gujarat, Karnataka, Madhya Pradesh, Maharashtra, Rajasthan and Uttar Pradesh.

It is the world's largest community-led ground water management program which is helping villagers understand the water availability and usage pattern in their areas.

Atal Bhujal Yojana received the Central Board of Irrigation and Power Award 2024 for "Optimum and Efficient Utilization of Water Resources – Irrigation Sector" on March 21, 2025. The scheme has promoted water-efficient farming across 6.7 lakh hectares in seven water-stressed states. Key practices include drip and sprinkler irrigation, Direct Seeding of Rice (DSR), mulching, protected cultivation, laser land levelling, rainfed horticulture, and cultivation of water-smart crops like millets, pulses, and oilseeds.

- **Jal Sakti Abhiyan (JSA)**

Jal Sakti Abhiyan - I was launched in the year 2019 in the stressed districts of the country to promote conservation of water, water resource management, implementing rain water harvesting, renovation of traditional water bodies, reuse of water, recharging water body structures, watershed development and afforestation. The actual expenditure from MGNREGS fund was Rs. 180.66 Billion.
JSA is expanded to 'Jal Sakti Abhiyan: Catch the Rain' to cover all the blocks of the districts across the country to focus on –

1) Rainwater harvesting & water conservation
2) Enumerating, geo tagging & making inventory of all water bodies
3) Setting up Jal Shakti Kendras
4) Afforestation
5) Generation of awareness

The progress of the Jal Shakti Abhiyan: Catch the Rain campaign of 2022 as uploaded on the portal from 29.3.2022 to 31.01.2023 are as follows: -

- Water Conservation & Rainwater Harvesting Structures: 1.19 Million
- Renovation of Traditional Water Bodies: 0.26 Million
- Reuse and Recharge Structures: 0.85 Million
- Watershed Development: 1.58 Million
- Intensive Afforestation: 783.79 Million
- and Training Programmes/ Kisan Melas: 0.05 Million

The above details include completed as well as ongoing works. Actual expenditure from MGNREGS fund was Rs. 226.66 Billion. States/UTs have also been directed to utilize their own resources.

- **Water Vision@2047**

'Water Vision@2047' conference was held in Bhopal on 6th January,2023 under the Ministry of Jal Sakti. In this conference different ways of increasing water availability and efficient utilization of water resources and their development was discussed. Challenges of water conservation, increasing population, climate change, rapid industrialization and urbanisation, and economic boom which will lead to increase in demand of water were discussed. It was also stated that the harvestable component of water resources is to be surpassed and planning is to be done towards 2047 to achieve the water conservation goals were discussed. Water quality was also discussed and the vision was set to creating over 2,000 water quality testing laboratories, training 4 lakh women for using Field Testing Kits to testing water using Internet of Things based on sensor.

Building on the outcomes of the Bhopal conference, the Second State Water Ministers Conference was held in Udaipur on February 18–19, 2025. Aligned with the theme "India@2047 – A Water Secure Nation", the conference focused on actionable steps for sustainable water management. Key discussions included water governance, use efficiency, community participation, and sectoral coordination, with an emphasis on six core themes central to achieving the Water Vision@2047.

- **Atal Mission for Rejuvenation and Urban Transformation (AMRUT)**

The Atal Mission for Rejuvenation and Urban Transformation was launched in June 2015 under GoI. It is the first focused national water mission and was launched in 500 cities and covers 60% of the urban population. In the financial outlay 2025-26, the allocation to AMRUT has been Rs. 100 Billion.

The program focuses on basic urban infrastructure in water supply system and access to potable water for every household.

Universal coverage of water supply is the priority under the Mission, under which 2.28 Million tap connections have been provided. The total plan size of all State Annual Action Plan (SAAPs) was Rs. 776.40 Billion. out of which Rs. 390.11 Billion i.e. 50% has been allocated to water supply.

Waste water management:

- **Jawaharlal Nehru National Urban Renewal Mission**

This scheme was launched in December 2005 and is the largest national urban initiative to encourage reforms and fast track planned development of 63 identified cities. The focus is improving efficiencies of the urban infrastructure and services. It consists of two sub-missions - Urban Infrastructure & Governance and Basic Services to the Urban Poor.

It focuses on many aspects of urbanization like redevelopment, water supply, sewage and solid waste management, urban transport including roads, high ways, metro projects, parking lots, heritage area development, prevention of soil erosion, preservation of water bodies etc.

- **Atal Mission for Rejuvenation and Urban Transformation (AMRUT)**

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Under the program, 883 sewerage & septage management projects which amounts to Rs. 340.81 Billion. have been taken up out of which 370 projects costing Rs. 82.58 Billion. have been completed till date. In the financial outlay 2025-26, the allocation to AMRUT has been Rs. 100 Billion.

Namami Gange programme

It is an integrated Conservation Mission approved as 'Flagship Programme' by the Union Government in June 2014 with budget outlay of Rs. 200 Billion, for five years, up to March 2021 and has been further extended to March 2026 with a budgetary outlay of Rs. 225 Billion.

The Programme has main objectives of Sewerage Treatment Infrastructure, River Surface Cleaning, Afforestation, Industrial Effluent Monitoring, etc. For conservation of rivers, the Ministry of Jal Sakti has been supplementing efforts with the states and Union Territories by providing financial and technical assistance for abatement of pollution under the programme. The National River Conservation Plan has so far covered polluted stretches of 34 rivers across 77 towns and sanctioned cost of Rs. 59.61 Billion. and created a sewage treatment capacity of 2,677 Million litres per day.

Under the Namami Gange programme, so far, a total of 492 projects have been launched. Among these, 307 projects have reached completion and are now operational. 206 sewage treatment projects of Rs. 330 Billion has been sanctioned. Of these, 127 sewerage projects have been completed.

- **Swachh Bharat Mission (Urban & Grameen)**

Swachh Bharat Mission (SBM) (Urban) was launched by GoI with the vision of ensuring hygiene, waste management and sanitation across the country in 2019. The SBM (Urban) was implemented under the Ministry of Housing and Urban Affairs.

The key focus area under this is eliminating open defecation, eradication of manual scavenging by converting insanitary toilets to sanitary, solid waste manager, behavioural change, general sanitation awareness etc.

Under Swachh Bharat Mission (Urban) 2.0 launched on October, 2021 an amount of Rs. 158.83 Billion. has been allocated to states and union territories for waste water management including setup of sewage treatment plants and faecal sludge treatment plants.

Under Phase-I of Swachh Bharat Mission (Grameen), over 10 crore Individual Household Latrines (IHHLs) were built, and all villages declared themselves Open Defecation Free (ODF) by 2nd October 2019. Phase-II, implemented from 2020-21 to 2025-26, focuses on sustaining ODF status and ensuring comprehensive solid and liquid waste management in villages to achieve ODF Plus status.

7.5. Other Polices

- **Interlinking of rivers (Eastern Rajasthan Canal Project (ERCP) with the Parbati-Kalisindh-Chambal link)**

National Perspective Plan (NPP) for development of water resources was formulated by the GoI in the year 1980. 30 link projects (16 under Peninsular Component & 14 under Himalayan Component) have been identified under NPP. National Water Development Agency (NWDA) has been entrusted with the work of inter-linking of rivers under NPP.

Looking at the scarce water availability in the State of Rajasthan, the Special Committee for Interlinking of Rivers (SCILR) in its 20th meeting held in December, 2022 in New Delhi has approved the proposal of integration of the Eastern Rajasthan Canal Project (ERCP) with the Parbati-Kalisindh-Chambal link (a link under NPP) and the Modified Parbati-Kalisindh-Chambal (PKC), duly integrated with ERCP, to be a part of NPP of interlinking of rivers in the country. The project envisages mitigating the water needs, particularly the drinking water needs, in 13 districts of Rajasthan and 7 districts of Madhya Pradesh.

- **Namami Gange Mission II approved with a budgetary outlay of Rs. 225 Billion till 2026:**

Namami Gange Programme which was launched in June 2014 for a period up to 31st March, 2021 with the objective to rejuvenate River Ganga and its tributaries with a budgetary outlay of Rs. 200 Billion has been further approved with a budgetary outlay Rs. 220 Billion till 2026 inter alia including projects for existing liabilities (Rs. 112.25 Billion) and new projects/interventions (Rs. 112.75 Billion).

Under the programme, a comprehensive set of interventions such as waste water treatment, solid waste management, river front management (Ghats and crematoria development), e-flow, afforestation, biodiversity conservation and Public Participation etc. have been taken up for rejuvenation of river Ganga and its tributaries. The increased budgetary outlay will help the programme to achieve its goal of waste water treatment significantly.

8. Copper

8.1. Overview

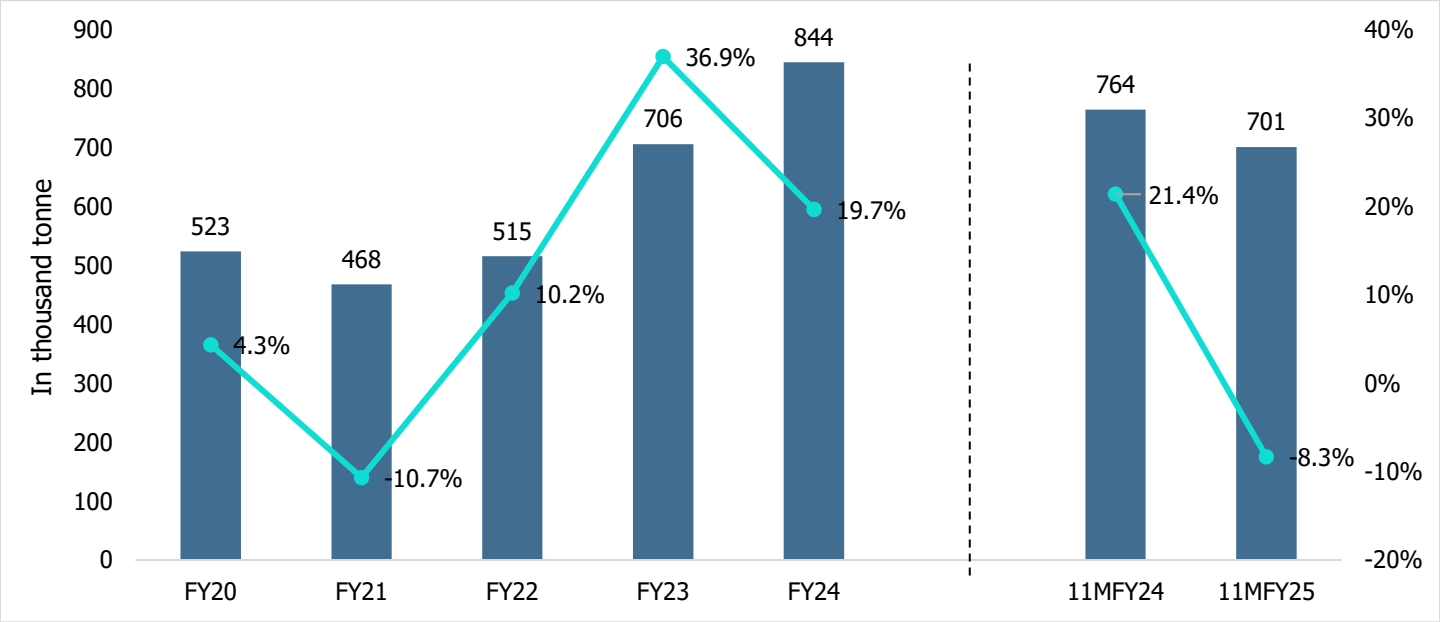
Copper is primarily used in sectors like building and construction, infrastructure, consumer durables, electricals, telecommunications, etc. Additionally, it's application in other sectors including e-mobility (primarily electric vehicles, metros, etc.), renewable energy, and engineering goods. The copper manufacturing process involves various stages, including mining, grinding and crushing, concentration, smelting, and refining.

Copper is then cast into different shapes such as rods, bars, wires, etc. Gold is a by-product obtained from mining and production of copper. Globally, per capita copper consumption was approximately 3.3 kg in 2022, whereas India's per capita consumption is estimated to be around 0.6 kg, with projections indicating an increase to 1 kg in the medium term.

8.2. Review of Domestic Consumption of Refined Copper

Refined copper accounts for a significant portion of domestic copper consumption, meeting a substantial portion of the demand. This refined form is derived through the processes of refining and smelting, which transform copper concentrate into its purified state.

Chart 41: Consumption of Refined Copper



Source: CMIE
Note: 11MFY24 refers to the period between April 2023 – February 2024
11MFY25 refers to the period between April 2024 – February 2025

During 11MFY25, copper demand in India declined year-on-year by 8.3%, primarily due to import restrictions that caused supply shortages. These curbs disrupted the availability of refined copper, significantly affecting downstream industries that rely on stable copper inputs.

In FY24, demand had risen by 19.6%, reaching 844 thousand tonnes. This surge was driven by robust infrastructure development and increased consumption from real estate, consumer durables, and the automobile sector, particularly the growing electric vehicle (EV) segment.

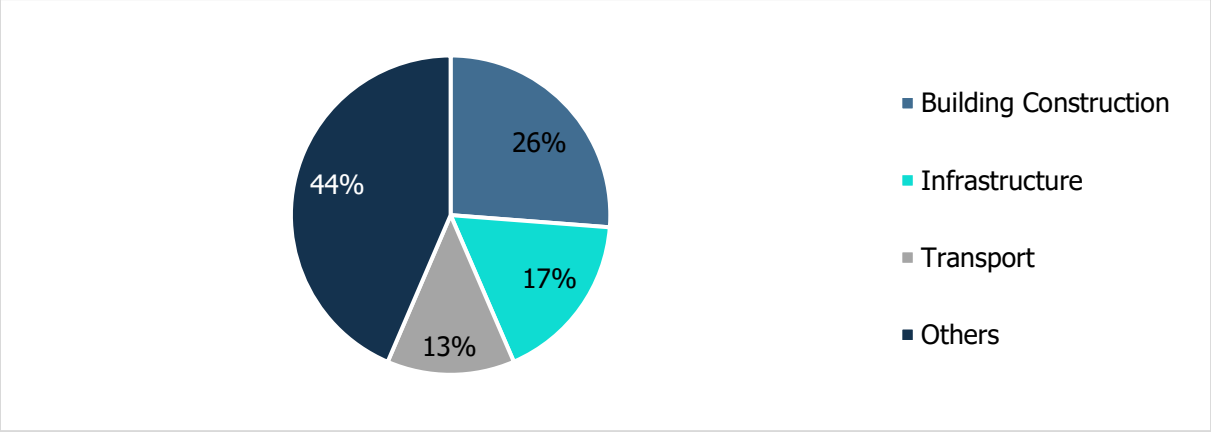
The previous year, FY23, recorded a sharp 36.9% year-on-year growth in copper demand to 706 thousand tonnes. This growth was largely attributed to strong performance in the infrastructure and auto sectors, along with capacity additions in the power sector, especially those driven by renewable energy.

In FY22, copper demand rebounded by 10.2% after a challenging FY21, which saw a 10.7% decline—from 523 to 468 thousand tonnes—due to the COVID-19 pandemic. The nationwide lockdowns and restrictions during that period had severely impacted industrial activities.

Overall, between FY20 and FY24, copper demand in India grew at a CAGR of approximately 12.7%, underpinned by sustained demand from power, consumer durables, and the automobile industries.

8.3. Key End-Use Industries

Chart 42: Share of Global Copper Consumption Across Key End-Use Industries in CY23 (%)



Source: International Wrought Copper Council (IWCC)

i. Building Construction

In recent years, the utilization of copper in building and construction has surged, driven by its exceptional properties and adaptability across various applications. From piping and plumbing to electrical wiring and roofing, copper stands out for its corrosion resistance and durability.

Moreover, copper's integration into structural components showcases its flexibility alongside other materials. This trend aligns with government initiatives aimed at fostering sustainable and resilient urban development, such as Pradhan Mantri Awaas Yojana-Urban (PMAY-Urban). Through schemes like PMAY-Urban, which has seen significant growth, governments strive to address housing challenges while promoting the adoption of innovative and efficient building materials like copper.

ii. Infrastructure

Copper is used in electrical applications, power systems and telecom network. Its high conductivity, endurance, ductility and resistance to corrosion make it useful across a range of applications. Copper remains the preferred material for wiring, ensuring efficient electricity flow with minimal energy loss. In power transmission networks, its conductivity facilitates seamless electricity transfer over long distances.

Copper plays a crucial role in transformers and coils, enabling high-current applications without compromising performance. It is also integral to switchgear, circuit breakers, and busbars, underscoring its significance in ensuring safe and efficient power distribution. Furthermore, copper's characteristics are important in grounding and earthing systems as their properties are critical for protecting equipment and personnel. Looking ahead, copper's presence in power generation

components demonstrates its long-term importance in supporting efficient energy conversion and assuring excellent conductivity.

The usage of copper is significant in telecom network for transmission of voice and data signals as it is used in wiring. Copper wires are also utilized in providing Ethernet services to both businesses and residential areas. Moreover, the growth of the telecommunication is driven by increase in rural penetration and deployment of 5G networks, alongside urban infrastructure development indicating the growing demand for copper.

iii. Transport

Copper is widely used in different components of the transportation industry, including copper motors, tubing, radiators, connectors, brakes, bearings and lithium-ion batteries. It is a key component in EVs, found in electric motors, batteries, inverters, wiring, and charging stations. It clearly indicates a substantial reliance on copper.

Copper is used extensively in the EVs. The conventional vehicles typically use approximately 23 kg of copper. Hybrid electric cars (HEVs) increase the demand to roughly 40 kg, while plug-in hybrid electric vehicles (PHEVs) require around 60 kg. Battery electric vehicles (BEVs) significantly increase the demand for copper, which averages around 83 kg. Moreover, hybrid electric buses (Ebus HEVs) contain around 89 kg of copper. The copper demand peaks with battery-powered electric buses (Ebus BEVs) weighing between 224 and 369 kg, depending on battery size. The demand for EVs is expected to rise on account of advancement in technology advances, affordability and deployment of more electric chargers (each EV charger will add 0.7 kg of copper. Fast chargers can add up to 8 kg of copper each).

Further, copper is not only widely used in automobile sector but also used for high-speed rail networks, railway signalling systems, shipping and marine.

iv. Others

The 'Others' primarily includes industrial transformers & motors, consumer appliances. Copper usage in consumer durables remains strong, driven by its unique properties and flexibility. In electronics, copper serves as a fundamental component due to its exceptional conductivity and thermal characteristics. It is widely used in devices such as smartphones, computers, and televisions, ensuring reliable performance and efficient heat management.

The copper's corrosion resistance and heat transfer efficiency contribute to enhanced functionality and longevity in household appliances such as refrigerators, air conditioners, and washing machines. In the kitchen, copper cookware remains highly sought after for its superior heat conductivity and precise temperature control, catering to both professional chefs and home cooks. Furthermore, its utilization in water heaters, power tools, and lighting fixtures also highlights its significance across diverse consumer sectors.

Precious metals recovered during copper processing, such as gold, silver, and platinum group metals, have potential for usage in jewellery, electronics, and industrial catalysts, contributing to revenue generation and innovation. Sulphur compounds captured during smelting enable the production of sulfuric acid which benefits sectors such as agriculture, chemicals, and metals processing. Additionally, slag from the smelting process finds application in construction, cement production, and other sectors, enhancing infrastructure development and resource utilization efficiency. Furthermore, copper matte, an intermediate product, serves as a precursor to pure copper and copper alloys, essential in electrical, plumbing, and industrial applications worldwide.

8.4. Outlook for Domestic Copper Consumption

Copper is essential for the transition to a low-carbon economy because it plays a critical role in the construction of renewable energy infrastructure and EV components. Additionally, the rising urbanization in the economy will fuel the need for infrastructure development. This includes the construction of buildings, transportation networks, and smart city initiatives which rely heavily on copper for electrical wiring and connectivity.

The consumption of copper in India is expected to continue its upward growth trajectory, given the infrastructure push by the government and rising demand from the automobile and construction sectors. Further, the recent increase of 0.9% in the allocation of Capex (Capital Expenditure) towards infrastructure from Rs. 11.1 lakh crore to Rs. 11.2 lakh crore in Union Budget 2025-26, a capital outlay of Rs. 2.5 lakh crore for Indian Railways and the continued expansion and development of airports under the Ude Desh ka Aam Naagrik (UDAN) scheme to enhance regional air connectivity will boost the copper demand.

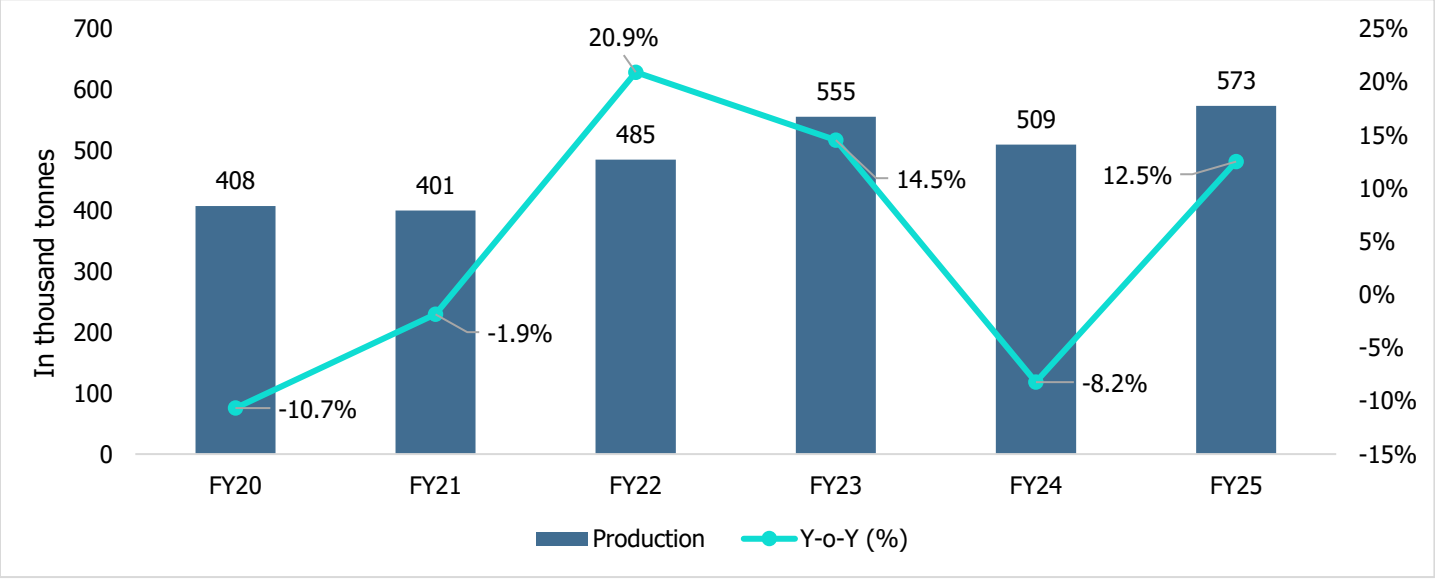
In addition, the demand from e-mobility (electric cars, metro etc.) and renewable power (solar and wind power) have supplemented copper consumption. The production of electric vehicles requires a substantial amount of copper as it is used in batteries, motors, and charging infrastructure.

Moreover, railway electrification and renewable energy projects will drive the demand for copper. Besides, the demand for technological infrastructure (increased usage for wiring in telecom) and energy transition to renewables will also support the demand for copper.

8.5. Review of Domestic Supply of Refined Copper

During FY25, copper production in India increased year-on-year by 12.5%, driven by rising demand from renewable energy, electric vehicles, and infrastructure development. This growth was supported by expanded domestic smelting capacities and favourable government policies aimed at promoting industrial growth.

Chart 43: Production of Refined Copper



Source: CMIE

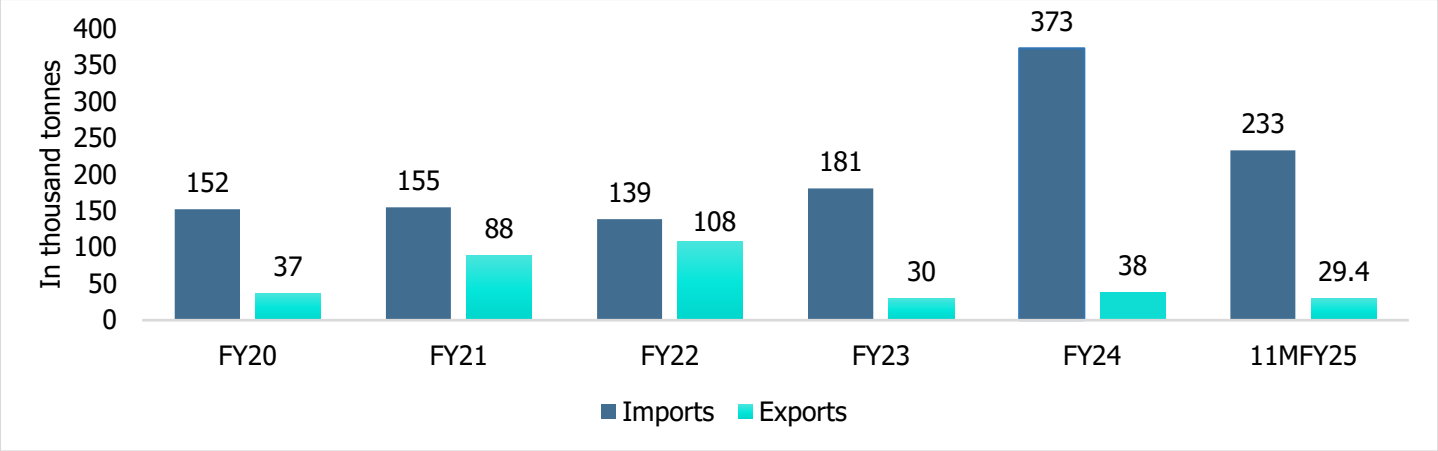
In contrast, FY24 witnessed a decline of about 8.2% in copper production, primarily due to a drop in output from major players like Hindalco Industries and Sterlite Industries. The reduction stemmed from maintenance shutdowns and a shortage of blister in the global market, respectively.

From FY21 to FY23, copper production had shown a steady recovery, registering a compound annual growth rate (CAGR) of 17.7%. This growth was a result of easing lockdown restrictions following the COVID-19 pandemic, which had initially disrupted manufacturing activity and led to lower production levels in FY20 and FY21.

Earlier, the copper supply was significantly impacted by the closure of Sterlite Copper's smelter in Thoothukudi in FY19 due to environmental concerns. This led to a sharp fall in production from 766 thousand tonnes in FY18 to 457 thousand tonnes in FY19, marking a major disruption in domestic supply.

8.6. Refined Copper Trade Assessment

Chart 44: Imports and Exports of Refined Copper

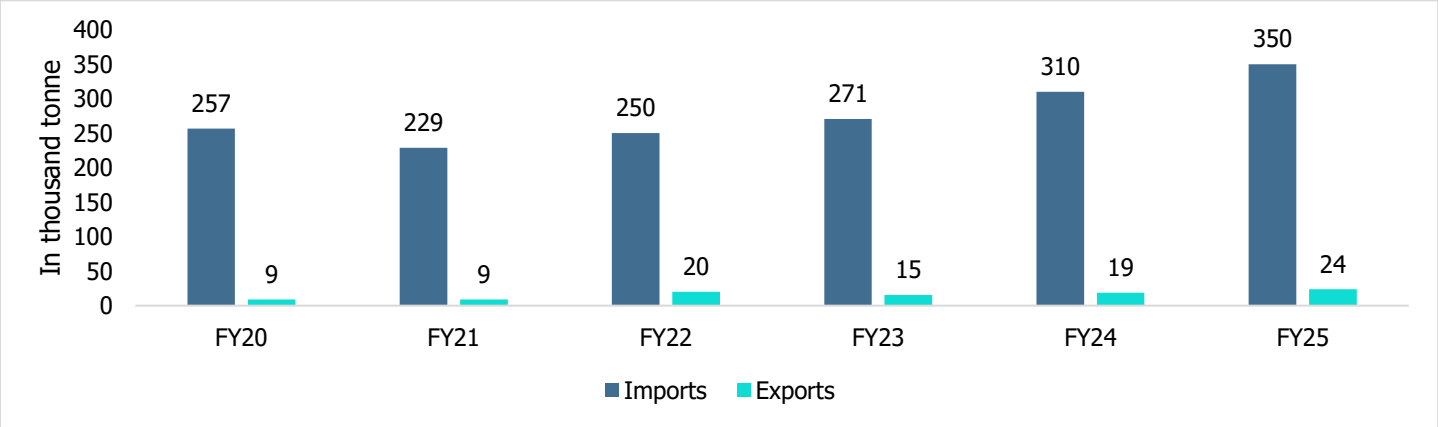


Source: CMIE

8.7. Copper Scrap Trade Assessment

Scrap copper is any piece that is no longer being used for its intended purpose. The recycling process consumes far less energy than mining and producing new copper ore. Copper scrap finds use in wide range of applications due to its outstanding properties and recyclability. It is used in electronic devices, electric wiring, cables, plumbing, heat exchangers, piping, coils, medical equipment and other applications.

Chart 45: Imports and Exports of Copper Scrap



Source: Directorate General of Foreign Trade

Copper scrap is essential for producing secondary copper, leading India to heavily import copper scrap. India remains a net importer of copper scrap, with total imports reaching 350 thousand tonnes in FY25, while exports stood at 24 thousand

tonnes during the same period. The imports of copper scrap have grown by a CAGR of around 6.4% during the period FY20 to FY25. The demand for copper scrap has been on the rise over the years due to advancements in construction, transportation, and consumer durables.

8.8. Risk and Challenges for Domestic Copper Industry

- **Low grade concentrates:** India has low grade concentrates of domestic copper and mainly imports from Chile, Australia and Indonesia. The industry is highly dependent on imported raw materials and any issues such as trade regulations, delay in shipping and geo-political tension may cause disruption in supply chain.
- **High energy costs:** Energy is a cost factor in aluminium production and fluctuations in energy prices, particularly coal, directly impact manufacturing costs. Volatility or supply disruptions can therefore influence market competitiveness and overall industry stability.
- **Foreign exchange rates:** Uncertainty in economies, geopolitical tensions, and changing demand-supply dynamics may cause fluctuations in prices which can have a substantial impact on the profitability of domestic copper producers.

8.9. Impact of FTAs and Tariff on Domestic Copper Industry

India's domestic copper industry faces significant headwinds due to Free Trade Agreements (FTAs) and tariff structures, particularly with ASEAN countries and Japan. These agreements allow the import of refined copper at zero or minimal duty, while domestic producers continue to bear high import duties on copper concentrate, creating an inverted duty structure. This has made Indian copper manufacturing less competitive, with lower-cost imports displacing locally refined copper.

The recent increase in U.S. tariffs on strategic materials like copper also adds uncertainty for Indian exporters. Although the U.S. is not the largest market for Indian copper, such protectionist measures may limit future export potential and redirect global trade flows. Indian companies are calling for parity in duty structures and policy reforms to support the sector. Additionally, there is a push for improved access to raw materials and government support through bilateral negotiations to ensure a level playing field for domestic producers amid shifting global trade dynamics.

8.10. Competitor Profiles

a) Vedanta Limited

Sterlite Industries (India) Ltd, a division of Vedanta Limited is one of India's largest copper manufacturers established in the year 1996. The company is renowned for its production of copper cathode and copper rods. As the foremost mining and non-ferrous metals enterprise in India, Sterlite extends its operations across Australia and Zambia, with additional involvement in oil and gas ventures spanning three countries. Vedanta, the parent company, ranks as the second-largest copper producer in India, with a production output of 141 thousand tonnes of copper in FY24.

However, following protests by residents citing environmental breaches at Sterlite's copper plant in Thoothukudi, Tamil Nadu, the Tamil Nadu Pollution Control Board (TNPCB) mandated the plant's closure in May 2018. The Supreme Court dismissed Vedanta's Special Leave Petition challenging the plant's closure on February 29, 2024. A subsequent review petition is pending listing. Copper cathode and Continuous Cast Rods (CCR) stand as the primary products manufactured by Vedanta, each finding widespread application across various industries. Beyond these core offerings, Vedanta utilizes copper by-products such as Phosphoric acid, utilized in fertilizer production. Sterlite Copper's Phosphoric Acid plant boasts an annual capacity to produce approximately 230,000 metric tons of P2O5. Additionally, Vedanta maximizes the utility of other by-products including Sulphuric Acid, Hydrofluorosilicic Acid, Ferro Sand (Copper Slag), and Phospho Gypsum, each serving diverse industrial purposes.

b) Hindalco Industries Limited

Hindalco's copper division operates one of the world's largest single-location custom copper smelters founded in 1958. Located at Dahej in the Bharuch district of Gujarat, Birla Copper, Hindalco's copper unit, utilizes integrated port facilities, making it a global giant in the copper smelting industry. The Dahej unit encompasses copper smelters, supported by a captive power plant, oxygen plants, by-products facilities, utilities, and a captive jetty. Hindalco stands at the forefront of copper manufacturing in India, with a total production of 368 thousand tonnes.

Birla Copper finds applications in manufacturing continuous copper rods for wire, cable, and transformer industries, as well as copper tubes for consumer durable goods and various other applications in the form of alloys and sheets. The co-product, sulphuric acid, is utilized in the production of phosphoric acid and value-added fertilizers like di-ammonium phosphate (DAP). Additionally, Dahej hosts a precious metals recovery plant that yields gold, silver, and selenium. Hindalco manufactures copper cathodes and continuous cast copper rods in diverse sizes. The company's products are served across different markets such as automotive and transport, consumer durables, electrical equipment including wires and cables, railway electrification, electric vehicles and renewables.

c) Hindustan Copper Limited

Hindustan Copper Ltd (HCL), a public sector entity, was established in 1967 to take over control of copper operations from National Mineral Development Ltd (NMDC). It achieved the status of India's sole fully integrated copper company in 1975 by inaugurating a 31 thousand tonnes refinery in Khetri. In 1989, it expanded its operations with a downstream facility utilizes a capacity of 60 thousand tonnes in Taloja, Maharashtra. Subsequently, in 2015, the company further enhanced its operations by establishing a 50 thousand tonnes of secondary copper smelter and refinery unit in Gujarat.

The Company has the facilities for production & marketing of copper concentrate, copper cathodes, continuous cast copper rod and by-products, such as anode slime (containing gold, silver, etc.), copper sulphate and sulphuric acid. HCL's mines and plants are spread across five operating Units, one each in the States of Rajasthan, Madhya Pradesh, Jharkhand, Maharashtra and Gujarat.

d) Adani Enterprises Limited

The company has a diverse portfolio of business including roads, airports among transport and logistics, Food FMCG, and digital among retail business, mining, PVC, value added products such as copper, aluminium, silver, gold, Phosphoric Acid and Selenium, sulfuric acid and solar and wind turbine manufacturing, green hydrogen among energy.

Kutch Copper, a subsidiary of Adani Enterprises Limited, launched its greenfield copper refinery project in Mundra on 28th March 2024, dispatching the first batch of cathodes. This marks Adani entry into the metal industry. The project has established a 0.5 MTPA copper smelter, with plans to expand it to 1 MTPA.

9. Poly Vinyl Chloride (PVC)

9.1. Industry Developments

Vinyl chloride is used to produce the synthetic resin known as polyvinyl chloride, or PVC. PVC is the third-most common synthetic plastic polymer globally and is a high-strength thermoplastic material. It is used in various products, including raincoats, shower curtains, window frames, indoor plumbing pipes, medical equipment, wire and cable insulation, bottles, credit cards, and flooring.

PVC can be classified into two types -flexible and rigid. Rigid PVC is used in constructing pipes, doors, and windows, while flexible PVC is applied in products such as flooring, garden hoses, pool liners, rainwear, boots, and medical tubing. Compared to other plastics, PVC exhibits poor heat stability, especially at high temperatures. To address this, manufacturers incorporate additives during production to enhance its thermal stability.

Further, the building industry uses pure PVC for pipes, conduits, siding, window frames, and door frames because of its strength, stiffness, and resistance to flames. Additionally, it is blow-molded into transparent, clear bottles. However, its stiffness, requires molding or extrusion at temperatures exceeding 100 °C (212 °F), which can initiate chemical breakdown and release hydrogen chloride (HCl). The use of stabilizers, primarily metal compounds such as cadmium, zinc, tin, or lead, helps mitigate this decomposition.

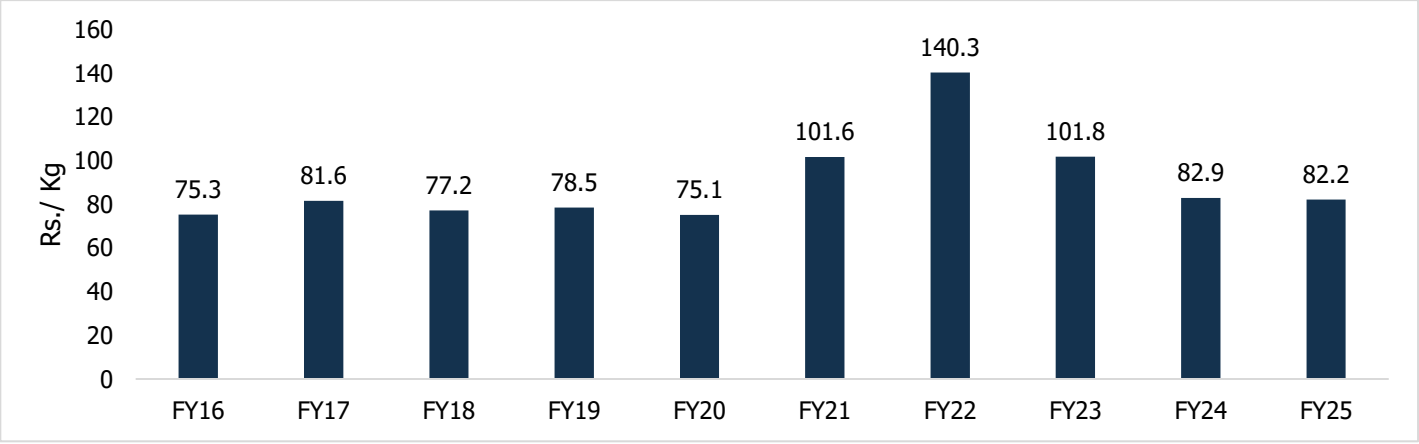
Domestic Price Trend

The prices for PVC were range-bound in the years CY16 to CY20. However, in CY21, the prices of PVC exponentially increased, owing to the supply constraints amid revival in economy post COVID-19. Although the plants in the country were operating at full capacity after the revival of the economy, insufficient production and supply in the global market put upward pressure on the prices. The prices observed a hike in December 2021 owing to the rise in cost and freight of Inland Container Depot (ICD). There was also increased demand from the construction sector.

In 2023, the prices retreated to normalcy owing to the easing of supply from China and a fall in crude oil prices. The domestic prices follow the international price trend.

Due to excess capacity and weak demand in China, India witnessed sizeable dumping of PVC from China during the last few years. Weak demand in the USA led to diverting surplus production to the Indian market. This put sustained pressure on PVC prices It is the key raw material for plastic pipes and fluctuation in prices can impact margins.

Chart 46: Domestic Price Trend



Source: CMIE

Note: The above prices are average prices.

9.2. Demand Review & Outlook

PVC products are widely utilized in construction for flooring, roofing, insulation, plumbing, and window frames. The material is ideal for enduring the harshness of weather, temperature fluctuations, and other external elements because of its flexibility and durability. PVC is a useful material for lowering energy loss and improving the energy efficiency of buildings since it is also a superior insulator.

The construction and agricultural industries in India are the main consumers of PVC. The majority of the nation's PVC demand is met by PVC pipes used for water distribution and irrigation. PVC products are utilized in the infrastructure sector to build public works like tunnels and bridges. PVC pipes, sometimes referred to as "infrastructure plastic," are extensively utilized in drainage, sewage, and plumbing systems because of their resistance to corrosion, portability, and simplicity of installation. Lead-free, it is a suitable substitute for concrete and metal pipes, guaranteeing consistency and quality without sacrificing health.

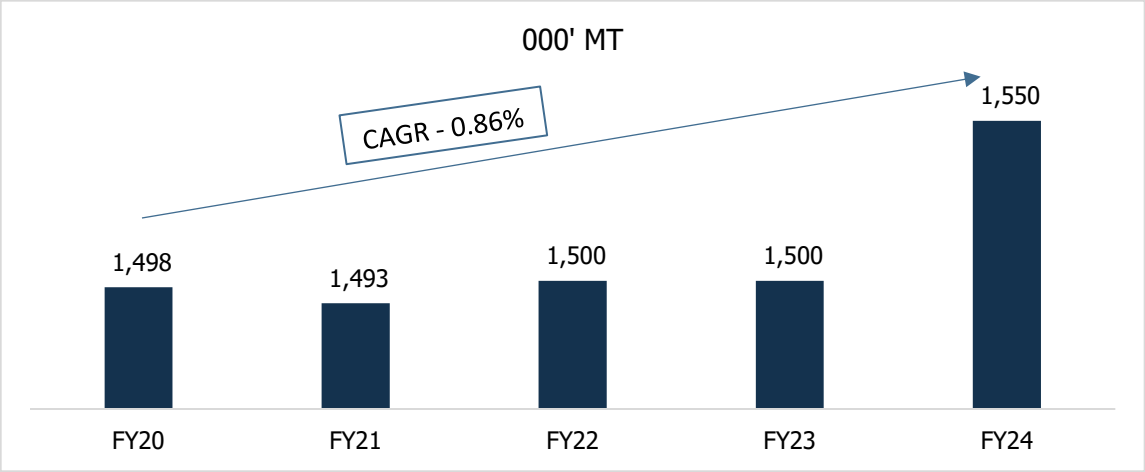
The main factor driving the demand for PVC worldwide is the building industry. The worldwide demand for PVC in building applications is being driven by low per capita PVC consumption and increased economic development in the rapidly developing nations of China, India, and Brazil.

A significant portion of PVC demand from this industry is accounted for by pipes and tubes and profiles, with pipes and tubes accounting for about half of PVC demand from construction applications. The key factors propelling the PVC pipes and fittings market in India are the increasing government spending on housing, sanitation, and irrigation through programs like PMKSY, AMRUT, and Housing for All.

9.3. Capacity & Production Outlook

After polyethylene and polypropylene, PVC is the third most produced synthetic plastic polymer worldwide. PVC is produced by suspension polymerization of vinyl chloride monomer. PVC is widely utilized in a variety of industries, including the pipe industry, automotive and sanitary fittings, wires and cables, bottles, containers, transparent films, and flexible hoses. Given that PVC is an industrial material input for many industries in the economy, having adequate domestic PVC capacity is essential to India's ambitious goal of surpassing the $7.5 trillion mark in GDP by 2030.

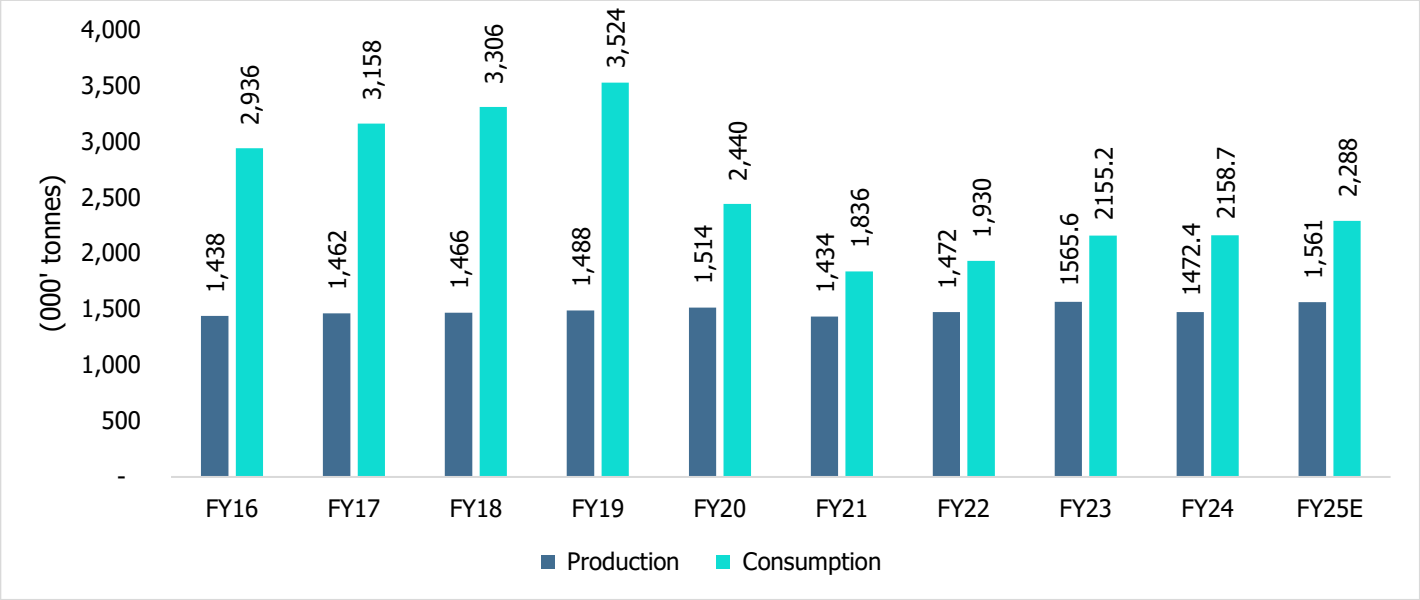
Chart 47: India's PVC Installed Capacity



Source: Chemicals.gov

Further, during FY16- FY24, the production of PVC increased marginally from 1,438 thousand MT in FY16 to 1,472 thousand MT in FY24. However, the consumption increased in the initial years but declined later substantially. The consumption was supported by the demand from user industries like infrastructure and housing. With government aid and the implementation of various policies in infrastructure & housing, the demand for PVC is expected to rise. Some of the other sectors including FMCG, agriculture, pharmaceuticals, and retail are also expected to drive the demand for the PVC industry.

Chart 48: India's PVC Production, Consumption



Source: Chemicals.gov; CareEdge Estimates
Note: (E) stands for Estimated

9.4. Growth Drivers

The demand for PVC in India is being driven by strong growth across key end-use sectors such as construction, infrastructure, and automobiles. Rapid urbanization, rising population, and increased infrastructure spending are fuelling the need for durable materials like PVC, especially in piping, housing, and transportation.

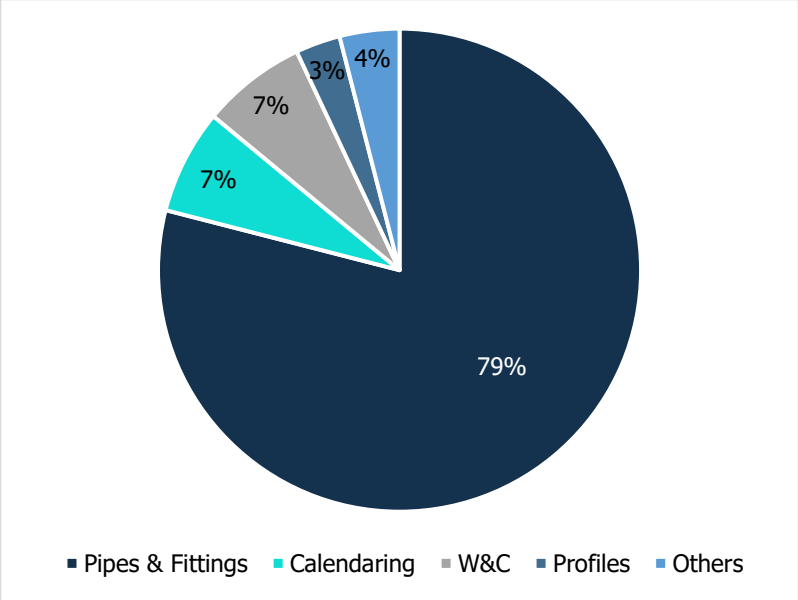
India is also making strategic moves toward self-reliance in PVC production. Leading companies are investing in expanding manufacturing capacities, supported by government initiatives like "Make in India". Efforts to reduce import dependency and promote domestic production are expected to boost the sector further.

Additionally, regulatory measures aimed at restricting certain imports and the growing use of CPVC in industrial applications are contributing to the market's upward trajectory.

9.5. Application- wise Growth Outlook

In India, Pipes and fittings account for almost 80% of the demand. About 65% of the plastic pipe market is dominated by organised companies. Globally, PVC market was dominated by Pipes and fittings in FY24 and is expected to continue to do so.

Chart 49: Segment- wise PVC Demand-FY25E



Source: CareEdge Research Estimate

- PVC is widely used in the **building sector** for a variety of purposes, including wall covering, flooring, carpets, laminating, and fixed window frames. India's construction sector is expected to continue to be a major source of demand for adhesives and sealants in the country if it increases spending on building construction and makes more infrastructure investments.

- The Indian **plastic pipe market** offers potential in various areas, including potable water supply, wastewater supply, electrical and telecommunication cable protection, agriculture, chemicals, and oil and gas. The market is anticipated to expand at a remarkable CAGR of 10.3% from 2022 to 2027, reaching a valuation of $10.9 billion, as the nation continues its steady march toward prosperity. Numerous factors, such as government infrastructure spending, an increase in residential and commercial building, industrial growth, the irrigation industry, and the replacement of aging pipes, are drivers for this surge.

- One important factor driving the need for PVC has been India's burgeoning **aerospace sector**. PVC is designed to be strong, resistant to chemicals and cleaning, and fireproof, all of which are necessities for airplane interiors. The demand for adhesives and sealants is expected to expand steadily in tandem with the remarkable boom in activity seen by the civil aviation and defence industries. Additionally, the aerospace sector will probably continue to expand due to India's massive capital expenditure spending on defence, offering plenty of chances for both new and established PVC market participants.

By 2027, India is predicted to be the nation adding the most polyvinyl chloride capacity, followed by China and the US. The construction and agriculture sectors will be driving the PVC demand in India.

9.6. Government Initiatives

The following are government initiatives that could support the expansion of the PVC market:

• **Housing for Everybody:** The Indian government has launched a program to provide housing for everyone, realizing the seriousness of the problem. The goal is to close the gap between supply and demand in the housing market. India's piping business has a lot of prospects due to the country's housing crisis and slums' inadequate sewage and drainage systems. PVC pipes are widely used in the agricultural and residential sectors for water management, which can be a significant growth driver.

As of the end of FY 2023–24, nearly all the 2.95 crore houses targeted under PMAY-G have been sanctioned, with 2.69 crore houses completed. To continue progress under the "Housing for All" mission, the Union Cabinet has approved the extension of PMAY-G for the period 2024–25 to 2028–29, aiming to construct an additional 2 crore rural houses, along with the remaining houses from the original target, by March 2025.

- The government established the **Altal Mission** for Rejuvenation and Urban Transformation (AMRUT) to construct amenities in urban areas and offer basic services to households. The country's infrastructure has to be improved, which could stimulate the plastic pipe market.

- **Swachh Bharat Mission (SBM):** This initiative builds community restrooms, cluster toilets, and individual home latrines (IHHL) with the goal of eliminating open defecation (particularly via PPP mode). The program's treatment of both liquid and solid waste is another crucial component. The mission's emphasis on drinking water facilities and sanitation presents a significant potential for PVC pipe makers.

- **The Jal Jeevan Mission:** This initiative, which is being carried out in collaboration with the states, aims to provide tap water to all rural households as well as public buildings in villages, including gram panchayat buildings, schools, health centers, anganwadi centers, and ashramshalas (tribal residential schools). This could increase the need for water supply distribution pipes, which would support the expansion of the PVC sector.

- **Anti-dumping Duty:** To assist home producers, the government placed an anti-dumping duty on PVC imports in 2008. After several extensions, the duty came to an end in February 2022. The government agreed in May 2022 to lower the customs tariff on PVC from 10% to 7.5% due to rising inflation. Nevertheless, this led to a rise in Chinese imports in the 2022 and 2023 fiscal years.
  To support the growth of the domestic PVC industry, India initiated an investigation in January 2025 into the alleged dumping of PVC paste resin from the European Union and Japan. The Directorate General of Trade Remedies (DGTR) is assessing the impact of these imports on local manufacturers.

- **Government's Focus on Infrastructural Development:**
  - A notable 33% increase in capital expenditure funding, to Rs. 10 Lakh Crore indicates the government's intention to make sure that infrastructure serves as a force multiplier.
  - The PM Awas Yojana increased funding for the "Housing for All" program by about Rs. 79,000 Crore, which is 65% more than in 2022.
  - In FY25 Budget, the total budget outlay for Jal Jeevan Mission has been enhanced to Rs 67,000 Crore and the Mission stands extended until 2028.

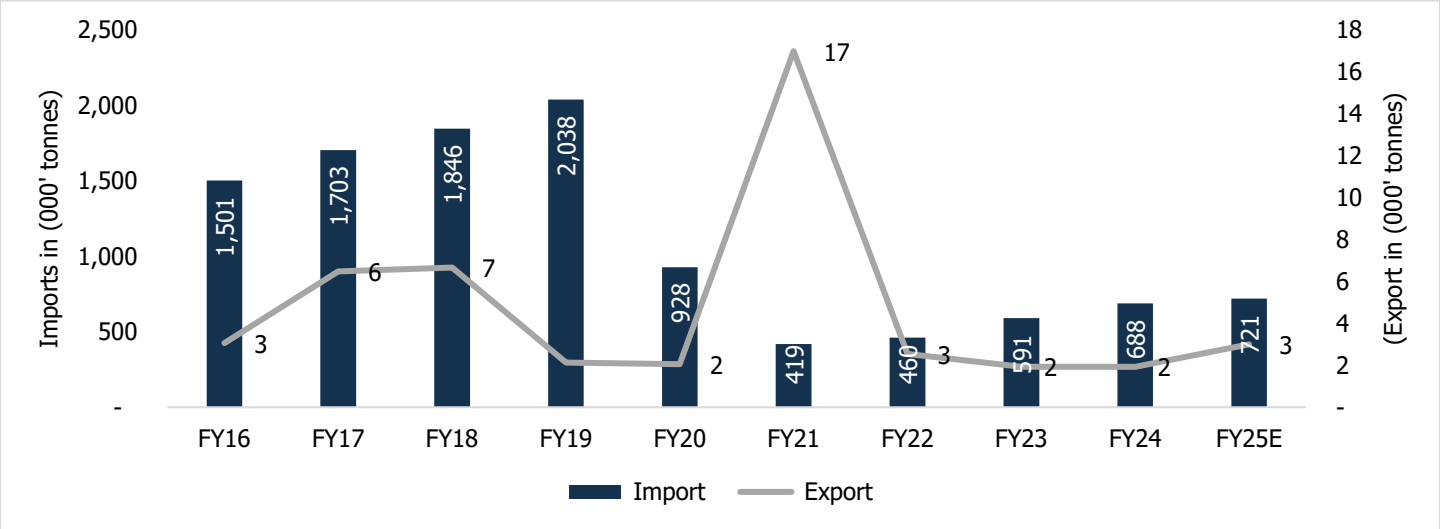
9.7. Trade Outlook

PVC Imports & Exports

India's production of PVC is insufficient to meet the consumption demand, necessitating significant imports. Consumption continues to rise in the country owing to the demand from user industries like housing, infrastructure and agriculture. A significant factor that hindered the growth of the Indian PVC markets in FY20 was the unusually low demand brought on by the COVID-19 pandemic. Due to plentiful supply in Asian markets, there was little interest domestically, and import and local prices decreased.

India, the world's largest importer of PVC worldwide, eliminated its anti-dumping tariffs in February 2022, enabling producers to obtain more affordable raw material suppliers. In addition, the government reduced the import duty on PVC from 10% to 7.5% in May 2022. Following the government's dismantling of the prior import anti-dumping levies, which suppressed and reduced local market prices and severely financially harmed local companies, PVC imports into India increased dramatically in FY23. Conversely, PVC exports from India declined sharply in FY22. For the last 2 years, exports have been close to 2000 MT, with imports gradually increasing from FY22 levels.

Chart 50: India's PVC Export & Import Trend



Source: Chemicals.gov; CareEdge Estimates
Note: (E) stands for Estimated

9.8. Competition Landscape

9.9. Key Leading Manufactures

Table 35: Revenue

Revenue (Lakhs)	FY21	FY22	FY23	FY24	FY25
Chemplast	3,79,870	5,89,200	4,94,110	3,92,298	2,38,761
Finolex	2,76,810	3,76,810	4,48,110	5,01,439	4,14,197
DCW	1,46,430	2,45,470	2,63,380	1,87,159	2,00,034
DCM Shriram	8,21,200	9,67,660	11,81,150	11,17,089	12,44,196

Source: Company Reports

Table 36: EBITDA

EBITDA (Lakhs)	FY21	FY22	FY23	FY24	FY25
Chemplast	97,780	1,25,430	54,800	10,631	10,194
Finolex	67,060	82,700	69,710	93,889	47,580
DCW	22,070	34,480	49,070	21,205	19,344
DCM Shriram	1,22,740	1,85,920	1,76,310	55,026	1,26,750

Source: Company Reports

Table 37: PAT (INR Lakhs)

PAT	FY21	FY22	FY23	FY24	FY25
Chemplast	54,970	79,560	17,150	-22,557	-6,557
Finolex	46,150	59,910	50,430	65,169	77,786
DCW	380	10,750	19,200	1,566	3,028
DCM Shriram	66,250	1,04,880	96,150	42,625	56,653

Source: Company Reports

9.10. Capacity of Leading Players

- **Finolex Industries** is one of India's major manufacturers of PVC pipes and fittings. It can generate 4,00,000 metric tons of pipes and fittings and 2,72,000 metric tons of PVC resin annually. It operates four modern manufacturing plants in Gujarat and Maharashtra.

- With an annual S-PVC capacity of 331,000 MT (as per FY24) and an annual capacity of 1,07,000 MT (increasing 41,000 MT in FY24) for paste PVC, **Chemplast Sanmar Limited (CSL)** is the largest producer of PVC in India, trailing only Reliance Industries Limited.

- **DCW Limited** Production for FY24 stood at 93,553 MT as compared to 96,348 MT for FY23. Capacity Utilisation decreased slightly from 96% in FY23 to 94% in FY24.

- With a capacity of more than 5.8 MMT annually, Reliance is among the biggest producers of polymers in the world today. Using cutting-edge technology, it runs large-scale polypropylene (PP), polyethylene (PE), and polyvinyl chloride (PVC) plants that establish global standards for service and product quality.

9.11. Planned Expansions in Short to Medium Term

- Adani Enterprises is looking at developing a petrochemical cluster in Mundra, Gujarat. The business intends to incorporate the initial phase of its 2 MMT coal-to-PVC plant, scheduled for completion by FY 2025–2026, into the cluster.

- DCW Limited has made capital expenditure to increase capacity and optimum utilisation of C-PVC & SIOP plants.

- **Reliance Industries Limited (RIL)** held the top spot in India's PVC production capacity as of 2022, with 750 kilotons, or about half of the nation's total capacity. The 1.20 mtpa RIL Dahej PVC Plant 2 is a planned project that is anticipated to begin operations by 2026. Additionally, RIL intends to develop world-scale plants in the UAE, Dahej, and Jamnagar, India, more than tripling its current capacity. By 2026, the business plans to finish phased expansion of 1.5 MMTPA of feedstock integrated Poly Vinyl Chloride (PVC) at Dahej and Jamnagar.

9.12. Opportunities for Adani Enterprises in India’s PVC Segment

Right now, the PVC pipe industry in India is seeing rapid expansion. In the new normal India, the polymer pipes business has been doing well despite the epidemic.

Plumbing and piping applications in the construction industry are among the many industries where the demand for metal to polymer pipes has changed dramatically. The hot- and cold-water plumbing sector has seen a notable increase in the

usage of CPVC pipes over the last few years. The upcoming year is expected to see producers of polyvinyl chloride (pvc) pipes and fittings maintain their volume growth due to increased funding allocated to government programs related to infrastructure, housing, irrigation, and water supply.

Adani's projected 2 MMT annual facility can support India's underserved market.

9.13. Risks & Challenges

The uncertainty surrounding the imposition of anti-dumping duty is one of the main reasons hindering the development of the PVC industry. Establishing a PVC plant requires a substantial capital expenditure, and the government's actions regarding anti-dumping levies have a notable influence on the company's profitability. Another barrier to capacity expansion is reliance on imports for raw materials. While domestic businesses are focusing on nation-building, the PVC industry in India is facing an unprecedented attack from imports, primarily from China and the USA.

India consumes significantly less PVC per person than the US and China do. The rising demand-supply imbalance presents a huge opportunity to enhance domestic PVC capacity. However, any significant capacity growth in India is anticipated to be hampered by the absence of dumping protection, unstable raw material prices, and increased susceptibility to currency rates.

10. Mining Services, Commercial Mining and Integrated Resource Management – Coal

10.1. Overview of coal industry

Coal is a combustible black or brownish-black sedimentary rock formed from fossilized plant matter. It is primarily composed of carbon, along with varying amounts of other elements such as hydrogen, sulphur, oxygen, and nitrogen. As one of the world's most abundant fossil fuels, coal has served as a key source of energy for centuries—supporting heating, electricity generation, and industrial processes.

Historically, industries have used coal for heating residential and commercial buildings, as well as for manufacturing activities such as steel production and cement manufacturing. At present, its dominant application lies in electricity generation through coal-fired power plants. The world's proven coal reserves stand at approximately 1,160 billion tonnes, with five countries—namely the United States, Russia, Australia, China, and India—accounting for nearly 75% of global reserves.

Coal is divided into two main categories: coking and non-coking coal. Coking coal is mainly utilized in the steelmaking process, while a significant portion of non-coking coal is utilized for generating electricity. In India, coking coal is classified based on its ash content, whereas non-coking coal is categorized according to the gross calorific value of the coal.

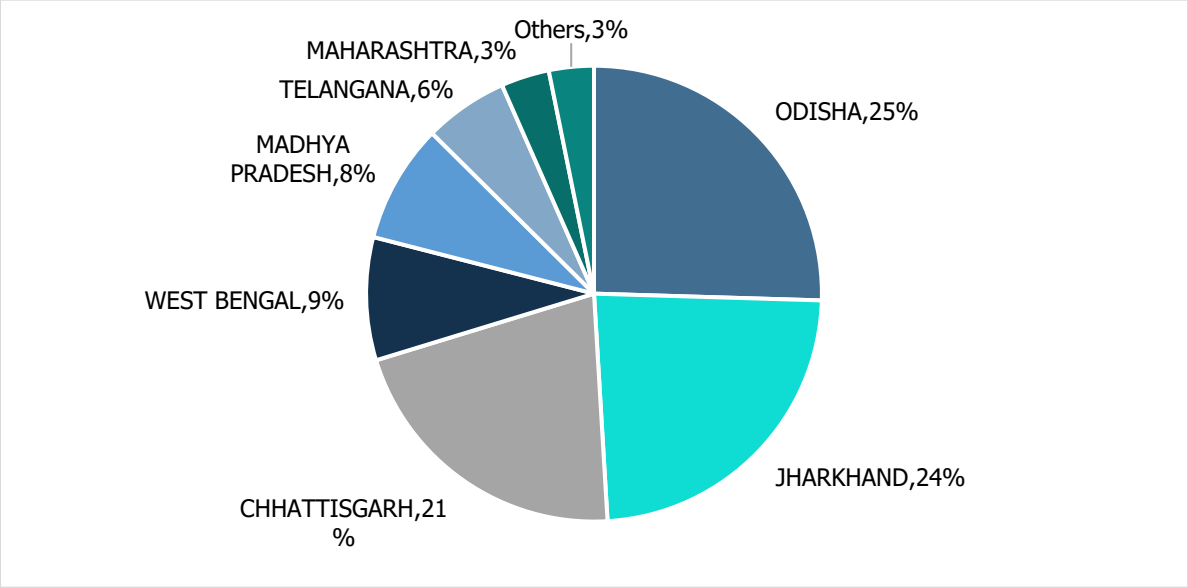
10.2. Overview of India's coal sector

Coal is the main fossil fuel of the country and back bone of energy production. Coal-fired power plants meet more than 70% of India's total electricity demand catering to domestic and well as industrial requirement including steel, cement, fertilizer industries and brick kilns.

India's coal sector remains primarily government owned and controlled. Coal production in India has been controlled by the central government since the nationalization of India's coal mines in the early 1970s. However, private sector participation has been on a rise with the auctioning of captive as well as commercial coal mines.

Most coal reserves are found in the eastern and south-central regions of the country. Jharkhand, Odisha, Chhattisgarh, West Bengal, Madhya Pradesh, Telangana, and Maharashtra collectively hold approximately 98% of the nation's total coal reserves. India's coal reserves stood at 389.42 Billion Tonnes as of 2024. Odisha and Jharkhand have the largest coal reserves of 99.2 Bn Tonnes and 91.81 Bn Tonnes followed by Chhattisgarh with 82.7 Billion Tonnes of reserves.

Chart 51: Coal Resources in India FY24



Source: Ministry of Coal

Coal production in India is dominated by Coal India Limited (CIL) and Singareni Collieries Company Limited (SCCL) which accounted for 75% & 7%, respectively of the total coal production in FY25. The remaining 19% was produced by captive players which are owned by both public and private sector players. Earlier the captive miners were not allowed to sell the coal produced in the open market but in October 2021, the government relaxed the norms and allowed to sell up to 50% of the coal produced in the open market.

In the past, the domestic coal production has faced challenges due to delays in getting environment and forest approvals, hurdles in land acquisitions, despite abundant coal reserves. Hence, this resulted in high dependence on imports to meet the domestic demands. However, recently the government has been focusing on reducing dependence on the imports and improving the indigenous coal production.

As a result of this, the domestic coal production has been growing at a CAGR of 6.4 % from FY19 to FY24. However, there has been an increasing demand from power and other sectors leading to the increase in imports of coking and non-coking coal as the domestic production is not able to keep with the increasing demand.

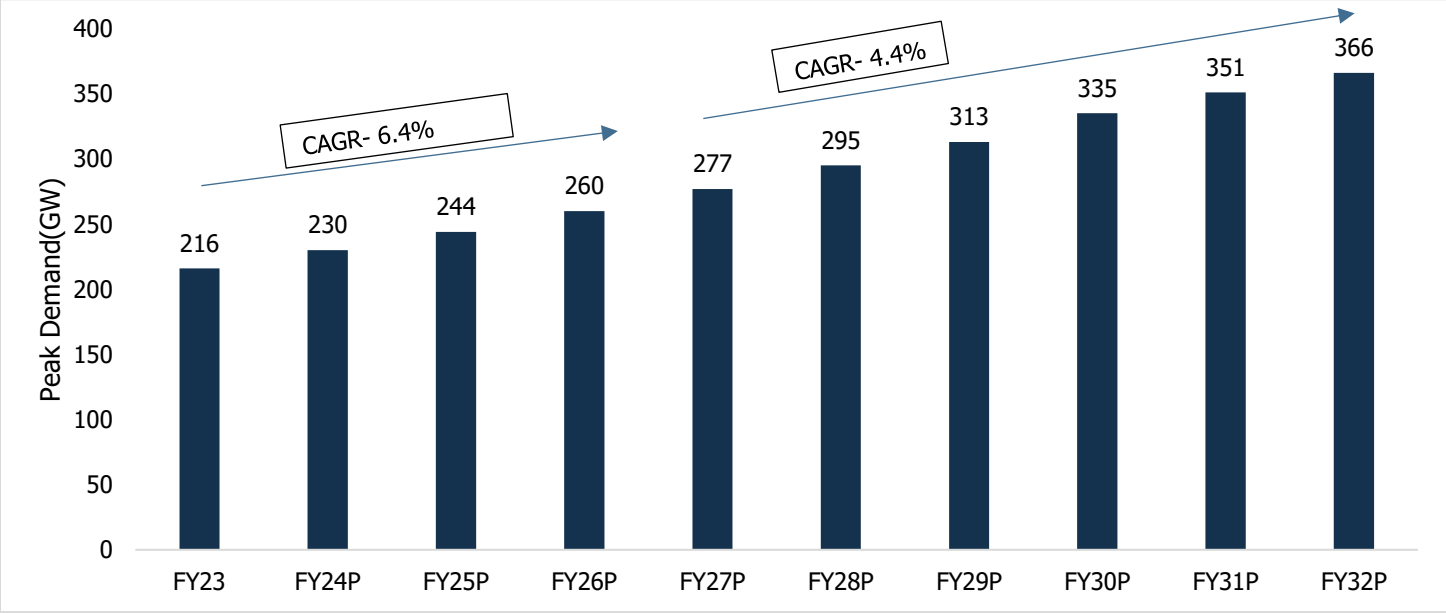
10.3. Key Demand Drivers for India's Coal Sector

1. Growing Electricity Demands

The country's high population and the resultant demand for more energy remains a major driver of electricity generation. Accordingly, the coal sector's sustained growth is linked to its ability to cater to the growing electricity energy needs of the country.

According to the 20th Electric Power Survey of India, the all-India peak electricity demand is projected to grow to 277 GW by FY27 and 336 GW by FY32, implying a CAGR of 6.4% over FY23-27 and 4.4% over FY27-32. The energy requirement is projected at 1,908 BU by FY27 and 2,474 BU by FY32, implying a CAGR of 6% over FY23-27 and 4.1% over FY27-32.

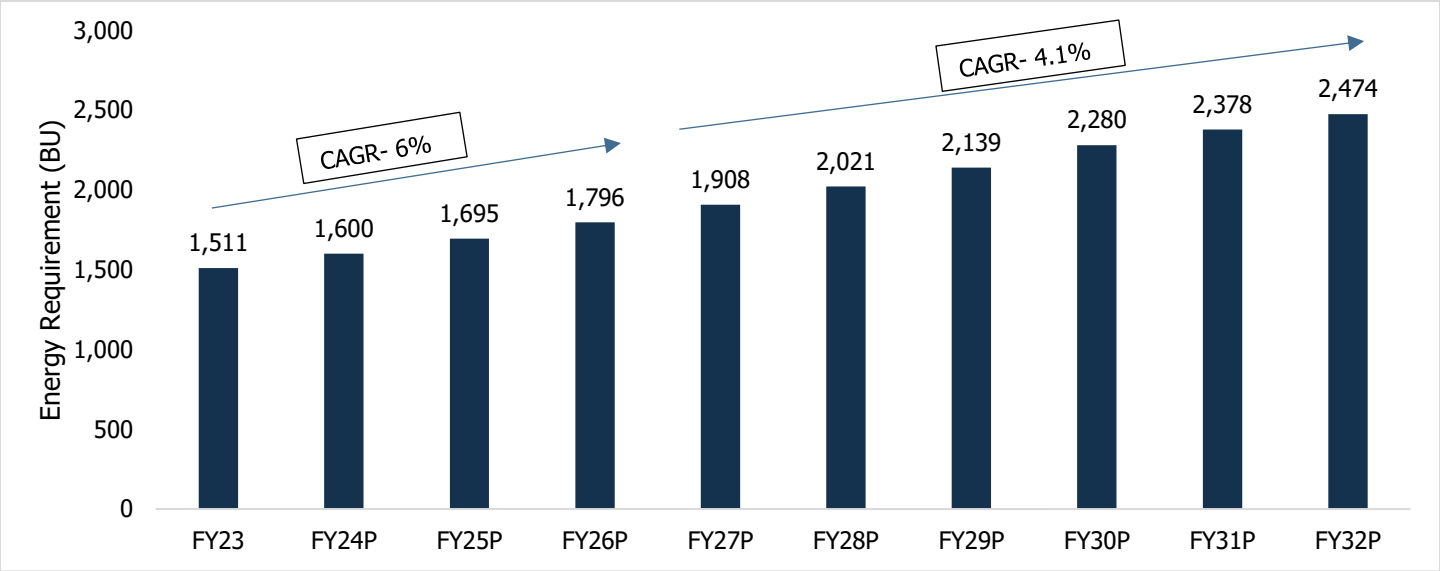
Chart 52: Projected All India Peak Demand



P- Projected

Source:20TH Electric Power Survey of India, CareEdge Research

Chart 53: Projected All India Energy Requirement



P- Projected

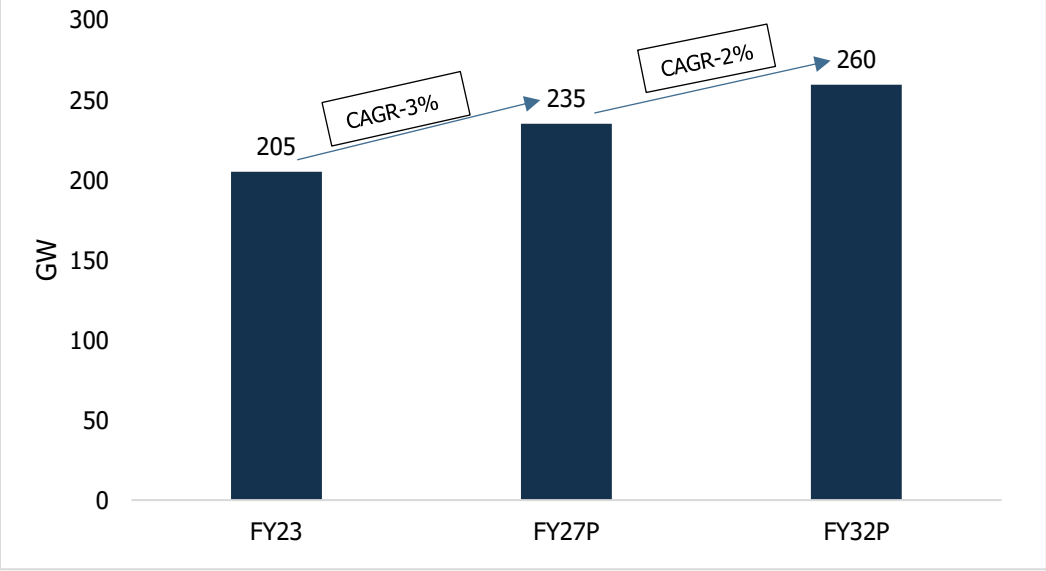
Source: 20TH Electric Power Survey of India, CareEdge Research

2. Increasing Coal-based Power Generation

India's power sector is highly dependent on coal-fired power plants as their primary source of electricity generation, accounting for 74.5% of the country's total power generation as on April 2025. Furthermore, the industrial sector relies on coal as a primary energy source for industrial processes specifically in metal and cement production. While the government's thrust on raising the contribution of power generated from renewable sources is increasing, coal-based power is expected to remain a major source in the near to medium term.

The capacity addition for coal-based power generation is expected to grow at a CAGR of 3% from 205 GW in FY23 to 235 GW in FY27. It is expected to further grow at a CAGR of 2% from FY27 to FY32 to reach 260 GW.

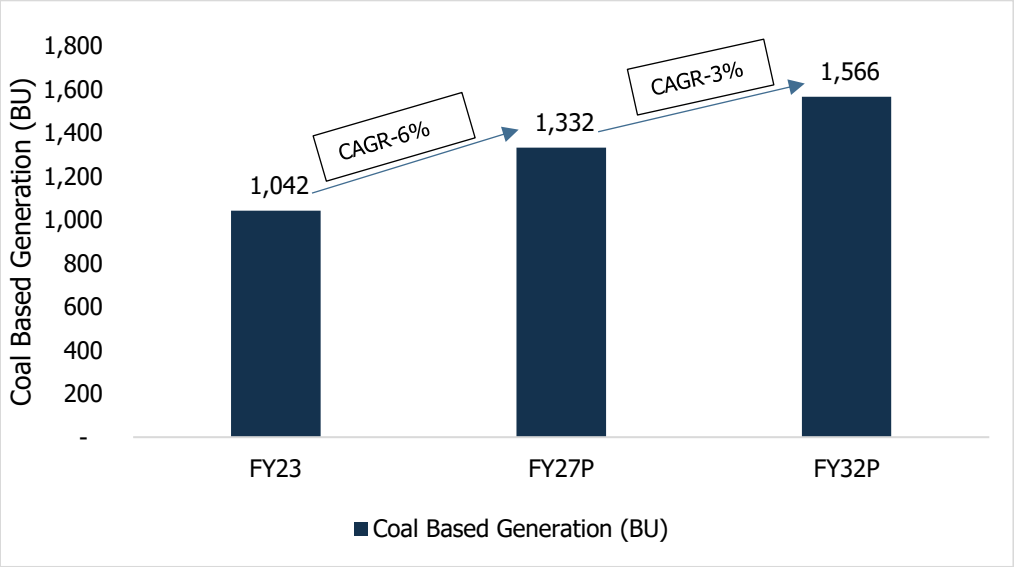
Chart 54: Projected All India Coal-based Power Generation Installed Capacity



Source: National Electricity Plan 2022-32, CEA

The coal-based power generation is expected to grow at a CAGR of 6% from 1,042 BU in FY23 to 1,332 BU in FY27, and further at a CAGR of 3% from FY27 to FY32 to reach 1,566 BU.

Chart 55: Projected All India Coal Power Generation



Source: National Electricity Plan 2022-32, CEA

3. Electrification of Mobility Infra

The growth of the EV segment in India has also been on an increasing trend. The penetration of EVs has increased to 7.8% of the total vehicle sales in FY25, supported by favourable government policies for EVs supporting the reduction in upfront cost and expansion of charging infrastructure, rising fuel prices and shifting consumer preferences**.**

Further, the two-wheeler and three-wheeler segments dominate the electric vehicles market in India, comprising around 58% and 36%, respectively, of total EV sales in FY25. Electric two-wheelers (E2Ws) are a key segment of the electric vehicle market in India, with growing interest amongst consumers and increasing government support for electric mobility. On the other hand, Electric three-wheelers (E3Ws) are also an important mode of public transportation in India, particularly for last-mile connectivity and intra-city transportation.

The historical trends of sales of EVs in each segment are depicted in the table below:

Table 38: Sale of EV Units in India (In Units)

EV Sales Units	FY21	FY22	FY23	FY24	FY25
Two-wheeler	44,782	2,52,568	7,28,069	9,44,907	11,49,422
Three-wheeler	90,073	1,82,604	4,04,427	6,32,520	6,99,063
Four-wheeler	5,132	18,567	47,486	90,696	1,07,645
Commercial vehicle	400	2,203	5,487	8,494	8,844
Total EV sales units	1,40,387	4,55,942	11,85,469	16,76,617	19,64,974

Source: Council of Energy & Environment & Water (CEEW), CareEdge Research

Moreover, the Government of India has targeted 30% EV penetration by 2030.

As EV adoption grows, there will be additional power demand for EVs, and hence, the readiness of the electricity grid for EV charging demand is critical to achieving a rapid and large-scale transition to EVs.

The total electricity demand for EVs, at a 30% EV penetration by 2030, is projected to be 37 TWh as per the NITI Aayog. This constitutes less than 2% of the total electricity demand across the country by 2030. The charging demand by vehicle segment is depicted below in the table:

Table 39: Charging Demand by Vehicle Segment

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

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

10.4. Overview of pricing regime of coal sector

The Cabinet Committee of Economic Affairs. has approved the initiation of Commercial Coal Mining Blocks. The National Coal Index (NCI) and Representative Prices (RP) will play pivotal roles in the auction process. The Indian Statistical Institute, Kolkata, conceptualised and designed the Index and Representative Prices. Current guidelines outline the technical specifications to be followed at various stages of compiling the NCI and RP, in accordance with the Standard Operating Procedure (SOP) issued by the Ministry of Coal.

Overview of NCI and RP: The NCI is a composite price index that reflects coal prices from multiple sales channels, including Notified Prices, Auction Prices, and Import Prices. Notified Prices, which form the primary method of coal sales, are determined by Coal India Limited (CIL) for various coal grades and differentiated between the Regulated Sector and Non-Regulated Sector (NRS). CIL and Singareni Collieries Company Limited (SCCL) regularly conduct auctions, both electronically and through linkages. Import Prices, which represent specific coal types sourced from designated countries, are also incorporated into the NCI and R.

Data Collection: The Office of the Deputy Director General (DDG) oversees the collection of price data in coordination with the Marketing Division of CIL and the Directorate General of Commercial Intelligence and Statistics (DGCIS). The DDG maintains regular engagement with CIL to obtain Notified Prices for coking coal from key subsidiaries, including Bharat Coking Coal Limited (BCCL), Central Coalfields Limited (CCL), Eastern Coalfields Limited (ECL), and Western Coalfields Limited (WCL).

Table 40: National Coal Index for different grades of coal

Channel	Mar-21	Mar-22	Mar-23	Mar-24	Mar-25
Indian Coal	101.89	193.02	168.96	150.13	128.27
Non-coking	107.32	184.79	156.83	137.45	129.09
Coking	86.26	216.73	203.92	186.65	125.92
Non-coking, top grade (G1-G6 or imported)	107.61	223.28	163.48	141.69	131.62
Non- coking, middle grade (G7-G14 or imported)	107.36	171.9	154.8	136.07	128.23
Non-coking, bottom grade (G15-G17)	91.21	215.96	138.59	136.3	132.09
Coking, top grade (STI- STII or imported)	78.98	234.18	220.07	203.1	127.95
Coking, bottom grade (WI-WIV)	115.27	147.2	139.58	121.11	117.84

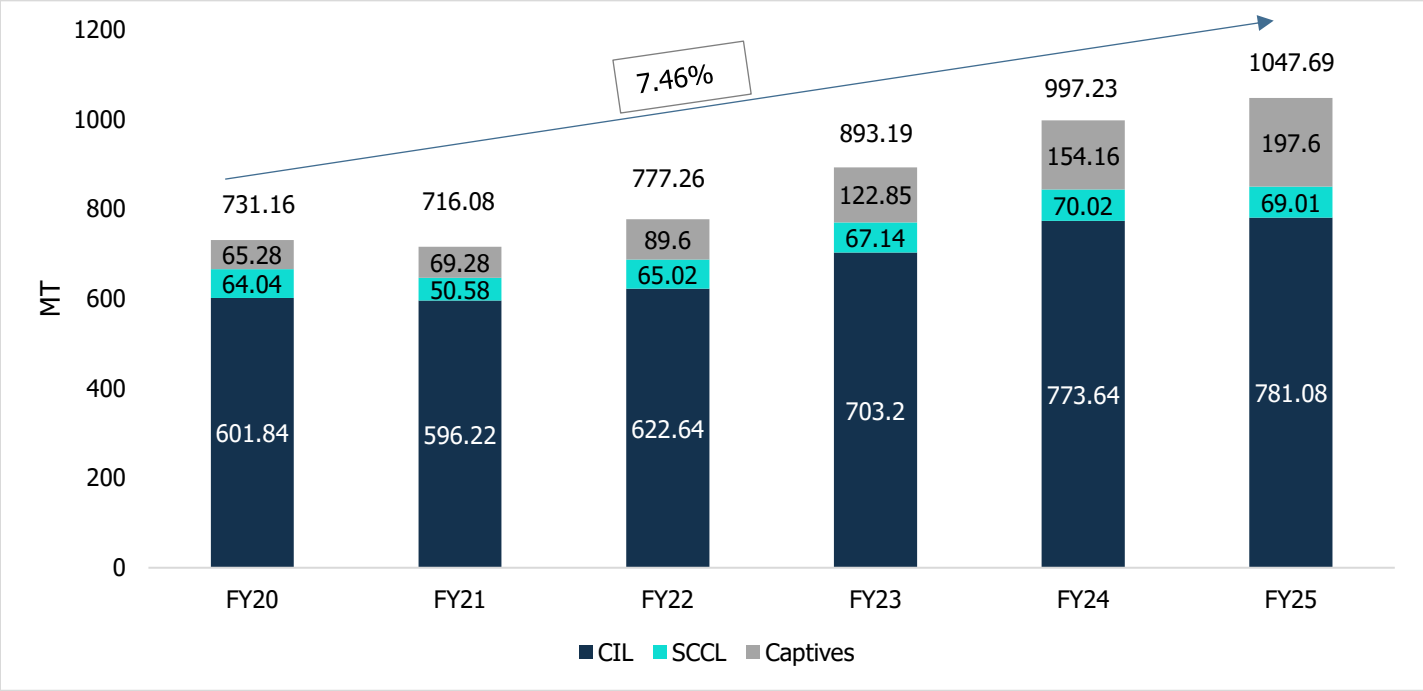
Source: Ministry of Coal

10.5. Review of Coal Production

Coal production has grown at a CAGR of 7.5% during FY20-FY25. However, in FY21, the sector saw a decline over FY19 due to the pandemic-induced lockdowns and lower-than-expected electricity and fuel demand.

Further, the high growth of 8.5% in FY22 (on the lower base) is attributed to the post-pandemic economic activities which raised the demand for electricity and fuel. Moreover, in FY25, the production increased by 5.1% y-o-y reaching 1047.7 MT, majorly driven by the continual increase in production by Coal India Limited (CIL). Meanwhile, coal imports declined by 8.4%, dropping from 200.19 MT in Apr-Dec FY23–24 to 183.42 MT in the same period of FY24–25.

Chart 56: Domestic Coal Production

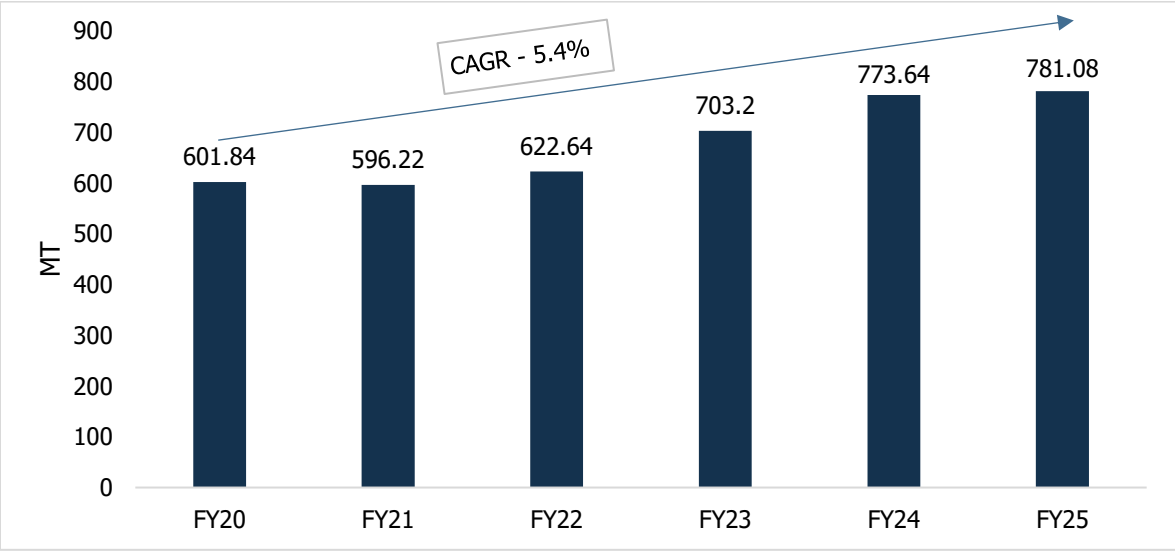


Source: PIB, Ministry of Coal, CareEdge Research

Key Domestic Producers

India's domestic coal production is dominated by Coal India Limited (CIL), a state-owned coal mining corporation established in November 1975. CIL functions through 11 fully-owned subsidiary companies in 83 mining areas spread over eight states in India. As of April 01, 2023, CIL has 322 mines, of which 138 are underground, 171 opencast, and 13 mixed mines.

Chart 57: CIL – Production Trend



Source: Ministry of Coal, CareEdge Research

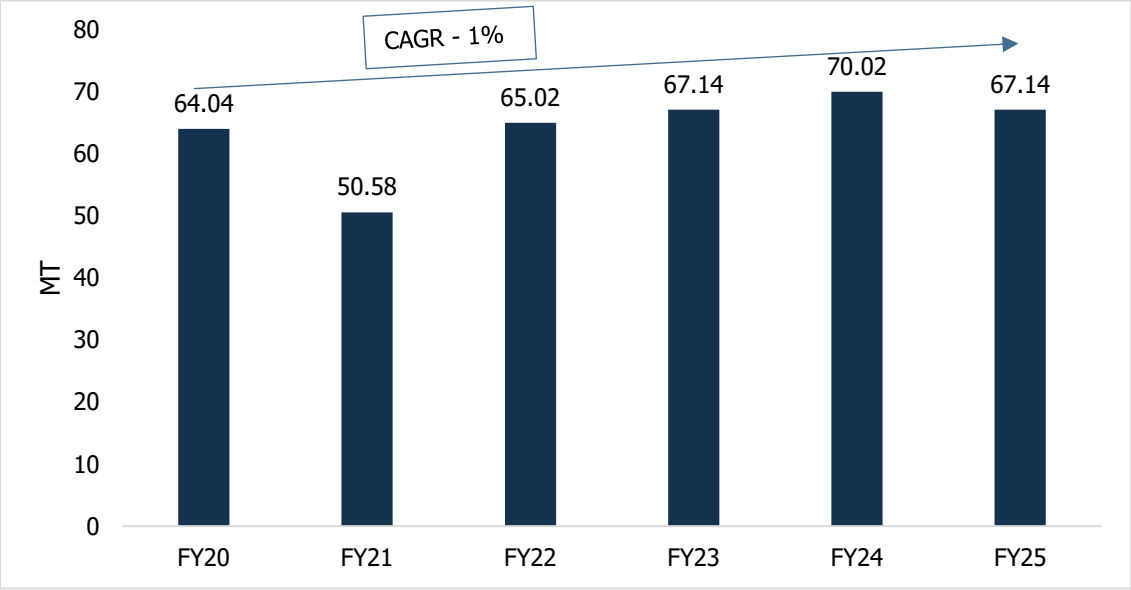
CIL's production has achieved a CAGR of 5.4% during FY20-25. In FY24, production nearly grew by 10% y-o-y. Further, in FY20, CIL contributed to around 82% of the total domestic production. However, with the gradual commissioning of captive mines amidst easing regulations, its share has declined to 75% in FY25.

The Singareni Collieries Company Limited (SCCL)

The Singareni Collieries Company Limited (SCCL) is a government-owned coal mining company jointly owned by the Government of Telangana and Government of India on 51:49 basis. SCCL's primary business is coal mining. In addition, the company has ventured into setting up coal-based power plants, which commenced commercial operations from September 2016.

Further, SCCL operates 29 underground mines, and 19 opencast mines situated in 4 districts of northern Telangana, i.e., Khammam, Karimnagar, Warangal, and Adilabad. Its operations are directed toward meeting the linkage requirements of Power (66%), Cement (13.5%), Captive Power (6.6%), Sponge Iron (3.1%), and other customers (10.8%).

Chart 58: SCCL – Coal Production Trend



Source: Ministry of Coal, CareEdge Research

SCCL is India's second-largest coal producer, accounting for 7% of the total domestic coal production in FY25. Its production has grown at a CAGR of 1% over FY20-25.

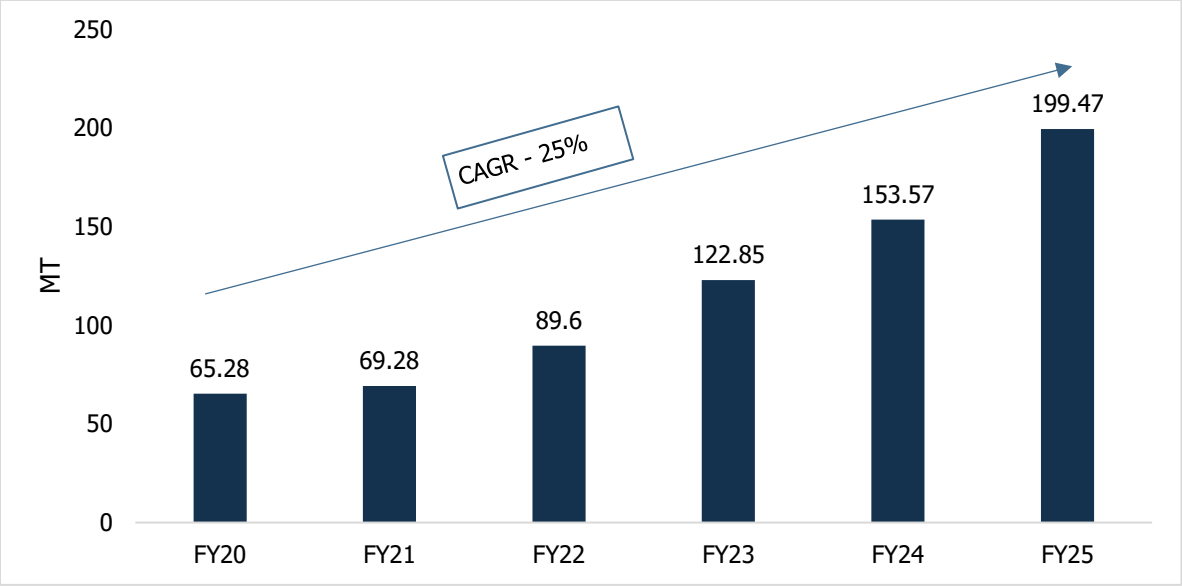
Captives

The government permits privately owned end-users (such as electricity generators and companies in industrial sectors like cement) to produce their own coal, by auctioning coal blocks.

Captives producers receive significant support through policy initiatives, notably the amendment to the Mines and Minerals (Development and Regulation) Act, 1957, which allows them to sell up to 50% of their annual coal output in the open market after fulfilling the requirements of their end-use plants. Another key enabler is production under the Mine Developer and Operator (MDO) model.

Captive producers have further benefited from the adoption of mass production technologies, expansion of existing projects, privatisation of coal blocks, the allowance of 100% Foreign Direct Investment (FDI), and operational efficiencies introduced via the Single-Window Clearance system. Collectively, these measures are expected to sustain and enhance domestic coal production over the medium to long term.

Chart 59: Captive coal Production Trend



Source: Ministry of Coal, CareEdge Research

Production from Captives has grown at a CAGR of 25% during FY20-FY25. Also, in FY25, Captives' production grew at a staggering rate of over 29% y-o-y. Further, steady growth in captive coal production is accredited to the pace of commercial mine auctions and the commissioning of auctioned mines. For instance, four new captive mines were commissioned during FY23.

10.6. Outlook of Coal Industry Production

Coal production to continue to witness healthy growth

Domestic coal production has grown steadily over the past two years. In FY25, it surpassed 1 billion MT mark, following 997.83 million metric tons in FY24, a 4.9% increase. Captive and other entities also saw robust growth of about 29%. The domestic coal production is estimated to grow with significant upside potential in the medium term led by ramp up in CIL's production and gradual commissioning of mines auctioned by the Government. The Ministry of Coal, with the help of CIL's expected ramp up in production, targets to produce 1 billion tonnes by FY26 and 1.5 billion tonnes by FY30. The 1 billion tonne already being achieved in FY25.

The Ministry of Coal (MOC) has also approached MoEF&CC to allow coal mines with current environmental clearance to increase production up to 40% without any further assessments and single portal approvals. In line with this, CIL plans to ramp up their production through mine developer cum contractor (MDO) model, increasing use of mass production technologies, new projects and expansion of existing projects, and auction of coal blocks to private companies/PSUs.

India's coal production exclusively from captive/ commercial mines has crossed 100 Million Ton (MT) for the first time in FY23. 100% FDI has also been allowed for commercial mining.

The 6th tranche of coal block auctions witnessed healthy participation, including several first-time bidders, reflecting continued private sector interest in the coal mining industry. Government reforms, such as the introduction of commercial coal mining, have been well received by the industry. In March 2023, the 7th round of coal block auctions commenced, offering approximately 106 mines, including fully explored, partially explored, coking, non-coking, and lignite blocks.

Although coal imports have increased compared to the previous year, government initiatives aimed at boosting domestic production are expected to reduce import dependence over the medium to long term. To support this objective, the government has constituted an Inter-Ministerial Committee (IMC) on coal import substitution. The IMC comprises representatives from the Ministry of Coal, Ministry of Power, Ministry of Railways, Ministry of Shipping, Ministry of

Commerce, Ministry of Steel, Ministry of Mines, Ministry of Micro, Small & Medium Enterprises (MSME), Department for Promotion of Industry and Internal Trade (DPIIT), Central Electricity Authority (CEA), Coal India Limited (CIL), Singareni Collieries Company Limited (SCCL), Paradip Port Trust, Visakhapatnam Port Trust, and Kolkata Port Trust.

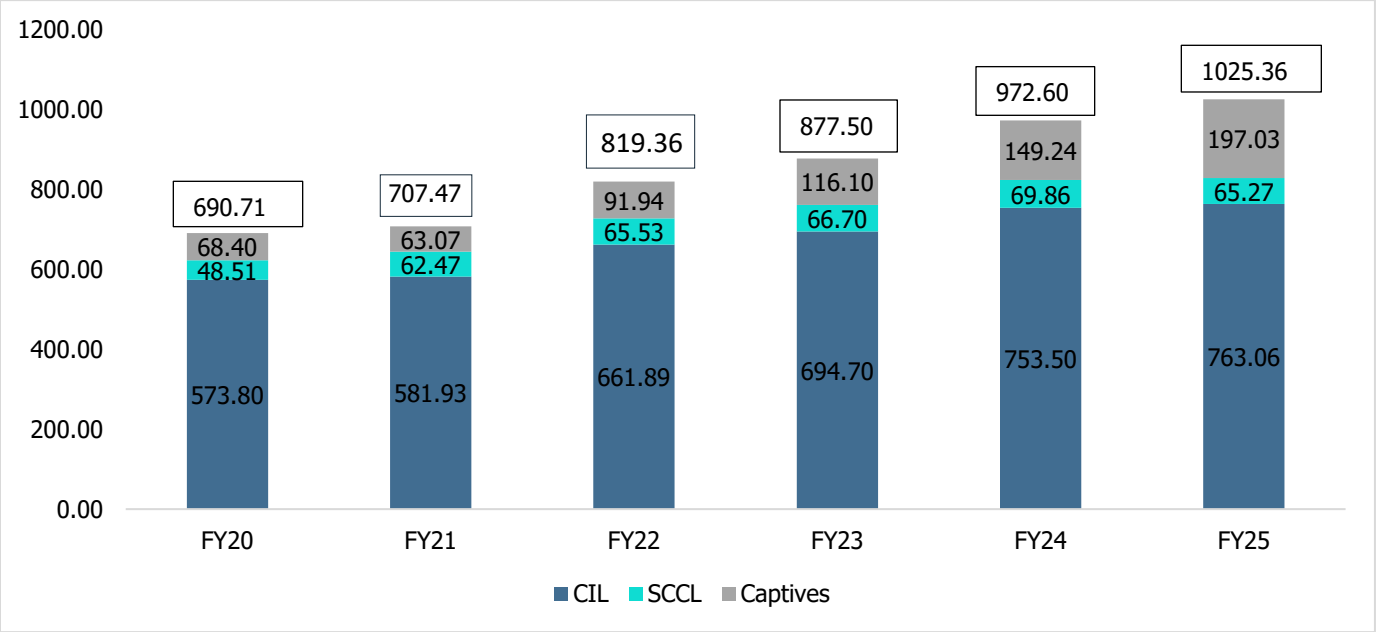
Average annual coal prices dropped in FY25 compared to FY23 and FY24, however, it continued to be higher that previous 5 years' averages as the global demand continues to remain high owing to increased demands specially in China and India.

10.7. Review of coal dispatch in India

The end-users of coal use coal for purposes such as electricity generation and steel or cement production. Over the past decade, there has been a significant uptick in dispatch towards the power sector. This is due to increased dependency on coal-based power generation to meet the growing energy demands.

Further, coal is also one of the essential raw materials required for steel and cement production. Hence, timely and effective dispatch of coal to its end-users is essential for ensuring continual business operations.

Chart 60: Coal Dispatch



Source: Ministry of Coal, CMIE, CareEdge Research

Total coal dispatches have grown at a CAGR of 8.2% during FY20-FY25, and crossed 1 billion MT in FY25. The y-o-y growth rate stood at 5.4% in FY25 as compared to 10.8% in FY24. This decline can be attributed to India's self-sufficiency push and reduction in imports.

In FY20, the total coal dispatches de-grew by 3.5% y-o-y, due to supply crunch and COVID-19 impact in the last quarter of the fiscal. It further declined by 2.2% in FY21 due to the continual impacts of COVID-19-linked lockdowns and reduced power demands.

However, coal dispatches have recovered over FY20-25. In FY23, the total coal dispatches increased by around 7.1% y-o-y, supported by higher production and a steady increase in the availability of railway rakes during the period.

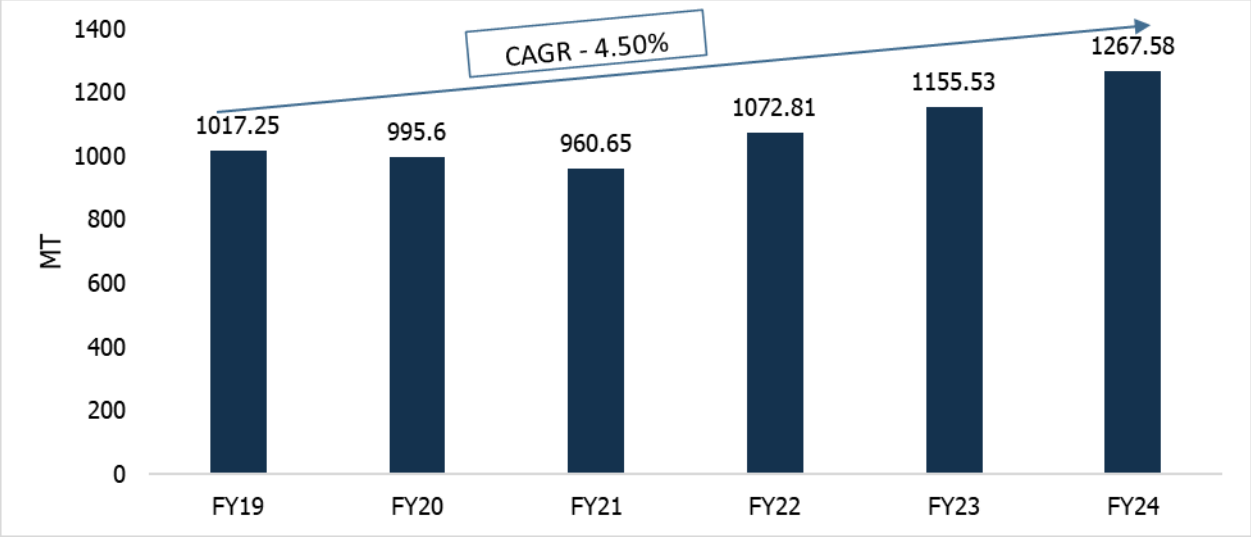
Further, the power sector accounted for 82% of the total coal dispatches during FY25, from 80% in FY20. This is attributed to increased electricity demands due to seasonal changes and warmer temperatures. Besides, the government has prioritized the power sector for domestic coal dispatches.

10.8. Review of coal demand in India

India's coal consumption has steadily increased in recent years, primarily driven by the country's expanding energy requirements linked to industrialisation, urbanisation, and infrastructure development.

Total domestic coal consumption grew at a CAGR of 4.5% to 1267.58 MT in FY24 from 1,017.25 MT in FY19. This upward trend is expected to continue in the coming years, supported by economic growth, accelerated infrastructure development across the country, and rural electrification initiatives under various government schemes.

Chart 61: Coal Consumption in India

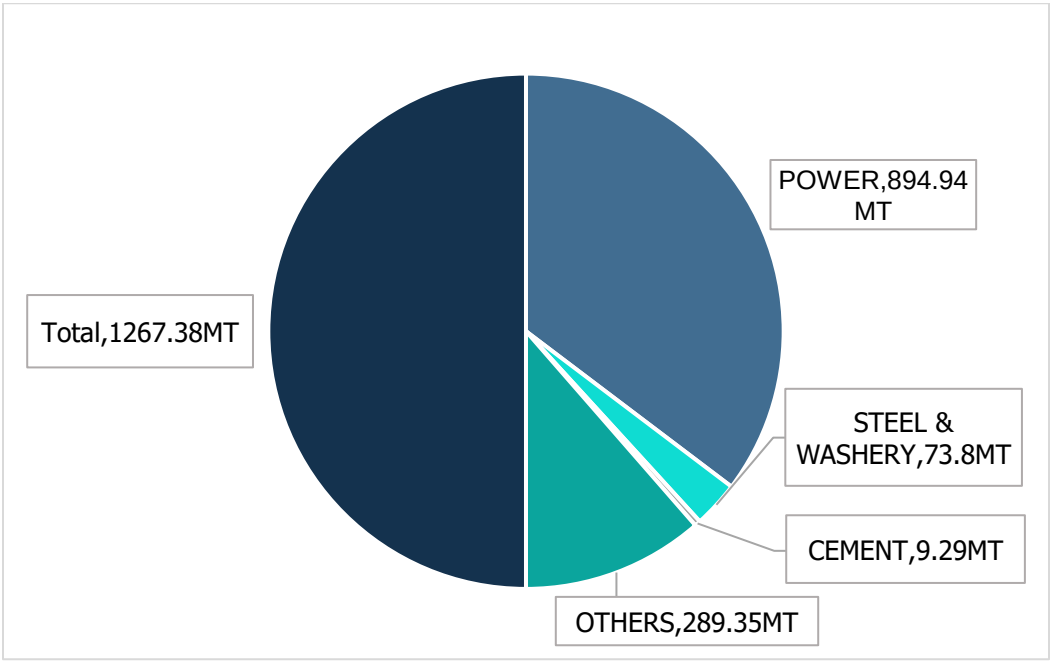


Source: NITI Aayog

10.9. Sector-wise Coal Consumption

Power sector among others is heavily driven by coal as their main fuel, which accounts for more than a third of the total energy consumed in the country, followed by captive power generation in many sectors.

Chart 62: Sector wise coal consumption in FY24



Source: NITI Aayog

Power: The current power installed capacity i.e. of FY25 is 472.46 GW out of which 219.34 GW of the capacity is of coal and lignite which makes up to 46% of the total capacity. The energy requirement is expected to grow to 1,907.8 BU in FY27 and 2,473.7 BU in FY32 from the current 1,821 BU in FY25. It is envisaged that to meet the base load requirement of the country in 2032, the required coal & lignite based installed capacity is 283 GW against the present installed capacity of 217.58 GW. Considering this, Government of India proposes to set up an additional minimum 80 GW coal-based capacity by 2031-32. Currently, 26380 MW of thermal capacity is under construction, 11960 MW has been bid out and 19050 MW is under clearance.

Steel & Washery: Steel and washery consists of about 3% of the total coal consumption in India. Steel production processes use coking coal. According to National Steel Policy 2017, to achieve steelmaking capacity of 300 MTPA (including 181 MTPA through blast furnace route) by FY 2030, huge volumes of coking coal (~170 MT of domestic raw coking coal) would be required. Since domestic coking coal is of high ash variety and the demand of coking coal in India is much higher than domestic production, about 50 MT coking coal is imported by the country on an annual basis. To improve the availability of coking coal, the government has launched Mission Coking Coal. Under this coking coal is washed to reduce the ash percentage and Indian Prime Coking Coal and Medium Coking Coal (<18% ash) is blended with imported coking coal (~9% ash) before utilization in the Coke Ovens to make Coke for feeding into the Blast Furnace.

Cement: The cement sector accounted for only 0.7% of the coal consumption in FY25. The cement sector is expected to grow at 8-9% in the coming years driven by the increased focus on infrastructure sector in the country and revival of housing demand. This in turn is expected to pass on the demand to coal sector.

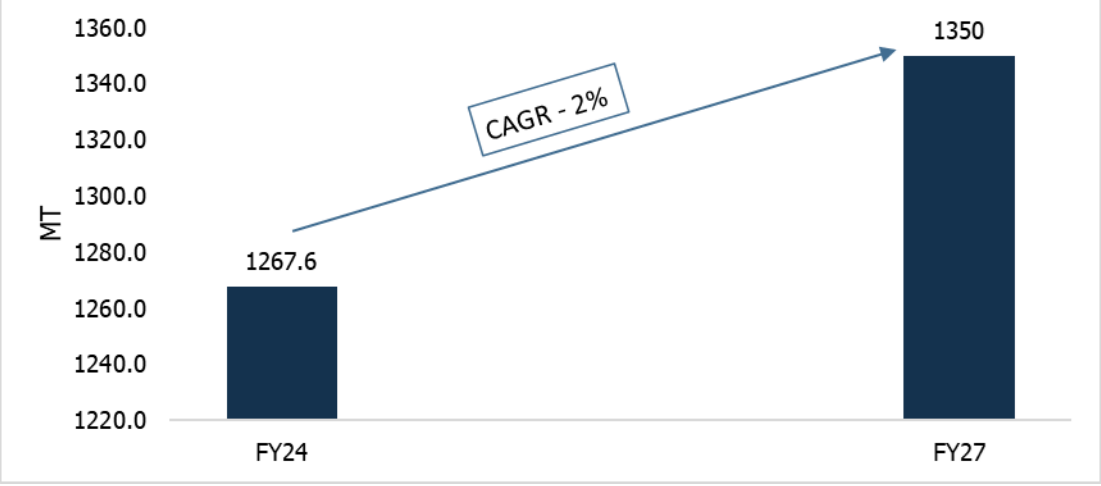
Others: Other sectors include paper, fertilizers, sponge iron etc. also consume coal. These sectors constitute to 23% of the total coal consumption. These sectors are expected to grow by 7-9% in the coming years.

10.10. Coal Consumption Outlook

The domestic coal consumption is expected to reach 1,350 MT in FY27, growing at a CAGR of 2% from 1,267.6 MT in FY24. Coal demand is expected to grow at a faster pace supplemented by increased demand from the power generation sector. Consumption growth is subsequently expected to moderate from FY25 to FY27 due to increase in share of renewable energy in the power sourcing mix of the country.

Power sector is expected to remain the largest consumer of coal along with the thriving end-user industries like steel and cement are expected to increase the demand.

Chart 63: Projected Coal Consumption

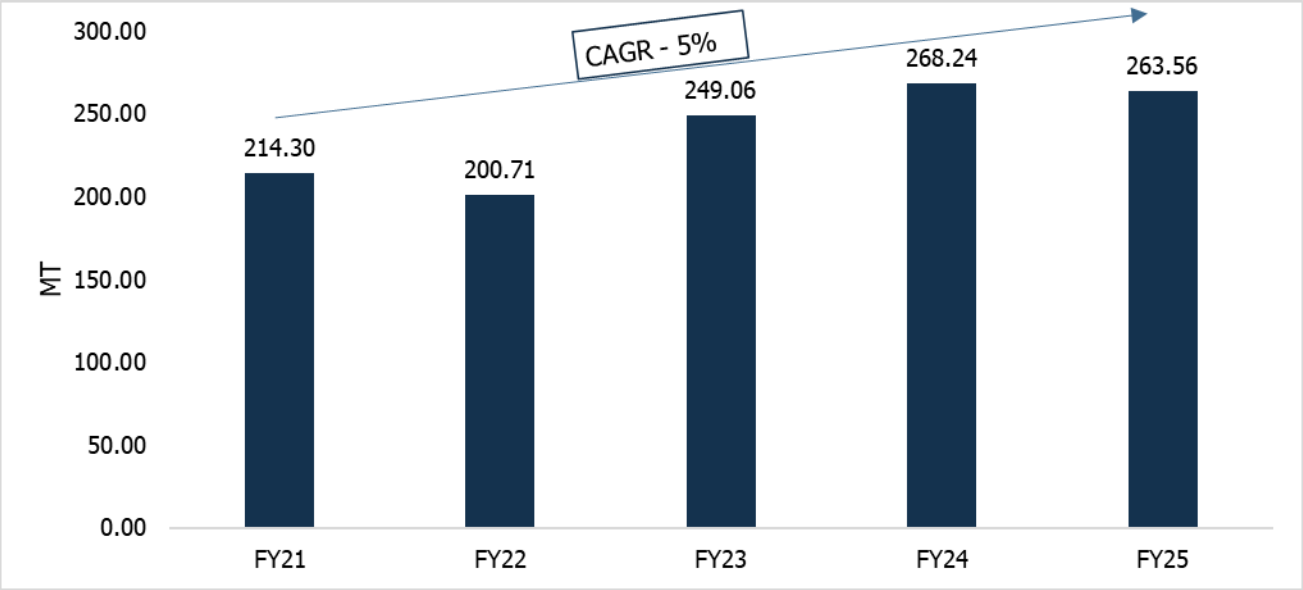


Source: Ministry of coal, CareEdge Research
Note: P- Projected

10.11. Review of Coal Imports in India

Coal imports have increased at a CAGR of 5% during FY20-FY25. During the pandemic-impacted FY21 and the subsequent year of recovery FY22, India saw a decline in coal imports amid halted operating power plants and overall economic movements. However, in FY23, coal imports surpassed pre-COVID-19 levels of FY20, despite domestic coal production registering an all-time high of 892 MT in FY23. At the same time, coal imports have declined by 1.8% y-o-y in Q1FY24 and further de-grew by 1.7% in FY25

Chart 64: Coal Imports in India



Source: Ministry of Coal, CMIE, CareEdge Research

Adani Enterprises Ltd, India Coke and Power Pvt. Ltd and Swiss Singapore Overseas Enterprises Pvt. Ltd. are some of the major coal trading companies in India who imports steam coal, coking coal, petroleum coke and thermal coal from Indonesia, South Africa, USA, Australia and Russia and deliver it to the energy deficit countries. Companies like Steel Authority of India, JSW Steel Ltd, Tata Steel Limited etc. import steel for their internal uses.

Apart from these, local coal trading companies in Gujarat include Shree Chamunda Coal Pvt Ltd., Zenyam Energy Resources Ltd., MCD Coal Pvt. LTD., Naini Coal Company Ltd., etc.

Coking vs Non-Coking Coal

Coking coal, also known as metallurgical coal, is the primary raw material in the steel industry. It is used in coke production and as a fuel and reducing agent in blast furnaces. Coke plays a vital role in the blast furnace, converting iron ore into molten iron, an essential step in steel production.

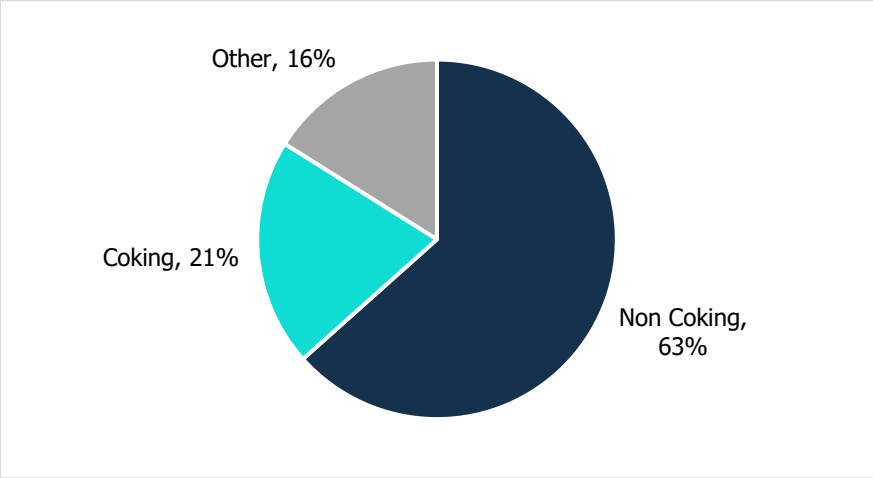
Further, coking coal has a high carbon content, ranging between 70% to 90%, making it suitable for high-temperature applications. It also has relatively low levels of ash and sulphur. High-quality coking coal produces coke with desirable properties, such as strength and porosity, crucial for efficient iron and steel production. Hence, coking coal is often imported from other countries to meet the quality requirements. India's coking coal imports accounted for nearly 21% of total coal imports in FY25.

Whereas non-coking coal, also known as thermal coal, is mainly used for power generation and different industrial processes/applications requiring heat energy. These include cement production, paper mills, and chemical manufacturing.

The non-coking coal has lesser carbon content, ranging between 45% to 70%, suitable for combustion. It has high levels of ash and sulphur. India needs large quantities of non-coking coal for power generation and to supplement the significant

efforts of ramping up domestic coal production. Non-coking coal continues to form a major chunk of coal imports at nearly 63% during FY25.

Chart 65: Share in Total Coal Imports (FY25)



Source: Ministry of Coal, CMIE, CareEdge Research
Note: * includes anthracite, PCI Coal, pet coke, met coke

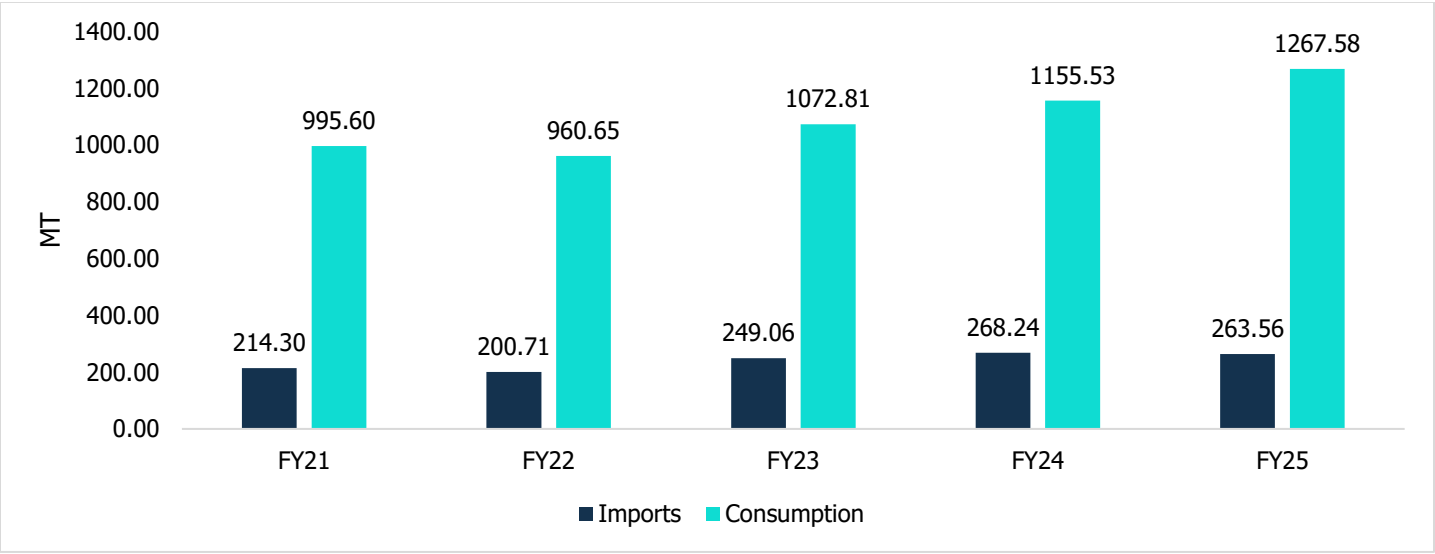
10.12. Risks and Challenges

Dependency on Coal Imports

Despite being one of the largest coal producers of coal in the world with substantial coal reserves, India is highly dependent on imports of high-quality coking coal to meet the demand of the steel industry, which requires specific grades of coal for the metallurgical process.

In FY25, coal imports accounted for approximately21% of total coal consumption in FY25. This reliance on imports not only elevates production costs but also exerts pressure on the country's foreign exchange reserves, rendering the sector vulnerable to global market fluctuations.

Chart 66: Total Coal Imports vs Total Consumption



Source: Ministry of coal, NITI Aayog

Need for Infrastructure Development

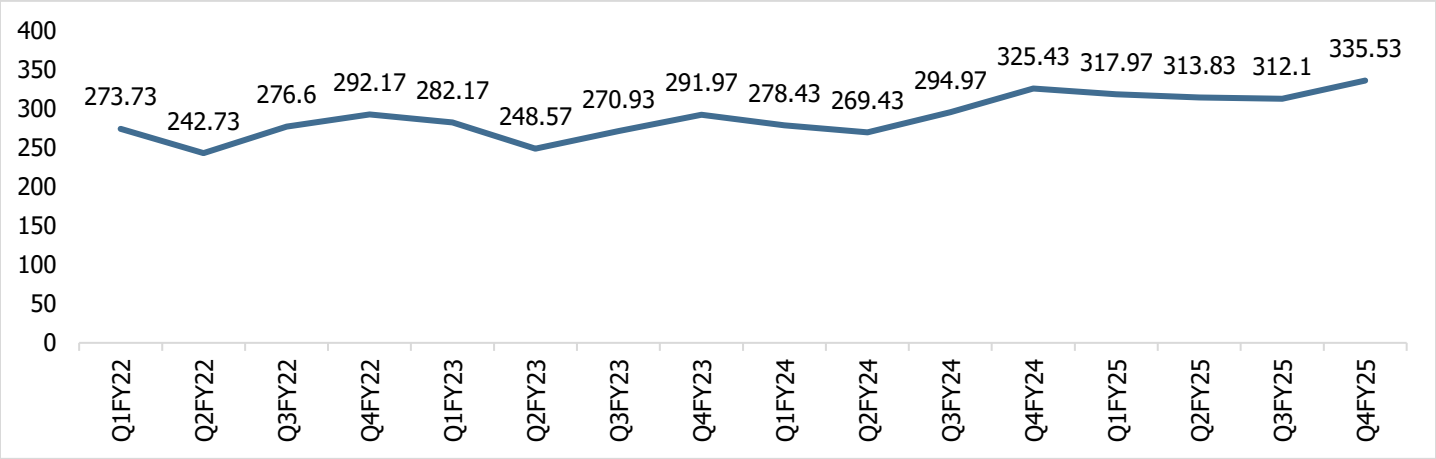
Moreover, the Ministry has already undertaken 51 FMC projects of 522 MT at an outlay of Rs 18,000 crore out of which 8 projects of 95.5 MT have been commissioned. These projects are targeted to be commissioned by FY2025 and an additional 19 FMC projects with a capacity of 330 MT will be implemented by FY2026-27.

The Ministry is also developing the Coal Logistics Policy and National Coal Evacuation Plan to address the challenges and reduce the cost of coal logistics in India. While the government is taking initiatives to augment the transportation infrastructure from coal mines, it has to keep pace with the increased domestic production and demand.

Unavailability of Sufficient Rakes

The availability of rakes has been a challenge for the coal mining industry which has led to delay in supply of coal to essential industries such as power. The railways have some constraints in coal evacuation from certain locations of the coal mines. This is majorly due to the distribution pattern of coal companies and far off locations of power plants from the pitheads. When rakes are dispatched to longer distances from the pithead, they take longer to come back empty, hence the shortage. The average number of rakes available per day decreased by 3% y-o-y during Q1FY24 due to constraints in railway logistics but increased in Q4FY24, hence indicating uncertainty.

Chart 67: Average Rake Availability – Quarterly



Source: Ministry of coal

Coal Quality

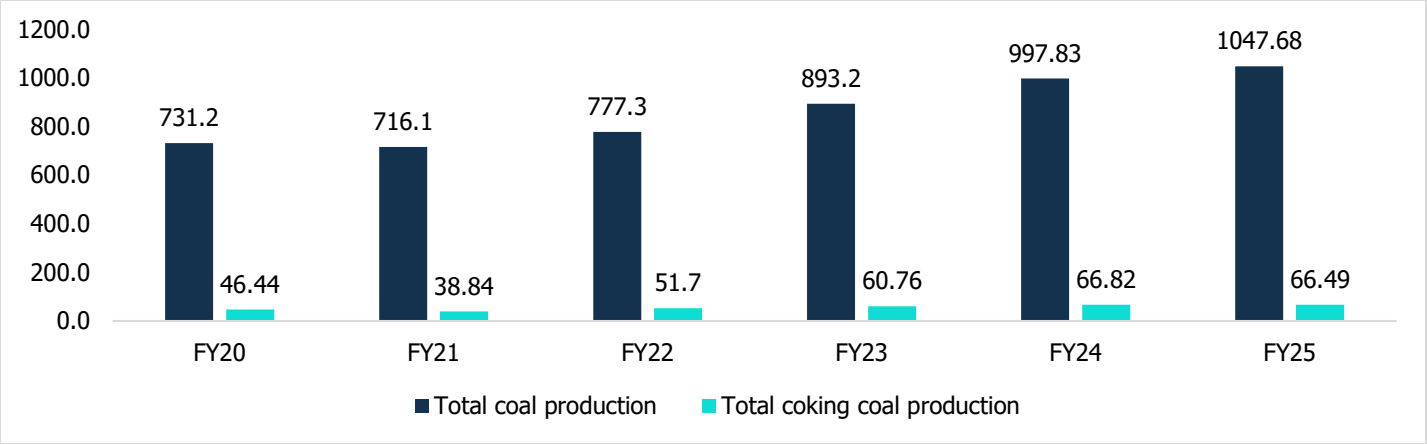
A large part of India's coal reserve is of Southern Hemisphere Gondwana coal, i.e., it has low calorific value and high ash content. Out of the total proven coal reserves, about 79% of coal is of this type, about 20% is of coking coal quality, and about 6% is of prime coking quality. This means that the average Indian power plant consumes more coal to generate a kWh as compared to when high quality is used.

The Government of India is taking various steps like the periodic re-gradation of coal mines, improved technology, first-mile connectivity for direct conveying of coal on the Belt from Coal surface/face to Rapid loading Silo, installation of Auto Analysers, coal beneficiation, etc. These have led to substantial improvement of coal and the grade conformity has jumped from 51% in FY18 to 69% in FY23.

Lack of Domestic Coking Coal

Coking coal is used to produce coke and then used alongside iron ore and limestone to produce steel and cement, respectively. However, the domestic availability of coking coal is limited when compared with its consumption in India. Accordingly, India is largely dependent on imports for meeting coking coal demand.

Chart 68: Coking Coal Production vs Total Coal Production



Source: Ministry of coal

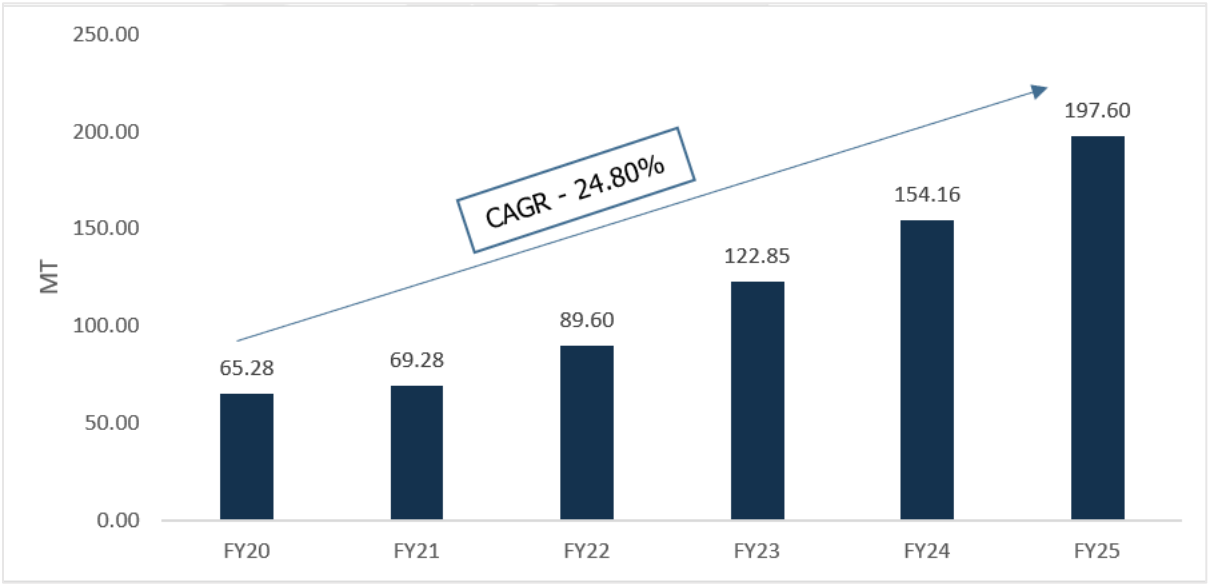
10.13. Overview of the captive coal mining and coal logistics segments

Captive Coal Mining

Coal is produced in India majorly from CIL, SCCL and captive mines which are allocated to both state and private enterprises for the mining and consumption for their own use. Under the Coal Mines (Nationalization) Act, 1973, coal mining was mostly reserved for the public sector. By an amendment to the Act in 1976, two exceptions to the policy were introduced (i) captive mining by private companies engaged in production of iron and steel and (ii) sublease for coal mining to private parties in isolated small pockets not amenable to economic development and not requiring rail transport. Captive coal mining allows companies in sectors like power, steel, and cement to secure their own coal supply to ensure consistent and reliable access to this critical raw material.

For examples: Tata Steels owns West Bokaro Colliery and Jharia Mines in Jharkhand, Steel Authority of India Limited owns Chasnalla Colliery and Jitpur Colliery in Jharkhand, Hindalco Industries have Kathautia Mine and Lohardaga Mines in Jharkhand, JSW Steel have Moitra Coal Mine (Jharkhand) and Gare Palma IV/1 Mine (Chhattisgarh) and Adani Enterprises have Parsa East and Kanta Basan Mine in Chhattisgarh and Talabira II & III Coal Mines in Odisha etc.

Chart 69: Captive Coal Production



Source: Ministry of coal

The coal mines often contract the operations to a third party i.e. Mine Developers and Operators (MDO). They are responsible for the mining, productions, washing, transporting and dispatching of coal from these coal blocks.

Coal mining in India has undergone significant transformation with the active involvement of Mine Developers and Operators (MDOs), who play a crucial role in enhancing operational efficiency and productivity. MDOs undertake a wide spectrum of responsibilities, including project development, coal extraction, processing, and transportation. By introducing advanced technologies and domain expertise, they streamline operations while ensuring adherence to environmental and regulatory standards.

Prominent MDOs in India, such as Adani Enterprises, Essel Mining, and Thriveni Earthmovers, manage major coal projects like the Parsa Kente Collieries and Pakri Barwadih Coal Mining Project. Their involvement not only boosts coal production to meet the country's energy demands but also fosters economic growth and technological advancement in the mining sector.

India's coal logistics segment constitutes a critical part of the national energy supply chain, encompassing the transportation, handling, and storage of coal from mines to end users. This system operates through multiple modes of transport, including railways, roadways, and coastal shipping. Indian Railways remains the backbone of coal transportation, accounting for approximately 60–65% of total coal movement, due to its extensive network and cost efficiency.

Road transport is used for short-distance and last-mile delivery, providing flexibility in accessing remote locations. Coastal shipping is increasingly being utilized to transport coal to coastal power plants, reducing pressure on the railway network and offering a cost-effective alternative. Additionally, coal handling facilities at major ports and warehouses equipped with advanced technologies ensure efficient unloading, storage, and dispatching of coal. These logistics segments work in tandem to ensure a steady and reliable supply of coal to power plants, steel manufacturers, and other industries across India, supporting the nation's energy security and industrial growth.

Table 41: Mines where Adani Enterprises Functions as an MDO

Type	Name	Capacity (MMTPA)	Location	Status
Coal Mining Services	Parsa Coal Block	5	Chhattisgarh	Under Development
	Kente Extension Coal Block	7	Chhattisgarh	
	Gidhmuri Paturia Coal Block	5.6	Chhattisgarh	
	Gare Pelma-I Coal Block	15	Chhattisgarh	Conditional LOI received. Agreement signing awaited
	Gare Pelma-II Coal Block	23.6	Chhattisgarh	
	Parsa East and Kanta Basan Coal Block	15	Chhattisgarh	Operational
	Gare Pelma Sector-III Coal Block	5	Chhattisgarh	
	Talabira II & III Coal Block	20	Odisha	
	Suliyari Coal Block	5	Madhya Pradesh	

Source: Company Website

10.14. Regulatory Framework in the Coal Industry

The Government has been taking various initiatives to increase coal availability in India. These initiatives include auctioning of coal blocks for commercial mining, FDI under the automatic route, expansion of existing mines, opening of new mines under CIL and development of evacuation infrastructure.

- **The Coal Mines (Special Provisions) Act, 2015-** This act was implemented to provide for allocation of coal mines and vesting of the right, title and interest in and over the land and mine infrastructure together with mining leases to successful bidders. This step was taken with a view of ensuring continuity in coal mining operations and production of coal, and for promoting optimum utilization of coal resources consistent with the requirement of the country in the national interest.

Currently, under the seventh round of coal block auction under the Act, which commenced in March 2023, about 103 fully explored, partially explored, coking, non-coking, lignite etc. coal mines are being offered. In this round, 35 bids have been received for 18 coal mines.

- **Mineral Act Amendment 2020-** This act was implemented to regulate the development and mining of minerals in a sustainable and environmentally responsible manner. Several amendments have been made to address the changing needs of the mineral sector and to improve the efficiency and effectiveness of the act.

Amendments made under this Act are:

- **Ease of end-use restriction**: Prior to the amendment, companies acquiring Schedule II and Schedule III coal mines through auctions could use the coal produced only for specified purposes like power generation and steel production. After the amendment the companies are allowed to use the coal produced for any purpose, the amendment also removes a barrier to entry for new companies and foreign investors. This is expected to lead to lower costs and better-quality services for consumers, allowing companies to use the coal for any purpose.

- **Amendment in eligibility criteria for participation in auctions**: As per the latest amendment in order to participate in auctions of coal and lignite blocks, participants need not possess any prior coal mining experience in India. With this change in criteria the Government aims to attract increased investment from new participants and foreign investors.

- **Reallocation of earlier terminated coal mines:** As per the latest amendment, the earlier terminated coal mines under can be reallocated through auction or allotment at the discretion of the central government. This ensures continued benefit from resources in the mines that were otherwise left idle. The reallocation of these mines is expected to support growth in domestic coal production and increase efficiency of the coal sector.

Overall, the amendments made in the Mineral Laws (Amendment) Act, 2020 are a comprehensive set of reforms that are aimed at making the coal sector more competitive, efficient, investment-worthy, and transparent. These reforms are likely to benefit consumers, the environment and the economy.

- **'Mission Coking Coal', August 2021-**

This was launched by the Government to provide a roadmap to increase the production and utilization of domestic coking coal in India by 2030. This was taken as measures under "Atmanirbhar Bharat" to reduce coking coal imports and to achieve 140 MT of coking coal production FY2030X. The following measures are taken under this initiative-

- **Auction of coking coal blocks-** 16 coking coal blocks has been allocated out of which 4 blocks were auction in FY23. This effort is projected to contribute 1.54MT to coking coal production.
- **Revival of abandoned mines-** Bharat Coking Coal Limited (BCCL) has been inviting agencies and companies to undertake coking coal extraction from abandoned or discontinued BCCL owned mines. LoA has already been issued to 4 mines and other 4 are under process.
- **Strategic Collaboration with SAIL-** Steel Authority of India Limited (SAIL) and BCCL have signed an MoU to supply 1.8 MT of washed coking coal.
- **Auction of Raw Coking Coal-** BCCL and Central Coalfields Limited (CCL) has organized auction in June 2023 while Tata Steel secured auction of 50,000 tonnes of raw coking coal from CCL.
- **Innovative Greenfield Washeries-** The ministry is encouraging establishment of Greenfields washeries or refurbishment of existing BCCL washeries to increase coking coal availability.
- **Commercial Auction Scheme, 2020-**

It was launched in 2020, under which commercial mines are auctioned on revenue sharing basis. Under this, a rebate of 50% on final offer would be allowed for quantity of coal produced before the production schedule date. Also, rebate of 50% on final offer was provided on coal gasification or liquefaction.

As on August, 2023, 86 coal mines have been successfully auctioned under the scheme. Details are as below:

Table 42: State wise Revenue Generated from Commercial Mines (in Rs Crores)

State	FY21	FY22	FY23	Jan-25
Chhattisgarh	28.8	14.9	481.5	1722.85
Jharkhand	35.3	2.3	38.2	579.07
Madhya Pradesh	-	225.4	20.4	549.21
Maharashtra	-	52.9	9	143.07
Odisha	38.8	125	109.3	1061.78
West Bengal	-	-	18.6	93.6
Assam	-	-	0.2	0.18
Total	**102. 9**	**420.5**	**677.3**	**4149.76**

Source: Press Information Bureau
Note: Latest data is available till Jan'25 after FY23

- **Permitting MDO/Open Market Sale-**

The Ministry of Coal has engaged MDOs in coal mines, through open global tenders, and to ramp up domestic coal output to reduce dependence import. The contract period of engagement is for 25 years or life of mine whichever is less.

The state-owned coal miner is currently tracking a total of 15 greenfield projects for implementation through MDOs with investment of around Rs 20,600 crores to be spent on land acquisition, rehabilitation and resettlement issues and railway sidings.

The MDOs would excavate and deliver coal to coal companies in line with the approved mining plan. MDOs is expected to lead to beneficial technology infusion, economically viable operations and increased production. Since contracts offered to them are on long-term basis, allied infrastructure at mine projects also would be developed by these private players. The players are expected to take care of land acquisitions, green clearances and coordination with State and Central Pollution Boards.

Coal India Limited (CIL) has issued letters of acceptance for 7 coal projects to be pursued through engagement of Mine Developer cum operator mode. Cumulatively, these projects have production capacity of close to 100 million tonne per year.

- **Reopening of Discontinued Mines on Revenue Sharing Modal**

There are many operational mines with appropriate volumes and sufficient mineable reserve which were closed for safety reasons and primarily due to unprofitable operations which resulted into difficulty in providing for the wages to the employees.

Discontinued mines results in large amounts of reserves not extracted. Therefore, Ministry of Coal is offering these mines in revenue Sharing model. This is an attempt to bring these abandoned mines back into operation. The private sector is expected to bring efficiency through lower overhead expenses and state-of-the art technology. Subsequently, CIL has offered 20 Mines in Tranche-I and 10 mines in Tranche-II to promote utilization of coal resources in the national interest.

- **Imported Coal Blending Norms (Till Oct'24)**

Blending of imported coal by power plants have been undertaken since 2009. After the Covid-19 pandemic, the power demand increased rapidly leading to higher demand in the thermal power plants. As a result, the coal stock depleted in the power plants. In December 2021, the power ministry advised the state Generation Companies (GENCOs) and Independent power producers (IPPs) to import coal at 4% by weight. During April 2022, there was 12% increase in coal consumption in power

plants as compared year on year, so the ministry advised to import coal at 10% by weight in April 2022 to maintain sufficient stock till December 2022.

On January 2023, the power ministry directed the thermal power plants to import coal to achieve imported to domestic coal blending at the rate of 6% for the remaining period of FY23 and H1FY24 which is extended to June 2024. The move is targeted to reduce the coal shortfall in the power plants and build sufficient stock of coal. To ensure uninterrupted power supply during the monsoon, the Ministry of Power extended its advisory, required to maintain adequate coal reserves in domestic coal-based plants and modify the coal blending requirement to 4% by weight until Oct'24.

As on March 2023, the total stock at thermal power plants in the country was 33.3 MT i.e. only 49% of the Normative stock requirement. The coal stocking norms of Central Electricity Authority mandate the power plants to maintain coal stock which varies from month-to-month basis. The stocking norms are 20 to 26 days in non-pithead plants and 12 to 17 days in pithead plants to ensure sufficient coal stock at power plants to meet demand.

- **Duty on Coal Imports**

Presently custom duty applicable to import of coal is 1% Basic Custom Duty and 1.5% of Agriculture Infrastructure and Development Cess (AIDC) totalling to 2.5%. The same was revised for a short duration with effect from 22nd May, 2022 exempting import duty on coal due to increased coal demand led by increased power demand in the country post- COVID. However, exemption of import duty on coal has been again withdrawn with effect from 19.11. 2022.

- **Free Trade Agreement- India Australia Economic Cooperation and Trade Agreement-**

Majority (96%) of India's import from Australia% consists of raw materials & intermediate goods. About 74% of Australia's export to India is coal out of which 71.4% is coking coal. Under the agreement, India has removed the 2.5% of import duty on high- grade Australian coal. India has also been offered zero duty access to 90% value of products from Australia which includes coal. India has also been offered concessions on Tariff lines of export interest to Australia on coking coal and thermal coal.

10.15. Commercial Coal Mining in India

After decades of public-sector dominance and controls that relegated the private sector to a minority status in coal mining, India initiated commercial coal mining through coal mine auctions in 2020. In June 2020, the auction process for 41 coal mines was launched, which was later reduced to 38 coal mines for commercial mining. This initiative aimed to achieve self-sufficiency in meeting energy needs and boost industrial development.

India concluded its first commercial coal mine auctions in 2020, auctioning a total of 20 coal mines in this first tranche. The states aim to garner a total revenue of Rs 7,358 crores annually from the success of the nation's first-ever commercial mining auction. By March 2023, a total of 87 mines had been successfully auctioned in six tranches. These mines are expected to create about 3 lakh jobs and provide revenue of more than Rs 33,000 crores to the states.

The government responded with a series of calibrated steps. To begin with, a transparent mechanism was established through legislation, the Coal Mines (Special Provisions) Act, 2015, to return the blocks to industry via auctions.

Table 43: Commercial Mining Auction: Tranche-wise details

Tranche	Date	No. of mines offered
1st Tranche	Nov-20	71
2nd Tranche	Aug-21	75
3rd Tranche	Feb-21	86
4th Tranche	Apr-22	95
5th Tranche	Mar-22	109
6th Tranche	Nov-22	133
7th Tranche	Mar-23	101

Tranche	Date	No. of mines offered
8th Tranche	Nov-23	39
9th Tranche	Dec-23	27
10th Tranche	Nov-24	9
11th Tranche	Dec-24	12

Source: Press Information Bureau

With the progressive allocation of coal blocks, the number of coal blocks available for allocation is declining, while the number of applicants per block in increasing, as the demand for coal keeps increasing. This has made selection of an applicant in respect of a block difficult and vulnerable to criticism on the ground of lack of transparency and objectivity. While efforts are on hand to continuously add blocks to the captive list, it is also expected that the demand for blocks would remain far ahead of supply.

Players from various sectors such as commodity trading, steel, aluminium, power generation, mine developers and operators. Following are the winners of coal commercial auction-

Table 44: Profile of coal mine commercial auction winners

Sr. No.	Name of Coal Mine	Successful Bidder / Allottee
1	Alaknanda	Rungta Sons Pvt Ltd.
2	Arjuni East	Ultratech Cement Limited
3	Arjuni West	Ganga Khanij Private Limited
4	Babupara East	Rungta Sons Private Limited
5	Baisi	Indermani Mineral India Pvt Ltd
6	Baitarni West	Gujarat Mineral Development Corporation Ltd
7	Bandha	EMIL Mines And Mineral Resources Limited
8	Bandha North	Jaiprakash Power Ventures Limited
9	Bankhui	Yazdani Steel and Power Limited
10	Barra	Bharat Aluminium Company Ltd
11	Bartap(Revised)	JSW Energy Utkal Limited
12	Basantpur	Gangaramchak Mining Pvt Ltd
13	Beheraband North Ext.	Auro Coal Private Limited
14	Bhaskarpara	Prakash Industries Limited
15	Bhivkund	Sunflag Iron and Steel Company Limited
16	Bijahan	Mahanadi Mines & Minerals Pvt. Ltd.
17	Bikram	Birla Corp. Ltd
18	Binja	Assam Mineral Development Corporation Limited
19	Binodpur Bhabhaniganj	JMS Mining Private Limited
20	Brahampuri	Birla Corp. Ltd
21	Brahmdiha	APMDCL
22	Brinda & Sasai	Dalmia Cement (Bharat) Limited
23	Bundu	S M Steels and Powver Limited
24	Burakhap Small Patch	Shreesatya Mines Private Limited
25	Burapahar	Gujarat Mineral Development Corporation Ltd
26	Chakla	Hindalco Industries Ltd
27	Chendipada (Revised)	Rungta Sons Private Limited
28	Choritand Tiliaya	Rungta Metals Private Limited
29	Dahegaon-Go wari	Ambuja Cements Limited
30	Datima	Shree Cement Limited
31	Dhirauli	Stratatech Mineral Resources Private Limited
32	Dumri	S M Steels and Powver Limited
33	Duni Central	Bull Mining Private Limited
34	Durgapur-II/T araimar & Durgapur-II/S	KPCL
35	Garampani	Assam Mineral Development Corporation Limited

Sr. No.	Name of Coal Mine	Successful Bidder / Allottee
36	Gare Palma IV/1	Jindal Power Limited
37	Gare Palma IV/2 and Gare Palma IV/3	Jindal Power Limited
38	Gare Palma IV/5	Sarda Energy and Minerals Limited
39	Gare Palma IV/6	Jindal Steel and Power Limited
40	Gare Palma IV/7	Sarda Energy and Minerals Limited
41	Gare Palma Sector - I	Jindal Power Limited
42	Gawa (East)	Shreeji Nuravi Coal Mining and Trading Private Limited
43	Ghogharpalli & Its Dip Extension	Vedanta Ltd
44	Gonbahera Ujheni East	MP Natural Resources Private Limited
45	Gondbahera Ujheni	MP Natural Resources Private Limited
46	Gondkhari	Adani Power Maharashtra Ltd
47	Gondulpara	Adani Enterprises Limited
48	Gotitoria (East) & (West)	Boulder Stone Mart Pvt Ltd
49	Jaganathpur B	Powerplus Traders Pvt. Ltd
50	Jamkhani	Vedanta Ltd
51	Jhigador	CG Natural Resources Private Ltd
52	Jitpur	Terra Mining Private Ltd
53	Jogeshwar & Khas Jogeswar	South West Pinnacle Exploration Limited
54	Kagra Joydev	Orissa Metallurgical Industry Private Limited
55	Kalambi Kalmeshwar (Western Part)	Samlok Industries Pvt. Ltd.
56	Kasta East	Jitusol developers Pvt Ltd
57	Kerendari-BC North	Orissa Alloy Steel Private Limited
58	Khargaon	CG Natural Resources Private Ltd
59	Koilajan	Assam Mineral Development Corporation Limited
60	Kudanali Lubri	Gujarat Mineral Development Corporation Ltd
61	Kuraloi (A) North	Vedanta Ltd
62	Lalgarh South	Rungta Sons Private Limited
63	Lamatola	ACC Limited
64	Machhakata(Revised)	NLC India Limited
65	Mahan	JK Cement Ltd.
66	Maiki North	Maiki South Mining Pvt. Ltd.
67	Mandakini	KPCL
68	Mandla North	Dalmia Cement (Bharat) Limited
69	Mara II Mahan	Mahan Energen Ltd
70	Marki Barka	Birla Corp. Ltd
71	Marki Mangli- II	Yazdani International Private Limited
72	Marki Mangli- IV	Sobhagya Mercantile Limited
73	Marki-Zari-Jamani-Adkoli	Nilkanth Infra Mining Limited
74	Marwatola – VI	JSW Cement Limited
75	Marwatola – VII	Rama Cement Industries Private Limited
76	Marwatola South	Mineware Advisors Private Limited
77	Meenakshi	Hindalco Industries Limited
78	Meenakshi West	Hindalco Industries Ltd
79	Namchik Nampuk	Coal Pulz Private Ltd
80	New Patrapara South	NLC India Limited
81	North Dhadu (Eastern Part)	NTPC Miniing Ltd
82	North Dhadu (Western Part)	NLCIL
83	North West of Madheri	MH Natural Resources Private Limited
84	Parbatpur Central	JSW Steel Limited
85	Patal East (Eastern Part)	RCR Steel Works Private Limited
86	Pathora East	Shree Bajrang Power & Ispat Ltd
87	Pathora West	Shree Bajrang Power & Ispat Ltd

Sr. No.	Name of Coal Mine	Successful Bidder / Allottee
88	Purunga	CG Natural Resources Private Limited
89	Rabodih OCP	Twenty First Century Mining Private Limited
90	Radhikapur West	Vedanta Ltd
91	Rajhara North (Central & Eastern)	Fairmine Carbons Private Limited
92	Rampia & Dip Side of Rampia	Jhar Mineral Resources Private Limited
93	Rauta Closed	Shreesatya Mine Private Limited
94	Rohne	NMDC
95	Sahapur West	Sarda Energy And Minerals Limited
96	Sakhigopal – B Kankili	Rungta Sons Private Limited
97	Sakhigopal-B Kakurhi	TANGEDCO
98	Sarai East (South)	ACC Limited
99	Sherband	Neelkanth Coal Mining Pvt Ltd
100	Sitanala	JSW Steel Limited
101	South of Damuda	Rungta Sons Private Limited
102	Sugia Closed Mine	Jharkhand State Mineral Development Corporation
103	Takli-Jena-Bel lora (North) &Takli-Jena-B ellora (South)	Aurobindo Reality And Infrastructure Private Limited
104	Tokisud Block -II	Twenty First Century Mining Private Limited
105	Tokisud North	NMDC
106	Ulia Gamhardih	S M Steels and Powver Limited
107	Urma Paharitola	Aurobindo Reality And Infrastructure Private Limited
108	Urtan	JMS Mining Private Limited
109	Urtan North	JMS Mining Private Limited
110	Utkal B1 & B2	Jindal Steel and Power Limited
111	Utkal-A	MCL Ltd
112	Utkal-C	Jindal Steel and Power Limited
113	West of Shahdol(South)	JK Cement Ltd.

Source: Ministry of Coal

Presence of Adani Enterprises in commercial coal mining

The following are the commercial mines won by Adani Enterprises through the competitive bidding process under the Government of India-

Table 45: Commercial Coal Mines under Adani Enterprises

Type	Mine	Capacity	State	Project Status
Commercial coal mining	Dhirauli Coal Mine	5	Madhya Pradesh	Under Development
	Gondulpara Coal Mine	4	Jharkhand	
	Bijahan Coal Mine	5.3	Odisha	
	Gondbahera Ujheni East Coal Mine	NA	Madhya Pradesh	
	Gondbahera Ujheni Coal Mine	4.1	Madhya Pradesh	
	Purunga Coal Mine	NA	Chhattisgarh	
	North West of Madheri Coal Mine	NA	Maharashtra	
	Jhigador Mine	NA	Chhattisgarh	Temporarily Suspended
	Khargaon Mine	NA	Chhattisgarh	

Source: Company Annual Report

Further, Adani Enterprises also operates the Carmichael mine and rail project near the Queensland coast in Australia. The Carmichael project is a thermal coal mine and rail system that transports coal from the Galilee Basin to countries in Asia, including India. The Carmichael mine has a capacity of 10 MTPA and became operational in the fourth quarter of fiscal 2022.

11. Mining – Non-Coal and Iron Ore

11.1. Overview of Structure of The Mining Industry – Non-Coal

The mining industry stands as a cornerstone of India's economic landscape. Minerals, being an invaluable natural asset, serve as pivotal raw materials for multiple sectors including power generation, steel manufacturing, and cement production. India is bestowed with a wealth of resources, providing a diverse variety of metallic and non-metallic minerals. This sector holds great significance in fostering the economic growth and development of India, serving as a primary source of direct employment for millions and thus playing a key role in livelihood generation.

India presently boasts a diverse range of minerals, comprising 4 fuel, 10 metallic, 23 non-metallic, 3 atomic, and 55 minor minerals. The total worth of mineral production (excluding atomic, fuel minerals, and minor minerals) was valued at Rs. 1,48,185 crores in FY25. The Indian mining sector is marked by a significant presence of numerous small operational mines. In FY25, a total of 1,943 mines reported mineral production (excluding atomic, fuel, and minor minerals) in India as compared to 1,740 in FY24. The majority of mines were located in Madhya Pradesh, followed by Gujarat, Tamil Nadu, Karnataka, Andhra Pradesh, Odisha, Chhattisgarh, Rajasthan, Maharashtra, Jharkhand, Telangana, and Goa.

As per the provisional estimates, mining and quarrying sector accounted for about 1.9% of total GVA during FY25. India is near to self-sufficient in bauxite, chromite, iron ore and limestone.

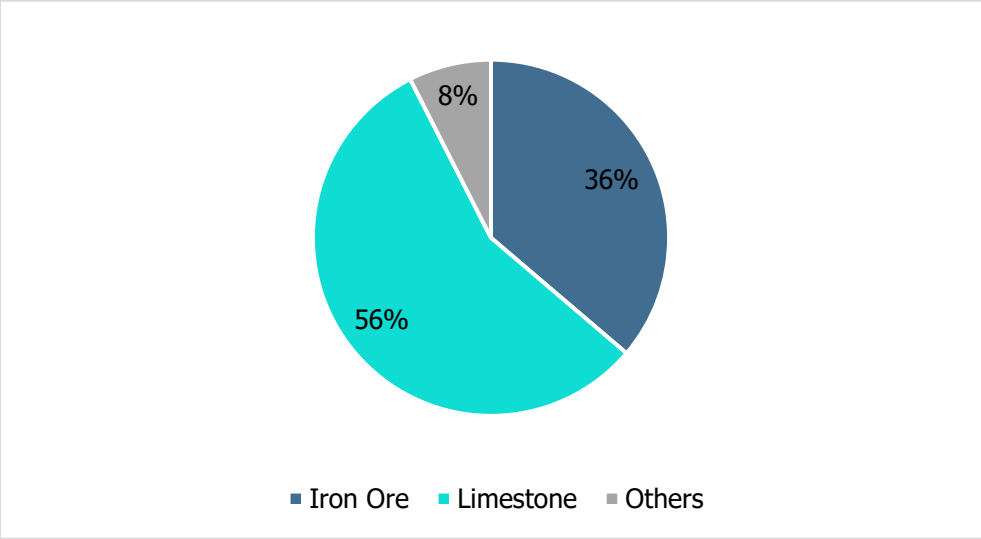
11.2. Overview of India's non-coal mining sector

In March 2025, the mineral production index reached 158.1, marking a 1.2% increase from March 2024. Moreover, the index witnessed a 3% rise in FY25, as compared to FY24.

In the non-coal segment of the Indian mining sector, iron ore and limestone jointly contribute to approximately 78% and 92% of the total Mineral Conservation and Development Rules (MCDR) mineral production by value and volume terms respectively. Other major minerals like bauxite, lead & zinc ore accounted for 11% of the total minerals produced in India, in value terms.

India is the 3rd largest lime producer and 4th largest iron ore producer in the world. The production of iron ore at 289 million metric ton (MMT) in FY25 was a 4.6% growth from 277 MMT achieved in FY24. However, limestone production has decreased, y-o-y, by 0.3% to 449 MMT in FY25 from 451 MMT in FY24. During FY24, limestone production increased by a record growth of 11.1% y-o-y from 406 MMT in FY23.

Chart 70: Total Mineral Production - Non-Coal Sector in India during FY25 (Volume - ~799 million tonnes)

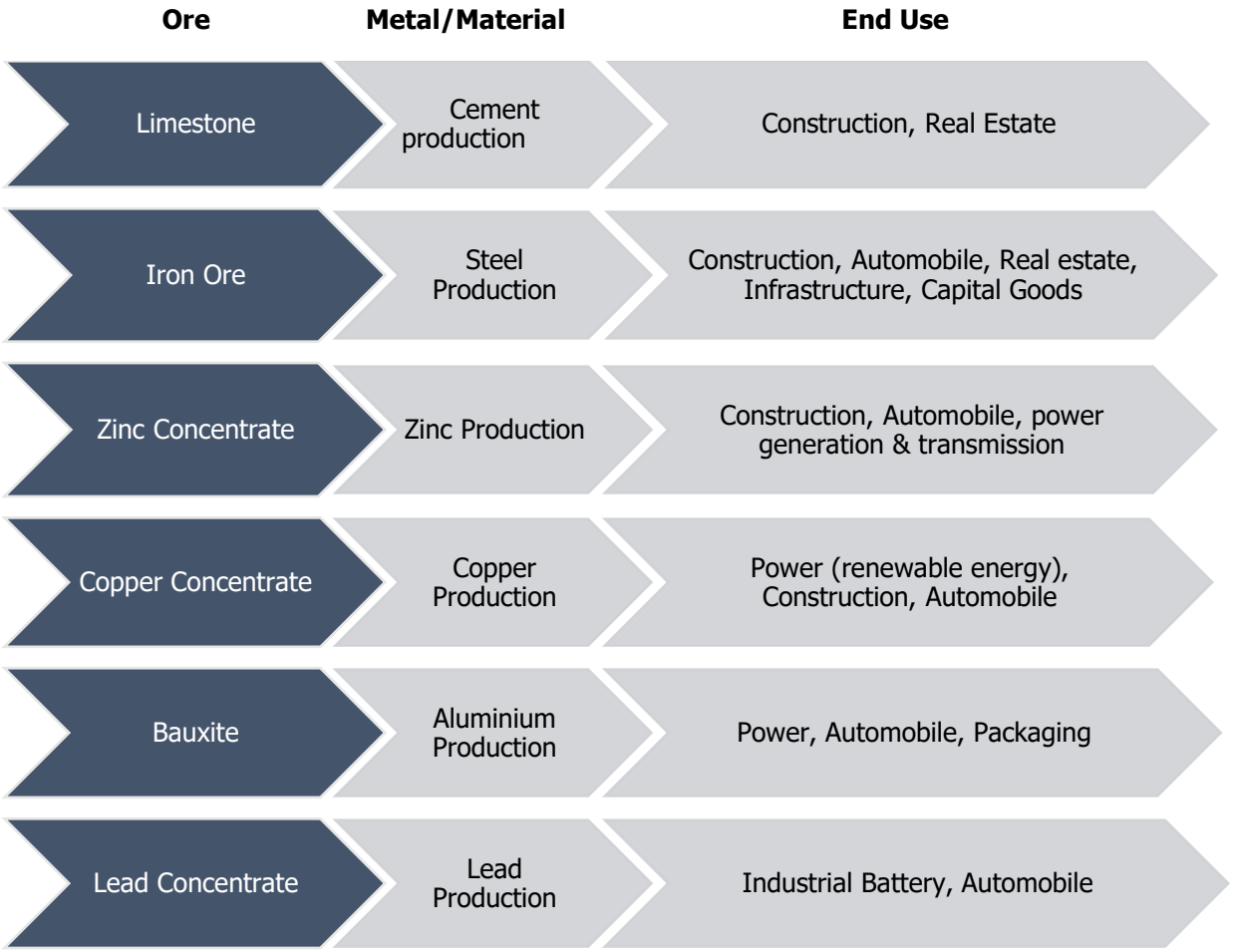


Source: Indian Bureau of Mines (IBM)

The significant increase in iron ore and limestone production during FY25 indicates the strong demand prevailing in key end user industries like steel and cement. This, combined with the substantial growth in aluminium production indicates good economic activity in end user sectors such as energy, infrastructure, construction, automotive and machinery.

11.3. Assessment of key demand drivers of India's non-coal mining sector

The country's economic growth serves as a key driver for the mining industry, with each mineral type possessing distinct downstream applications that significantly impact the sector. For instance, the rising need for infrastructure development will boost demand for cement, thereby driving the demand for limestone.



Source: CareEdge Research

11.4. Pricing regime overview of the iron ore sector

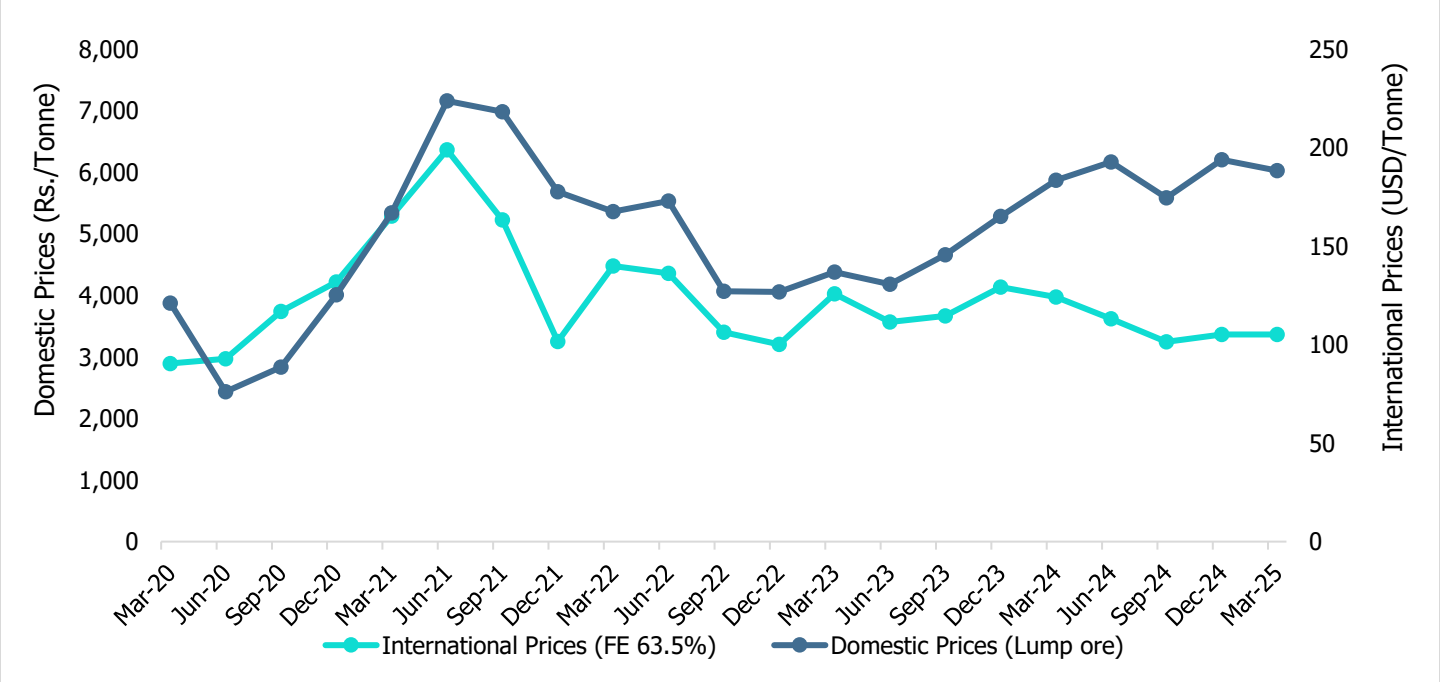
Iron ore is a major raw material used in steel production. The prices of iron ore are influenced by a variety of factors including ore quality, transportation expenses, global market rates, and current market conditions. The domestic prices of iron ore follow similar trend as that of global prices.

As of the quarter ended March 2025, international iron ore prices remained stable at USD 105 per tonne, reflecting no change on a quarter-on-quarter (q-o-q) basis. This stability followed a modest recovery in the previous quarter (December 2024), where prices had inched up slightly to USD 105 per tonne from USD 102 per tonne in September 2024. The September quarter had seen a sharper decline of about 10.3% q-o-q to USD 102 per tonne, driven by renewed concerns in China's real estate sector and weaker global demand. Prior to that, prices had fallen to USD 113 per tonne in June 2024 and USD 124 per tonne in March 2024, after peaking at USD 129 per tonne in December 2023. Earlier, in the September

2023 quarter, prices had shown a recovery, rising by 3% q-o-q and 8% y-o-y to USD 115 per tonne, following a drop to USD 112 per tonne in June 2023, which was a 11.3% q-o-q and 18.1% y-o-y decline.

As of the quarter ended March 2025, domestic iron ore (lump) prices declined by 2.9% q-o-q to Rs. 6,030 per tonne, down from Rs. 6,208 per tonne in December 2024. The December 2024 quarter had marked a strong recovery with an 11.1% q-o-q rise, driven by seasonal demand and increased buying from secondary steel producers. This followed a 9.5% q-o-q decline in September 2024 to Rs. 5,589 per tonne, due to weakened demand and global headwinds. Previously, prices had seen steady growth: in June 2024, they rose by 5.1% q-o-q to Rs. 6,173 per tonne, and in March 2024, they had increased by 11.2% q-o-q to Rs. 5,875 per tonne, up from Rs. 5,284 per tonne in December 2023. The surge in early 2024 was attributed to strong domestic steel demand and supply-side disruptions such as mining restrictions and logistical challenges. In September 2023, domestic iron ore prices rose by 11.4% q-o-q to Rs. 4,660 per tonne, driven by seasonal construction demand, increased steel output, and inventory restocking. This was preceded by a moderate 4.5% q-o-q decline in June 2023 to Rs. 4,184 per tonne, supported by gradually improving steel sector demand and mild supply constraints.

Chart 71: Price Trend of Iron Ore



Source: CMIE

11.5. Review of the Mining Industry — Iron Ore

India has large resources of iron ore and concentrates (both hematite and magnetite), estimated at 35,286 MT (million tonnes) in FY20 with 6,412 MT classified as reserves. Although India has sufficient iron ore reserves, the availability of high-grade iron ore is limited as they are being depleted because of their usage in blast furnace and direct reduced iron (DRI) plants. As a result, its critical to utilize low-grade deposits (45% Fe), which require beneficiation to make them suitable for use in steel plants. For every 1 tonne of steel produced through the BF-BOF[3] route, a suitable blend of 1.6-1.7 tonnes of iron ore is required.

[3] Blast Furnace – Basic Oxygen Furnace

Demand Review

The demand for iron ore is significantly influenced by the advancements in the steel industry. The global demand for steel continues to surge with the expansion in industrialization worldwide. The steel industry in India has consistently witnessed growth in steel production, reaching approximately 151 MT in the FY25.

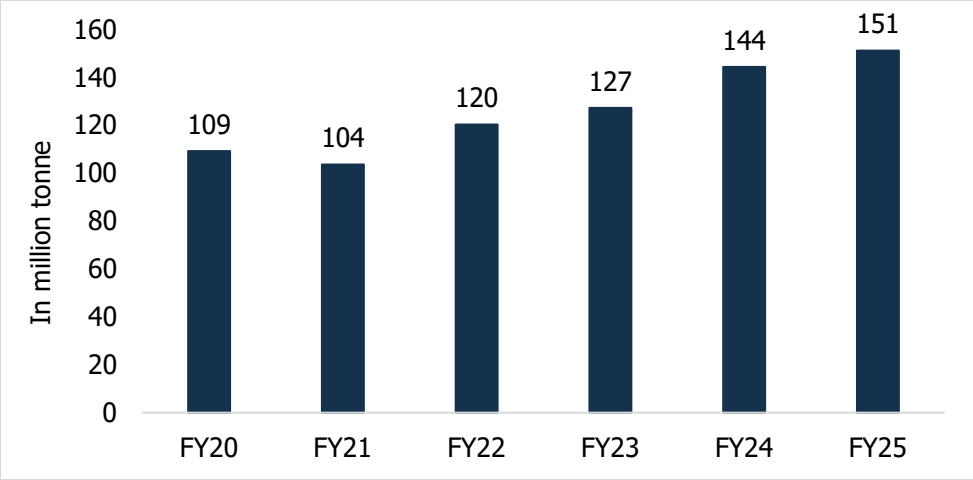
Until the end of the FY23, India remained a net exporter of steel. However, the trend has reversed in FY24 and continued to be the same during FY25 with rise in inbound shipments of about 14.6% y-o-y.

Overall, the country imported ~9.5 MT of finished steel shipments during FY25 marking a 14.6% y-o-y increase from the previous year. Concurrently, steel consumption in India has grown by 10.2% to ~150 MT during the same period, indicative of robust demand within one of the world's fastest-growing economies.

Furthermore, India's steel production is likely to increase in the coming years backed by infrastructure growth in the country. Furthermore, the robust demand in end-user segments such as automobiles, real estate, and construction is expected to boost the demand for steel products, thereby raising the demand for its raw material – iron ore. In addition to that, the National Steel Policy 2017 envisages achieving 300 MT of crude steel production capacity from the current level of 179.5 MT in FY24 to cater to the expected demand of 255 MT by FY31. This initiative is poised to further bolster the demand for iron ore, with the requirement for iron ore projected to reach 437 MT by FY31. This indicates that the demand for iron ore in India is expected to rise going ahead.

Besides steel, the demand is also driven by various end-use sectors such as cement, ferro-alloys, and coal washery. According to the IBM report, India's ferro-alloys industry boasts a total capacity of 5.15 MT. As of March 2024, India operates coal washeries with a combined capacity of 257.8 MT per annum (MTPA). Moreover, the government is actively pursuing initiatives to augment the capacities of coal washeries, aligning with India's pledge for cleaner and more efficient coal production.

Chart 72: Domestic Crude Steel production in India



Source: CMIE

Supply Review

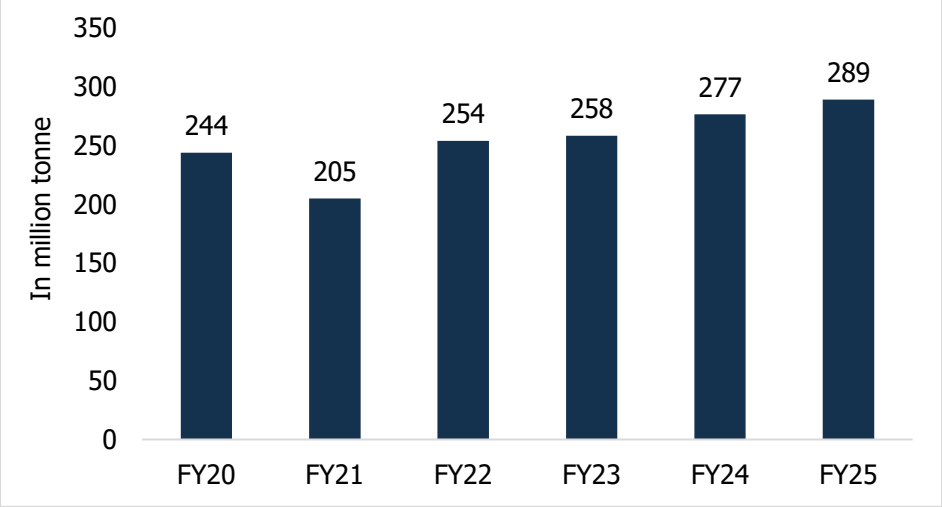
India is self-sufficient in iron ore. The major iron ore mines are located in Odisha, Chhattisgarh, Karnataka, and Jharkhand. Iron ore production in India grew at a compound annual growth rate (CAGR) of 3.5% over FY20–FY25. In FY25, India produced 289 million tonnes (MT) of iron ore, reflecting a year-on-year growth of 4.6%. This production output surged on the back of sturdy steel-sector demand. Market signals and policy stability encouraged miners to boost extraction efforts. Expansion of capacities by state and private firms underpinned higher yields. Accelerated auctions of mine blocks unlocked new sources of raw material, while improvements in transportation infrastructure facilitated smoother movement from mines to ports. The sustained growth in allied mineral sectors further underscored the economy's resilience. Strategic

initiatives to secure overseas ore reserves provided long-term supply security. Additionally, increased mechanisation and the adoption of digital monitoring systems enhanced operational efficiency.

India's iron ore production reached 277 million tonnes (MT) in FY24, marking a 7.3% year-on-year (y-o-y) growth. This increase follows a strong performance in FY23, when production stood at 258 MT, aided by a suite of government initiatives. These included reforms in the Mining and Mineral Policy, faster auctioning and operationalization of expired mines, and focused efforts to improve the ease of doing business in the sector—all aimed at enhancing availability and production.

These recent gains came after a challenging period in FY21, when iron ore production saw a notable 16% y-o-y decline. The downturn was primarily driven by a sharp dip in output from Odisha, India's leading iron ore producer, along with reduced production from Jharkhand. This slump was further exacerbated by the COVID-19 pandemic and the expiration of a significant number of mining leases on March 31, 2020. However, the sector rebounded strongly in FY22, recording a 24.5% y-o-y growth, setting the stage for the continued momentum in subsequent years.

Chart 73: Domestic Production of Iron Ore



Source: CMIE

11.6. Assessment of regulatory framework in the iron ore industry

The iron ore industry operates under strict regulations, affected by regulations such as export duties and restrictions on mining and exports. Consequently, the sector's production has shown considerable fluctuations over time. Additionally, significant changes in regulations, such as the Mines and Minerals Development and Regulation (MMDR) Amendment Act of 2015 and subsequent revisions, have had a notable impact on the industry.

Export Duty changes

Iron ore production in India caters to the domestic demand alongside contributing a significant volume of exports from India. In FY16, the export duty on iron ore lumps and fines remained at 30%, while the duty on iron ore pellets was lifted to encourage their export along with low-grade ore.

In May 2022, due to a significant and consistent increase in steel prices, the government implemented several tariff measures as below:

- Duty on iron ore lumps with more than 58% Fe content was raised from 30% to 50% ad valorem.
- Duty of 50% was imposed on iron ore with Fe content below 58%.
- Duty of 45% was imposed on iron ore pellets.

The imposition/increase in export duty was mainly intended to increase the availability of both finished steel and raw materials for steel production. However, this duty was subsequently reversed in November 2022 due to fall in exports. The

Government revoked the export duty on iron ore lumps and fines below 58% Fe content, iron ore pellets, and specified steel products, including pig iron. Additionally, import duty concessions on Anthracite/PCI coal, coking coal, coke & semi-coke, and ferronickel were also revoked.

Table 46: Changes in Export Duty on Iron Ore

Material	Exports Duty	
	After May 2022 Order	After Nov 2022 Order
Iron ore lumps and fines (< 58% Fe)	50%	0%
Iron ore lumps and fines (> 58% Fe)	50%	30%
Iron ore pellets	45%	0%
Pig iron and steel products (HS 7201, 7208, 7209,7210,7213, 7214, 7219, 7222 & 7227)	15%	0%

Source: Ministry of Finance

Export ban and production cap in Karnataka

Till FY10, Karnataka emerged as the second-largest iron ore producer in India, trailing behind Odisha, with a production output of approximately 43.1 MT, representing a share of about 19.7% of the total national production. However, in 2011, the judiciary uncovered extensive illegal mining activities in the state, posing severe environmental hazards. Consequently, in July 2011, the courts issued a sweeping ban on mining operations in the Bellary district. This prohibition was later extended to encompass mining activities in the adjacent districts of Tumkur and Chitradurga in August 2011.

Despite the court gradually raising the production cap to 35 MT by 2020, Karnataka continued to face an export ban. However, in 2022, the apex court lifted this ban, allowing the operations of mines that were closed through previous ruling. As of FY23 it has produced ~39.8 MT of iron ore elevating it to the position of the third-largest producer of iron ore in India.

Recent data from the National Mineral Development Corporation (NMDC) shows continued growth, with a significant portion of their 2024 production and sales attributed to Karnataka, reflecting a positive trend. Additionally, following a 2024 Supreme Court ruling empowering states to levy taxes on mineral rights and mineral-bearing lands, Karnataka introduced the Karnataka (Mineral Rights and Mineral Bearing Land) Tax Bill, which aims to regulate mineral taxation, including retrospective provisions. While these developments indicate sectoral progress, challenges remain as the state balances growth with regulatory measures impacting iron ore mining operations.

Goa Mining Ban

Goa's iron ore mining industry, as of 2025, is in the process of a major change towards sustainable and transparent operations. The state government has resumed mining activities through the Goa Mineral Development Corporation (GMDC) with emphasis on environmentally friendly practices and community participation. One of the key features of this resurgence is the use of e-auctions for selling iron ore blocks, making it transparent and providing equal access.

Environmental conservation continues to be the focus, with mining activities now necessitating clearance through the PARIVESH portal and compliance with the Mineral Conservation and Development Rules (MCDR). The tracking of barges and vehicles in real time is also being introduced to avoid unauthorized transport of ore. Yet, there are challenges that remain. E-auctions for many iron ore leases within the proposed Eco-Sensitive Areas (ESAs) of the Western Ghats have been put on hold pending the Union Ministry of Environment, Forest and Climate Change final notifications. The Goa government has sought the deletion of few villages from the ESA list, which may redefine the opening up of mining opportunities in those regions. In spite of these challenges, the proactive role of the state to revive the mining industry reflects its intent to balance economic development with the environment.

Mineral Laws (Amendment) Act, 2020

To ensure the sustainable production of minerals in the country, particularly with a significant number of mining leases that were set to expire in March 2020 under Section 8A (6) of the MMDR Act, the Central Government introduced amendments to the MMDR Act through the Minerals Laws (Amendment) Act, 2020. The primary objectives of this amendment are to empower State Governments to proactively initiate auctions for mineral blocks before lease expiration and to facilitate the smooth transfer of statutory clearances and permissions to new lessees, ensuring uninterrupted mining operations.

Key Highlights:

- The Central Government shall not be required for grant of reconnaissance permit, prospecting license or mining lease in respect of the minerals specified in Part A of the First Schedule
- The Central Government can set conditions for holders of mining leases to start or continue production, ensuring sustained mineral output in the country.

MMDR Amendment Act, 2023

The Mines and Minerals (Development and Regulation) Act of 1957 underwent significant amendments in 2015, introducing reforms such as auction mandates for mineral concessions, the establishment of District Mineral Foundation (DMF) and National Mineral Exploration Trust (NMET), and stringent penalties for illegal mining. Further amendments in 2016, 2020, and 2021 addressed emergent issues, including removing distinctions between captive and merchant mines, transferring statutory clearances for continuity in operations, and removing restrictions on concession transfers.

This Act was further amended in 2023 by passing the Mines and Minerals (Development and Regulation) Amendment Bill, 2023. This amendment responds to the global emphasis on critical minerals and introduces significant reforms in the mining sector, including:

- Omitting six minerals from the list of 12 atomic minerals specified in Part-B of the First Schedule.
- Empowering the Central Government to exclusively auction mineral concessions for critical minerals specified in Part D of the First Schedule, with revenue accruing to the concerned State Government.
- Introducing exploration licenses for deep-seated and critical minerals in response to global focus on these resources.

Commercial Mining of Iron Ore

In India's commercial iron ore mining sector, major government entities such as the National Mineral Development Corporation (NMDC) and the Odisha Mining Corporation (OMC) hold significant dominance, collectively controlling around 62.7% of the market share.

The major iron ore mines are located in Odisha, Karnataka, Chhattisgarh, and Jharkhand. They collectively accounted for around 92.7% of the total production in FY25 (April 2024-February 2025). Odisha is the largest iron ore-producing state with a 54.9% share in production. Iron ore is abundantly available in the Mayurbhanj, Sundargarh, and Keonjhar districts of Odisha.

11.7. Impact of FTAs and Tariff on Non-Coal Mining Industry

The recent U.S. tariff increases on aluminium and steel imports have adversely affected India's non-coal mining sector, particularly aluminium producers. Vedanta, a leading Indian aluminium producer, has expressed concerns that the U.S. decision to double aluminium tariffs to 50% threatens India's aluminium industry, which is already facing challenges due to rising imports. The company has urged the Indian government to introduce protective tariffs to shield the domestic aluminium sector.

In response to these challenges, India is actively pursuing greater market access for its steel exports through ongoing Free Trade Agreement (FTA) negotiations with various countries and trade blocs, including the European Union, the United States, and the UK. Additionally, India has initiated an anti-dumping investigation targeting coal imports from countries including Australia, China, Colombia, Indonesia, Japan, and Russia, aiming to protect its domestic industry from unfair pricing practices.

11.8. Profile of key iron ore commercial miners in India

a) National Mineral Development Corporation (NMDC)

NMDC, a Navratna Public Sector Enterprise under the Ministry of Steel, Government of India, is the largest producer of iron ore in India with an average annual production of over 40 MT. It owns and operates highly mechanized iron ore mines in Chhattisgarh and Karnataka, as well as the only mechanized diamond mine in India, located in Panna, Madhya Pradesh. It is primarily engaged in the business of exploring and extracting various minerals, including copper, iron ore, rock phosphate, limestone, dolomite, gypsum, bentonite, magnesite, diamond, tin, tungsten, graphite, and beach sands.

The company produces iron ore from its major units, including the Bailadila Sector in Chhattisgarh and Donimalai in the Bellary-Hospet region of Karnataka. The company has plans to expand its iron ore production capacity to 67 MTPA by FY26 and further to 100 MTPA by FY30 to meet the growing demand. In the Bailadila area, NMDC operates two Iron Ore Mining Complexes: the Bailadila Iron Ore Mine – Kirandul Complex (Dep-14, 14 NMZ, 11B & 11C) and the Bailadila Iron Ore Mine – Bacheli Complex (Dep-5,10 & 11A). Additionally, the Donimalai Complex comprises two Iron Ore Mines: the Donimalai Iron Ore Mine and the Kumaraswamy Iron Ore Mine.

In FY25, NMDC achieved a total production of 44.04 MT and sales of 44.4 MT.

b) Odisha Mining Corporation Limited (OMC)

OMC was established on May 16th, 1956, as a joint venture between the Government of Odisha and the Government of India. Its primary aim was to exploit the mineral resources of Odisha through exploration, extraction, and value addition. Four years later, on November 17th, 1961, OMC transitioned into a fully state-owned corporation under the Government of Odisha. OMC operates major mines producing iron, chrome, bauxite, and manganese, which serve the needs of various mineral-based industries including steel, sponge iron, pig iron, ferro-manganese, ferrochrome, and similar sectors.

Currently, OMC's major iron ore mines are Daitari, Gandhamardan – A & B, Kurmitar, Guali, Jilling, Khandbandh, Banspani, Unchabali, Kolha-Roida (ROIDA-C) and Tiringpahar, totalling 11 active mines. In FY24, OMC achieved a total production of 33.2 MT and sales of 38.8 MT.

c) Essel Mining & Industries Limited (EMIL)

EMIL stands as one of the oldest mining companies in India, being a part of the Aditya Birla Group. Operating since 1950, EMIL has diversified its operations to include coal mining, diamond mining, Noble Ferro Alloys, iron pellets, and renewable energy.

Initially focused solely on iron ore and manganese mining during its inception, the company later ventured into Noble Ferro Alloys manufacturing. EMIL's sole iron ore mine is situated in Koira, within the Sundargarh district of Odisha. While the company used to operate other iron ore mines, it was unsuccessful in securing them during their re-auctioning in 2020. The company is into the manufacturing of iron pellets through its advanced Circular Pelletization Technology (CPT). Rebranded as Pro Minerals Private Limited (PMPL), it became a division of EMIL in 2019.

The plant, located in Basantpur, Keonjhar district of Odisha, consists of a 1 MTPA Iron Ore Beneficiation Plant utilizing innovations from All Mineral GmbH, Germany, and a 1 MTPA capacity iron ore Pelletization plant employing the advanced and versatile CPT.

d) Adani Enterprises Limited

Adani Enterprises is a Mine Developer and Operator (MDO) player in India, with significant involvement in the coal and iron ore sectors. The company presently operates at ~6 MMT capacity in Kurmitar iron ore mine, Odisha. Additionally, Adani Mining has established its Mineral Resource Exploration Division, offering comprehensive mining solutions for surveying, coal block exploration, and grading assessment. This division not only oversees exploration activities for the group but also extends its services to other companies.

Table 47: Iron ore mines with Adani Enterprises as MDO

Iron Ore Mining as an MDO-Chhattisgarh	Block Area (~Sq. Km.)	Mineable Reserves (MT)	Peak Capacity (MMTPA)	Production Commencement
Bailadila Iron Ore Mine	6.42	326	10	Under Development
Kurmitar Iron Ore Mine	6.51	145.35	6	Operational

Source: Company Website

12. Aluminium

12.1. Overview

Aluminium is one of the lightest and second-most used metals globally, after steel. The primary raw material used in the production of aluminium is bauxite ore. India has sizable bauxite reserves, amounting to around 49,58,248 thousand tonnes. Of these, 13% comes under the reserve category, whereas the remaining 87% belong to remaining resources.

Table 48: Bauxite Resources in India as of April 2020 (In Thousand Tonnes)

Particulars	Reserves	Remaining resources	Total resources
Ore	6,46,493	43,11,754	49,58,248

Source: Indian Bureau of Mines

Note: 1) A resource is that amount of a geologic commodity that exists in both discovered and undiscovered deposits

2) Reserves are that subgroup of a resource that have been discovered, have a known size, and can be extracted at a profit.

Aluminium production can be split into two parts, upstream and downstream processes. The upstream process involves bauxite mining, alumina refining, and smelting activities whereas the downstream process involves casting, rolling, extrusion, and fabrication activities.

India is the second-largest producer of aluminium after China. In India, aluminium production is largely led by three players namely National Aluminium Company Limited (NALCO), Hindalco Industries Limited, and Vedanta Limited. The global average per capita consumption of aluminium is about 11 kg (CY20), whereas India's per capita consumption is low at about 2.5 kg (FY21).

12.2. Review of Domestic Primary Aluminium Consumption

During 11MFY25, consumption of primary aluminium increased year-on-year by 21.8%, reaching 2,660 thousand tonnes. This surge was driven by strong demand from infrastructure development, growing use of aluminium in lightweight and electric vehicles within the automotive sector and expanding renewable energy projects requiring aluminium components.

In FY24, aluminium consumption rose by 18.8% year-on-year, supported by high government spending on infrastructure and consistent demand from both automotive and power sectors.

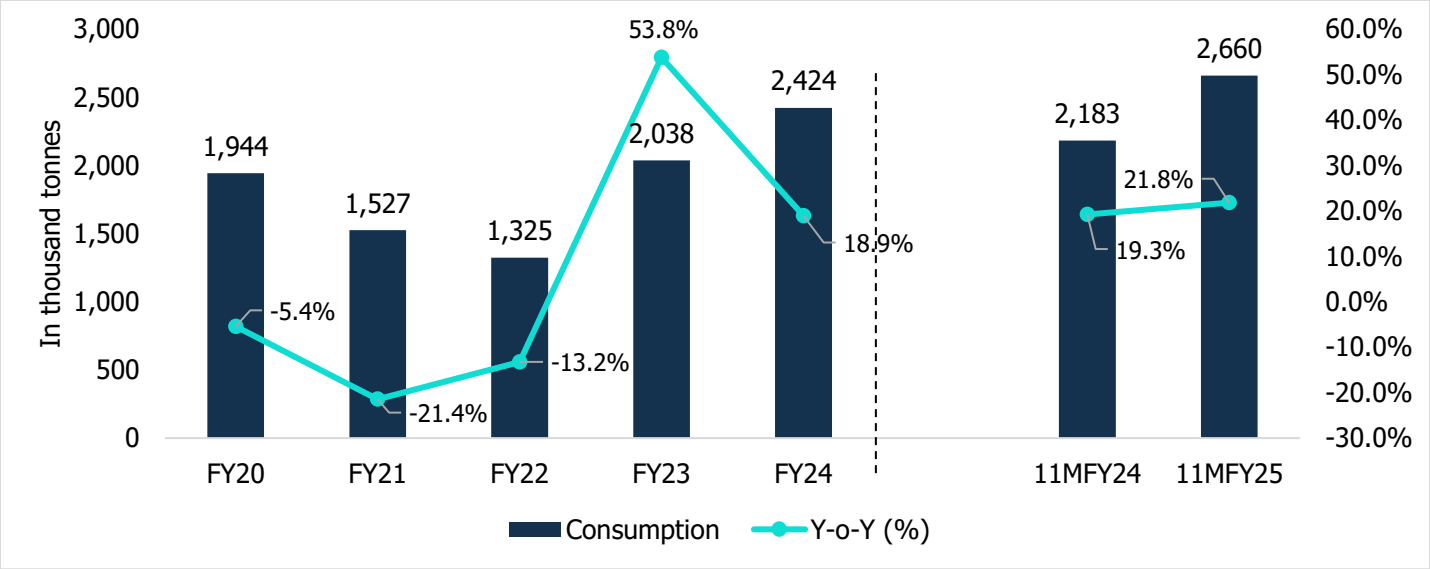
The previous year, FY23, witnessed a sharp year-on-year growth of 54%, fuelled by overall economic momentum. Key contributing factors included a notable increase in automotive production, recovery in construction activity, and growing power sector requirements.

While FY22 saw a revival, the growth was moderated due to a semiconductor shortage, which dampened automobile production and, consequently, aluminium consumption. Auto sector sales dropped by 5.4% year-on-year, limiting the pace of recovery.

In the earlier years, the industry faced headwinds. FY21 recorded a steep decline of 21.4% in consumption owing to the COVID-19 pandemic, which disrupted industrial activity. FY20 also saw a 5.4% drop in demand, primarily due to weakening consumption from the power and automotive sectors.

Overall, from FY20 to FY24, aluminium consumption in India expanded at a compound annual growth rate (CAGR) of 5.7%, reflecting a steady recovery and growing relevance of aluminium across critical sectors.

Chart 74: Consumption of Primary Aluminium

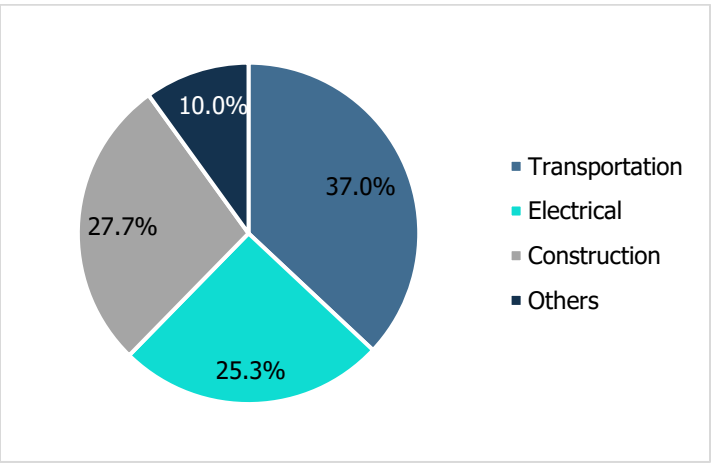


Source: CMIE
Note: 11MFY24 refers to the period between April 2023 – February 2024
11MFY25 refers to the period between April 2024 – February 2025

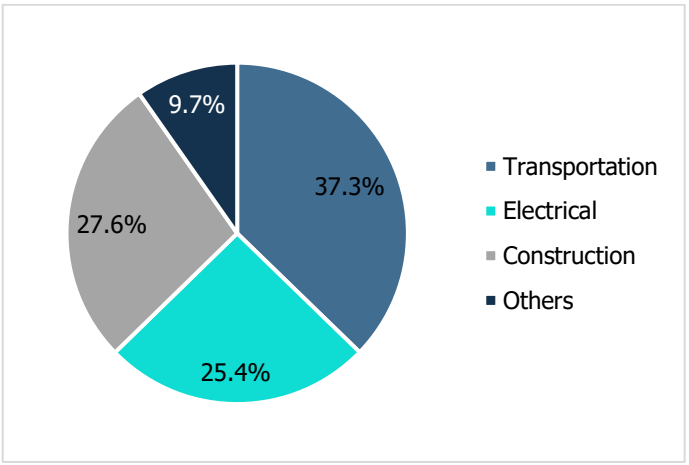
12.3. Key End Use Industries

Chart 75: Share of Global Aluminium Extrusion Market by End-User Industry (%)

CY24



CY29F



Source: Technavio, EMIS
Note: Others include packaging, machinery & equipment, consumer durables etc.
'F': Forecasted

v. Transportation:

Primary aluminium is the main material in India's transport sector, finding extensive applications across various modes of transportation. Its lightweight nature and corrosion resistance make it indispensable in automobile manufacturing, where it's utilized in engine components, body panels, and structural parts, enhancing fuel efficiency and performance.

In rail transport, primary aluminium contributes to the construction of carriages and locomotives, reducing overall weight and improving energy efficiency. Similarly, in aircraft manufacturing, aluminium alloys are essential for fabricating airframes and structural components, ensuring lightweight yet durable aircraft.

Moreover, in maritime transport, aluminium's corrosion resistance makes it ideal for constructing ships and boats, bolstering the sector's efficiency and longevity. Overall, primary aluminium plays a pivotal role in driving innovation and sustainability in India's diverse transport landscape.

vi. Electrical:

Aluminium's conductivity, lightweight nature, and corrosion resistance make it ideal for cables, conductors, transformers, and renewable energy components. Its efficiency in transmitting electricity and dissipating heat improves system performance, while its non-magnetic properties minimize electromagnetic interference. As energy demand rises and renewable energy usage grows, aluminium's role in power infrastructure becomes increasingly crucial. In the Electrical sector, aluminium usage is in overhead conductor, and power cable used in generation, transmission, and distribution of electricity. It is also used in switch boards, coil windings, capacitors, etc.

India is committed to the United Nations' Sustainable Development Goals to "ensure access to affordable, reliable and modern energy for all by 2030". This move is expected to increase the electricity demand to double in the next 10 years. As a result, there will be an increased demand for high-quality conductors and cables. Aluminium and its alloys have long been indispensable in the power industry because to their high structural strength, low weight, strong conductivity, ductility, and nonmagnetic qualities. Cables, busbars, motors, overhead transmission lines, electrolytic capacitors, foil windings, heat sinks, heating elements, and other products are among the most common applications.

vii. Construction:

Aluminium offers a perfect blend of strength, lightness, and versatility. Its remarkable properties enable architects to push the boundaries of creativity, crafting structures that are both innovative and practical. It significantly reduces weight and costs compared to steel. From towering skyscrapers with sleek aluminium frames to functional elements like roofs, siding, and even intricate decorative features, the metal's presence in the construction industry is indispensable. Its resistance to corrosion, non-toxic nature, and ease of shape makes it an invaluable asset for creating the country's skyline with durability and grace.

New-age industries

i. Renewable energy:

Aluminium is often used in the construction of renewable energy platforms like solar panels and wind turbines due to its lightweight strength, corrosion resistance and durability. It is also widely used mineral material in solar photovoltaic (PV) applications including frames and panels. Aluminium extrusions are extremely adaptable, making them an ideal material for solar panel frames. The metal can potentially boost the performance of solar cells.

Aluminium is also an important component in other low-carbon technologies such as wind, energy storage, and hydroelectricity. It is used in the transmission and distribution of electricity from renewable sources such as hydroelectric and solar power plants. The metal is also used in onshore and offshore wind projects, such as tower platform components and turbines.

ii. Electric vehicles:

The adoption of EVs and the use of aluminium to enhance performance and sustainability of EV is on the rise. Aluminium plays an important role in the shift toward greener transportation alternatives as it is an essential EV component. Lightweight aluminium battery trays, chassis, and subframes have potential to transform EV design by providing structural support while reducing the overall weight of the vehicle. It is also used in suspension components, interior elements etc. The Indian EV industry is making consistent efforts to embark on a transformative journey of aluminium-centric innovation.

12.4. Outlook for Domestic Aluminium Consumption

The consumption of aluminium in India is likely to show an upward trajectory in the medium term as the demand outlook for the aluminium industry is expected to be stable, driven by healthy growth in end-user industries - power and automobiles. Further, sectors like aviation, aerospace, construction, packaging, renewable energy, consumer durables, defence, etc., will supplement the aluminium demand. The aluminium industry is one of the leading segments of the Indian economy. It is expected to play a significant role in the country's future growth.

India is endowed with large deposits of high-quality bauxite ore and a formidable pool of manpower – both skilled and unskilled. Accordingly, the Indian aluminium industry is forging ahead with rapid expansion in both primary metal and downstream sectors.

Furthermore, the recent announcements made in the Union Budget 2025-26 such as the 0.9% y-o-y increase in capital outlay toward infrastructure to 11.2 lakh crore, 2.5 lakh crore for railways, and the expansion and development of airports under the Ude Desh ka Aam Naagrik (UDAN) scheme to enhance regional air connectivity will boost the demand for aluminium.

The power sector accounts for a large share of the consumption of primary aluminium. With the growing demand for power, the need to strengthen the transmission system prevails in the country. Also, huge investments are being made to push the transmission infrastructure. The interstate transmission lines are expected to add 13,042 CKm from FY24 to FY28, according to the Inter-State Transmission System (ISTS) Rolling Plan 2027-28 alongside the increasing transformation capacity of 96,905 MVA in the same period. This will attract an investment of Rs. 429.98 Billion from FY24 to FY28.

Whereas the investment required for green transmission is estimated to be around Rs. 2,440 billion as per the Ministry of Power. Of this, Rs. 281 billion will be required for the integration of offshore wind capacities while Rs. 2,160 billion will be required for new solar and wind (onshore) plants. Additionally, rural electrification is also expected to drive investments in the power sector, which will further raise the demand for aluminium.

Moreover, the growing consumer shift toward electric vehicles (EVs) will contribute to increased aluminium demand.[4] In addition to the government's efforts towards cleaner and sustainable transportation, there has been increased focus on EVs, specifically for public transportation that will further aid the demand in the industry.

In September 2024, the government approved the PM E-Drive scheme with a budget of Rs. 10,900 crore over two years, providing Rs. 3,679 crore in subsidies to incentivize E2Ws, E3Ws, e-ambulances, e-trucks, and other emerging EVs. The scheme aims to support 24.79 lakh E2Ws, 3.16 lakh E3Ws, and 14,028 e-buses, while also allocating Rs. 780 crore to enhance vehicle testing infrastructure. It also includes e-vouchers, and a streamlined EV buying process. The scheme proposes the installation of 22,100 fast chargers for e-4 Ws, 1800 fast chargers for e-buses and 48,400 fast chargers for e2W/3Ws. A notable feature is the scheme's promotion of electric ambulances, marking a key step in integrating EVs into the healthcare sector. Also, Battery-as-a-Service (BaaS) will also play a vital role in EV adoption. This announcement is expected to increase sales and accelerate the demand for EVs. Besides, the recyclable nature of aluminium aligns with the goal of reducing carbon emissions in many countries.

12.5. Review of Domestic Aluminium Supply

During FY25, primary aluminium production in India increased by 0.9% year-on-year to 4,199 thousand tonnes. This growth was driven by rising domestic demand from sectors such as construction and automotive, higher bauxite output, and supportive government policies that improved mining efficiency.

[4] Production of electric vehicles will require more aluminium than conventional vehicles.

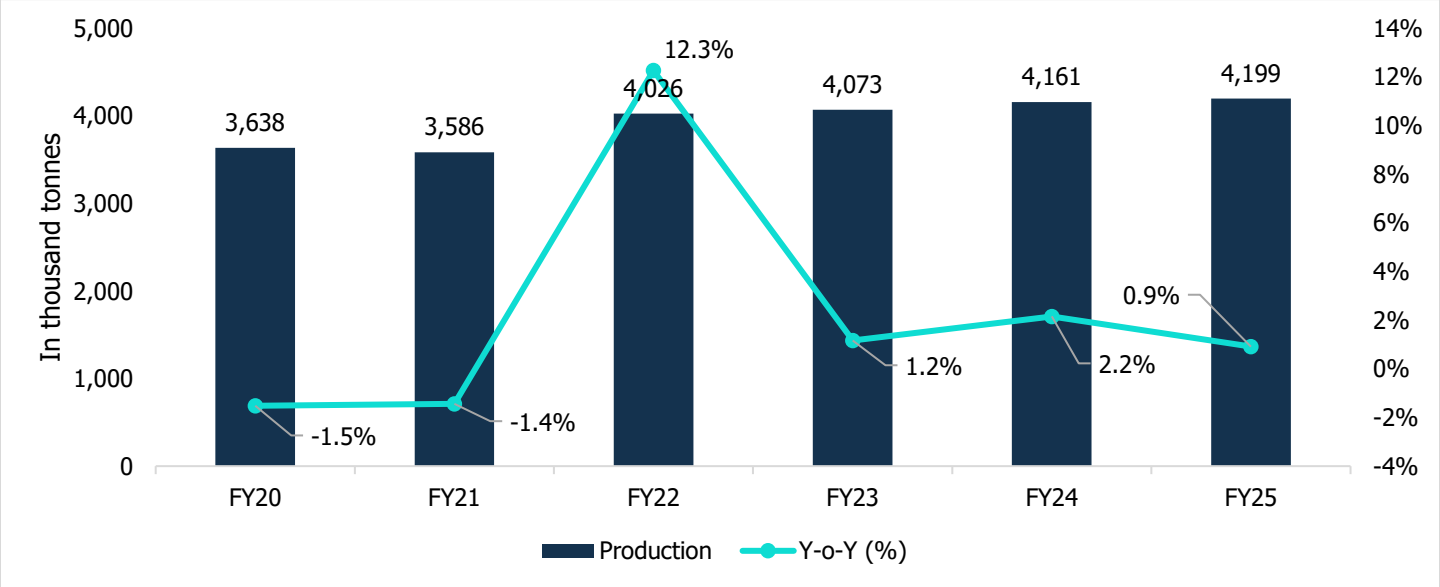
In FY24, production rose by 2% year-on-year to 4,159 thousand tonnes, supported by robust economic activity across key user sectors including energy, infrastructure, construction, automotive, and machinery.

Earlier, in FY23, aluminium production grew modestly by 1.2% year-on-year, following a strong 12.3% growth in FY22. These increases were backed by steadily rising consumption within the country.

In contrast, FY21 saw a slight decline of 1.4% in aluminium output, falling to 3,586 thousand tonnes from 3,638 thousand tonnes in FY20. However, the sector remained largely unaffected by external disruptions like the COVID-19 pandemic and geopolitical tensions.

Over the period FY20 to FY24, India's primary aluminium production grew at a compound annual growth rate (CAGR) of about 3.4%, reinforcing the country's position as the world's second-largest producer of aluminium.

Chart 76: Domestic Primary Aluminium Supply Trend



Source: CMIE

12.6. Risk and challenges

- **Availability of Raw Material**: It has become important to preserve raw materials, such as alumina, bauxite, and coal. The bauxite (primary raw material) requirements for alumina refinery are majorly met from captive mines domestically and rest is through imports. Uncertain economic events, supply chain disruptions, geopolitical tensions in key mining regions, may impact the accessibility and availability.
- **Reduction of Carbon footprint:** The manufacturing process of aluminium is power-intensive. Most of the power is produced through thermal coal. With the increased focus on climate risk mitigation, countries are formulating various rules and regulations to reduce the usage of fossil fuels. The growing awareness to use more renewables sources of energy and promote sustainability is a need of the hour.
- **High Energy Costs:** Energy is a cost factor in aluminium production and fluctuations in energy prices, particularly coal, directly impact manufacturing costs. Volatility or supply disruptions can therefore influence market competitiveness and overall industry stability.
- **Other**: Some challenges the country faces in the aluminium industry are delayed project approvals, quality standards, and skilled labour shortages.

12.7. Impact of FTAs and Tariff on Domestic Aluminium Industry

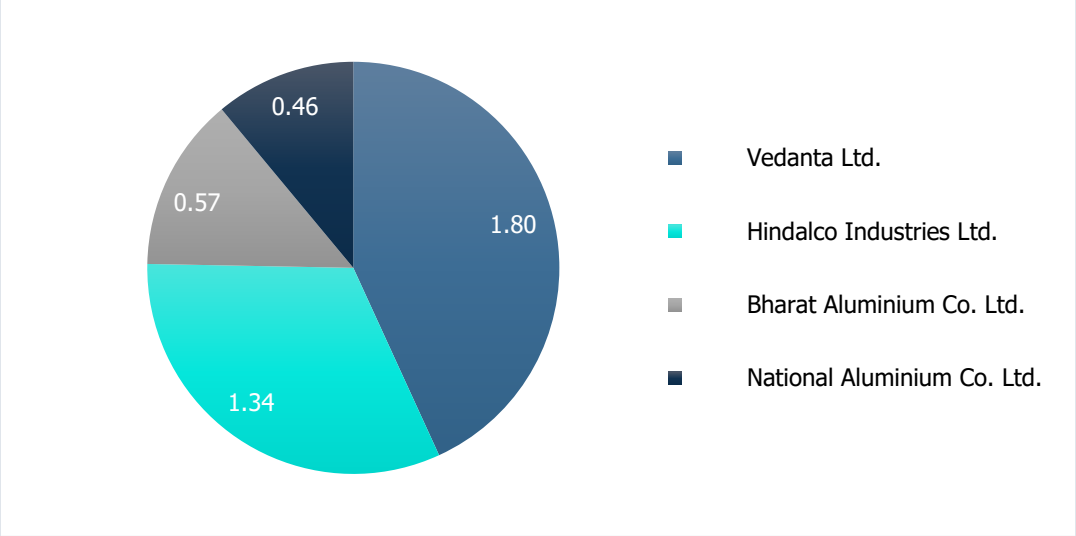
The recent escalation of U.S. tariffs on aluminium imports to 50% poses significant challenges for India's aluminium industry. Major exporters like Vedanta have expressed concerns over the adverse effects on export competitiveness and profitability. The increased tariffs are expected to make Indian aluminium products less competitive in the U.S. market, potentially leading to a decline in export volumes and profitability for Indian producers.

In response to these challenges, Indian aluminium producers are exploring alternative markets, such as Europe and Southeast Asia, to mitigate the impact of the U.S. tariffs. Additionally, the Indian government is actively engaging in negotiations to secure favourable terms through Free Trade Agreements (FTAs) with various countries, aiming to reduce reliance on the U.S. market and enhance global competitiveness.

Domestically, the industry is advocating for protective measures, including import curbs, to shield against potential surges of low-cost imports that could further strain the sector. These combined efforts are crucial for sustaining the growth trajectory of India's aluminium industry amidst evolving global trade dynamics.

12.8. Competitor Profiles

Chart 77: Existing Capacity of Primary Aluminium in India - FY25 (Million Tonne)



Source: CMIE

e) Vedanta Limited

Vedanta Limited dominates India's aluminium production, leveraging integrated operations, advanced technology, and strategic assets. Vedanta produced 2,370 thousand tonnes in FY24, about 50% of total aluminium production in India. As the largest producer, it operates key facilities including the alumina refinery in Lanjigarh (Odisha), the Jharsuguda aluminium smelter (Odisha), and the Bharat Aluminium Company (BALCO) smelter in Korba (Chhattisgarh). The company's sustainability focus ensures compliance and long-term viability. With a global market reach spanning critical sectors like aerospace, defence, smart infrastructure and renewable energy, the company maintains a strong presence in nearly 60 countries. Its position reflects a commitment to efficiency, quality, and environmental responsibility, demonstrating the firm as one of the leading companies in aluminium industry in India.

f) Hindalco Industries Limited

Hindalco ranks among the world's top five aluminium producers by shipments and operates as an integrated manufacturer with a low-cost base and a robust presence across the value chain. It has a significant footprint in key regions across India. With bauxite mines spanning four states—Jharkhand, Odisha, Chhattisgarh, and Maharashtra—and a total of 27 leases, Hindalco demonstrates its commitment to sustainable mining practices.

The company's emphasis on environmental initiatives, such as the Bagru ropeway and Long-Distance Conveyor at Baphlimali mines, underscores its dedication to eco-friendly operations. Moreover, its CSR endeavours, focusing on health, education, infrastructure, livelihood, and social causes, reflect a holistic approach towards societal development. Hindalco's accolades in safety and environmental stewardship, including National Safety Awards and recognition from Federation of Indian Mineral Industries (FIMI) underscore its industry-leading standards. Beyond mining, Hindalco's alumina refineries at Utkal, Renukoot, Muri, and Belagavi, coupled with its advanced R&D capabilities, position it as a frontrunner in aluminium production and innovation. Additionally, its smelting operations in Uttar Pradesh, Odisha, and Madhya Pradesh contribute significantly to the national aluminium output, further solidifying Hindalco's pivotal role in India's aluminium landscape.

The company provides a wide range of aluminium downstream products, including extrusions, flat-rolled products, foils, wire rods, and billets, which are utilized in a variety of industries such as automotive, packaging and pharmaceuticals.

g) National Aluminium Company Limited (NALCO)

NALCO achieved significant milestones in production and sales within the aluminium industry in FY24. The company recorded high cast metal production of 463 thousand tonnes and metal sales reaching 470 thousand tonnes. The production of bauxite also peaked at 7,600 thousand tonnes. NALCO has expanded their product range by introducing of Aluminium Alloy Ingot (AL59). Additionally, with a capacity utilization rate of 101.2%, NALCO's alumina refinery produced 2,124 thousand tonnes of Alumina Hydrate, while its captive power plant generated 7,193.6 million units of power, reflecting the company's commitment to sustainability.

h) Adani Enterprises Limited

The company has a diverse portfolio of business including roads, airports among transport and logistics, Food FMCG, and digital among retail business, mining, PVC, value added products such as copper, aluminium, silver, gold, Phosphoric Acid and Selenium, sulfuric acid and solar and wind turbine manufacturing, green hydrogen among energy. The company has received the clearance to set up a 4MTPA alumina refinery and a 175MW captive power plant at bauxite-rich Kashipur in Rayagada district, Odisha with investment value of Rs 41,653 crore in the unit.

13. Special Manufacturing- Aerospace & Defence

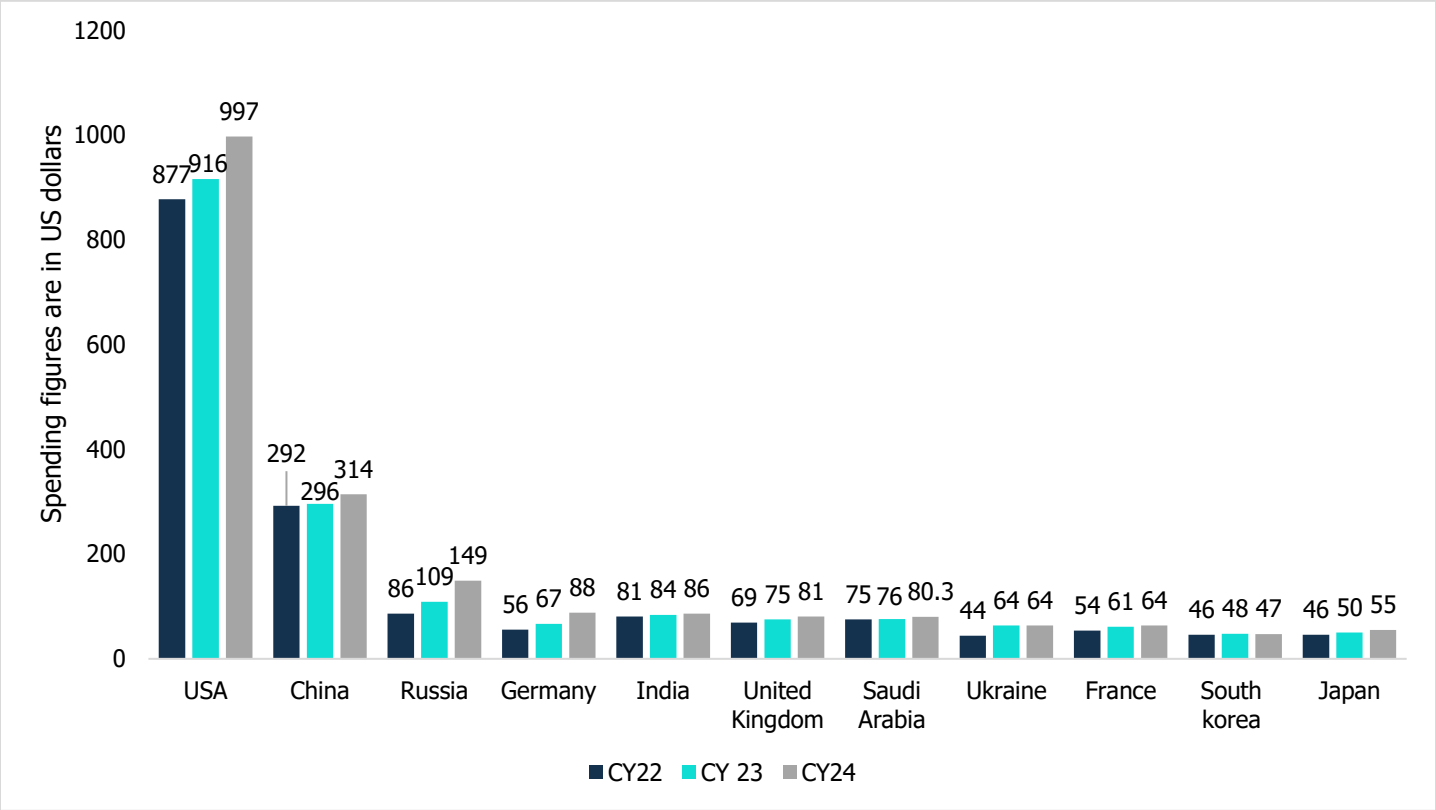
13.1. Overview

The aerospace and defence sector involve the manufacturing and supply of various items such as aircraft, helicopters, missiles, radars, satellites, and associated defence equipment or components. In this sector, manufacturers are generally classified into Tier 1 and Tier 2. Tier I manufacturers primarily concentrate on producing final products like aircraft, helicopters, and missiles, while Tier II manufacturers specialize in providing components for these systems.

According to Stockholm International Peace Research Institute (SIPRI), India accounted for 3.2% of the global military expenditure in CY24, securing its position as the world's fifth-largest military spender in constant USD terms. With the government's push on "Make in India" initiative and Atmanirbhar Bharat, the government made it mandatory to procure 75% of annual defence requirement from India which was earlier 68% in FY22.

The proportion of defence expenditure relative to GDP has been steadily increasing. It rose from 1.64% in fiscal 2016 to 2.08% in FY25. Notably, defence spending continued to rise even during the pandemic period.

Chart 78: Global Military Spending's

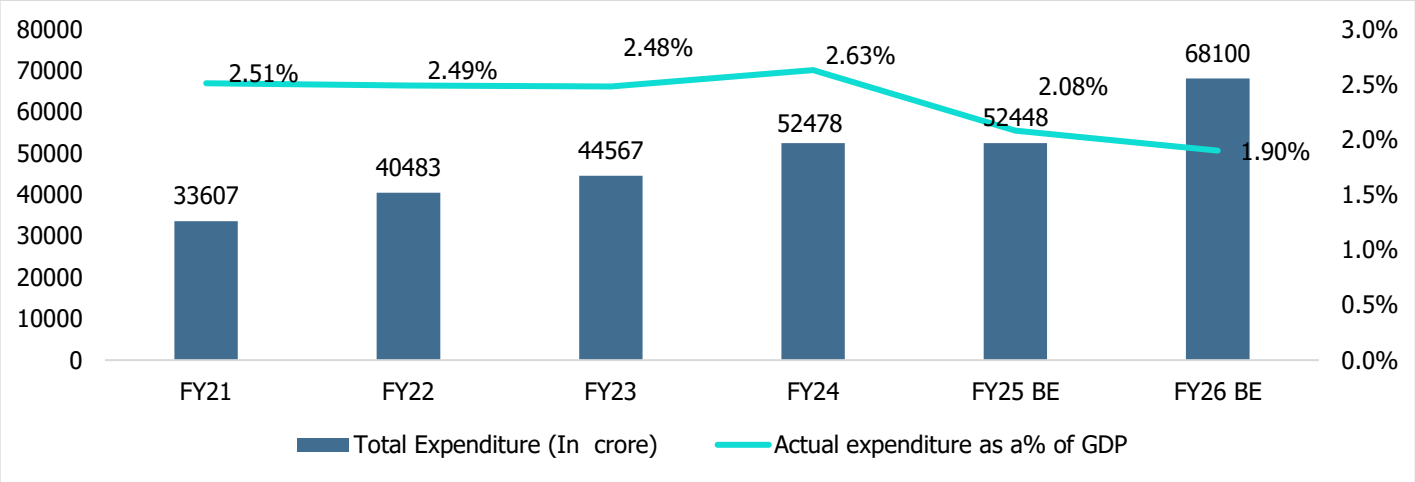


Source: SIPRI, Care Edge Research

13.2. Annual Defence Budget expenditure in value, as % of GDP and growth rate in defence expenditure

The key growth driver is the government's capex in defence procurement. Over the fiscal years 2016 to 2025, defence spending (both revenue and capex) exhibited a robust 14.8% Compound Annual Growth Rate (CAGR), rising from Rs 226 thousand crore in 2016 to Rs 621 thousand crore in 2025. The budgeted outlay for fiscal 2026 stands at Rs 681 thousand crore.

Chart 79: Annual defence budget expenditure as a percentage of GDP



Note: 1. Budget expenditure excluding civil and pension
2. GDP for FY25 are projected and FY24 are Revised Estimates

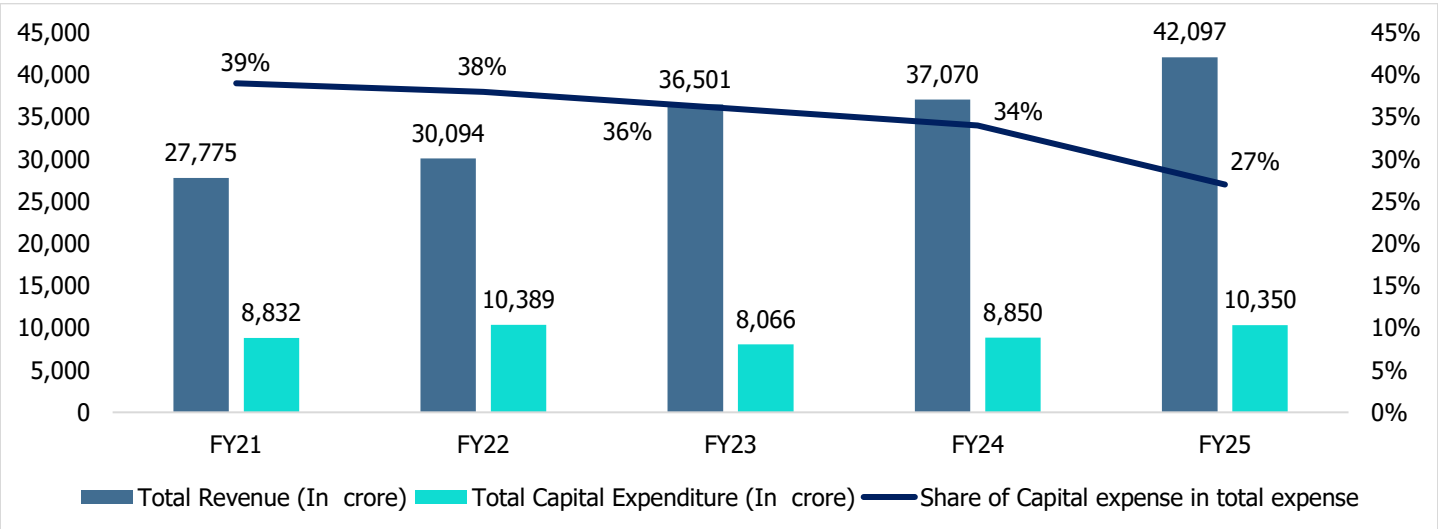
RE – Revised Estimates, BE – Budget Estimates, Source: MOSPI, Union budget documents, Care Edge Research

13.3. Segmentation and details on defence expenditure- capital, and revenue expenditure, spending on modernisation & store, etc.

Capital outlay encompasses expenditures related to the acquisition of new weapons, aircraft, warships, and various military hardware, whereas revenue expenditure covers costs related to payroll, transportation, repairs, and procurement of supplies, among other operational expenses. Capital expenditure notably contributes to the growth of the local manufacturing ecosystem by involving the procurement of equipment and ammunition.

In fiscal terms, capital expenditure witnessed significant growth, boasting an 9.6% CAGR to reach Rs. 180,000 crore in the Budget Estimate (BE) for fiscal 2026, up from Rs. 72,000 crore in fiscal 2016 and Rs. 172,000 crore in fiscal 2025.

Chart 80: Segmentation and details of defence expenditure – capital and revenue expenditure



Note: Budget expenditure excluding civil and pension expenses
BE – Budget Estimates

Source: Union budget documents, Care Edge Research

13.4. Review of defence production for fiscals 2017-2025

In May 2001, the previously state-controlled Defence Industry sector was opened to 100% participation by the Indian private sectors, with Foreign Direct Investment (FDI) capped at 26%, subject to licensing. Subsequently, the Department

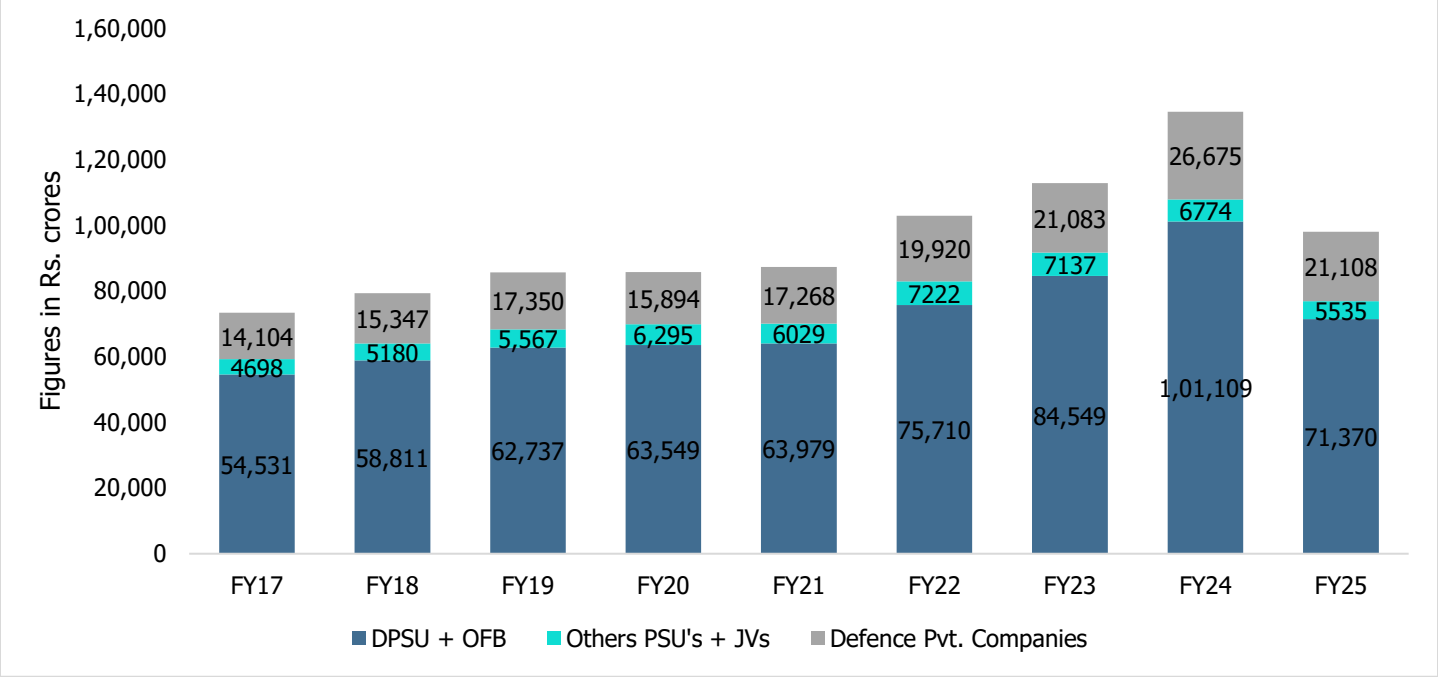
for Promotion of Industry and Internal Trade, Ministry of Commerce & Industry permitted FDI up to 49% under the automatic route and beyond 49% through the government route, particularly if it promised access to modern technology or for other specified reasons. In May 2020, the Government of India announced a significant reform in the defence sector aimed at enhancing self-reliance. This reform included raising the FDI limit in Defence Production from the existing 49% to 74% under the Automatic Route. It was proposed to allow FDI up to 74% through the Automatic Route for companies applying for new defence industrial licenses, and up to 100% via the Government Route, under specific circumstances such as ensuring access to modern technology or for reasons to be duly recorded. In February 2025, the Ministry of Defence recorded Rs 6400 crore worth of FDI investment in the companies operating in the defence sector.

Notably, India's defence budget trajectory reflects a strategic shift from manpower-heavy to technology-driven forces. The post-2020 budgets have marked a transformative phase with focus on domestic industry participation, modernization of legacy systems and strategic deterrence through technology--driven warfare (AI, drones, space, etc).

13.5. Share of Public vs private sector production

DPSUs (Defence Public Sector Undertakings) and OFBs (Ordnance Factories Board) currently hold a dominant position in defence production, accounting for ~70% of the market share. However, with various initiatives aimed at enhancing private sector involvement, there has been a notable increase in contributions from the private sector.

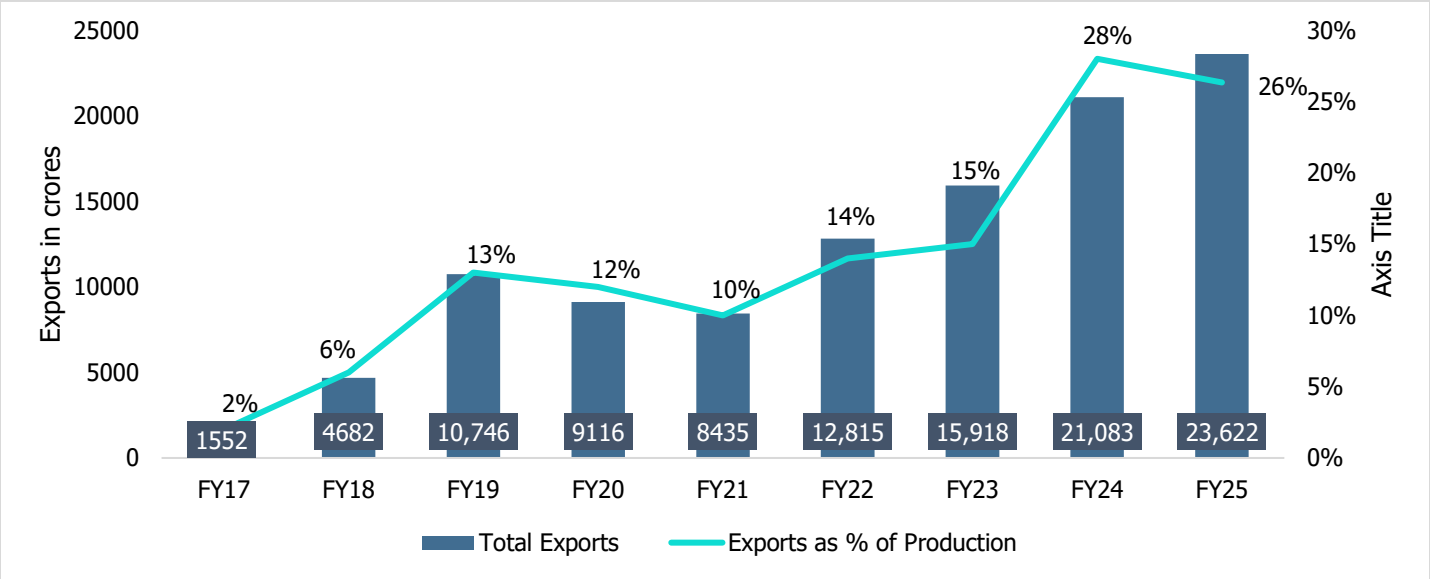
Chart 81: Share of public vs private sector production



Source: Ministry of Defence, Care Edge Research

Notably, defence exports have surged nearly 15 times, achieving a remarkable 48% CAGR to reach a Rs 23,622 crore in fiscal 2025 from levels recorded in fiscal 2017. Indian industry has demonstrated its design and development prowess globally, with defence products now being exported to more than 85 countries by over 100 companies.

Chart 82: Defence exports



Source: Ministry of Defence, Care Edge Research

Operation Sindoor represents a pivotal step in India's pursuit of technological autonomy in defence. The successful integration of homegrown systems in active combat situations not only strengthens India's defence capabilities but also positions the country as a credible player in the global arms market. The operational success of indigenous platforms such as the Hermes 900 UAV and locally developed missile systems demonstrates their reliability and is likely to open new avenues for defence exports. At the same time, the Drone Federation of India's (DFI) vision to establish India as a global drone hub by 2030 aligns with these developments, as it actively supports the innovation, production, adoption and international distribution of Indian drone and counter-drone technologies. Furthermore, the operational risks underscored by such missions highlight the critical need for continued and enhanced investment in defence, especially in cutting-edge technology, to fortify border security and elevate national defence readiness.

Chart: 83 Budget Allocations for the Aerospace and Defence sector

Particulars	Allocations	% of total capital outlay
Aircraft and Aero Engines	INR 48,614 (USD 5.6 Bn)	27%
Other Equipment	INR 63,099 (USD 7.3 Bn)	35%
Naval Fleet	INR 24,391 (USD 2.8 Bn)	14%
Construction Works	INR 11,452 (USD 1.3 Bn)	6%
Technology Development	INR 2,037 (USD 0.24 Bn)	1%
Others (Land, Naval Dockyards,	INR 30,407 (USD 3.5 Bn)	17%
Portion of total expenditure covered	**INR 180,000 (USD 20.8 Bn)**	

In the Union Budget 2025, a total allocation of INR 681,210 crore (USD 78.8 billion) has been made towards the Defence Budget for FY 2025–26, including defence pensions. This marks an increase of INR 59,269 crore (approximately USD 6.85 billion), reflecting a nearly 10 percent rise over the original budget estimate for FY 2024–25, and about a 6 percent increase compared to the revised estimate for the same year.

The government's continued emphasis on self-reliance in defence manufacturing is expected to generate significant export potential. By showcasing the effectiveness of indigenously developed military technologies, India aims to position itself as a trusted exporter of advanced defence equipment in the global market. The FY 2025–26 defence budget underscores a

clear strategic pivot towards modernization, indigenization, and global competitiveness, ensuring that India's defence ecosystem remains resilient and future-ready.

13.6. Defence corridor and investments

The Government of India (GoI) has established two Defence Industrial Corridors (DICs) across the country. These corridors are in Uttar Pradesh (UP) and Tamil Nadu (TN). Subsequently, specific nodes have been identified within each corridor: Aligarh, Agra, Chitrakoot, Jhansi, Kanpur, and Lucknow for the Uttar Pradesh Defence Industrial Corridor (UPDIC), and Chennai, Coimbatore, Hosur, Salem, and Tiruchirappalli for the Tamil Nadu Defence Industrial Corridor (TNDIC).
The primary objective of these Defence Industrial Corridors (DICs) is to catalyse the defence manufacturing ecosystem in both states and attract investments totalling Rs 20,000 Crore each by the year 2024-25. The respective State Governments are responsible for providing the necessary land, connectivity, and basic infrastructure for the DICs. These two defence corridors aim to bolster the defence manufacturing landscape in India, benefiting all states involved.

The Kanpur node of the Uttar Pradesh Defence Industrial Corridor (UPDIC) is rapidly advancing to boost India's self-reliance in defence manufacturing. With the highest investment among all nodes. Over 218 hectares of land in Narwal Tehsil of Kanpur are being developed as part of the Defence Industrial Corridor. So far, investments totalling more than Rs 1,700 crore have materialized. With the highest investment among all nodes, Kanpur is set to manufacture a wide range of defence products, including weapons, ammunition, military attire, and space-related equipment.

13.7. Review of defence production

To enhance self-sufficiency in the defence sector, the Ministry of Defence has made efforts towards indigenization by entering several contracts with domestic companies. In the Union Budget for 2025-26, the government earmarked Rs 6.81 thousand crores for defence (including civil and pension expenses), projected to represent 1.96% of the GDP. India's defence production has grown at an extraordinary pace since the launch of the "Make in India" initiative, reaching a record Rs 1.27 lakh crore in FY 2023-24, 65% of defence equipment is now manufactured domestically, a significant shift from the earlier 65-70% import dependency, showcasing India's self-reliance in defence. Driven by the successful implementation of government policies and initiatives, focusing on attaining Atmanirbharta. (Production data)

The Indian government has set a target for defence production to reach Rs 3 lakh crore by 2029 including Rs 50,000 crore of exports. This objective is supported by various initiatives aimed at bolstering domestic manufacturing, combined with increased capital expenditure by the Indian armed forces.

13.8. Government policies and regulations

13.8.1. Defence Acquisition Procedure (DAP) 2020

The Defence Acquisition Procedure (DAP) 2020 marks a significant evolution in India's defence procurement policies. Initially established in 2002 with the aim of formalizing and streamlining the acquisition process, it underwent a revision in March 2016, shifting its focus towards fostering indigenous design, development, and manufacture of weapon systems.

In 2020, the Ministry of Defence introduced an updated version of the DAP, aimed at simplifying the procurement process to modernize the armed forces. This revised procedure is aligned with the government's vision of positioning India as a global manufacturing hub. Its primary objectives include enhancing indigenous defence capabilities and reducing reliance on imports, in line with the Make in India and Atmanirbhar Bharat initiatives.

The core objective of the DAP is to ensure the timely acquisition of military equipment, systems, and platforms that meet the stringent performance, capability, and quality standards required by the armed forces, all while optimizing the utilisation of allocated budgetary resources.

The DAP categorizes capital acquisition schemes broadly into five categories: buy, buy and make, leasing, design and

development (D&D), and strategic partnership model (SPM).

Under the buy scheme, procurements are classified as buy (Indian - IDDM), buy (Indian), buy (global - manufacture in India), and buy (global). The buy and make scheme further categorize procurements as buy and make (Indian) and buy and make.

In decreasing order of priority, the categories will be as follows:
(a) Buy (Indian - IDDM)
(b) Buy (Indian)
(c) Buy and make (Indian)
(d) Buy (global - manufacture in India)
(e) Buy (global)

(a) Buy (Indian - IDDM) – The "Buy (Indian-IDDM)" category involves acquiring products from an Indian vendor that are domestically designed, developed, and manufactured, ensuring a minimum of 50% Indigenous Content (IC) in terms of cost, calculated as the base contract price minus taxes and duties.

(b) Buy (Indian) – This category involves acquiring products from an Indian vendor, even if they were not designed and developed domestically, if they contain 60% Indigenous Content (IC) in terms of cost, calculated based on the base contract price. Vendors eligible for the "Buy (Indian-IDDM)" category are also allowed to participate in this category if their products have indigenous design and at least 50% IC in terms of cost, calculated based on the base contract price.

(c) Buy and make (Indian) – This category involves initially acquiring equipment in a Fully Formed (FF) state, as necessary, from Indian vendor(s) in collaboration with a foreign Original Equipment Manufacturer (OEM), followed by indigenous production in stages. This process includes the Transfer of Technology (ToT) for critical technologies from the foreign OEM, according to specified parameters regarding range, depth, and scope. For acquisitions under this category, a minimum of 50% Indigenous Content (IC) is required in terms of cost for the domestically manufactured portion of the contract, excluding taxes and duties. Additionally, acquisitions under this category can also proceed without any initial procurement of equipment in the FF state

(d) Buy (global - manufacture in India) - This category refers directly purchasing equipment from foreign vendors as required, followed by the indigenous manufacturing of either the entire equipment or a portion of it, along with the production of spares, assemblies, sub-assemblies, and maintenance, including Repair and Overhaul (MRO) facilities (if included in the main contract). This manufacturing process can be undertaken through a subsidiary in India, a Joint Venture, or an Indian Production Agency (PA), with the Transfer of Technology (ToT) for critical technologies to the Indian PA as per specified parameters regarding range, depth, and scope. The domestically manufactured portion of the equipment must meet a minimum of 50% Indigenous Content (IC) in terms of cost based on the Base Contract Price. Indian vendors are permitted to participate in this category, known as Buy (Global Manufacture in India). Moreover, acquisitions under this category can also proceed without any initial procurement of equipment in the FF state. All payments for the domestically manufactured portion will be made to the vendor in Indian Rupees according to the contract provisions.

(e) Buy (global) – This category encompasses the direct purchase of equipment from either foreign or Indian vendors. If the procurement is from foreign vendors, the Government may opt for the Government to Government (G2G) route or Inter-Government Agreement (IGA) for equipment meeting strategic or long-term requirements. Indian vendors participating in this category must meet a minimum of 30% Indigenous Content (IC). Failure to meet this requirement would necessitate the vendor to fulfil offsets as applicable in the case. Foreign vendors, in Buy (Global) cases with an Acceptance of Necessity (AoN) cost of Rs 2000 crores or more, are also required to fulfil offsets, except for all ab-initio Single Vendor Cases, including procurements based on IGA/FMS.

- **D&D/Innovation -** Design and Development (D&D) cases advanced by DRDO/DPSUs/OFB for the acquisition of equipment/system/sub-system/assembly/sub-assembly, major components, or their upgrades, to be designed, developed, and manufactured by an Indian vendor, will adhere to the procedures and standards outlined in DAP.

- **SPM-** In the Strategic Partnership model, private Indian firms collaborate with foreign OEMs in the 'Make in India' initiative for defence, acting as System Integrators to establish a broad ecosystem with development partners, specialized vendors, and suppliers, especially from the MSME sector. These partnerships aim to boost indigenous defence manufacturing capabilities through the private sector beyond the current production base.
- **Leasing** - Introducing leasing as an additional category for acquisition alongside the existing 'Buy' and 'Make' categories offers an innovative financing method for equipment/platforms. Leasing allows for the possession and operation of assets without ownership, offering an alternative to significant initial capital investments through periodic rental payments. Leasing is divided into two subcategories: Lease (Indian), where the lessor is an Indian entity and owns the asset, and Lease (Global).

13.9. Strategic partnership model in defence acquisition

In support of the 'Make in India' campaign within the defence sector, the government has introduced the strategic partnership model for procuring aircraft, helicopters, submarines, and armoured fighting vehicles/main battle tanks. This model is intended to facilitate the transfer of specialised technology and increase indigenous content among the Indian entities, thereby advancing the nation's development as a regional and global manufacturing hub.
Under this strategic partnership model, private Indian firms and foreign Original Equipment Manufacturers (OEMs) collaborate to reinforce the 'Make in India' initiative within the defence sector. Serving as System Integrators, they establish an extensive ecosystem involving development partners, specialized vendors, and suppliers, particularly from the Micro, Small, and Medium Enterprises (MSME) sector. These collaborations aim to bolster indigenous defence manufacturing capabilities within the private sector, complementing the existing production infrastructure. This model contributes to the growth of the indigenous industry by nurturing the Indian defence manufacturing ecosystem.
The primary objective of this policy is to establish a transparent, objective, and efficient mechanism that encourages broader private sector participation - alongside Defence Public Sector Undertakings (DPSUs) and the Ordnance Factories Board (OFB), in manufacturing defence platforms and equipment such as aircraft, submarines, helicopters, and armoured vehicles. It aims to promote competition, enhance efficiency, accelerate technology absorption, develop a multi-tiered industrial base, foster skill development, drive innovation, reduce import dependency, and strengthen self-reliance in meeting national security requirements. The strategic partnership model identifies four segments for acquisition:

- Fighter aircraft
- Helicopters
- Submarines
- Armoured fighting vehicles (AFVs)/ main battle tanks (MBTs)

In a move to boost private sector involvement in domestic defence manufacturing, the DAC has sanctioned the implementation of strategic partnership guidelines to streamline processes and ensure timely delivery of equipment to the armed forces. Additionally, platform-specific guidelines for the procurement of naval utility helicopters have also been approved by the DAC.

13.10. Offset policy

The primary aim of the Defence Offset Policy is to utilize capital acquisitions and technology to nurture the Indian defence industry by (i) encouraging the growth of globally competitive enterprises and (ii) enhancing capacity for research, design, and development of defence products.

The Offsets clause applies to Buy (Global) procurement categories where the estimated AoN cost is Rs. 2000 crores or more. Indian Vendors participating in the Buy (Global) category must meet a minimum of 30% Indigenous Content (IC), or else they must fulfil offset obligations as applicable. The Defence Acquisition Council (DAC) may consider partial or full waiver of the Offsets clause in certain cases, but eligible/selected Indian vendors still need to adhere to IC stipulations. No offsets are applicable in ab-initio Single Vendor Cases, including procurements based on IGA/FMS.

In Buy (Global) category procurements, if an Indian firm, including a Joint Venture with a foreign partner, bids for the proposal, the offset obligation clause won't apply if the IC in the product exceeds 30%. However, if the IC is less than 30%, the Indian firm or Joint Venture must ensure offset obligations are met to the tune of '30% IC' (IC to be declared upfront at bid submission). In such instances, the Indian firm will clearly delineate the IC and offset portions in the offset contract and claims.

The required value of offset obligations will be 30% of the estimated cost of acquisition in Buy (Global) category acquisitions.

13.11. Defence Testing Infrastructure Scheme (DTIS)

The Defence Testing Infrastructure Scheme (DTIS), introduced by the Ministry of Defence, aims to enhance domestic defence and aerospace manufacturing. This scheme facilitates MSMEs and start-ups in accessing defence testing infrastructure more conveniently. With a budget of Rs 400 crore allocated, the scheme targets the development of cutting-edge testing facilities over five years.

The government's goal is to establish 6-8 new defence testing infrastructure facilities, with up to 75% of the funding provided by the government. The remaining 25% will be contributed by a special purpose vehicle (SPV) supported by Indian private entities and state governments. Three major testing facilities will soon be launched in Uttar Pradesh located in Kanpur and Lucknow. These facilities are designed to strengthen the nation’s defence capabilities. With a substantial financial backing of over Rs 117 crore, the DTIS projects are set to revolutionize testing standards in the region. This initiative underscores India's commitment to advancing its defence technology and infrastructure.

13.12. Innovations for Defence Excellence (iDEX)

The Ministry of Defence, Government of India, launched the Innovations for Defence Excellence (iDEX) initiative in 2018 to promote innovation and technology development in the defence and aerospace sectors. iDEX aims to achieve self-reliance and support start-ups, MSMEs, individual innovators, R&D institutes, and academia in developing prototypes and commercializing products/solutions.

The Department of Defence Production, Ministry of Defence, has approved a central sector scheme known as Innovations for Defence Excellence (iDEX) with a budgetary allocation of Rs 498.80 crore for the next five years from 2021-22 to 2025-26. The scheme's objective is to provide financial assistance to nearly 300 start-ups/MSMEs/individual innovators and about 20 partner incubators through the Defence Innovation Organisation (DIO).

13.13. Geopolitics

India encounters a diverse security challenge, ranging from territorial disputes to cross-border terrorism and geopolitical tensions. Maintaining a strong defence capability is imperative to uphold the nation's sovereignty, territorial integrity, and overall national interests.

India holds strategic stakes in various regions, particularly the Indian Ocean, where it endeavours to uphold maritime security, combat piracy, and ensure the security of crucial sea lanes. A robust defence capability empowers India to assert its influence and safeguard its strategic interests effectively.

Operation Sindoor emerged as a calibrated military response to an evolving pattern of asymmetric warfare, one that increasingly targets unarmed civilians along with military personnel. The terrorist attack on tourists in Pahalgam in April 2025 served as grim reminder of this shift. India’s response was deliberate, precise, and strategic. Without crossing the

Line of Control or international boundary, Indian forces struck terrorist infrastructure and eliminated multiple threats. However, beyond tactical brilliance, what stood out was the seamless integration of indigenous hi-tech systems into national defence. Whether in drone warfare, layered air defence, or electronic warfare, Operation Sindoor marks a milestone in India's journey towards technological self-reliance in military operations. The overall geopolitical tensions increase the demand for modern aircraft, weaponry, and defence equipment for the Indian armed forces, coupled with initiatives like Make in India and Atmanirbhar Bharat, is poised to invigorate the country's defence and aerospace sectors.

13.14. Adani's positioning

In 2018, Adani Enterprises partnered with Elbit Systems, Israel's premier arms manufacturer, to establish a joint venture named Adani Elbit Advanced Systems India Limited. Its first project entailed manufacturing the Hermes 900 UAV for the Israel Defence Forces (IDF), as Elbit supplies nearly 85% of the drones used by the IDF. Operating outside of Israel, Adani-Elbit runs the sole Hermes 900 production facility, situated in Hyderabad, India.
In a major milestone, Adani-Elbit Advanced Systems India Ltd has become the first entity outside Israel to manufacture the Hermes 900 UAV. The Government of Uttar Pradesh has signed a Memorandum of Understanding with Adani Defence & Aerospace to invest Rs 1,500 crores in establishing a cutting-edge ammunition development and manufacturing complex in the Kanpur Node of the UP Defence Industrial Corridor. This complex, spanning over 250 acres, inaugurated in February 2024, is one of South Asia's largest integrated ammunition manufacturing hubs and will incorporate advanced technology to produce small- and medium-calibre ammunition, as well as short-range air defence missiles. UPEIDA has also signed Memorandums of Understanding with four major banks—SBI, BOB, PNB, and SIDBI—to support investors in setting up operations in the Defence Corridor.

13.15. Key Growth Drivers and Trends

- **Government Initiatives:** The Indian government's emphasis on modernizing the armed forces and promoting indigenous defence manufacturing through initiatives like "Make in India" and the Defence Procurement Procedure (DPP) is driving growth in the sector. These initiatives aim to reduce dependency on imports, enhance self-reliance, and foster innovation and technology development.
- **Defence Budget:** India's consistent increase in defence spending reflects its commitment to strengthening its defence capabilities. The allocation of funding for defence procurement, research and development, and infrastructure development is a significant growth driver for the sector.
- **Indigenous Manufacturing:** There is growing emphasis on indigenous manufacturing and technology development to reduce reliance on foreign suppliers and enhance self-sufficiency. Partnerships between domestic defence firms, foreign original equipment manufacturers (OEMs), along with technology transfer agreements are advancing indigenous capabilities.
- **Offset Obligations:** India's offset policy mandates foreign defence suppliers to invest a portion of their contract value in India's defence sector. This approach fosters technology transfer, collaboration, and investment in domestic production capabilities, stimulating innovation and sectoral expansion.
- **Emerging Technologies:** The adoption of advanced technologies such as artificial intelligence (AI), unmanned systems, cyber security, and space-based capabilities is transforming defence operations and capabilities. Investments in research and development (R&D) and collaboration with academia and the private sector are driving innovation and technological advancements in the sector.
- **Export Opportunities:** India's growing defence capabilities and expertise present opportunities for defence exports. Strategic partnerships, international collaborations, and participation in defence exhibitions and trade shows are enabling Indian defence firms to explore and capitalize on export opportunities in global markets.

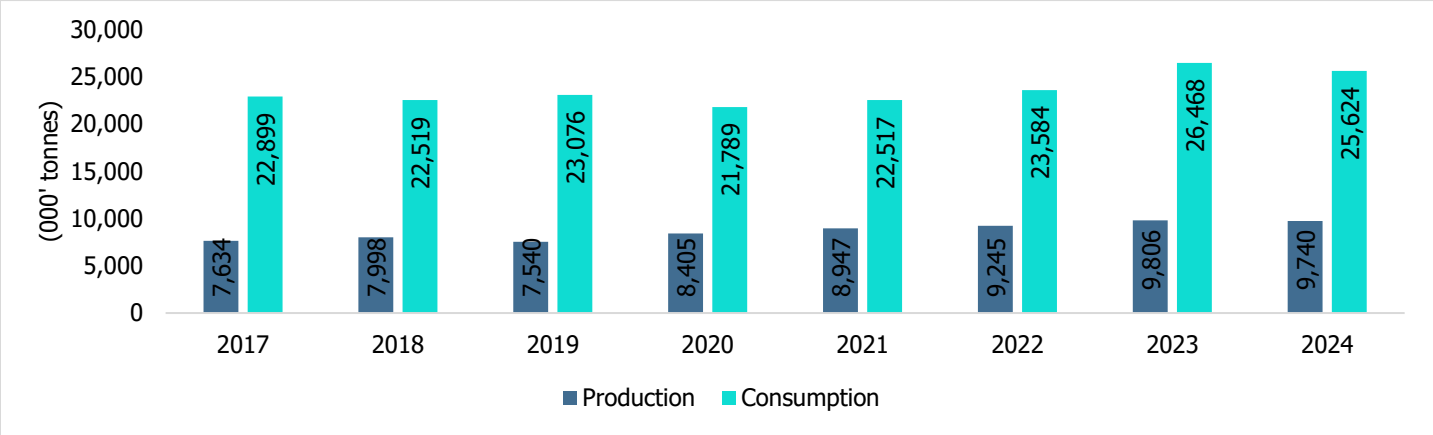
- **Dual-Use Technologies:** The convergence of defence and civilian technologies is blurring the lines between the defence and aerospace sectors. Dual-use technologies such as drones, satellite communication, and unmanned aerial vehicles (UAVs) are finding applications in both defence and civilian domains, opening up new avenues for growth and collaboration.
- **Geopolitical Dynamics:** India's strategic location and geopolitical importance in the Indo-Pacific region are driving investments in defence infrastructure, maritime security, and strategic partnerships. Collaborations with friendly nations, joint exercises, and defence agreements are bolstering India's defence capabilities and influence in the region.

14. Consumer Food Industry

14.1. Consumer Food – Edible Oil

India is the third largest consumer and the largest importer of vegetable oil in the world. Crude palm oil, sunflower oil, soybean oil and RBD Palmolein are some of the high-quality edible oils, used in food products, detergents, biofuel, cosmetics, etc. India is majorly dependent on imports to meet its demand, considering limited domestic production. Recently, refined, bleached, and deodorized (RBD) Palmolein and crude palm oil (CPO) imports increased because of decline in global prices. Global prices impact the domestic prices as it is based on the prices of imported oil.

Chart 83: Edible Oil Production & Consumption



Source: CMIE; (Note: - Oil Year has been considered from November-October)

Domestic edible oil production has shown a positive upward trend over the past three years post the COVID-19 pandemic. Government has implemented schemes to cater to the ongoing increasing demand of edible oil. Some of the initiatives includes- National food security mission and decrease in basic duty of crude palm oil. Government is also addressing micro-irrigation, marketing infrastructure, quality of seeds, enhancement of technologies to increase oil seed production in India.

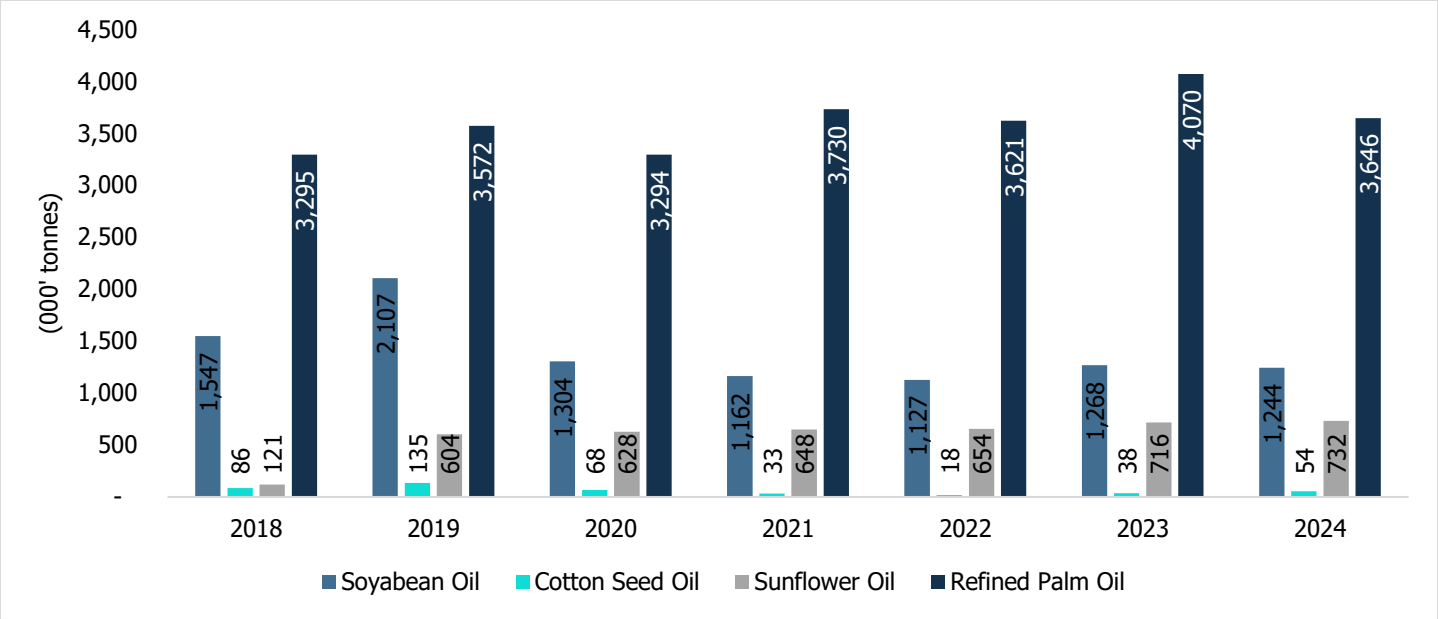
India's per capita consumption of edible oil is far lower than the world, indicating headroom for future growth.

Table 49: Per Capita Consumption of Edible Oils (Kg. per annum)

Year	FY18	FY19	FY20	FY21	FY22
India	19.5	21.6	19.8	19.7	21.0
World	29.3	30.5	27.0	30	30

Source: Department of Food & Public Distribution

Chart 84: Production of Edible Oil- Product Wise

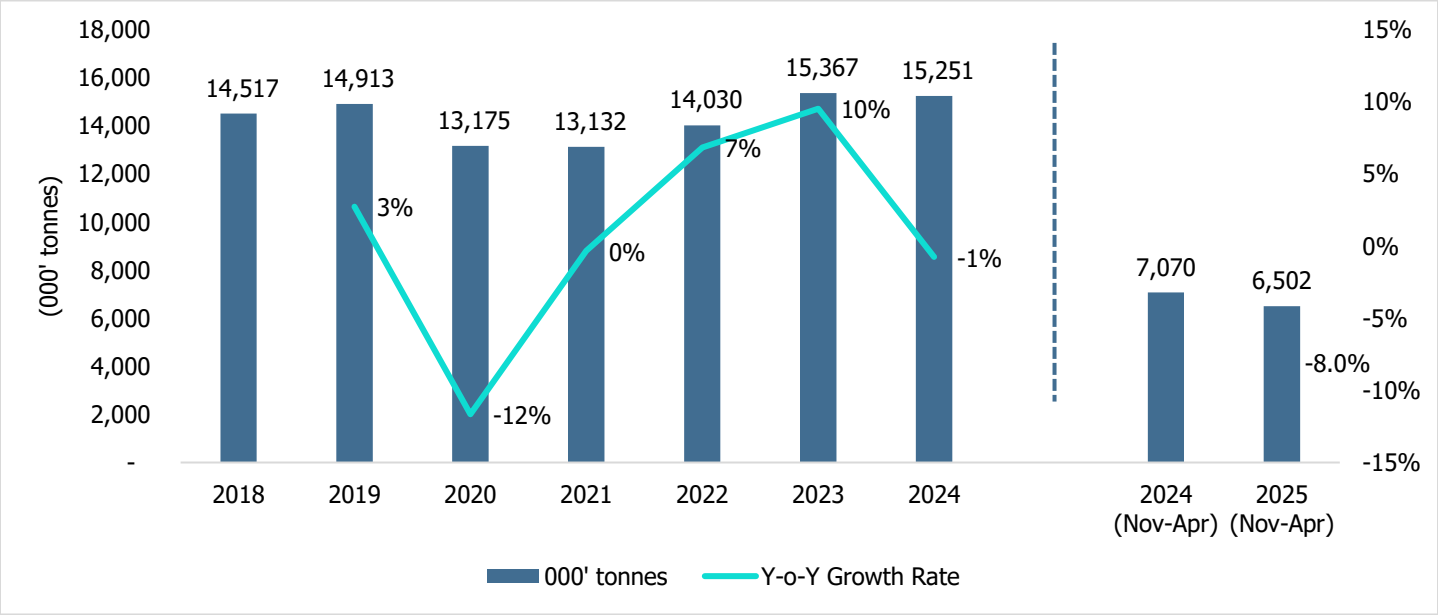


Source: CMIE, (Note: - Oil Year has been considered from November-October)

Sector Dynamics during the Oil year FY24

For FY24, imports of edible oils remained flat at 15,251 thousand tonnes. This was mainly due to higher stock and price fluctuations. The details are mentioned below:

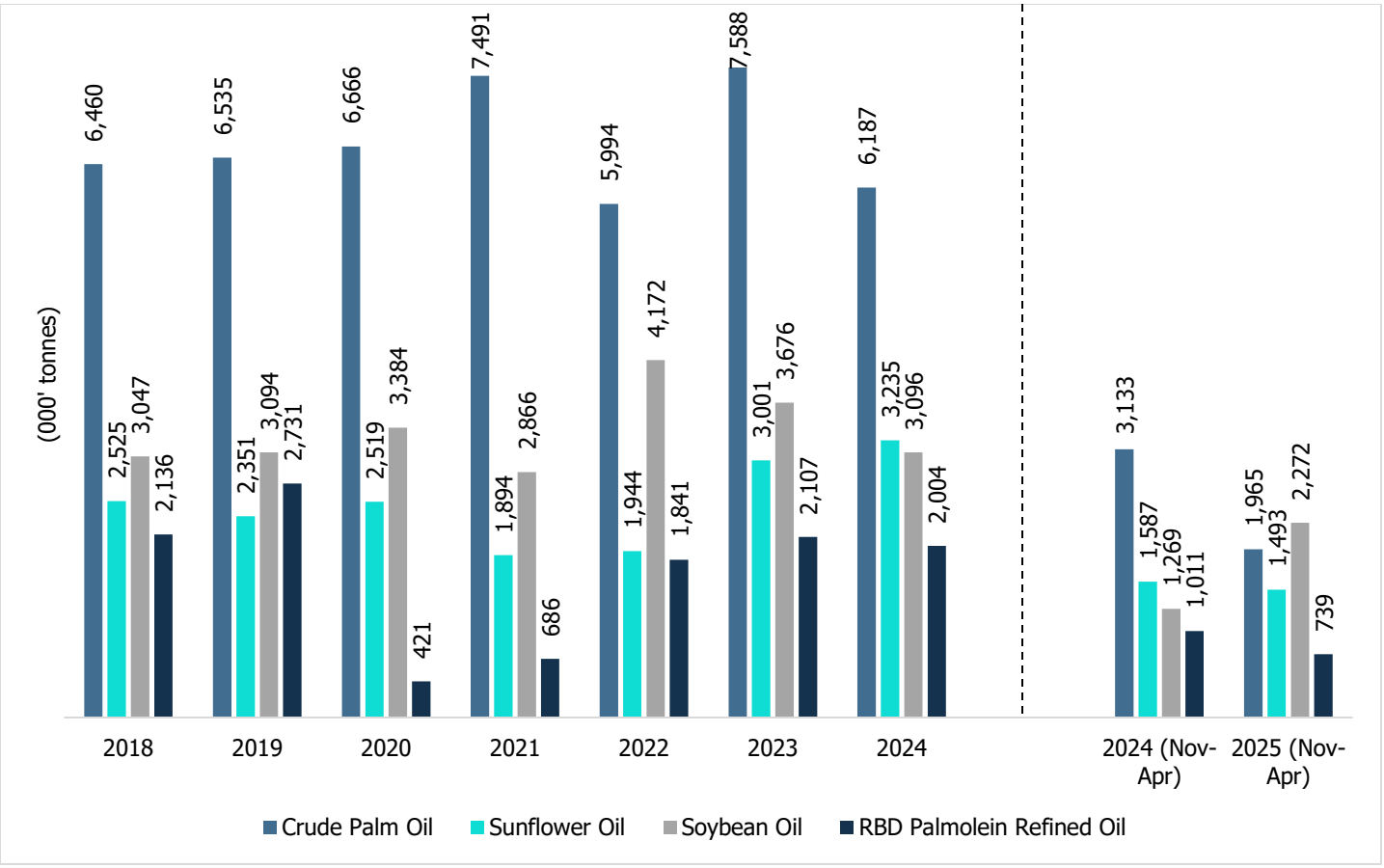
Chart 85: Edible Oil Imports



Source: CMIE, (Note: - Oil Year has been considered from November-October)

Of the total imports, the major share consists of crude edible oil (85%), and the remaining is refined oil for the year FY24.

Chart 86: Edible Oil Imports (Product-Wise)



Source: CMIE, (Note: - Oil Year has been considered from November-October)

The imports of RBD Palmolein (widely used as a frying oil) decreased marginally to 739 thousand tonnes in the period FY25 (Nov-Apr) from 1,011 thousand tonnes during the same period in the previous year. The imports of crude palm oil (CPO) also showed a decreasing trend when compared to the corresponding period of FY24. The decline in oil imports was largely on account of an increase in palm oil prices.

The government periodically examines the edible oil tariff structure in an effort to balance the interests of farmers, processors, and consumers. The Basic Import Duty on Edible Oils has been lowered by the Central Government so that consumers can purchase edible oil at reasonable costs. Domestic price, which is mainly driven by import prices and lower import duty, is likely to help in lowering the final cost.

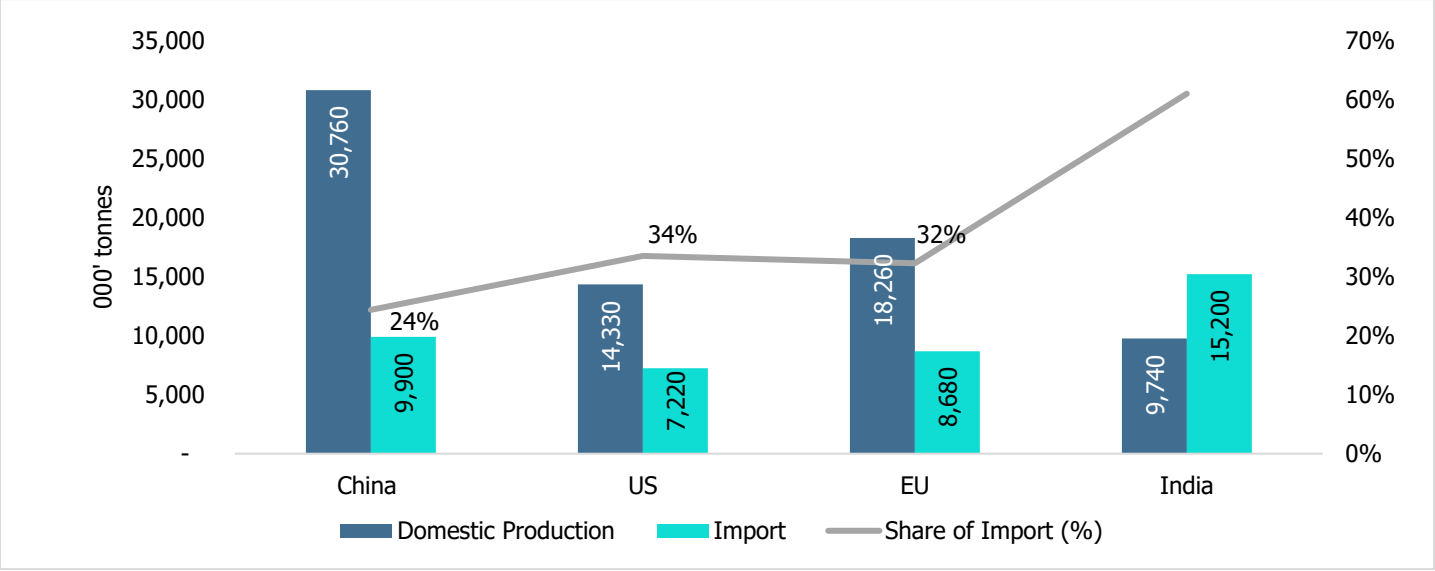
In October 2021, the import duties on refined sunflower oil and refined soybean oil were last lowered from 32.5% to 17.5%. This was done considering skyrocketing global and, hence, domestic edible oil prices in 2021.

The reduced import tariff structure on crude palm oil, crude sunflower oil, and crude soya oil was supposed to end in March 2024. However, the order was extended to allow imports at reduced duties until March 2025.

As per May 2025, the government has further extended the reduced import duty structure on crude edible oils until March 2026. The basic customs duty on crude palm oil, crude soybean oil, and crude sunflower oil has been reduced from 20% to 10%, bringing the total effective duty down to 16.5%. However, the duty on refined edible oils remains unchanged at an effective rate of 35.75%.

Among the top major edible oil-consuming countries, India has a higher dependency on imported edible oil as compared to other major countries. Most of the countries had a dependency on imported edible oil in the range of 25-40% during MY2024/25, whereas India's dependency on imported oil was around 61%.

Chart 87: Import Dependency of major countries during (MY* 2024/25)

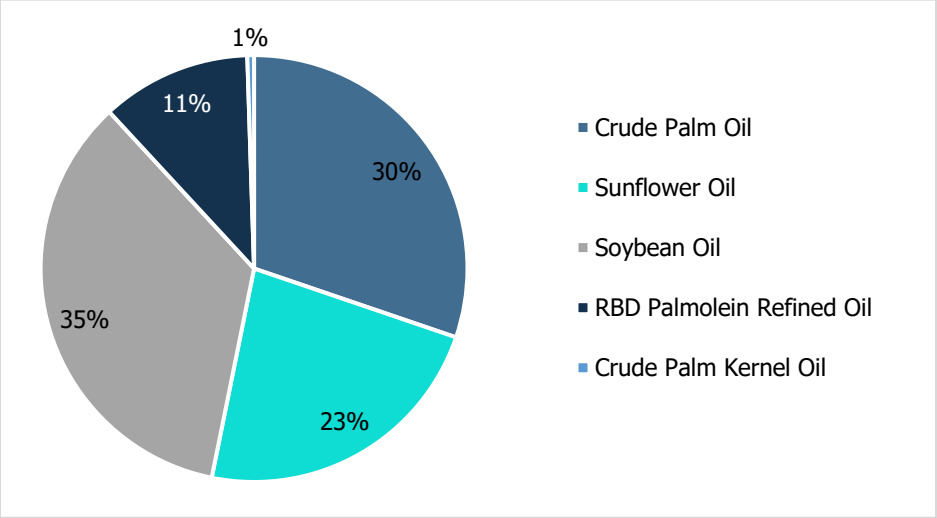


Source: United States Department of Agriculture

Note: MY stands for Marketing Year; China & US Marketing Year is from Oct- Sep; EU Marketing Year is from Jan- Dec: India marketing year is Nov-Oct

Amongst edible oils imported by India, Soybean oil accounted for the largest share of 35%, and crude palm oil accounted for around 30%, in FY25(Nov-Apr)

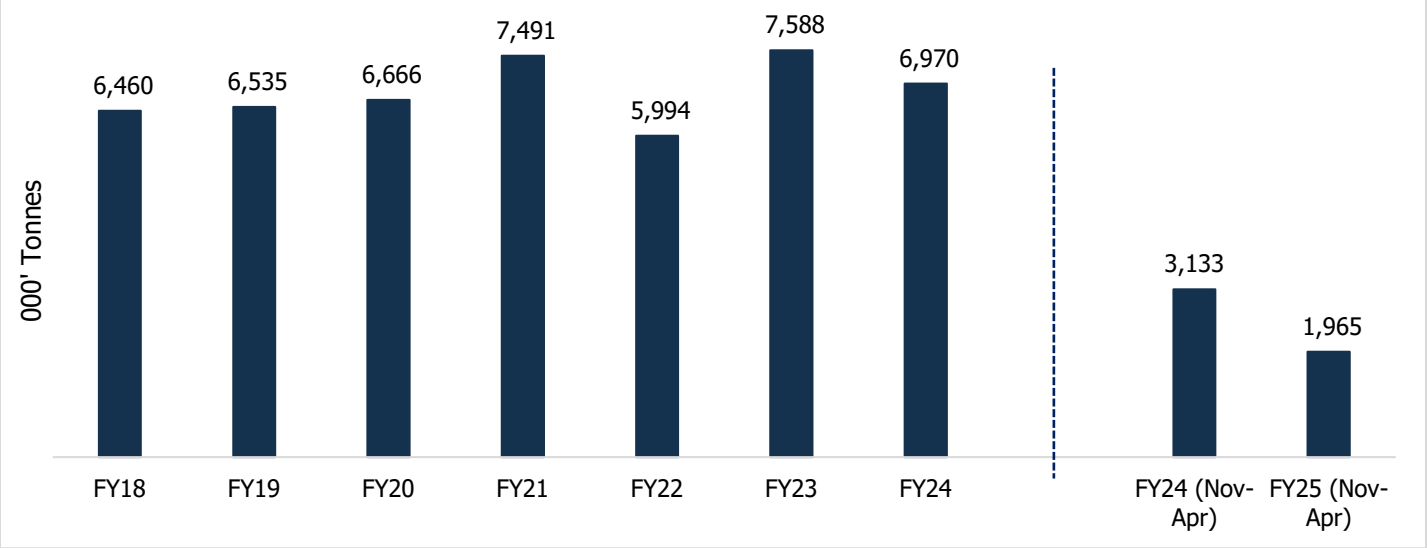
Chart 88: Edible Oil Imports Share, FY25(Nov-Apr)



Source: CMIE

India is the world's largest importer of palm oil, and it is mostly imported from the Southeast Asian countries of Malaysia, Indonesia and Thailand.

Chart 89: Crude Palm Oil Import Trend



Source: CMIE

Table 50: Import Duty Structure on Edible Oils

	(w.e.f. May 30th, 2025)				(w.e.f. September 14th, 2024)			
Particulars	**Basic Customs Duty**	**Agri Cess**	**Social Welfare Cess**	**Effective Import Duty**	**Basic Customs Duty**	**Agri Cess**	**Social Welfare Cess**	**Effective Import Duty**
Crude Palm Oil	**20%**	5%	10%	**16.5%**	**20.00%**	5.00%	10%	**27.50%**
RBD Palmolein	**32.5%**	-	10%	**35.75%**	**20.00%**	-	10%	**35.75%**
Crude Soybean Oil	**20%**	5%	10%	**16.5%**	**20.00%**	5.00%	10%	**27.50%**
Refined Soybean Oil	**32.5%**	-	10%	**35.75%**	**32.50%**	-	10%	**35.75%**

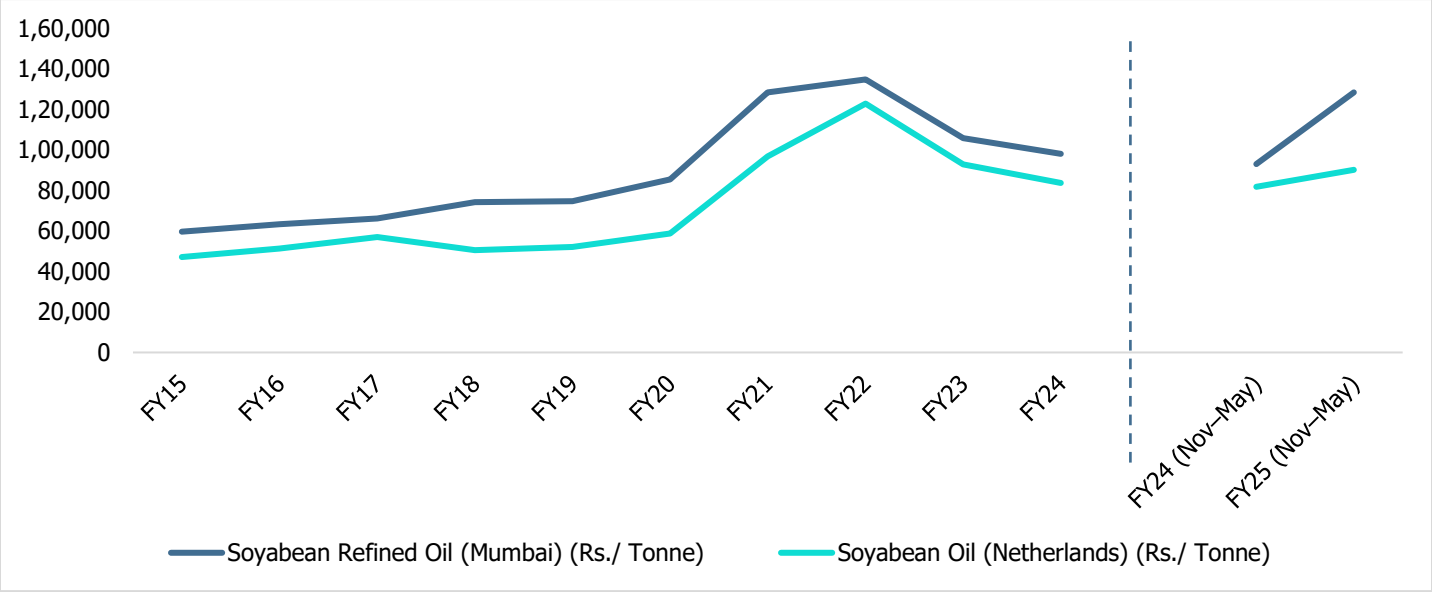
Source: Solvent Extractors' Association of India (SEA)

Note: Bold figures denote changes in duty from last year.

The government has reduced the import duty on crude edible oils, namely crude palm oil and crude soybean oil, with effect from May 30, 2025. This move brings down the effective import duty from 27.5% to 16.5%. The duty structure for refined oils (RBD Palmolein and Refined Soybean Oil) remains unchanged at 35.75%.

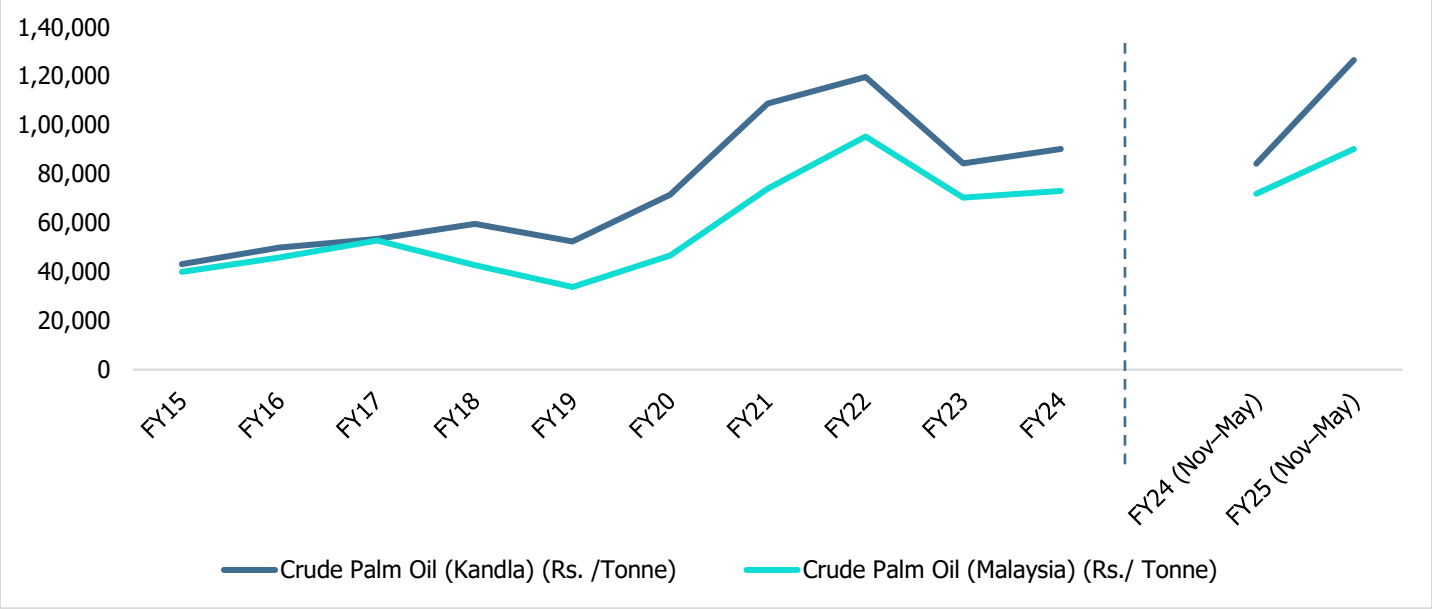
This decision aims to ease inflationary pressures and stabilise domestic edible oil prices by making imports more economical. Notably, the last revision in September 2024 kept duties high to protect domestic oilseed producers. However, the recent reduction reflects a policy shift prioritising consumer affordability over producer protection amid rising food inflation.

Chart 90: Movement in Prices of Refined Soybean Oil



Source: CMIE

Chart 91: Movement in Prices of Crude Palm Oil



Source: CMIE

In December, imports of palm oil from India reached a four-month high as a result of a spike in the demand for refined Palmolein at competitive pricing. As various vegetable oils compete for market share globally, palm oil prices remain sensitive to fluctuations in the prices of related oils. The greatest producer of soybeans, Northern Brazil, saw its output projections slashed due to the hot, dry weather, but the upcoming rains might help crops and raise estimates. Any losses in Brazil's crop production are also expected to be mitigated by increased supplies from other South American nations, such Argentina.

14.2. Key Drivers & Risks for the Oil Industry in India

14.2.1. International Risk Factors

India receives its palm oil and sunflower oil primarily from Brazil, Argentina, Malaysia, Indonesia, Ukraine, and Russia. Unfavourable weather in these nations adversely affects production, which in turn affects costs. Edible oil prices have been impacted by significant swings in these countries' respective currencies. Further, prices in these countries are impacted by export tax policies of the governments.

For instance, India imports soy oil and sunflower oil from Argentina, Brazil, Russia, and Ukraine, and palm oil mostly from Indonesia, Malaysia, and Thailand. The conflict between Russia and Ukraine has affected India's purchase of sunflower oil, which further caused a dramatic rise in the price of edible oils.

The scarcity of manpower in Indonesian and Malaysian palm oil plantations, the drought in Argentina, which **reduced** soybean output, the low yield of sunflower harvests in Ukraine, and China's large purchases of edible oils have all historically impacted prices.

14.2.2. Domestic Risk Factors

Over the past six decades, India's per capita edible oil consumption has multiplied due to growth in income, population, and processed food preferences. The edible oil industry had been overly reliant on external forces due to the lack of a strong domestic strategy.

Regardless, a handful of domestic elements that impact the edible business are as follows:

- MSP for oil seeds
- Yield output of oilseeds farmed domestically
- Currency value volatility
- Consumption patterns
- Meteorological circumstances
- Market availability of stock and increase in taxes on import of crude edible oil.

14.3. Industry Growth Drivers/ Outlook

Global prices of edible oil have reduced considerably in recent months. A dip in edible oil prices in the global market has a direct impact on the domestic market due to India’s significant dependence on imports. Considering the fall in global prices and reduction in import duty, all major domestic edible oil brands had cut prices by Rs10-15 per litre. The declining price trend is expected to help ease cooling down of the consumer food inflation.

In August 2021, the government announced a scheme, ‘National Mission on Edible Oils – Oil Palm (NMEO-OP)’ to increase the country’s palm oil self-sufficiency by increasing the area under palm oil cultivation, thereby reducing dependency on imports. The scheme also aims to benefit palm oil farmers through a remunerative pricing mechanism. The edible oils sector expects prompt and decisive policymaking in support of the government's initiative to encourage the expansion of oil palm plantations in India.

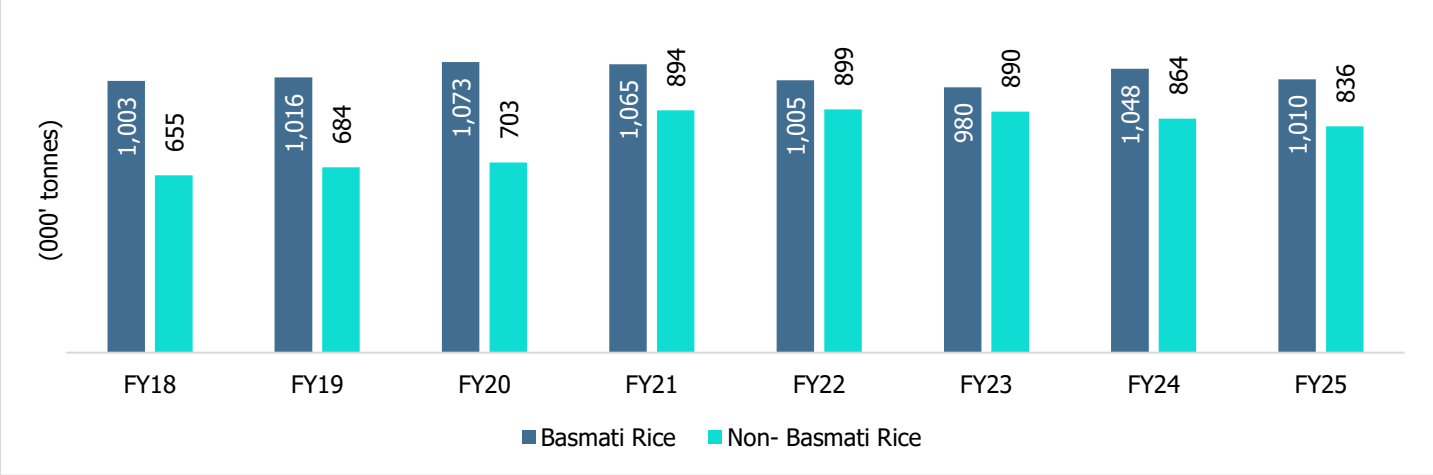
In addition, the demand for edible oil is bound to increase in India, with the growing population. Income and population growth are important indicators that contribute to the rising consumption of edible oil. With the entry of the private sector and expected healthy demand growth, India is focusing on increasing the cultivation and procurement of edible oil in its domestic land.

14.4. Packaged Food: Rice, Pulses

14.5. Overview

The packaged rice market in India is expected to grow because of the country's growing urban population and rising demand for high-quality goods, as well as rising per capita income.

Chart 92: Rice Production



Source: CMIE

In recent years, India's rice production has experienced fluctuations influenced by varying monsoon patterns and procurement policies across major producing states such as Uttar Pradesh, West Bengal, Bihar, and Chhattisgarh. To stabilise domestic rice prices and protect farmers, the Government of India's Department of Commerce implemented, on July 20, 2023, an immediate prohibition on the export of non-basmati white rice. Conditional exemptions were granted for shipments already underway to balance farmer interests with global trade commitments. In FY24 and FY25, basmati rice production remained robust at 1,048 thousand tonnes and 1,010 thousand tonnes, respectively, while non-basmati rice production recorded moderate numbers of 864 thousand tonnes and 836 thousand tonnes, reflecting a stabilising supply scenario under the current regulatory framework.

The State-by-State procurement of rice for the past four years and the current year (marketing season-wise) is provided below:

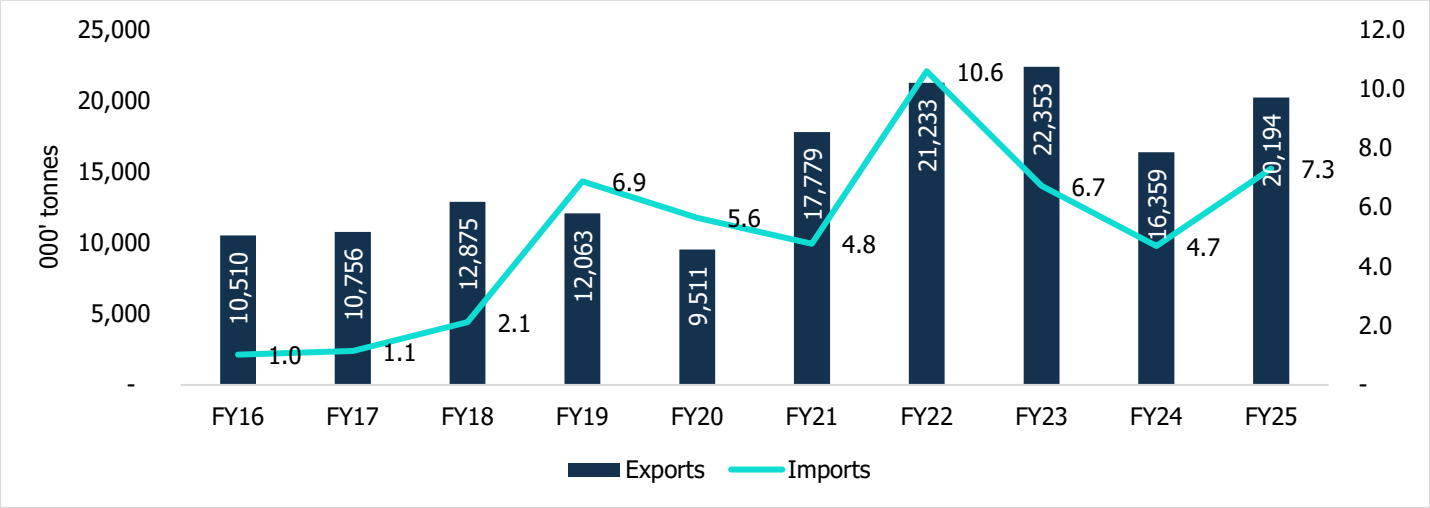
Table 51: State procurement of Rice (in lakh MT)

State/ UTs	FY19	FY20	FY21	FY22	FY23	FY24	FY25*
Andhra Pradesh	48.06	55.33	56.66	44.61	27.55	20.39	10.98
Telangana	51.9	74.54	95.25	73.94	88.35	63.86	28.25
Assam	1.02	2.11	1.42	3.79	4.01	2.64	0.47
Bihar	9.49	13.41	23.84	30.09	28.17	20.63	6.79
Chandigarh	0.13	0.15	0.19	0.18	0.13	0.17	0.18
Chhattisgarh	39.71	52.24	47.62	61.65	58.65	83.00	52.84
Gujarat	0.09	0.14	0.74	0.82	1.18	0.57	0.22
Haryana	39.42	43.07	37.89	37.06	39.77	39.49	35.99
Jammu & Kashmir	0.09	0.1	0.26	0.27	0.23	0.16	0.22
Jharkhand	1.52	2.55	4.28	5.12	1.17	0.50	0.00
Karnataka	0.59	0.41	1.38	1.47	0.14	0.00	0.00
Kerala	4.65	4.83	5.2	5.09	4.97	3.80	0.68
Madhya Pradesh	13.95	17.4	24.97	30.7	31.02	28.25	16.65

State/ UTs	FY19	FY20	FY21	FY22	FY23	FY24	FY25*
Maharashtra	5.8	11.67	12.72	12.27	12.38	7.80	3.69
Odisha	44.48	47.98	52.58	48.31	53.83	48.17	7.87
Punjab	113.34	108.76	135.89	125.48	122.01	124.14	116.12
Tripura	0.07	0.14	0.16	0.39	0.30	0.22	0.04
Tamil Nadu	12.94	22.04	30.53	18.76	23.01	23.77	3.63
Uttar Pradesh	32.33	37.9	44.78	43.9	43.89	36.05	23.88
Uttarakhand	4.62	6.82	7.18	7.74	6.00	4.89	4.34
West Bengal	19.79	18.38	18.9	24.01	21.82	16.79	0.005
Others	0.2	0.29	0.01	0.27	0.11	0.15	0.25
All India Total	**444**	**520**	**602.5**	**575.9**	**568.7**	**535.4**	**313.1**

Source: Department of Food & Public Distribution, Annual Report 2024-25
Note: (*) represents- Data reported as of 31.12.2024

Chart 93: Import & Export of Rice



Source: CMIE

India is the world's largest exporter of basmati rice. About 20,194 thousand tonnes of rice were exported to other countries during FY25, valued at Rs 1,057,190.4 million, respectively. India exports both basmati and non-basmati rice to other nations. However, due to India's export limitations, rice shipments dropped significantly in FY24. India tightened export regulations on rice.

14.6. Key Drivers & Risks for the Rice Industry in India

India has one of the largest rice markets in the world. Globally, India is the leading country that produces and consumes the most rice. For more than half of the people in the nation, rice constitutes a staple diet. Growing income levels and a growing population are the main drivers of rice consumption. The Indian government also supports the rice industry through various initiatives, such as the development of infrastructure for rice storage and transportation and the promotion of high-yielding rice varieties.

- **Government Support-** The Indian government has plans to continue supporting the rice market. Numerous steps are taken, including the construction of infrastructure for rice storage and transportation and the promotion of high-yielding rice cultivars.

- **Growing Market Industry Demand for Organic and Healthful Rice:** There is a growing market industry demand for organic and healthful rice varieties. Red rice, brown rice, and ponni rice, for example, as customers grow more health concerned.

- **Growing Exports:** The demand for Indian Basmati rice and other premium rice types has kept India a dominant player in the world rice export industry.

Risks in the Rice Industry

- Major obstacles in rice farming include-
- Inadequate soil moisture
- Low soil fertility
- Soil erosion
- Draughts & Floods
- Water logging
- Unpredictable monsoons
- Ineffective fertilizer uses and government policies on export.

14.7. Competition Landscape

Within the foods sector, Adani Wilmar offers branded versions of wheat flour, rice, besan, pulses, sugar, and other kitchen staples. The rice section includes varieties of both basmati and non-basmati rice in the rice section. Fortune is the brand under which Adani Wilmar sells branded basmati rice. The Company sells premium Basmati rice under the Kohinoor brand, cheap rice under the Charminar sub-brand, and Trophy sub-brand to target the Hotel, Restaurant, and Café/Catering (HoReCa) segment after acquiring the well-known Kohinoor brand (domestic) and its sub-brands during the year.

Adani Wilmar is a leading player in India's edible oil business. Fortune, Adani Wilmar's flagship brand, is the largest selling edible oil brand in India. It offers a variety of edible oils, including Fortune Xpert Total Balance Oil, Fortune Xpert Pro Immunity Oil, Fortune Xpert Pro Sugar Conscious Oil, and Rice Bran Oil (RBO). In addition to Fortune, Adani Wilmar offers other brands like as King's, Aadhar, and Raag, which cater to diverse market groups and tastes. The company is well-known for its extensive distribution network, which ensures that its products are widely available across India.

15. Digital Industry

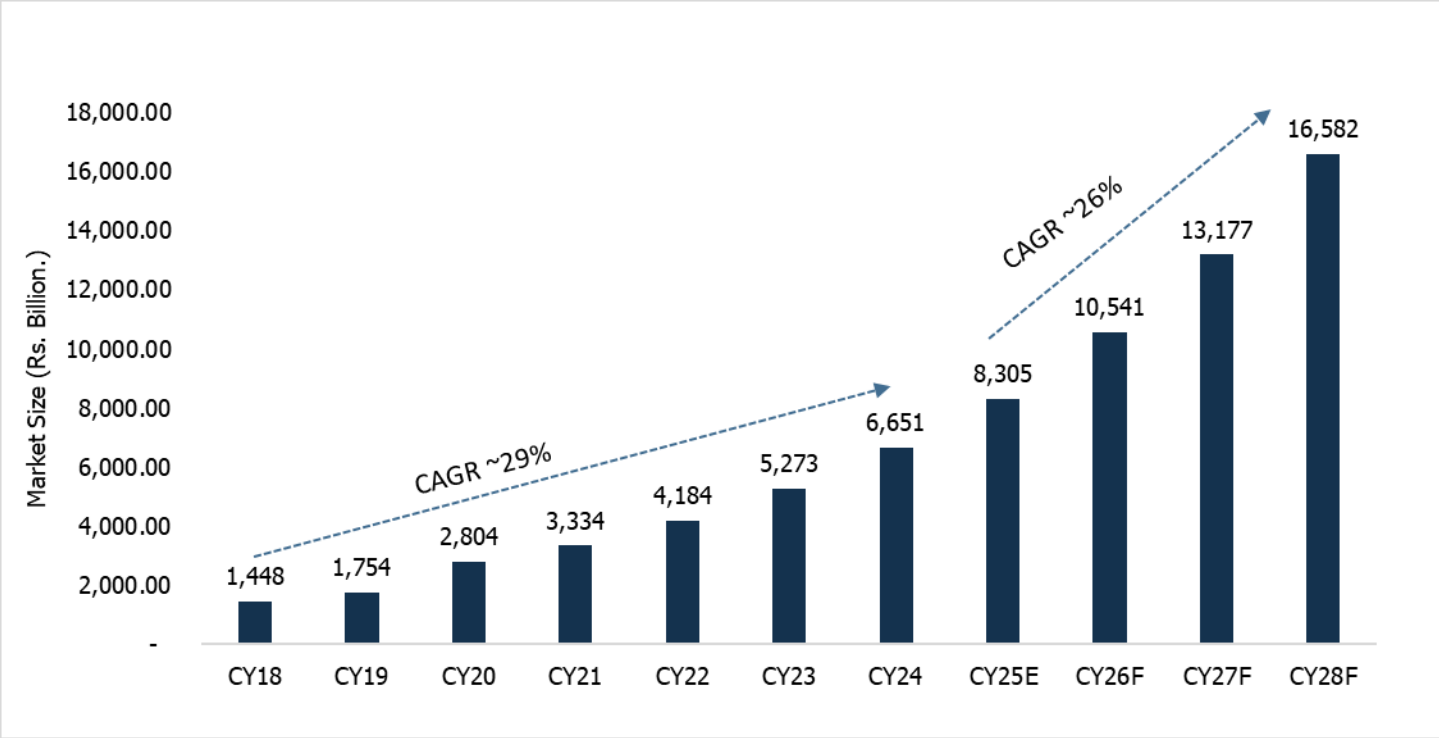
15.1. Review and outlook of the e-commerce industry in India

The e-commerce sector in India offers convenient access to a wide range of products, both indigenous and imported. Consumer electronics and apparels dominate e-commerce retail sales, followed by food & grocery, jewellery, furniture and others.

India's e-commerce industry has experienced exponential growth in years. The adoption of e-commerce significantly increased during the pandemic to counter the COVID-19-associated challenges, as major companies advanced towards digital sales channels, adopted new business strategies, and started or improved their social media presence.

The e-commerce market (B2B and B2C) was valued at Rs. 1,448 billion in CY18 and expanded to Rs. 6,651 billion in CY24, registering a CAGR of 29% over the six-year period. The Indian e-commerce market is expected to reach Rs. 16,582 billion in CY28, registering a CAGR of 26% during the period CY25 to CY28. This growth is expected to be fuelled by an increasing number of mobile users, expanded internet connectivity, and rising demand in grocery and fashion/apparel categories.

Chart 94: Indian E-Commerce Market Size (Rs. Billion)



Source: Maia Research, Care Edge Research
Note: E – Estimated, F - Forecasted

15.1.1 Share of e-retail sector in comparison with overall retail industry

The Indian retail sector is one of the fastest growing sectors, with the largest consumer base. This growth can be attributed to healthy demand, increasing investments, and continuous innovation to attract customers. As digitization widens the market, better access channels, faster customer acquisition leading to cash conversion and rapid shift in both demand & supply factors will accelerate the retail growth in India.

Chart 95: Indian Retail Sector Structure

Source: CareEdge Research

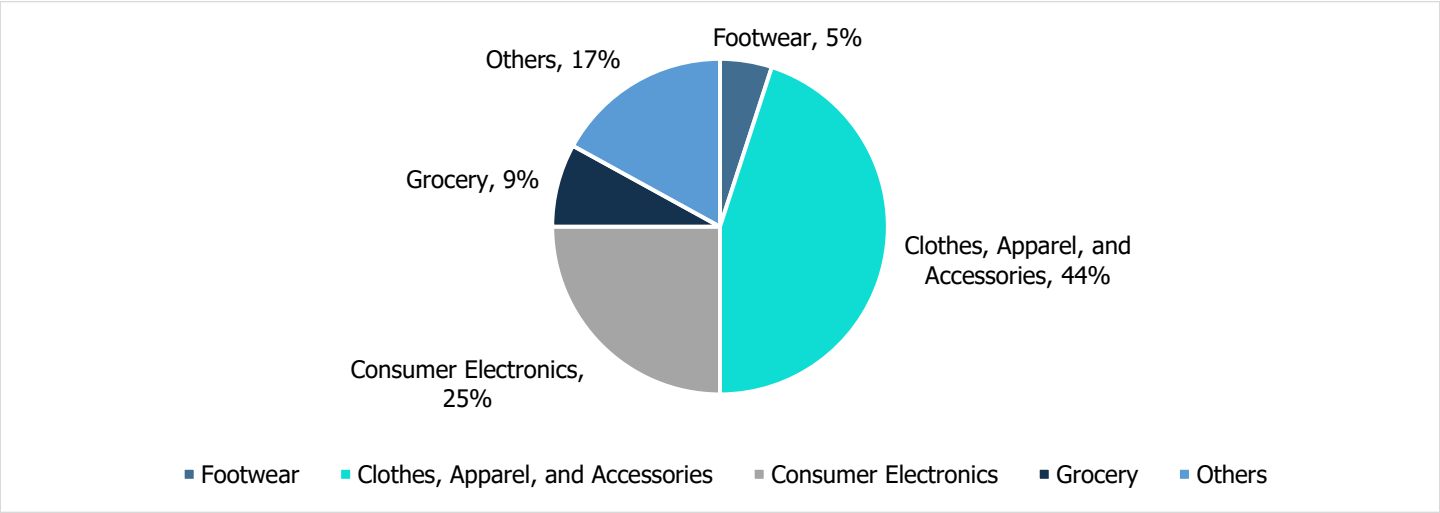
India is 4th largest retail market in the world and ranked No.1 in Global Retail Development Index (GRDI) in 2023 and employs around 8% of the workforce i.e. more than 35 million people. According to NASSCOM, Indian retail sector is likely to generate 25 million plus new jobs by 2030. The Indian retail industry consists of organized & unorganized segments. Currently, the unorganized sector dominates the retail industry and organized retail sector penetration in India is much lower than developed countries.

The outbreak of Covid-19 pandemic led to an acceleration in online sales of consumer products, as consumer behaviour changed during the lockdown. Industry participants consequently witnessed a transition from traditional to digital sales and are now moving towards an omni-channel mode of retail. Thus, the pandemic has aided in the transformation of retail to a more digitally enabled environment.

By 2028, the share of e-commerce and organized B&M is expected to reach at 16% and 11%, respectively, while the share of unorganized sector is expected to come down to 73%. The key growth drivers for growth in e-retail sector are urbanization, income growth, rise in modern trade formats, e-commerce and online sales, discounts and quick home delivery incentives for customers.

15.1.2 Share of key segments in e-commerce industry

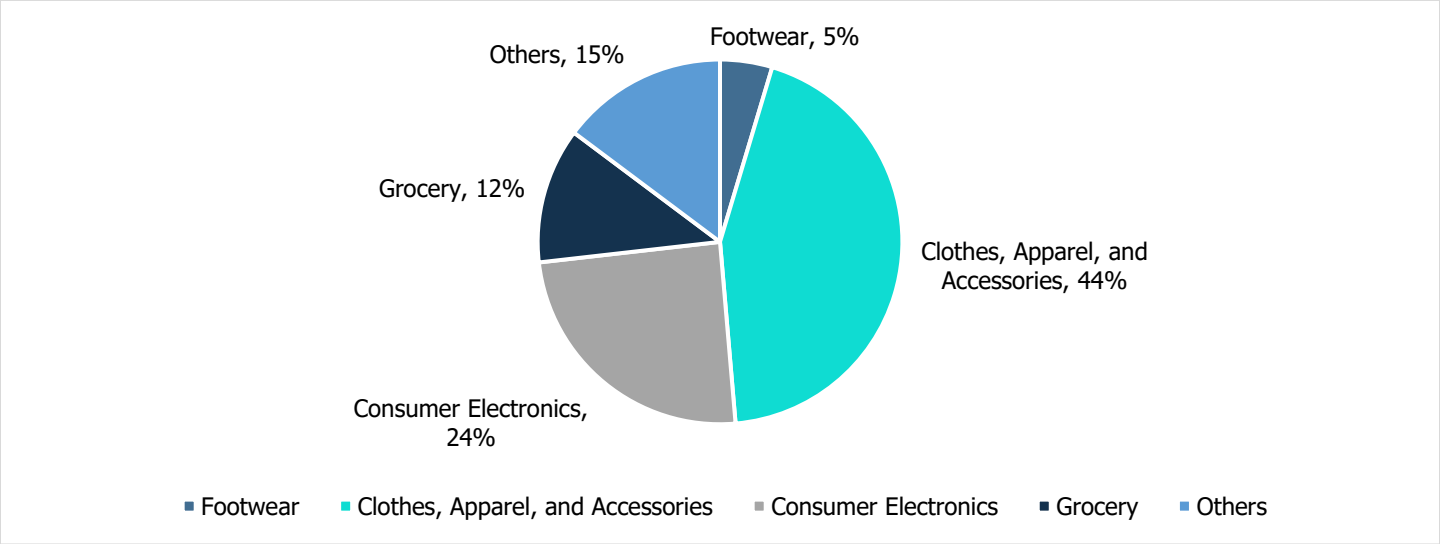
Chart 96: Share of various segments in e-commerce (CY25E)



Note: E- Estimate
Source: Maia Research, CareEdge Research

The fashion and consumer electronics sectors were among the first to establish a strong presence in the e-commerce landscape and have been consistently expanding their online presence. These segments are expected to remain the largest contributor to e-retail sales, while grocery sales contribution is expected to increase in the near future, which is led by the increasing trend of digitalization and customer shopping preferences.

Chart 97: Share of various segments in e-commerce (CY28E)



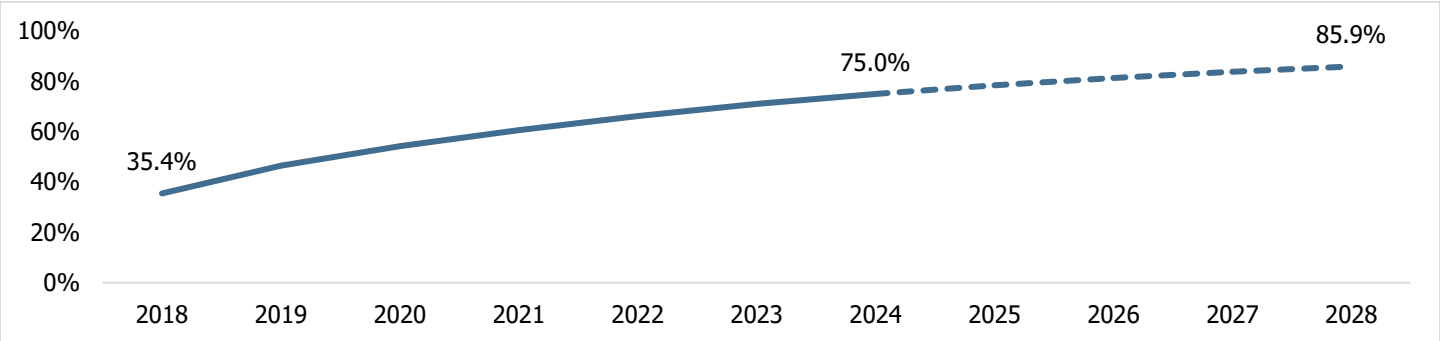
Note: E- Estimate
Source: Maia Research, CareEdge Research

15.2. Key Growth drivers and trends for the e-commerce industry in India

- **Increasing internet and smartphone penetration:**

The e commerce industry is dependent on internet and in the past few years it has risen with the growing internet penetration in the country. The proliferation of smartphones and tablets has further increased the access to internet leading to significant increase in average data spend with services like 4G being introduced. Additionally, the improvements in the telecom infrastructure and 5G services are expected support the growth of e-commerce industry.

Chart 98: Smartphone Penetration Rate

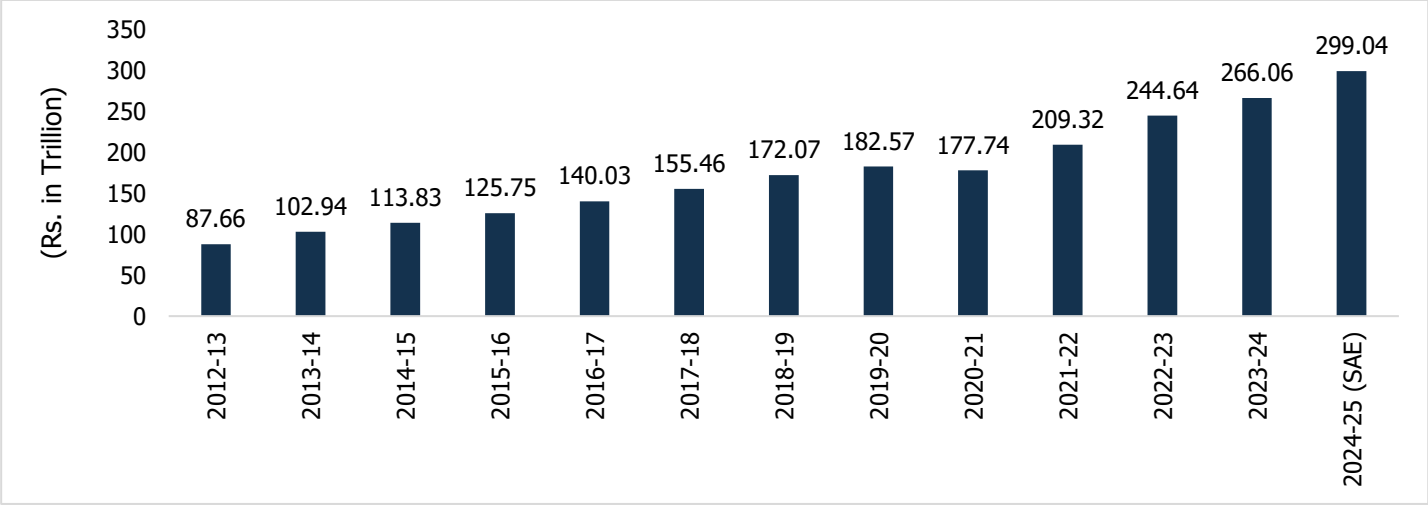


Source: Maia Research, CareEdge Research

- **Rising purchasing power**

With the rising disposable income, the demand growth in the retail sector is also accelerating in India. The overall increase in per capita income of the people has seen a healthy growth post the COVID-19 pandemic, thereby supporting healthy growth in the retail sector in India.

Chart 99: India Net Disposable Income for past decade



Source: MOSPI, CareEdge Research
Note: SAE – Second Advance Estimates

15.3. Omni-channel strategy

An omnichannel strategy is centred on integrating a company's various touchpoints, including physical stores, social media, website, email, and mobile platforms. This seamless integration allows customers to transition between these channels conveniently, avoiding any disruptions. Many prominent brands such as Nykaa, Lenskart, Mamaearth, and Caratlane have used an omnichannel approach, leveraging exclusive brand outlets to enhance brand visibility and support sales. An established physical store presence can significantly enhance customer conversion rates by bolstering brand recognition and fostering trust.

Companies employing omnichannel customer engagement strategies have demonstrated higher rates of customer retention, ultimately resulting in increased profits through repeat customer sales. Moreover, in the present market context, traditional brick-and-mortar companies are increasingly diversifying through online sales channels.

15.4. Subscription Based Models

The subscription business model functions on a recurring revenue framework, wherein customers make periodic payments (weekly, monthly, or yearly) in exchange for access to products or services. This strategy allows businesses to establish strong relationships with customers, ensuring a steady and predictable revenue stream. The subscription model is prevalent across diverse industries, including streaming services, food delivery, health and wellness, and Software as a Service (SaaS). Leading companies like Hulu, HelloFresh, and Google Workspace have effectively embraced this model, leveraging it to reduce customer acquisition cost and foster stronger customer relationship. By offering ongoing value and personalized experiences, businesses can enhance customer loyalty and drive sustainable revenue growth through the subscription business model.

15.5. Adani's Portfolio

Adani Digital Labs (ADL) is Adani Group company to focus on connectivity and seamlessly integrate diverse businesses and functions across the Adani Group. Through the strategic adoption of cutting-edge technologies, it will serve as the primary interface for consumers, offering a cohesive and intuitive experience across all operations. Embracing the digital landscape, it will leverage innovative solutions such as smart technologies, data analytics, and digital platforms to optimize efficiency, elevate customer experiences, and propel operational excellence into the future.

Adani One is the Adani Group's initiative towards airport digitization. Cleartrip, an online travel aggregator, which is a part of Flipkart group has entered a strategic partnership with Adani One, where they will offer their expertise in the domain of domestic and international flight bookings.

16. Indian Airports

16.1. Overview

The Indian airport sector has witnessed significant growth and transformation in the past few years, driven by a confluence of factors like rising passenger traffic, private sector participation, technological advancements and digitization, and government focus on improving the airport infrastructure.

The domestic aviation industry in India has positioned itself as the third-largest domestic aviation market globally in terms of domestic air traffic. There have been several notable developments in the sector, such as the construction of big-ticket greenfield airports, the privatization of airports, the launch of a new airline, and the formulation of a drone policy.

Airport infrastructure, as part of the aviation industry, plays a significant role in the development of the national economy due to its globalized nature. The entry of private players in this industry in India has boosted the concept of 'Airport Retailing', while the Regional Connectivity Scheme "Ude Desh ka Aam Nagrik" (RCS UDAN) scheme, has led to significant growth in air traffic.

Besides, technology has become an integral part of the aviation sector. Airports and airlines are extensively using technology and digitalization, including plane boarding procedures, contactless screening, and biometrics to make travelling more efficient and smoother for passengers.

16.2. Passenger Traffic movement

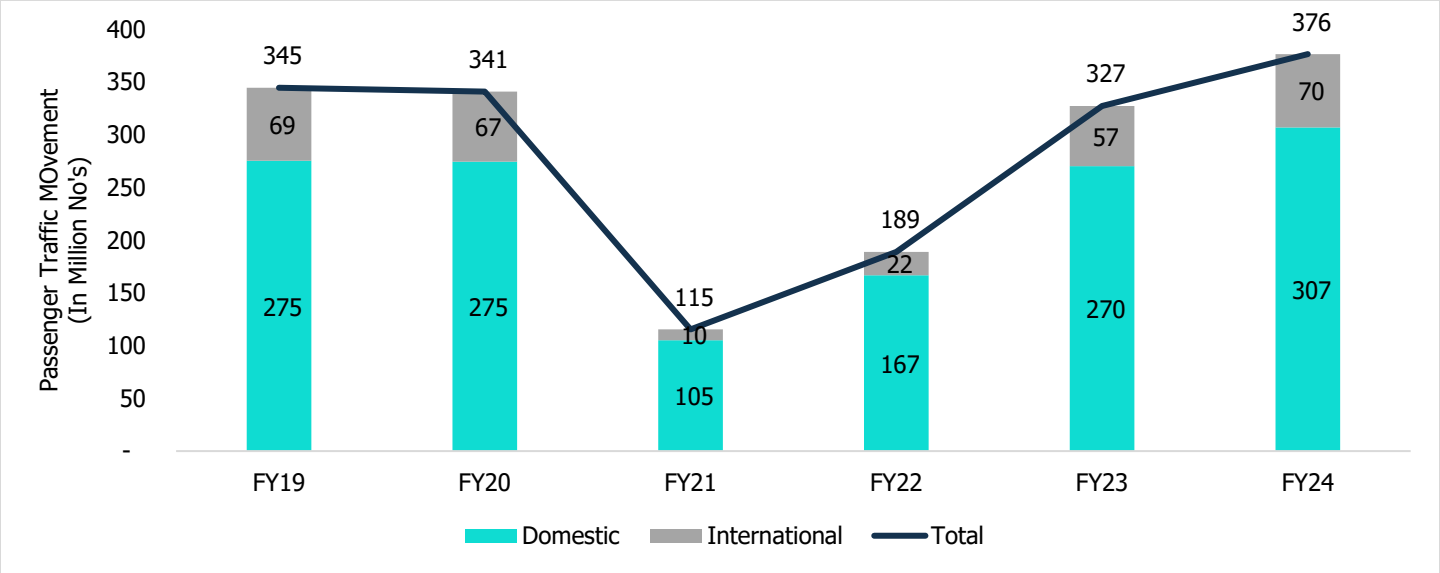
The Indian aviation sector is poised to strengthen its position globally, with the continuous expansion of the domestic market and the resurgence of international travel post the COVID-19 pandemic. The various operational indicators for Indian airports like passenger traffic and freight traffic movement are discussed below.

16.2.1. Total Passenger movement Domestic and International

Passenger traffic in India witnessed significant growth over the past years, except for the adverse impact of the COVID-19 pandemic during FY21 and FY22. This growth has been driven by several factors, including rising disposable income, increasing affordability of air travel, growing middle class, expansion of low-cost airlines, and government initiatives like the UDAN (Ude Desh ka Aam Nagrik) scheme for regional connectivity.

The low-cost airlines have captured a good market share, driven affordability and stimulating demand. While the business travel steadily recovered in FY22 and FY23 post the pandemic leisure travel picked-up sharply post the pandemic particularly for domestic destinations, passengers carried by domestic airlines during January-April 2025 were 575.13 lakh against 523.46 lakh during the corresponding period of the previous year, thereby registering an annual growth of 9.87 per cent and monthly growth of 8.45 per cent hence increasing domestic air traffic.

Chart 100: Passenger Traffic Movement Trend



Source- Airports Authority of India (AAI), CareEdge Research

In FY23, the aviation industry in India witnessed a significant 73% year-on-year increase in passenger air traffic as compared to FY22, led by 62% growth in domestic passengers and 158% growth in international passengers. This substantial growth can be attributed to a combination of a low base effect caused by the pandemic-related restrictions in FY22, administration of multiple doses of vaccine across the world, and the overall revival of the global economy. To recover the losses incurred during the pandemic, airlines increased fares during FY22. As the pandemic situation improved, the Ministry of Civil Aviation allowed airlines to operate at full capacity. International flights also resumed, reviving the air travel related to medical and tourism sector.

In FY24, the industry grew further by 15% to 376 million passengers as compared to FY23, mainly led by growth in both domestic and international traffic at 13.5% and 22.3% respectively.

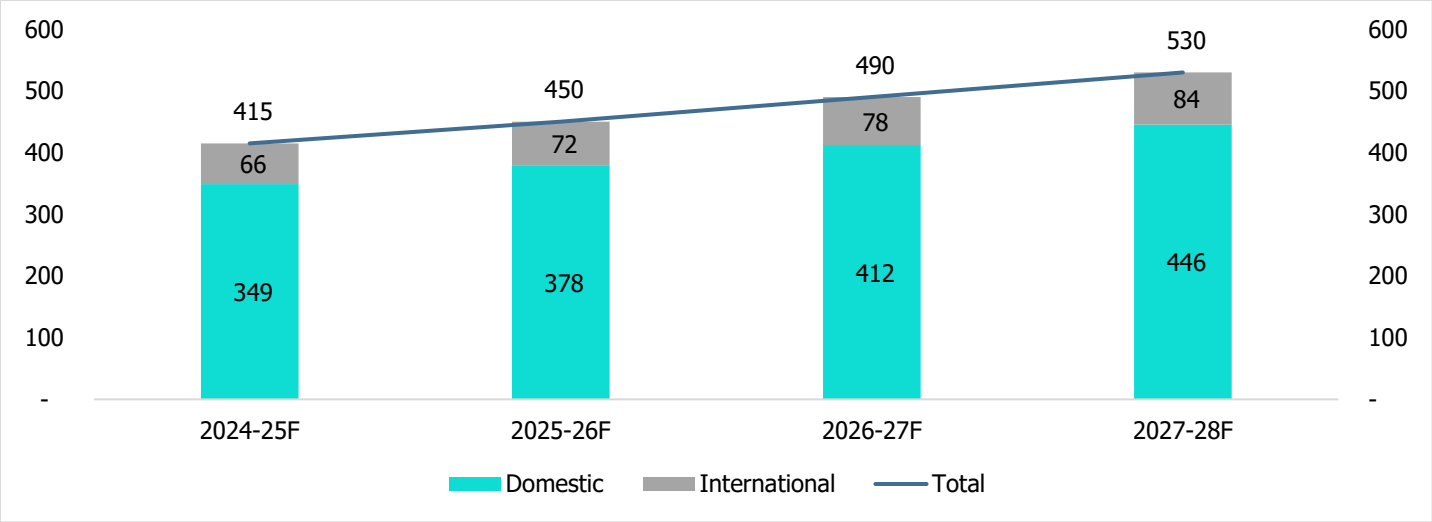
Furthermore, sustainable practices, technological advancements and digitization including plane onboarding, biometrics, automation, and AI are improving efficiency in the light of growing passenger traffic.

Passenger Traffic Outlook

The passenger traffic movement in India is expected to grow at a CAGR of 8%-10% over the period of FY24-FY28. Domestic traffic is projected to grow at a faster rate than international traffic. The growing middle class, increasing disposable income and India's growing MICE (Meetings, Incentives, Conferences, and Exhibitions) industry will support domestic passenger traffic growth over the medium term.

On the other hand, the thriving tourism sector including medical tourism, adventure tourism, religious tourism and eco-tourism will support international passenger traffic growth in the future. Moreover, the government initiatives and private sector investments are expected to support this growth momentum.

Chart 101: Passenger Traffic Outlook

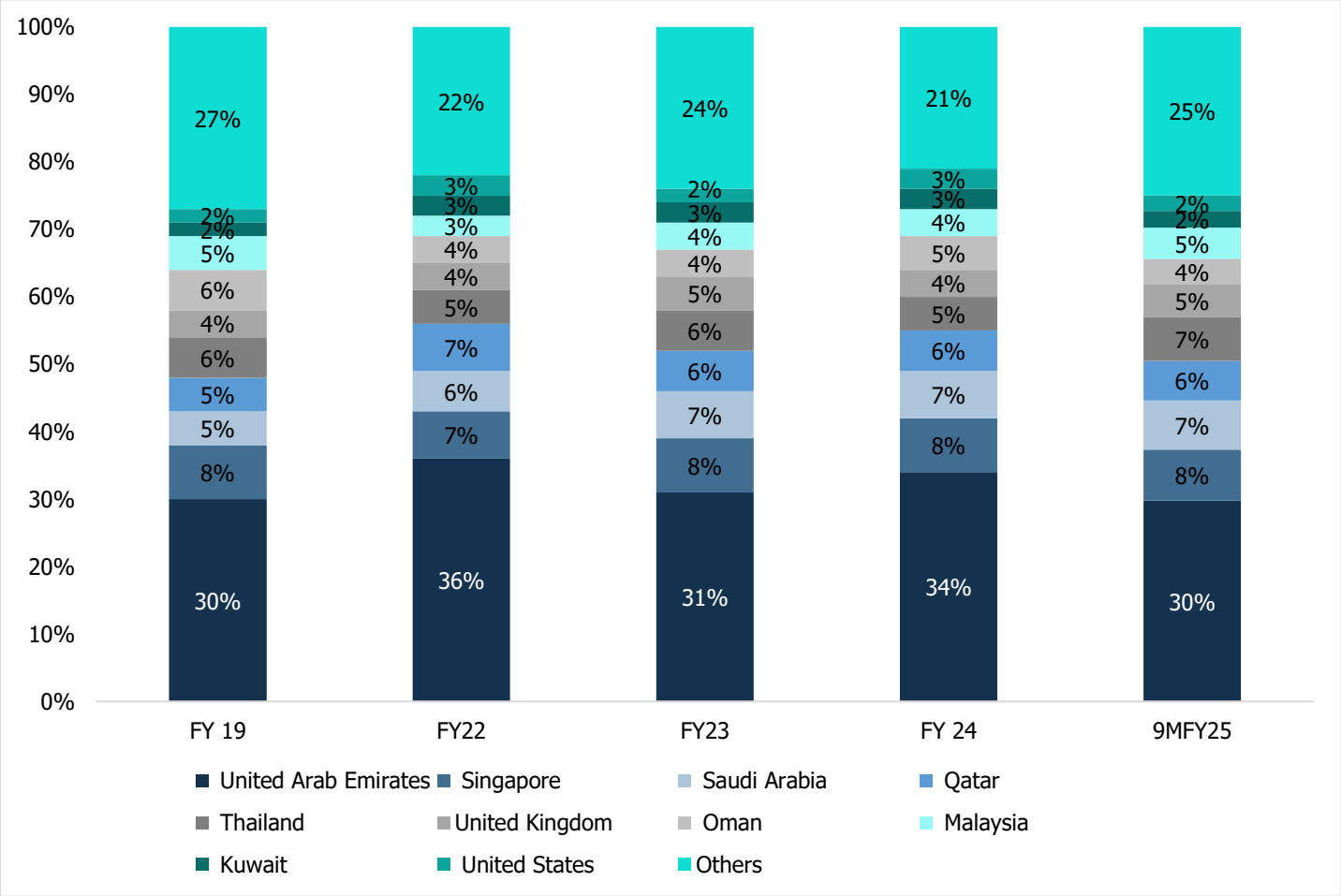


Source- Directorate General of Civil Aviation (DGCA), CMIE, CareEdge Research

Note: The forecasted numbers are represented by 'F' in the chart and ~ is the Approximate Passenger Traffic

16.3. Changing Trends in International Passenger Traffic

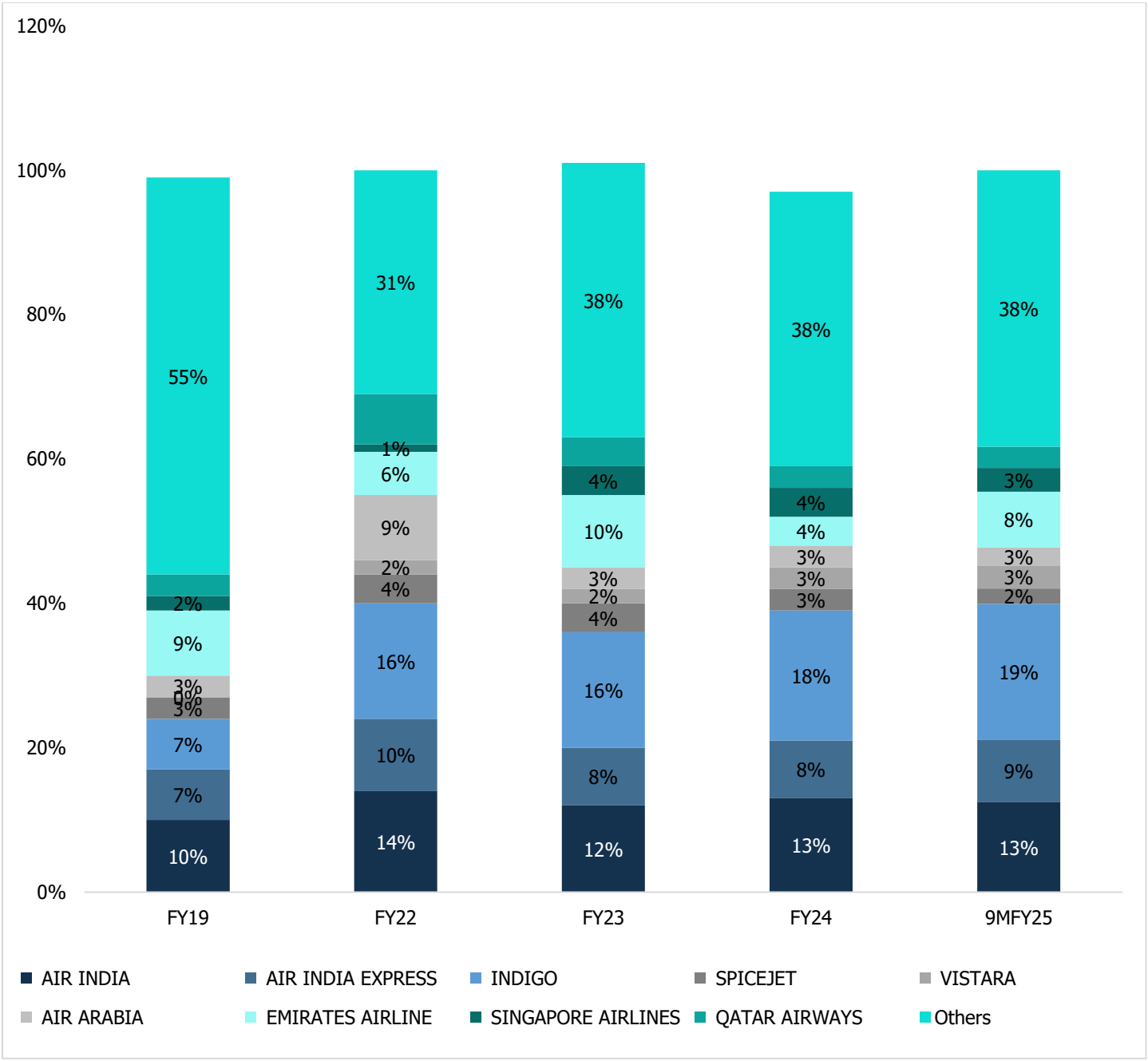
Chart 102: UAE - market leader in international passenger traffic



Source: Directorate General of Civil Aviation (DGCA)

Indian Airlines has gained market share of International Airline Traffic of passengers flying from India. Indigo's market share has increased significantly from 8% in FY19 to 31% in 9MFY25, whereas other Indian Airlines has gained marginal market share in the past five years.

Chart 103: Market Share of International Airline Traffic of Passengers from India

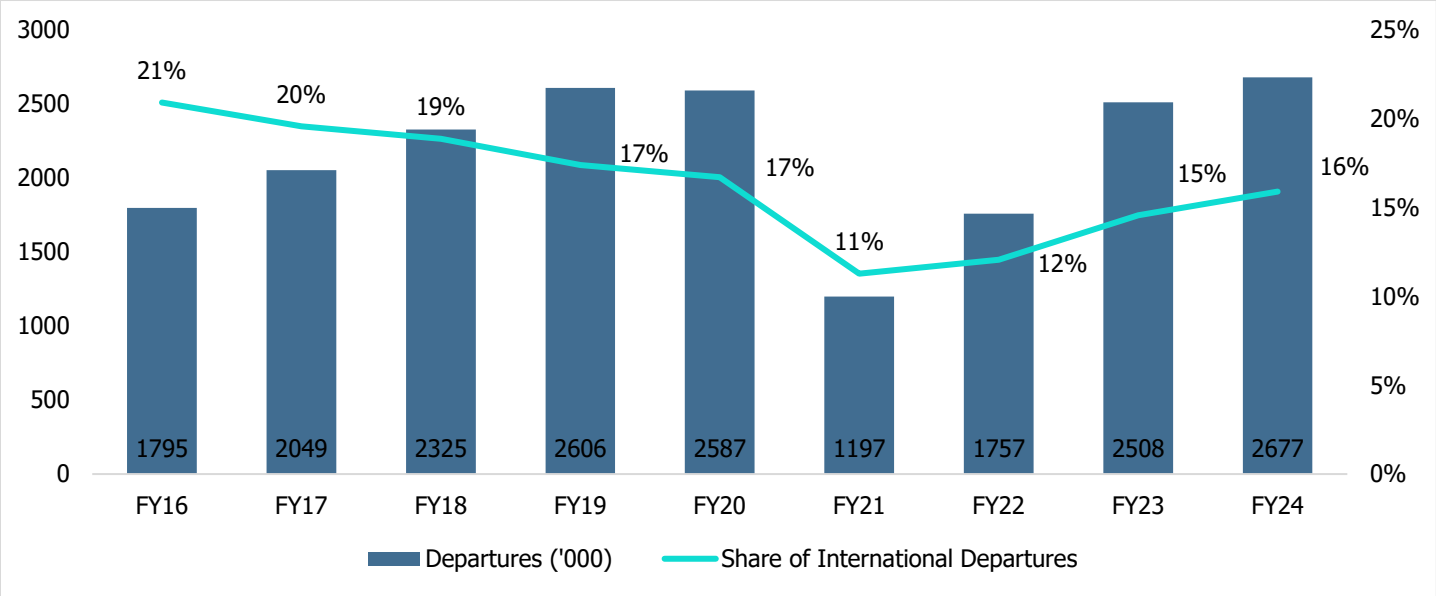


Source: DGCA, CareEdge Research

16.4. Air Traffic Movement

In FY24 total flight count reached 2.67 million higher than FY23 at 2.50 million. International flights were 16% of the total flights departed. The count of International flight was at 0.42 million and Domestic flights were 2.25 million as of FY24.

Chart 104: Air Traffic Movement

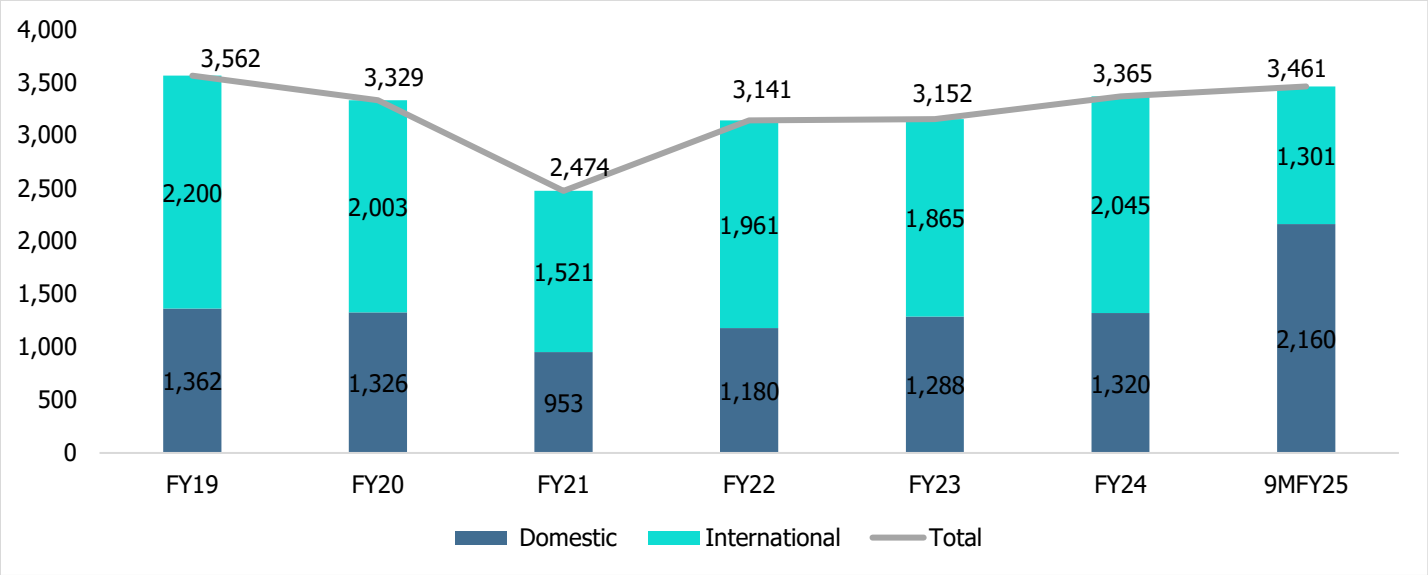


Source-AAI, CareEdge Research

Freight traffic in India witnessed moderate growth in FY23, with domestic freight traffic growth of 9% on a year-on-year basis. In FY24, the domestic and international freight traffic grew by 2.5% and 9.7% on a year-on-year basis to reach 1,320 and 2,045 thousand tonnes respectively. This growth was driven by the increasing demand for e-commerce & logistics services and the growing manufacturing activity. The rise of e-commerce significantly increased demand for air cargo, particularly for smaller parcels and time-sensitive deliveries.

Furthermore, the UDAN scheme and improved infrastructure in regional airports are facilitating the movement of cargo from the smaller towns and cities in India. The integration of AI, automation, and blockchain technology is improving efficiency and transparency in cargo operations. However, air cargo movement is impacted by procedural delays and a lack of efficient multi-modal transport options. While high aviation fuel prices and other operational costs can impact the competitiveness of air cargo. Air cargo also contributes to greenhouse gas emissions, requiring sustainable practices and cleaner technologies. Therefore, airports and cargo terminals need further expansion and modernization to handle the growing volume of freight and address these challenges.

Chart 105: Freight Traffic Movement Trend



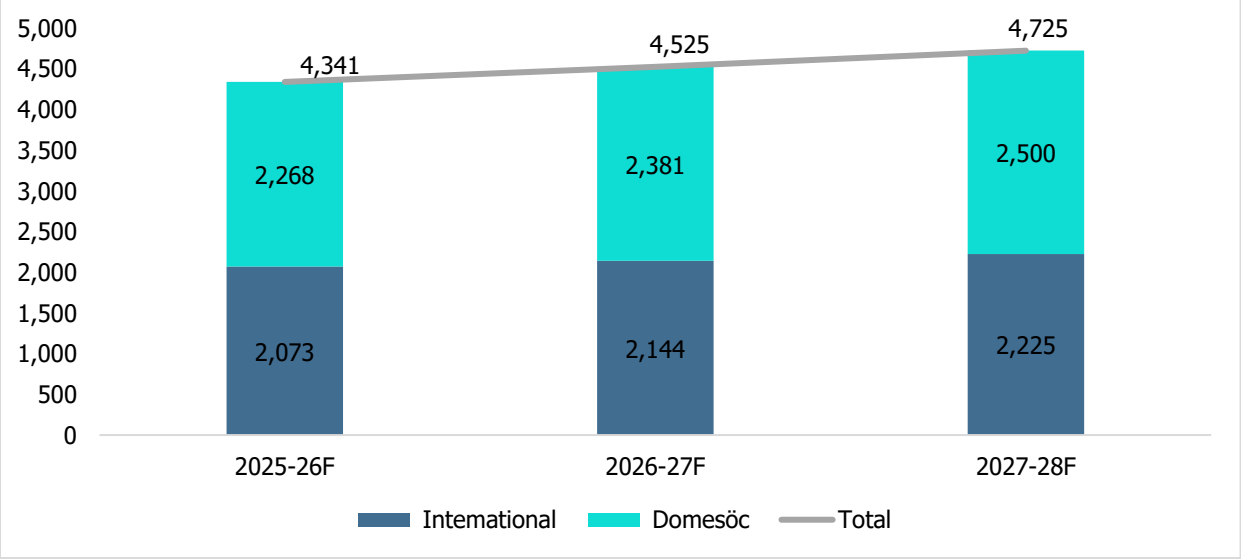
Source-DGCA, CareEdge Research

Freight Traffic Outlook

Freight traffic is expected to grow at a CAGR of 4%-6% over the period of FY24-FY28. This will be driven by growing e-commerce, expanding manufacturing sector activity, and international trade. In addition, air transportation will remain crucial for delivering essential medical supplies and pharmaceutical products. To help farmers in transporting agricultural products the government has launched Krishi Udan Scheme. Thus, air cargo will continue to be a preferred mode for transporting perishable goods like fruits, vegetables, and flowers.

Moreover, improved regional airports and cargo facilities will boost air cargo movement in underserved areas. Also, integration of air cargo hubs with other modes of transport like road and rail will provide last-mile connectivity. Initiatives like Sagarmala and Bharatmala projects will further improve infrastructure & logistics efficiency, facilitating cargo movement.

Chart 106: Freight Traffic Movement Outlook



Source- Airports Authority of India (AAI), CMIE, CareEdge Research

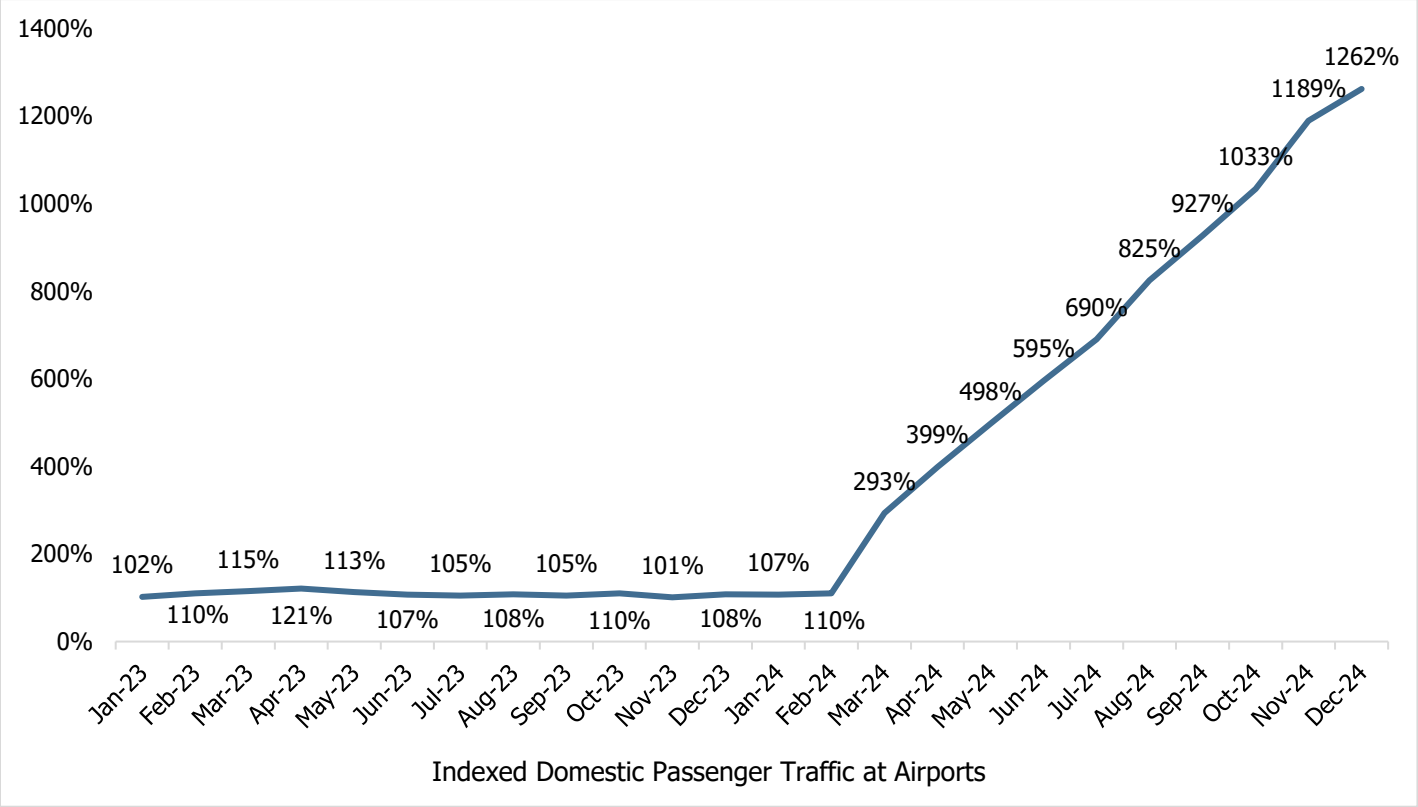
Note: The forecasted numbers are represented by 'F' in the chart and ~ is the Approximate Cargo Traffic

16.5. Impact of Pandemic and return to Normalcy

During the COVID-19 pandemic, the Indian aviation industry faced severe challenges and disruptions. The pandemic caused a dramatic drop in both domestic and international passenger traffic, with domestic air traffic plummeting by over 90% during the initial months. However, the industry has shown a robust recovery since then, experiencing significant growth in passenger traffic volumes.

Domestic air travel demand has surged, with traffic volumes now exceeding the pre-pandemic levels. This recovery is supported by an increase in the number of operational airports and improved connectivity across the country. By January 2023, domestic passenger traffic had recovered to 102% of pre-pandemic levels, driven by strong pent-up demand despite higher airfares. From January 2023 to January 2024, domestic passenger traffic consistently remained above pre-pandemic levels, averaging 109%.

Chart 107: Monthly domestic passenger traffic consistently above pre-pandemic levels since January 2023

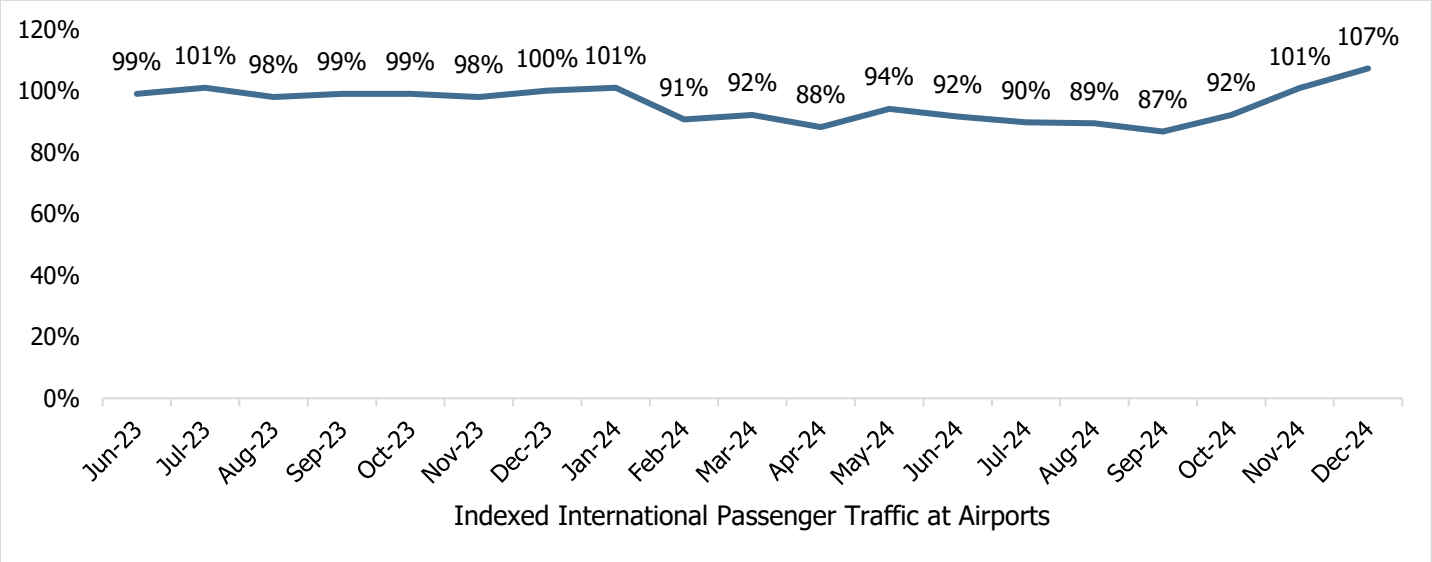


Note: Traffic indexed to CY19 base

Source: AAI, CareEdge Research

International passenger traffic recovered to 82% of pre-pandemic levels in July 2022, in just four months of resuming scheduled international services. It crossed the pre-pandemic levels in Jan 2023 at 102% of international passenger traffic and has remained consistently well above 100% thereafter.

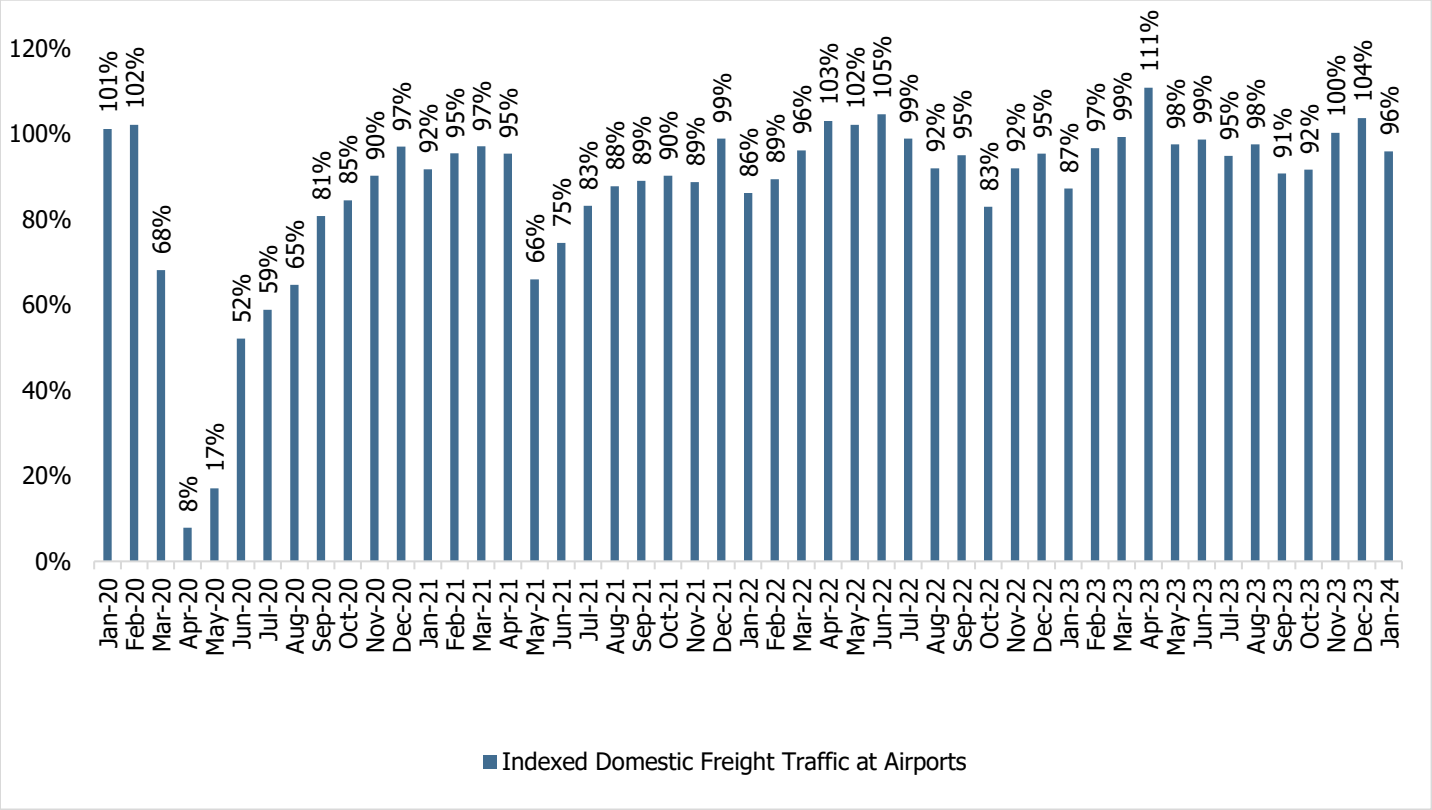
Chart 108: International passenger traffic reached pre-pandemic level in July 2023



Note: Traffic indexed to CY19 base
Source: AAI, CareEdge Research

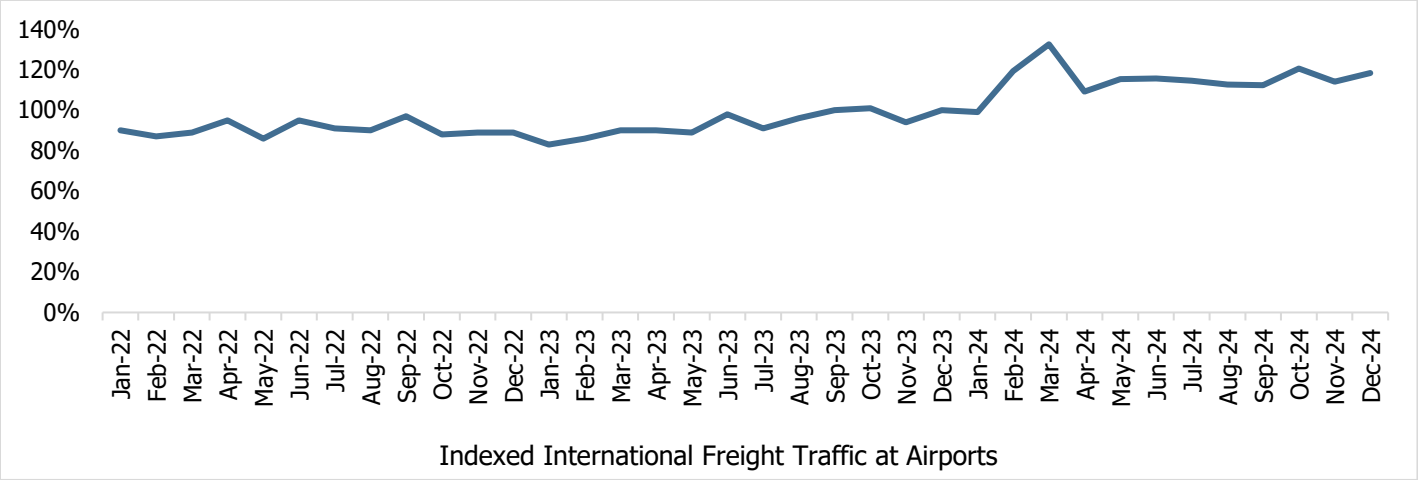
Domestic freight traffic recovered and reached above 100% of the pre-pandemic level in Jan 2023, whereas international freight traffic recovered to the pre-pandemic level in June 2023, due to several factors like recovery in economic activities, transportation of vaccines via air, and the need for faster transportation of goods.

Chart 109: Monthly domestic freight traffic recovered to pre-pandemic level in April 2023



Source: AAI, CareEdge Research

Chart 110: Monthly international freight traffic recovered to pre-pandemic level in September 2023



Source: AAI, CareEdge Research

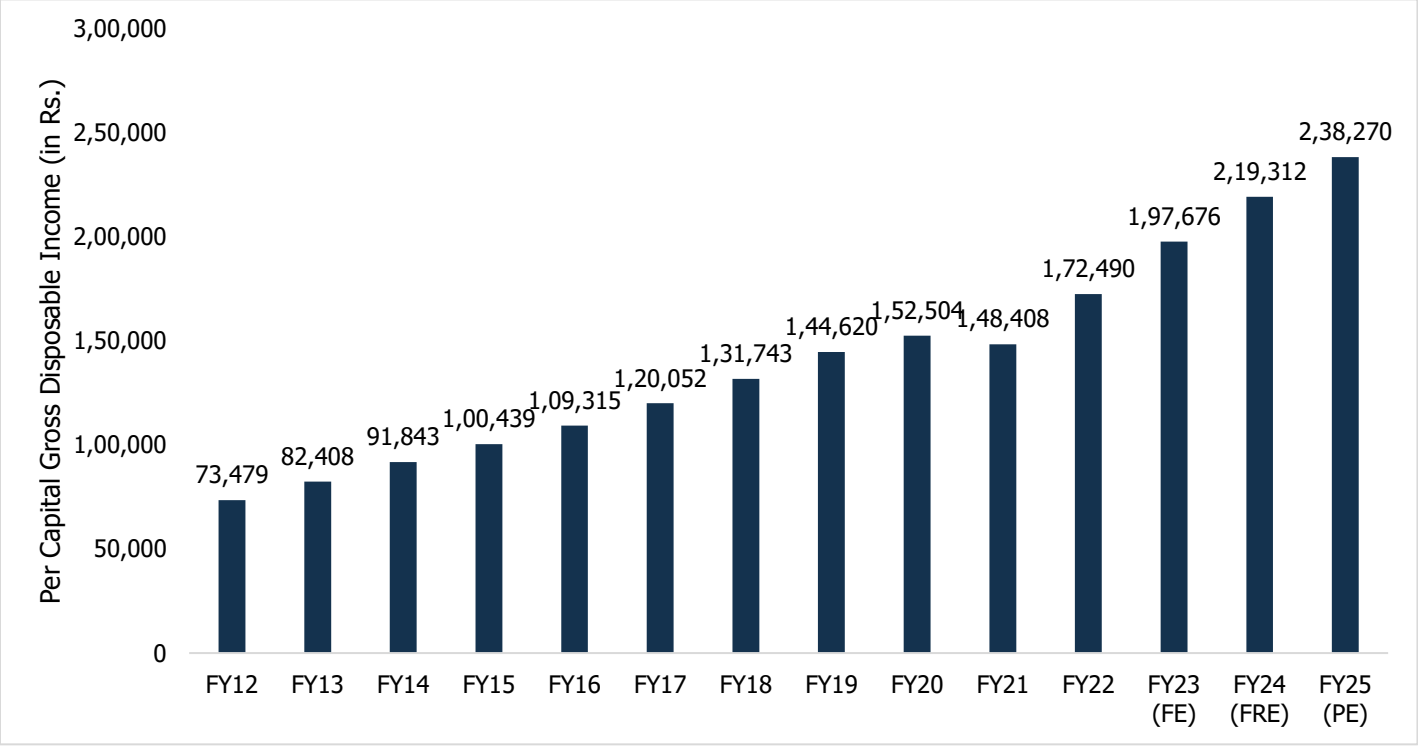
16.6. Key Growth Drivers of the Aviation Industry

India's aviation sector growth and demand for infrastructure development has surged on account of following key factors:

- **Economic Growth and Rising Disposable Incomes:**

India's robust economic growth leads to increased disposable incomes, making air travel more affordable for a larger segment of the population. The rising disposable income has grown at a CAGR of 9.4% between the period FY12 to FY23. This foster rising personal travel demand, both domestic and international. Furthermore, the growth in sectors like IT, e-commerce, and healthcare also necessitates faster air cargo movement, driving demand for cargo facilities and dedicated terminals.

Chart 111: Per Capita Gross National Disposable Income



Source: Ministry of Statics and Program Implementation (MOSPI)

Note: 3RE – Third Revised Estimate, 2RE – Second Revised Estimates, 1RE – First Revised Estimates, 2AE – Second Advanced Estimate

- **Government Initiatives and Policy Reforms:**

The Indian government actively promotes the development of airport infrastructure through initiatives like the Regional Connectivity Scheme (RCS-UDAN) and the National Aviation Policy 2016. These initiatives provide subsidies, incentives, and streamlined regulations to encourage investments in airports across the country. Focus on privatization and PPP (Public-Private Partnership) models is attracting private investments in the sector and accelerating infrastructure development. The Union Budget 2025-26 included following announcements for the aviation and airport sectors:

- **Revival of 50 additional airports, heliports, water aerodromes, and advanced landing grounds:** This aims to improve regional connectivity and boost air travel access in smaller cities and towns.

- **Doubling of allocation for the Regional Connectivity Scheme (RCS-UDAN):** This scheme subsidizes flights to underserved and remote areas, further promoting regional air travel. UDAN initiative will be launched to further enhance regional connectivity, adding 120 new destinations.

- **Investment in airport infrastructure:** The budget allocated funds for various airport expansion and modernization projects across the country, including major hubs like Delhi, Mumbai, Bangalore and greenfield airports will be built alongside the expansion of Patna Airport and in Puri (Shree Jagannath Airport).

- **Development of dedicated cargo terminals** & warehousing**:** This aims to facilitate efficient cargo movement and support the growth of e-commerce and international trade.

- **Focus on sustainability:** The budget highlighted the importance of green technologies and sustainable practices in airport development and operations.

- **Technological Advancements and Innovations:**

Advancements in aircraft technology, such as increased fuel efficiency and reduced noise emissions, make air travel more sustainable and accessible. The use of AI and automation in airport operations improves efficiency, passenger experience, and security, requiring continuous investments in technology infrastructure.

Demographic Dividend and Urbanization:

India's young and growing population represents a significant passenger base for airlines. This "demographic dividend" will continue to fuel the air travel demand in the coming years. Also, rapid urbanization bodes well for the sector. India is the second-largest urban system in the world. Indian cities are home to about 11% of the total global urban population. Urban growth is expected to contribute to around 73% of the total population growth by 2036, according to the Ministry of Health and Family Welfare (MoHFW), 2019.

According to the Census of India 2011, India has an urbanization level of 31.1% which has only increased over the years. Earlier estimations indicate that about 416 million people will be added as urban dwellers in India between 2018 and 2050, according to a United Nations study dated 2018 and India will be 50% urban by 2050 according to UN-Habitat, 2017. Rapid urbanization leads to the creation of new business centres and tourist destinations, requiring enhanced air connectivity through new airports and expansion of existing ones.

Moreover, numerous schemes and projects launched by the government such as the Smart Cities Mission, the Atal Mission for Rejuvenation and Urban Transformation (AMRUT), and the Pradhan Mantri Awas Yojana (Urban), among other initiatives have aided the urbanization growth momentum. Further, the rising urbanization is expected to facilitate higher income, brand awareness, and higher standard of living, which will generate higher demand for travel by air. This will positively impact the airport infrastructure industry.

- **Tourism and International Trade:**

Airlines and airports play a massive role in opening of new tourist destinations.

India's booming tourism industry attracts visitors from across the globe, necessitating expansion of airport capacity and improved connectivity to tourist destinations. Spending on leisure travel and tourism has been increasing over recent years and the emergence of business hubs like Mumbai (Finance), Bengaluru (IT), Chennai (IT), and Delhi (Manufacturing, IT) is likely to boost business travel as well. The thriving international trade further fuels the demand for efficient cargo infrastructure and dedicated cargo terminals at major airports.

Table 52: India Tourism

India Tourism Statistics 2023		Annual Growth Rate
No. of Foreign Tourist Arrivals in India	9.52 Million	47.90
No. of Indian Nationals Departures from India	27.88Million	29.07%
No. of Domestic Tourist Visits to all States/UTs	17312500 Million	15544.98%
Share of India in International Tourism Receipts (US$ terms)	1.45%	
India's rank in World Tourism Receipts	**14th**	

Source: Ministry of Tourism
Note - P: Provisional Estimates
Annual growth rate is w.r.t year 2021

- **Rise in Trade**

The rising trade is fuelling India's aviation industry and transforming the nation's economic landscape. This drives demand for dedicated cargo terminals, improved infrastructure, and efficient logistics solutions at airports. International trade thrives on seamless connectivity and expanding air travel options connect Indian businesses to global markets. This attracts foreign investments, expands export destinations, and fosters economic growth.

Air cargo offers the fastest and most efficient way to move goods, lowering transportation costs and accelerating supply chains. This makes Indian products more competitive globally and expands trade opportunities. A robust aviation network facilitates business travel, enabling executives, traders, and investors to quickly connect and engage in face-to-face interactions. This promotes collaboration, and deal-making, and strengthens trade partnerships.

- **Hub and Spoke Model**

In the air travel, the hub-and-spoke model is where major airports (hubs) serve as central points where passengers can connect to flights going to various destinations (spokes). This model helps airlines optimize routes, increase efficiency, and consolidate passenger traffic.

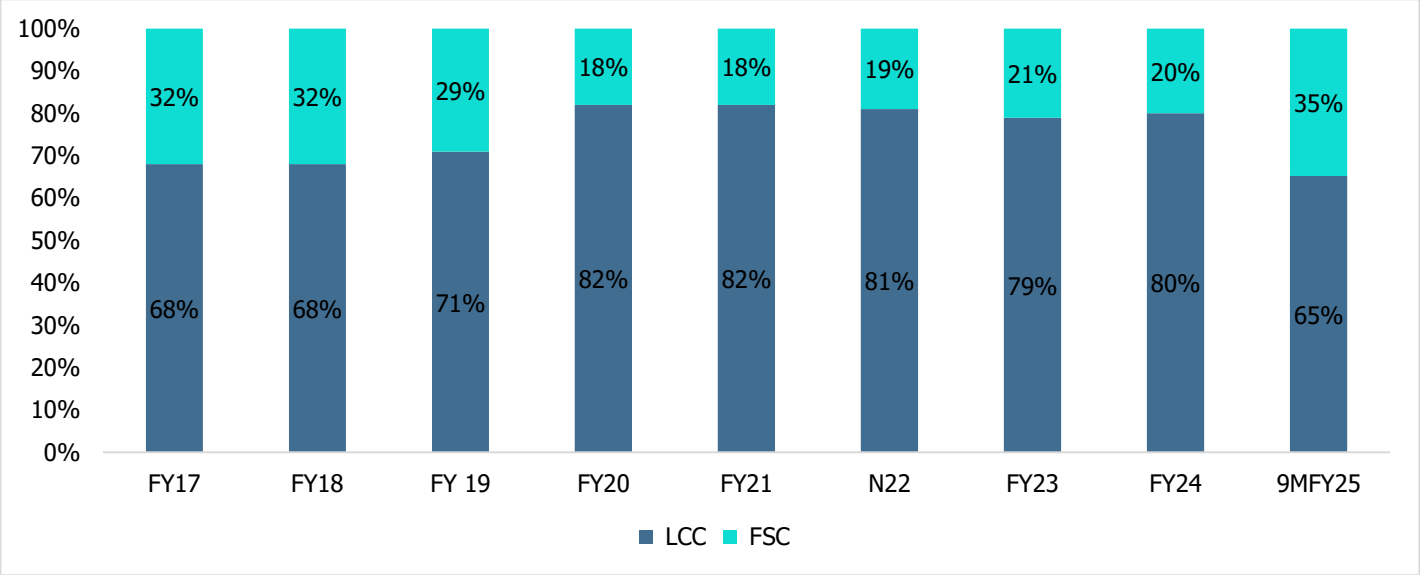
To make India a robust aviation hub, the government is looking at the hub & spoke model to fly more passengers from and into the country. Using the hub & spoke model benefits airlines and optimizes network coverage. **Improved Connectivity**

There is potential for India to be among the global top three nations in terms of domestic and international passenger traffic. Connectivity to difficult terrains and regions through air becomes indispensable as areas that cannot be connected meaningfully by road or rail must be linked by air. Air connectivity would not only bring down travel time but also be a boon in emergencies.

LCC's with Lion's Share in Domestic Market

Low-cost carriers (LCCs) have come to dominate the domestic civil aviation market, driven by the growth of airlines like IndiGo, SpiceJet, and Go First. Currently, only Air India and Vistara operate as full-service carriers (FSCs) in this market. Even FSCs have introduced hybrid services. LCCs increased from 68% in fiscal 2017 to 80% in fiscal 2024. From FY24 to 9MFY25, there is a notable shift in the market share between Low-Cost Carriers and Full-Service Carriers. LCC share decreased from 80% in FY24 to 65% in 9MFY25.

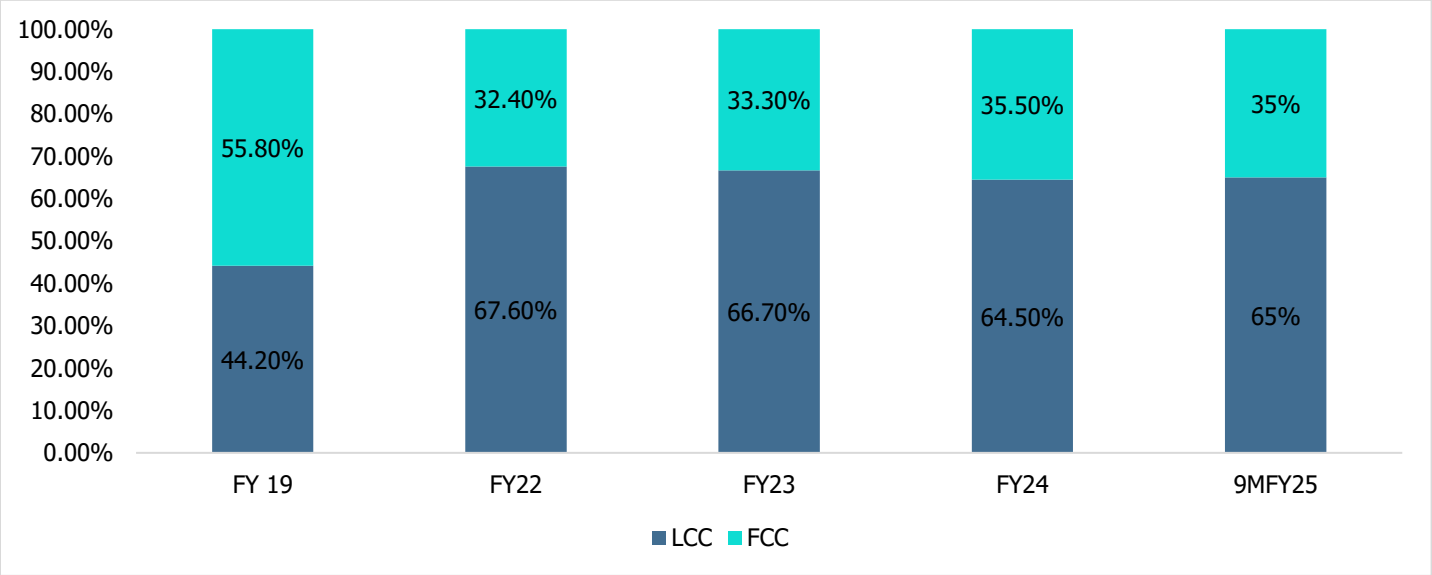
Chart 112: Domestic Aviation Market is Dominated by LCC's



Source: DGCA, CareEdge Research

FCC's were the dominant players in the international market pre-Covid – specifically Air India and Jet Airways. After Covid-19 pandemic, the FCC market included Air India and Vistara. LCC's have gained market share after Covid-19 pandemic, with significant market share gain by Indigo.

Chart 113: Domestic LCC Flight's Increased Market Share After Covid-19 in international Market



Source: DGCA, CareEdge Research

16.7. Connectivity Beyond Metro Cities

The metro airports boast world-class infrastructure, multiple runways, extensive lounges, and a diverse range of domestic and international flight options. They are the engines driving India's air travel growth and play a pivotal role in its economic development. On the other hand, the non-metro airports are constantly evolving, upgrading infrastructure, introducing new flight routes, and playing a crucial role in regional development.

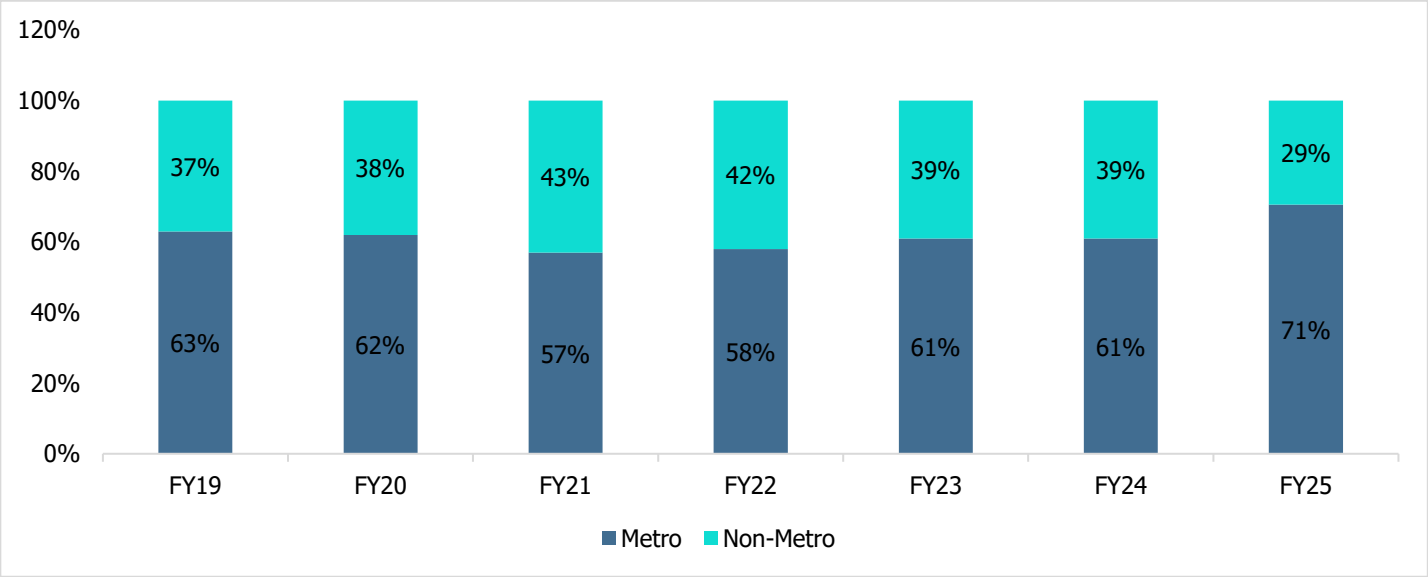
Passenger Traffic Trend – Metro and Non-Metro Airports

The metro airports handle a significantly higher share, around 71% more passenger traffic than the non-metro airports. In terms of passenger concentration, metro cities have higher population densities leading to greater air travel demand. In addition, metro economies are more active, attracting business travellers who contribute significantly to air traffic. Also, metro airports offer better connectivity with domestic and international destinations.

The non-metro airports have a smaller share, around 29% of passenger traffic currently. These airports cater to the needs of smaller cities and towns, fostering regional development and economic growth.

The chart below depicts the trend of passenger traffic across metro and non-metro airports in India:

Chart 114: Passenger Traffic Split Between Metro & Non-Metro Airports



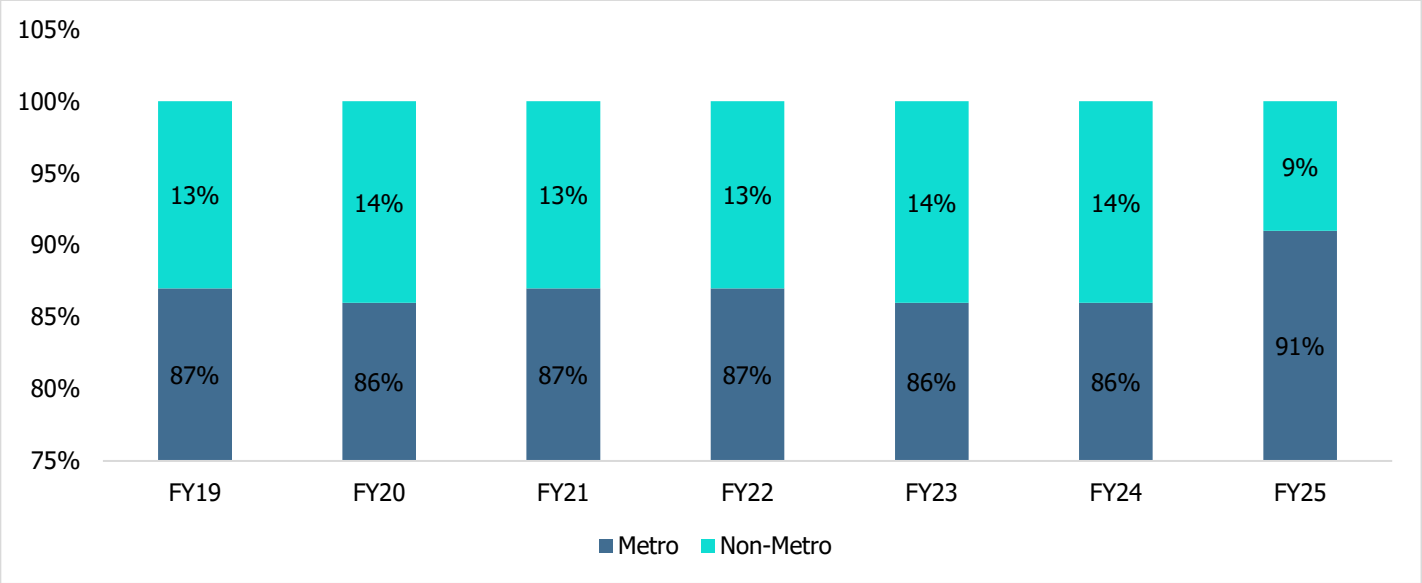
Source- CMIE, CareEdge Research

Cargo Traffic Trend – Metro and Non-Metro Airports

The metro airports handle a substantial amount of cargo traffic – around 91% share driven by both import and export activities. On the other hand, non-metro airports have a smaller share, around 9% of cargo traffic currently. These airports play a crucial role in regional development, handling mostly domestic cargo related to perishable goods, agricultural produce, and local industries. Dedicated cargo terminals are also being developed in non-metro airports to tap into regional freight potential.

The chart below depicts the trend of cargo traffic across metro and non-metro airports in India:

Chart 115: Cargo Traffic Split Between Metro & Non-Metro Airports



Source- CMIE, CareEdge Research

16.8. Challenges faced by the aviation sector and airport operators in India

Challenges of airlines sector:

- **Infrastructure Bottlenecks**

There are various infrastructure bottlenecks related to airport infrastructure which affect flight operations impacting passenger and cargo traffic.

- **Overcrowded Airfields:** Major airports like Delhi and Mumbai struggle to handle surging passenger and cargo traffic, leading to congestion, delays, and cancellations.
- **Limited Runway Capacity:** The lack of additional runways at crucial hubs restricts operational flexibility and restricts expansion potential.
- **Inadequate Cargo Facilities:** Many airports lack dedicated cargo terminals and efficient processing systems, hampering international trade and e-commerce growth.
- **Uneven Development:** Regional airports often lack adequate infrastructure and connectivity, hindering regional economic development and tourism potential.

- **Operational Hurdles**

With the increasing passenger traffic, the airports are facing various operational hurdles to operate.

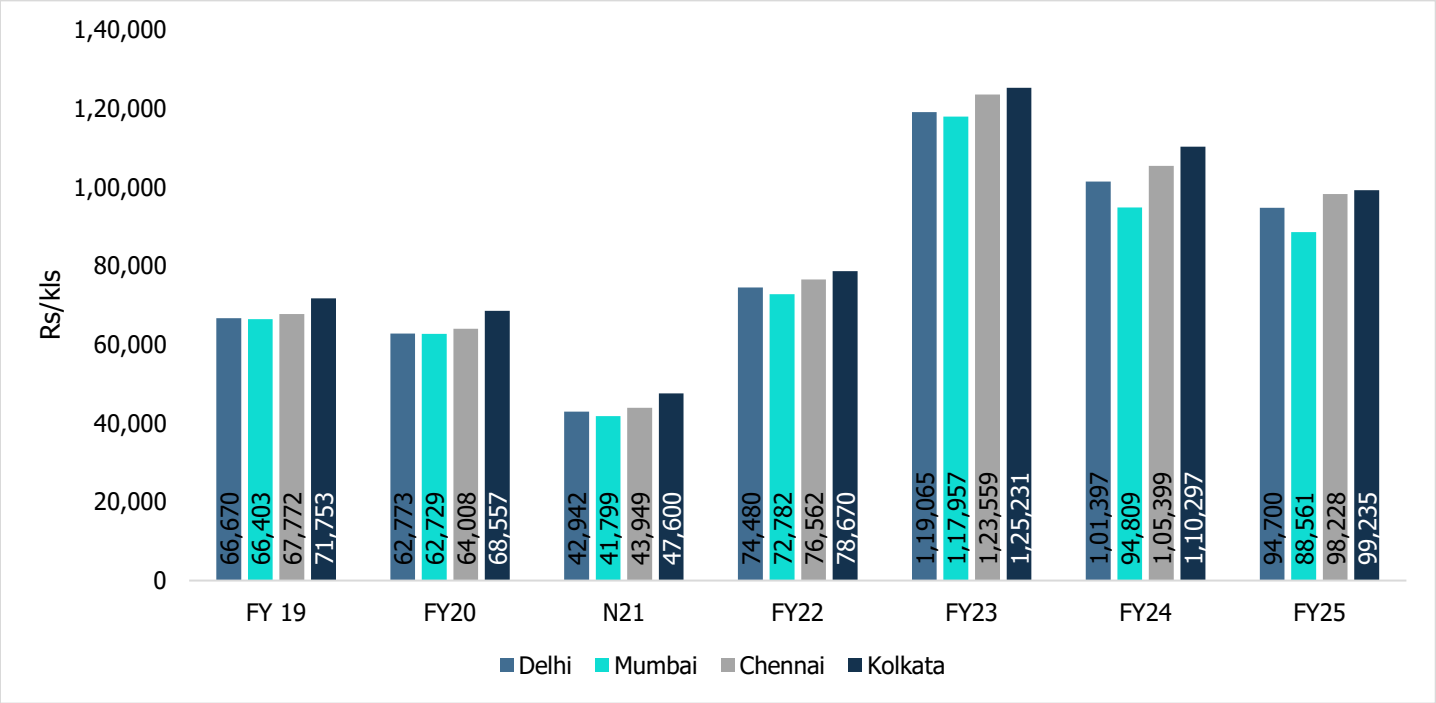
- **Regulatory Stringency:** Complex approval processes and bureaucratic hurdles for airport development and expansion stifle investments and slow down progress.
- **Skill Shortage:** A gap in skilled aviation personnel, from pilots and ground staff to air traffic controllers, poses operational challenges and safety concerns.
- **High Costs:** High operational and maintenance costs, including landing charges and ground handling fees, burden airlines and discourage travel, particularly in non-metro routes.
- **Sustainability Concerns:** Environmental impact through noise pollution and emissions from older aircraft and inadequate infrastructure requires urgent attention and investment in green technologies.

- **Fluctuations in Aviation Turbine Fuel Price**

The price of Aviation Turbine Fuel (ATF) had surged sharply in FY23, reaching an all-time high, primarily due to a spike in crude oil prices and rupee depreciation. In FY24, prices moderated as global crude oil prices softened and domestic pricing mechanisms were revised, providing much-needed relief to airline operators and improving their profitability margins.

However, in FY25, ATF prices have shown renewed volatility. This is largely attributed to fluctuating crude oil prices amid persistent geopolitical tensions, including conflicts in the Middle East and supply chain disruptions. Additionally, OPEC+ supply restrictions and uncertain demand recovery in China are contributing to market instability. ATF costs are likely to remain volatile. This continued uncertainty poses a risk to the operational costs and profitability of airline companies in the current fiscal.

Chart 116: Movement of Air Turbine Fuel (ATF) Price in India (Rs/kls)



Source: CMIE

- **Financial Constraints:**

The industry also faces various financial constraints. Some of the financial constraints faces by them are:

- **Public-Private Partnership (PPP) Challenges:** Attracting private investments into airport development remains a challenge due to long payback periods and uncertainties in project viability.
- **Limited Public Funding:** Government budgetary constraints restrict investments in necessary infrastructure upgrades and expansion projects.
- **Debt Burden of private sector players:** Some existing airport authorities grapple with significant debt, limiting their ability to reinvest in infrastructure and modernization.

Challenges of airport sector:

Airports in India face a range of challenges that impact their operations, development, and ability to meet the growing demand for air travel. These challenges encompass infrastructure, regulatory, financial, and environmental aspects.

- **Infrastructure Constraints**
  - **Capacity Limitations:** Many major airports, such as those in Delhi, Mumbai, and Bangalore, are operating at or above their designed capacity, leading to congestion and delays.
  - **Aging Infrastructure:** Older airports require significant upgrades and maintenance to meet modern standards and passenger expectations.
  - **Expansion Delays:** Land acquisition and regulatory approvals for airport expansion projects often face delays, slowing down the development of additional capacity.

- **Regulatory and Policy Issues**
  - **Complex Regulatory Environment:** Airports need to navigate a complex web of regulations and policies set by multiple authorities, including the Airports Authority of India (AAI), Directorate General of Civil Aviation (DGCA), and Airports Economic Regulatory Authority (AERA).
  - **Tariff Regulation:** Setting aeronautical charges is tightly regulated, and there can be disputes between airport operators and airlines over fair pricing.

- **Financial Challenges**
  - **High Capital Expenditure:** Developing and expanding airports requires substantial investment, and securing funding can be a challenge.
  - **Revenue Generation:** Balancing aeronautical and non-aeronautical revenues is crucial for financial sustainability. Airports need to maximize non-aeronautical revenue while keeping aeronautical charges competitive.
  - **Public-Private Partnerships (PPP):** While PPP models can bring in much-needed investment, they also involve complex agreements and risk-sharing arrangements.

- **Operational Efficiency**
  - **Technological Integration:** Airports need to invest in advanced technologies for efficient operations, such as automated check-in, baggage handling systems, and enhanced security screening.
  - **Resource Management:** Efficient management of resources, including manpower, energy, and materials, is critical for smooth airport operations.

- **Environmental and Social Issues**
  - **Sustainability:** Airports face pressure to adopt sustainable practices, including reducing carbon footprints, managing waste, and conserving water.
  - **Noise Pollution:** Managing noise pollution is a significant concern, particularly for airports located near residential areas.

- **Competition and Market Dynamics**
  - **Airline Competition:** Airports need to attract and retain airlines in a competitive market. This requires providing competitive charges and superior services.
  - **Regional Disparities:** While metro airports are experiencing growth, regional airports often struggle with low traffic volumes and financial viability.

16.9. Qualitative Performance of Private Airports

The Airports are majorly operated by 3 players in India which contribute 62% passenger traffic of India. The 3 players are Adani Enterprise, GMR Group and Achorage Infrastructure Investments Holding Limited. Adani Enterprise has 7 airports located in Mumbai, Ahmedabad, Lucknow, Mangalore, Jaipur, Guwahati and Trivandrum. Whereas GMR Group has 4 airports in India in Delhi, Hyderabad, Mopa Goa and Bidar. Achorage Infrastructure Investments operate sole airport of Bengaluru.

Domestic+ International	Adani Enterprise		GMR Group		Anchorage Infrastructure Investments	
	7 Airports		4 Airports		1 Airport (BIAL)	
	FY20	FY24	FY20	FY24	FY20	FY24
Pax Traffic	23%	24%	20%	28%	7%	10%
Cargo	32%	30%	33%	34%	11%	13%
Aircraft Movement	22%	22%	27%	25%	9%	9%

Note: Rank is based on pan-India airports
Source: AAI, CareEdge Research

16.10. New Models of Private Participation

The Airports Economic Regulatory Authority of India (AERA) has implemented a 30% hybrid till model for tariff setting. This model combines aspects of both single till and dual till approaches to airport tariff regulation.

Hybrid Till Model: The 30% hybrid till model is a middle ground between the single and dual till approaches. In this model, 30% of non-aeronautical revenues are included in the calculation of aeronautical charges. This helps in moderating the airport charges by partially subsidizing aeronautical costs with non-aeronautical revenues.

Balancing Interests: The hybrid till model aims to balance the interests of airlines, passengers, and airport operators. By including a portion of non-aeronautical revenues, it helps keep aeronautical charges at reasonable levels, benefiting airlines and passengers while still providing a fair return to airport operators.

Encouraging Investment: By allowing airport operators to retain a significant portion of non-aeronautical revenues, the model incentivizes investment in both aeronautical and non-aeronautical facilities, promoting overall airport development.

Promoting Efficiency: The model encourages airports to enhance their non-aeronautical revenue streams, leading to better service offerings like retail, food and beverage, and other passenger amenities.

Regulatory Oversight: AERA monitors and reviews the implementation of the hybrid till model to ensure that the tariff setting remains fair and transparent. The regulatory authority periodically assesses the financials and operational efficiencies of airports to adjust tariffs accordingly.

Impact: The 30% hybrid till model helps in maintaining competitive airport charges while ensuring that airports remain financially viable and attractive for investment. This approach aims to create a balanced and sustainable airport economic environment, contributing to the overall growth of the aviation sector in India.

Table 53: Aggregated revenue requirement for an airport

Source: CareEdge Research

Table 54: Changes in New Bidding Model

What remains the same?
•30% Hybrid Till •Tariff Setting remains same •The bidding model offers long-term concession periods, typically ranging from 30 to 50 years.
What Changes?
•The new bidding model adopts a per passenger fee (PPF) approach, where bidders compete based on the fee they are willing to pay per passenger handled. •AERA has been empowered under the hybrid till model to regulate both aeronautical and non-aeronautical tariffs

16.11. Split of Airports into PPP & Non-PPP Categories

Public-Private Partnership (PPP) has become a crucial driver for developing and managing airports in India. PPPs are the dominant model for major airport development and modernization projects in India. The Airports Authority of India (AAI) typically acts as the public partner, partnering with private companies or consortiums through various PPP models like Design-Build-Finance-Operate (DBFO) or Operate-Maintain-Develop (OMD). The PPP model is preferred for large-scale projects and major hubs due to its ability to mobilize significant investments and expertise.

Non-PPPs, also known as Private Greenfield Airports, involve private entities developing and operating airports entirely without AAI involvement. However, the government incentivizes Non-PPPs through concessions on land leases, tax breaks, and other benefits to encourage private investment in underserved regions. Non-PPPs are more suitable for greenfield airports in smaller Tier-I and Tier-II cities where AAI involvement might not be financially feasible.

Five key airports – Delhi, Bangalore, Hyderabad, Kochi, and Mumbai – handle over half of India's passenger air traffic, powered by private sector expertise. Delhi and Mumbai paved the way, becoming the first brownfield airports entrusted to PPPs. Kochi followed suit, inaugurating the greenfield PPP model, later joined by Hyderabad and Bangalore.

The momentum continues, with 14 airports currently thriving under PPPs, according to a December 2023 report by the Ministry of Civil Aviation [1]. The National Monetisation Pipeline (NPM) takes it further, earmarking 25 Airports Authority of India (AAI) airports for leasing between 2022 and 2025, including Bhubaneshwar, Varanasi, Amritsar, Chennai, Jaipur, and others. The non-operational are primarily greenfield projects planned for future development.

Table 55: Private Operational Airport List in India

Private Operational Airports	Private Group
Delhi Indira Gandhi International Airport (DEL)	GMR Group
Bangalore Kempegowda International Airport (BLR)	Bengaluru International Airport Limited (BIAL)
Mumbai Chhatrapati Shivaji Maharaj International Airport (BOM)	Mumbai International Airport Limited (MIAL) and Adani Group
Chennai International Airport (MAA)	Adani Airports
Jaipur International Airport (JAI)	Adani Group
Ahmedabad Sardar Vallabhbhai Patel International Airport (AMD)	Adani Airports
Kochi International Airport (COK)	GMR Group
Hyderabad Rajiv Gandhi International Airport (HYD)	GMR Group

Private Operational Airports	Private Group
Goa Dabolim International Airport (GOA)	AAHL (Adani Airport Holdings Limited) and Adani Group
Trivandrum International Airport (TRV)	Adani Group
Chandigarh Airport (IXC)	DIAL
Lucknow Chaudhary Charan Singh International Airport (LKO)	Adani Airports
Guwahati Lokpriya Gopinath Bordoloi International Airport (GAU)	Adani Airports
Kannur International Airport (CAN)	GMR Group

Source: AAI, MoCA, NPM, CareEdge Research

14 Airports are currently operating under PPP in the country and as per National Monetisation Pipeline (NMP), 25 AAI airports namely, Bhubaneshwar, Varanasi, Amritsar, Trichy, Indore, Raipur, Calicut, Coimbatore, Nagpur, Patna, Madurai, Surat, Ranchi, Jodhpur, Chennai, Vijayawada, Vadodara, Bhopal, Tirupati, Hubli, Imphal, Agartala, Udaipur, Dehradun and Rajahmundry have been earmarked for leasing over the years 2022 to 2025.

16.12. Government Measures to Push Privatization

The Indian government has implemented several measures to promote the privatization of airports. Here are key initiatives taken by government of India:

- Public-Private Partnership (PPP) Model: The government has been encouraging the PPP model for airport development and management. This involves collaboration between the government and private sector entities, combining public resources with private sector efficiency and investment.

- Airport Privatization Program: The Airports Authority of India (AAI) has been involved in leasing out airports to private players for operations, management, and development. Major airports like Delhi, Mumbai, Hyderabad, and Bengaluru have already been privatized, and more airports are being added to this list.

- Brownfield and Greenfield Projects: Privatization efforts have included both brownfield projects (existing airports) and greenfield projects (new airports). This dual approach helps in upgrading existing infrastructure while expanding capacity through new developments.

- Liberalized FDI Policies: The government has relaxed Foreign Direct Investment (FDI) norms to attract more investment into the aviation sector. Up to 100% FDI is allowed under the automatic route for greenfield airport projects, and up to 74% for brownfield projects.

- Revised Concession Agreements: The government has revised concession agreements to make them more investor-friendly. This includes clarity on revenue-sharing mechanisms, regulatory frameworks, and risk mitigation measures.

- Monetization of Airport Assets: Under the National Monetization Pipeline (NMP), the government aims to lease out existing airport assets to private players, generating revenue that can be reinvested into infrastructure development.

- Involvement of Global Players: By involving global airport operators and investors, the government aims to bring in international expertise and best practices, enhancing the efficiency and quality of airport operations in India.

- Regulatory Reforms: The government has undertaken regulatory reforms to create a more favourable environment for private investment. This includes setting up the Airports Economic Regulatory Authority (AERA) to regulate tariffs and charges, ensuring a transparent and predictable regulatory regime.

- Strategic Disinvestment: The government has identified specific airports for strategic disinvestment, aiming to reduce its direct involvement in airport management and foster private sector-led growth.

- Regional Connectivity Scheme (RCS): Also known as UDAN (Ude Desh ka Aam Nagrik), this scheme aims to enhance regional connectivity by reviving and developing underserved and unserved airports with the help of private players.

16.13. Investments across Major Airports in India

To increased capacity to handle passenger and cargo traffic, improved efficiency and service quality, enhance connectivity and accessibility and to boost economic activity and job creation, the major Indian airports are undergoing huge investments projects. These investment projects include construction of new terminals, expansion of existing terminals, and renovation/upgradation of existing facilities, construction of new runways, extension of existing runways, and rehabilitation of existing runways. There is also investment in various support facilities such as cargo terminals, MRO facilities, ground transportation infrastructure, air traffic control (ATC) towers, security systems, fire stations, and other operational buildings. The segment-wise investments across major airports in India are:

Table 56: Segment Wise Investments across Key Segments for Major Airports

Company Name	Project Name	Product	Total Project Cost (in Rs. Crore)	Status	Type
Bangalore International Airport Ltd.	Devanahalli (Kempegowda) Airport Expansion Project (Stage 2 & 3)	Terminal 2 (Phase 1) (PAl 1)	37,167	Under Implementation	Expansion
Navi Mumbai Intl. Airport Pvt. Ltd.	Navi Mumbai International Airport Project (Delhi Mumbai Industrial Corridor)	- Terminal Building (Passenger Capacity in Phase 1) - Runway	19,646	Under Implementation	New Unit
Delhi International Airport Ltd.	Delhi International Airport Expansion Project (Phase 3A)	- Fourth Runway (Phase 3A) - Elevated Eastern Cross Taxiway - T1 Apron (Phase 3A) - T1 Apron (Phase 1 of 3A) - Terminal 3 Expansion (Phase 3A)	10,500	Under Implementation	Expansion
Yamuna International Airport Pvt. Ltd.	Noida (Jewar) International Greenfield Airport Project (Phase 1)	- Runway - Terminal Building	6,000	Under Implementation	New Unit
G M R Hyderabad Intl. Airport Ltd.	Rajiv Gandhi (Hyderabad) International Airport Expansion Project (Phase-1C)	- Terminal 1 Expansion (Passenger Handling Capacity) - Apron Expansion - Taxiway Expansion - Parallel Taxiway Expansion - Cargo Terminal Building Expansion	3,500	Under Implementation	Expansion
Airports Authority of India	Chennai Airport Expansion Project (Phase 2)	Twin Tunnel	2,895	Under Implementation	Expansion
G M R Hyderabad Intl. Airport Ltd.	Rajiv Gandhi International Airport Expansion Project (Phase-1B)	- Remaining Parking Stand (Apron Expansion) - Cargo Complex - Passenger Handling Capacity (Terminal)	2,629	Under Implementation	Expansion
Airports Authority of India	Kolkata Airport Third Terminal Building Project	Phase 1, 2 & 3	1,000	Announced	Expansion

Source – CMIE, CareEdge Research

16.14. Major Upcoming Airports in India

India is seeing a surge in airport development, with several major projects in the pipeline across the country.

Greenfield Airports:

- **Navi Mumbai International Airport (Maharashtra):** Located near Mumbai, this greenfield airport is under construction and targeted for completion in June 2025. It is expected to handle over 60 million passengers annually, easing congestion at Chhatrapati Shivaji Maharaj International Airport.
- **Purandar Airport (Karnataka):** Situated approximately 100 km from Bengaluru, this greenfield airport is in the initial stages of development. It aims to cater to the growing air travel demand in the region and improve connectivity to South India.
- **Mopa International Airport (Goa):** This greenfield airport, already operational since July 2023, boasts a striking design inspired by a butterfly. It is projected to handle over 5 million passengers annually and further boost tourism in Goa.
- **Jewar Airport (Uttar Pradesh):** Planned as the second international airport for Delhi, this greenfield project is envisioned to be one of the largest airports in the world. Airport is undergoing construction and is scheduled to begin commercial operations on April 17, 2025.
- **Dholera International Airport (Gujarat):** Situated near Ahmedabad, this greenfield airport is part of the ambitious Dholera Smart City project. It aims to serve as a regional aviation hub and contribute to the development of the region.

Expansion of Existing Airports:

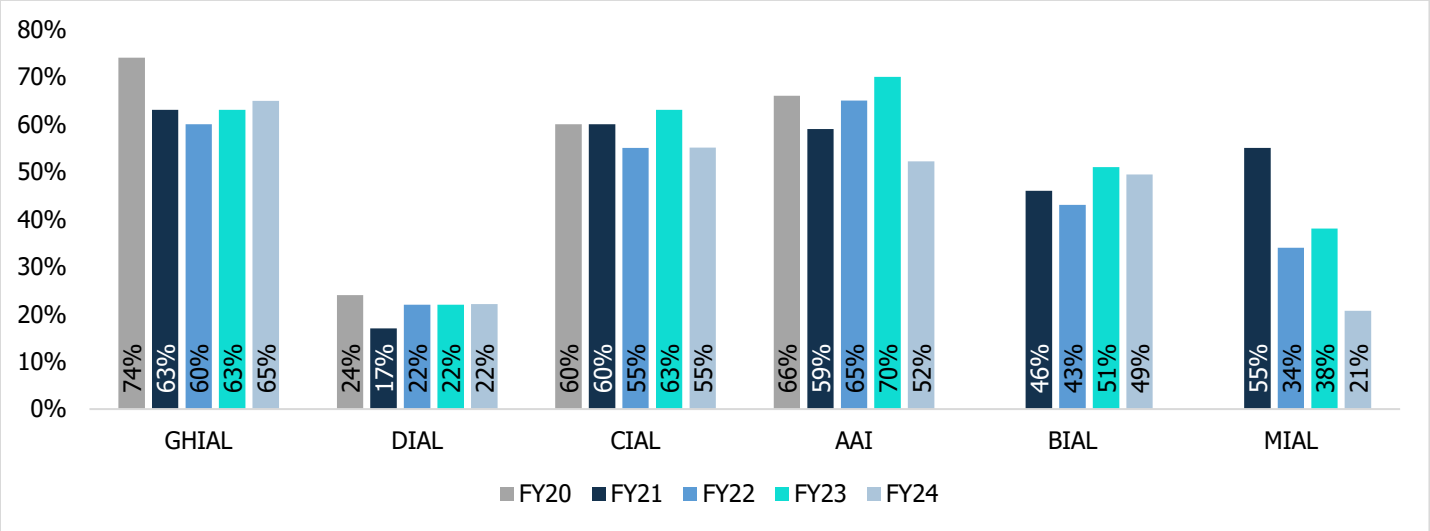
- **Chennai International Airport (Tamil Nadu):** Phase II of the airport expansion project is underway, including a new terminal and additional runways. This will significantly increase the airport's capacity and handle over 60 million passengers annually.
- **Bengaluru International Airport (Karnataka):** Phase IIA of the airport expansion project is nearing completion, adding a new runway and terminal. This will enhance the airport's capacity to handle over 70 million passengers annually.
- **Trivandrum International Airport (Kerala):** Expansion plans include a new terminal and parallel taxiway, aiming to boost capacity and cater to the growing tourist influx.
- **Hyderabad International Airport (Telangana):** Phase II of the airport expansion project is on the horizon, aiming to add a new runway and terminal. This will significantly increase the airport's capacity to handle over 50 million passengers annually.

16.15. Aeronautical Revenue

Aeronautical revenue refers to the income generated by airport operators from services directly related to the operation of aircraft and the handling of passengers and cargo. These revenues are crucial for the financial health of airports and are derived from various charges levied on airlines and passengers.

The main components of Aeronautical revenue are Landing fees, Cargo handling fees, Parking fees, Passenger service fee, Air navigation service charges and much more. AAI and GHIACL has the highest aeronautical revenue when compared to its peers. While DIAL has the lowest aeronautical revenue.

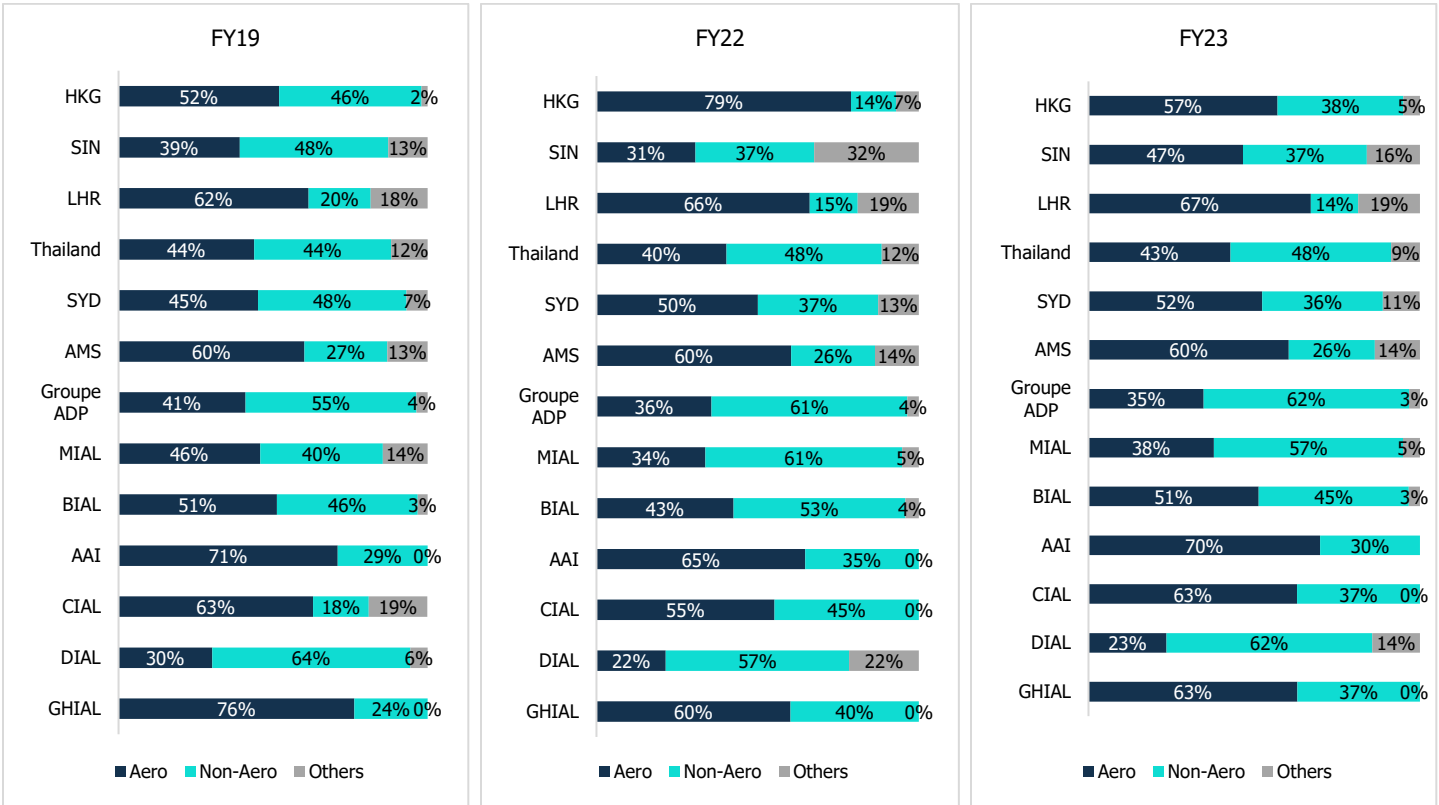
Chart 117: Aeronautical Revenue Share across Indian Airports



Do note: BIAL and MIAL FY20 figures are not available
Source: Company reports, CareEdge Research

The share of global aeronautical revenue is in line with Indian aeronautical revenue. In FY23, AAI had the best aeronautical revenues amongst the peers followed by LHR at 67%.

Chart 118: Global Share of Aeronautical Revenue across Airports



Note: April to March fiscal year followed for Indian airports, HKG and SIN while calendar years for LHR, SYD, AMS and Groupe ADP. Thailand airport follows October to September fiscal year.
Source: Company reports, CareEdge Research

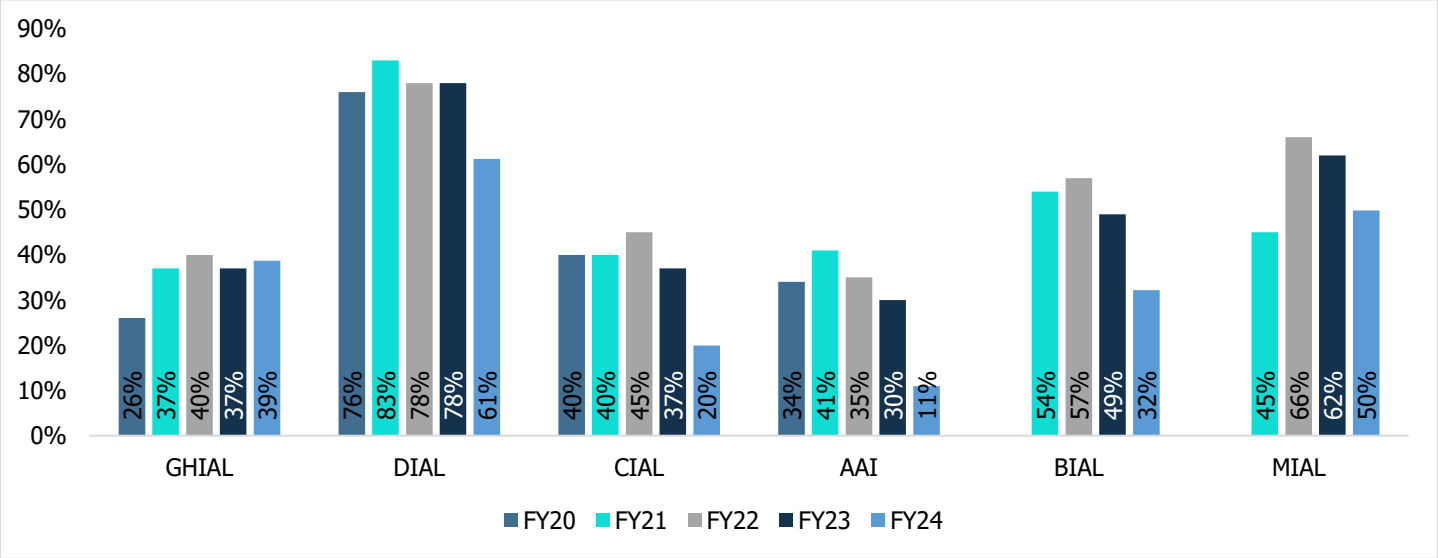
16.16. Non-Aeronautical Revenue

Non-aeronautical revenue refers to the income generated by airport operators from activities and services that are not directly related to the operation of aircraft and handling of passengers and cargo. These revenues are increasingly important for airports as they help diversify income streams and enhance financial stability. The main components and significance of non-aeronautical revenue are

- **Retail and Duty-Free Shops:** Rental income and concession fees from shops selling a variety of goods, including duty-free items.
- **Food and Beverage (F&B):** Income from restaurants, cafes, bars, and food kiosks within the airport.
- **Parking and Car Rental:** Fees charged for parking facilities and rental income from car rental agencies.
- **Advertising:** Fees from advertisements displayed throughout the airport, including billboards, digital screens, and sponsorship deals.
- **Real Estate and Property Leasing:** Leasing airport property and facilities to airlines, cargo operators, logistics companies, hotels, and office spaces.
- **Premium Services:** Charges for premium services such as lounges, fast-track security, meet-and-greet services, and VIP handling.

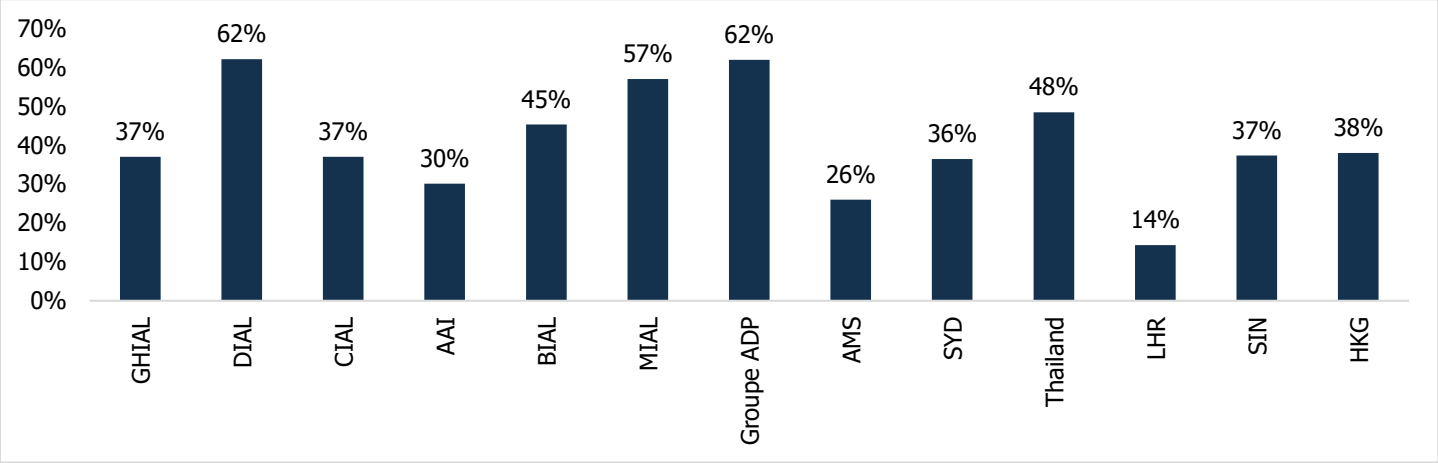
Non-aeronautical revenue plays a crucial role in the financial sustainability and growth of airports. By diversifying income sources and enhancing passenger services, airports can achieve greater financial stability, support infrastructure development, and contribute positively to the broader economy. Effective management and strategic development of non-aeronautical activities are essential for the long-term success of airport operations.

Chart 119: Non-Aeronautical Revenue Share across Indian Airports



Do note: BIAL and MIAL FY20 figures are not available
Source: Company reports, CareEdge Research

Chart 120: Global Share of Non-Aeronautical Revenue across Airports



Note: April to March fiscal year followed for Indian airports, HKG and SIN while calendar years for LHR, SYD, AMS and Groupe ADP. Thailand airport follows October to September fiscal year.
Source: Company reports, CareEdge Research

16.17. Competition profile

16.17.1. GMR Hyderabad International Airport (GHIAL)

GMR Hyderabad International Airport Limited (GHIAL), a joint venture by the GMR Group (74%), Airports Authority of India (13%), and the Government of Telangana (13%), was created to design, finance, build, and operate Rajiv Gandhi International Airport (RGIA) in Hyderabad under the Public-Private Partnership (PPP) model.

Inaugurated on March 14, 2008, the airport was developed in 31 months with an initial capacity of 12 million passengers and 150,000 tons of cargo annually. The master plan allows expansion to over 100 million passengers per annum (MPPA). Currently, Hyderabad Airport handles over 21 million passengers and 148,000 tons of cargo annually, serving 17 international destinations with 21 international and 3 Indian passenger carriers, 8 domestic carriers to 53 domestic destinations, and 5 dedicated cargo airlines from Hyderabad Airport.

16.17.2. Bengaluru International Airport (BIAL)

Kempegowda International Airport Bengaluru (BLR Airport) holds the distinction of being India's first greenfield airport established through a Public-Private Partnership (PPP) model, marking a significant shift towards airport privatization in the country. Bangalore International Airport Limited (BIAL) was incorporated in January 2001 under the Companies Act, 1956, to build, own, and operate BLR Airport for a 60-year concession period. The private promoters collectively hold a 74% stake (Anchorage Infrastructure Investments Holdings Limited: 43.64%; FIH Mauritius Investments LTD: 20.36%; Siemens Projects Ventures: 10%), while the government holds the remaining 26% (Karnataka State Industrial & Infrastructure Development Corporation Limited: 13%; Airports Authority of India: 13%).

BLR Airport began operations in May 2008, just 33 months after construction started. It has experienced remarkable growth, serving over 33 million passengers in 2019 and becoming one of the fastest-growing airports globally. As the busiest airport in South India and the third largest in India, BLR Airport reached a significant milestone on December 1, 2023, by surpassing 300 million passengers since its opening.

16.17.3. Delhi International Airport (DIAL)

In January 2006, the consortium was awarded the concession to operate, manage, and develop Indira Gandhi International (IGI) Airport following an international competitive bidding process. The GMR-led consortium signed the Operations, Management, and Development Agreement (OMDA) with the Airports Authority of India (AAI) on April 4, 2006. The initial term of the concession is 30 years, extendable by another 30 years.

Delhi Airport has been a leader in environmental sustainability, integrating the Green Building concept from the planning and design stages to the operational phase. This has earned the airport a LEED Gold rating for new construction and an IGBC Platinum rating for an existing building. It is the first Carbon Neutral Airport in the Asia-Pacific region under the Airport Carbon Accreditation Program of ACI. Additionally, Delhi Airport has installed a 7.84 MW solar power plant in the airside area, making it the first airport in the country to have such a facility.

16.17.4. Cochin International Airport (CIAL)

Cochin International Airport, owned and operated by Cochin International Airport Limited (CIAL), is the first airport in India built under a Public-Private Partnership (PPP). Remarkably, it is the world's first fully solar-powered airport. Located 28 km northeast of downtown Kochi, it is the third busiest airport for international passengers and the seventh largest overall in India. As of 2022, Cochin Airport handles 61.8% of Kerala's total air passenger traffic.

Cochin International Airport connects to 31 countries, working with 24 airlines, and serves over 10 million passengers annually with its world-class facilities. CIAL has three main terminals—two domestic and one international—and a cargo **terminal spread over 200 acres.**

16.17.5. AAI

The Airports Authority of India (AAI), an organization under the Ministry of Civil Aviation, was established on April 1, 1995, by merging the International Airports Authority of India and the National Airports Authority. This merger aimed to accelerate the development, expansion, modernization, and management of civil aviation infrastructure, both on the ground and in the airspace, across the country.

Its key functions include:

- Designing, developing, operating, and maintaining airports.
- Constructing, modifying, and managing passenger and cargo terminals.
- Controlling and managing Indian airspace beyond the country's territorial limits, as recognized by the ICAO.
- Expanding and strengthening operational areas such as runways, aprons, and taxiways.
- Providing visual, communication, and navigation aids.
- Conducting annual performance audits of all airports and reporting on the economic viability of airport operations.

16.17.6. Jewar Airport

Noida International Airport at Jewar, Uttar Pradesh, is being developed by Flughafen Zürich AG (Zurich Airport) south of Greater Noida. It has a master plan divided into four phases to eventually accommodate 60 million passengers annually. Prime Minister Narendra Modi laid the foundation stone for the airport in November 2021.

The project's final phase envisions two runways and four passenger terminals, making it the largest airport in India.
Area: 1,334 hectares
Estimated Cost: Rs. 29,650 crores
Deadline: 2024 (Phase 1 opening/start of operations)
Owner: Noida International Airport Limited (NIAL)
Operator: Yamuna International Airport Private Limited (YIAPL) – a 100% subsidiary of Zurich Airport International.

16.17.7. Bhogapuram Airport

GMR Visakhapatnam International Airport Limited (GVIAL), a subsidiary of GMR Airports Limited (GAL), is developing a Greenfield International Airport at Bhogapuram in Vizianagaram, Andhra Pradesh. This airport project follows the Public-Private Partnership (PPP) model on a Design, Build, Finance, Operate, and Transfer (DBFOT) basis.

GVIAL will develop the airport in stages. Initially, the airport will be built to accommodate 6 million passengers per annum, with plans to scale up based on passenger traffic growth. The airport will provide services for both domestic and international travel, as well as cargo.

16.17.8. Goa Airport (MOPA)

GMR Goa International Airport Limited (GGIAL), a subsidiary of GMR Airports Limited (GAL), developed Manohar International Airport at Mopa in North Goa. This airport project follows the Public-Private Partnership (PPP) model on a Design, Build, Finance, Operate, and Transfer (DBFOT) basis.

Spread across 2,132 acres, the airport initially serves 4.4 million passengers annually in Phase 1, with plans to expand based on traffic growth. Operational since January 2023, this full-service airport caters to domestic and international passengers, as well as freight services, for Goa and the Konkan region of Maharashtra.

Additionally, GGIAL has established the Aviation Skill Development Centre (ASDC) to train and empower local Goan youth with skills for employment in the aviation industry. The training at ASDC complies with the National Skills Qualification Framework (NSQF), the State Skills Mission, and the National Skills Development Corporation (NSDC).

16.18. Current trends in competition- Airport Infrastructure

The airport infrastructure sector in India is evolving rapidly, driven by the need to accommodate increasing passenger traffic, enhance operational efficiency, and meet global standards. The below trends highlight the dynamic changes in the airport infrastructure sector in India, focusing on capacity expansion, technological innovation, sustainability, and improved passenger experience to meet the growing demand for air travel.

- **Expansion and Capacity Enhancement:** With the rise in air travel demand, airports are focusing on expanding their capacities. This includes building new terminals, extending runways, and developing additional facilities to handle more passengers and flights efficiently. Major airports like Delhi, Mumbai, and Bangalore are undergoing significant expansions.
- **Technological Integration:** Airports are increasingly adopting advanced technologies to streamline operations and improve passenger experience. This includes biometric systems for seamless boarding, artificial intelligence (AI) for predictive maintenance and analytics, Internet of Things (IoT) for real-time monitoring, and automation in baggage handling and security checks.
- **Sustainability and Green Initiatives:** There is a strong emphasis on making airports more environmentally sustainable. Initiatives include the use of renewable energy sources such as solar power, energy-efficient building designs, waste management systems, and efforts to achieve carbon neutrality. Cochin International Airport, for example, is fully solar-powered, setting a benchmark for sustainability in the sector.
- **Improving Passenger Experience:** Enhancing the overall passenger experience is a major focus. Airports are investing in better amenities, faster processing times, comfortable waiting areas, and enhanced retail and dining options. Airports are also integrating digital services such as mobile apps for real-time information and self-service kiosks.
- **Regional Connectivity Development:** The UDAN (Ude Desh ka Aam Nagrik) scheme is driving the development of regional connectivity by establishing and upgrading underserved and unserved airports. This initiative aims to make air travel accessible to smaller cities and remote areas, promoting balanced regional development.

- **Cargo and Logistics Facilities:** With the growth of e-commerce and international trade, there is an increasing focus on developing efficient cargo handling and logistics facilities. Airports are investing in dedicated cargo terminals, cold storage facilities, and integrated logistics hubs to meet the rising demand for air freight services.
- **Digital Transformation:** Airports are undergoing digital transformations to enhance efficiency and passenger convenience. This includes implementing digital payment systems, mobile applications for real-time updates and services, and smart kiosks for self-service check-in and boarding.
- **Security Enhancements:** With increasing security concerns, airports are adopting advanced security measures. This includes deploying state-of-the-art surveillance systems, automated screening processes, and comprehensive cybersecurity protocols to protect both physical and digital infrastructure.
- **Smart Airport Concepts:** The concept of smart airports is gaining momentum, where various airport systems are interconnected and managed through a centralized digital platform. This includes smart lighting, climate control, resource management, and passenger flow management to optimize operations and sustainability.
- **Investment in Training and Development:** As airport operations become more complex, there is a growing need for continuous training and development of airport staff. This includes training in new technologies, customer service, and operational management to maintain high standards of service and efficiency.

16.19. Brief on institutional framework (AERA regulations) for aviation sector by the central government

16.19.1. Airport Economic Regulatory Authority (AERA)- regulatory for tariff fixation

The Airports Economic Regulatory Authority of India (AERA) is the regulatory body responsible for determining and regulating tariffs and other charges for aeronautical services at major airports in India. Established by the Government of India, AERA aims to foster fair competition, protect the interests of various stakeholders, and promote efficient and economic operation of airports.

Key Functions of AERA:

Tariff Determination:

- **Aeronautical Services:** AERA is responsible for setting tariffs for aeronautical services, which include landing, parking, and passenger service fees. These charges are crucial for the financial viability of airport operations.
- **Hybrid Till Model:** AERA has adopted the 30% hybrid till model, which involves using a mix of aeronautical and a portion of non-aeronautical revenues to determine tariffs. This approach balances the need for reasonable charges while ensuring adequate revenue for airport operators.

Regulation and Monitoring:

- **Service Quality:** AERA monitors the quality of services provided at airports to ensure that passengers and airlines receive efficient and satisfactory service.
- **Fair Competition:** The authority ensures that airport operators do not engage in monopolistic practices and that there is fair competition among service providers.

Dispute Resolution: AERA acts as a mediator to resolve disputes between airport operators and users, including airlines and passengers, related to tariffs and service standards.

Consultative Process: AERA engages with various stakeholders, including airport operators, airlines, passenger associations, and other relevant entities, to gather inputs and feedback before finalizing tariff orders. This consultative approach ensures transparency and inclusiveness in the decision-making process.

Impact of AERA's Regulatory Role:

Balanced Tariff Setting: By using the hybrid till model, AERA ensures that tariffs are not excessively high, protecting passengers and airlines from undue financial burden, while still allowing airport operators to generate sufficient revenue for operations and development.

Improved Service Quality: AERA's oversight helps maintain high standards of service at airports, contributing to a better passenger experience and operational efficiency.

Encouraging Investments: Stable and predictable tariff regulations make the Indian airport sector more attractive to domestic and international investors, fostering infrastructure growth and modernization.

Economic Growth: Efficient and well-regulated airports are crucial for the overall economic growth of the country, facilitating smoother trade, tourism, and connectivity.

AERA plays a vital role in the Indian aviation sector by regulating airport tariffs, ensuring fair competition, improving service quality, and promoting investment. Its regulatory framework, including the implementation of the 30% hybrid till model, aims to create a balanced and sustainable airport economic environment.

16.20. Key Trends of India Airport Infrastructure

India's Airports sector is witnessing significant growth and transformation due to several key trends:

1. **Rising Passenger Traffic:** The Indian aviation industry is one of the fastest-growing industries globally. The rising global population and burgeoning middle class, particularly in developing economies, are leading to a surge in air travel. Whereas increased disposable incomes and affordability of air travel are further fuelling demand.

2. **Expansion of Airport Infrastructure:** To cater to the increasing passenger traffic, the government and private players are heavily investing in airport infrastructure development. This includes building new airports, expanding existing airports, and upgrading facilities.

3. **Public-Private Partnerships (PPPs):** Public-Private Partnerships (PPPs) are playing a crucial role in airport development. The government is actively partnering with private companies to finance, build, and operate airports. This model allows for faster development and improved operational efficiency. This leverages private sector capital and expertise, accelerating infrastructure development. In addition, PPPs are particularly effective in developing new airports and modernizing existing ones.

4. **Focus on Regional Connectivity:** The government's UDAN (Ude Desh ka Aam Nagrik) scheme is promoting air connectivity to underserved regions. This scheme aims to make air travel affordable and accessible to a larger population.

5. **Technological Advancements:** Airports are integrating new technologies like AI, automation, and biometrics to improve passenger experience, security, and efficiency. This includes self-service kiosks, facial recognition technology, and smart baggage handling systems. These technologies improve passenger experience, security, and efficiency, further driving the demand for modern infrastructure.

6. **Sustainability Initiatives:** Airports are facing pressure to reduce their environmental impact. This is leading to investments in sustainable technologies and practices, such as renewable energy, water conservation, and waste reduction. Furthermore, sustainable infrastructure projects attract funding and improve public perception. Accordingly, airports are increasingly focusing on sustainability practices such as renewable energy usage and noise reduction. This aims to minimize the environmental impact of airport operations.

7. **Airport Cities and Aerotropolis Development:** The concept of airport cities and aerotropolis development is gaining traction, integrating urban development with airport operations. This involves constructing integrated urban centres around airports, including commercial, residential, and logistics facilities. Similarly, the concept of airport cities is gaining traction. This creates new economic opportunities and enhances the overall passenger experience.

8. **Cargo and Logistics:** The growth of e-commerce and globalization is driving the demand for air cargo services. Airports are investing in cargo terminals and logistics infrastructure to cater to this demand.

9. **MRO (Maintenance, Repair, and Overhaul):** India is emerging as a major MRO hub for the region. Several airports are developing dedicated MRO facilities to attract international airlines. The growing number of aircraft requires a robust MRO sector. Airports are investing in dedicated MRO facilities to attract airlines and generate additional revenue. This creates new jobs and contributes to the local economy.

10. **Focus on Skilled Workforce**: The airport sector requires a skilled workforce to handle complex operations. There is an increasing focus on training and development programs to meet this demand.

11. **Growth of Low-Cost Carriers:** Low-cost airlines are making air travel more accessible to a wider population, stimulating demand. These airlines typically operate from smaller, secondary airports, creating a need for infrastructure development.

12. **Focus on Security and Safety:** Airports are constantly evolving their security measures to address evolving threats. This requires investments in technology, training, and manpower. A safe and secure airport environment is critical for passenger confidence and industry growth.

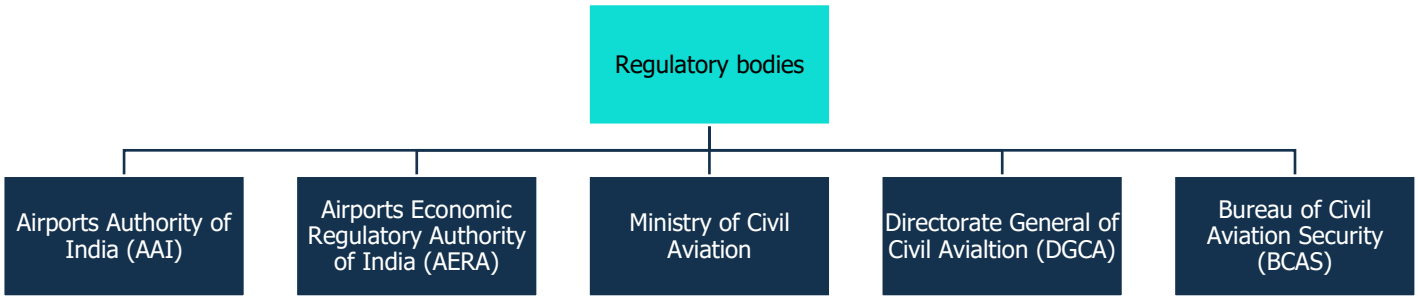
These trends are shaping the future of the Indian airport sector and are expected to contribute significantly to the country's economic growth and development.

16.21. Key initiatives taken by the government

16.22. Government Initiatives and Schemes

The Indian airport sector operates under a comprehensive framework of regulations and policies formulated by various government agencies and authorities. The principal regulators of the government that devise policies and ensure their implementation in the Indian airports infrastructure industry are:

Figure 1: Regulatory Bodies in Indian Airports Infrastructure Industry



Source: Ministry of Civil Aviation

The Indian government has launched several initiatives to support the growth and development of the airport sector.

- **Regional Connectivity Scheme (RCS-UDAN)**

RCS-UDAN scheme was launched in 2016 that aims to enhance regional air connectivity from unserved and underserved airports in the country and make air travel affordable to the masses. The scheme seeks to bring air connectivity to tier-2 and tier-3 cities, by taking up existing airstrips identified through UDAN bidding rounds, for development and upgradation under the 'Revival of unserved and underserved airports' scheme. As of December 2023, 517 routes connecting 76 airports, including 9 Heliports and 2 Water Aerodromes, have so far commenced operations. Out of 1300 valid routes awarded under the Scheme till 5.0 round of UDAN, 501 routes have been cancelled due to various reasons which include shutting down of the airlines, non-readiness of the aerodromes etc. Out of the remaining 799 routes, 517 routes have commenced so far. 201 routes have completed the prescribed 3 years tenure. This scheme plays a crucial role in promoting regional economic development, tourism, and healthcare access in remote regions.

UDAN was launches under various phases:

UDAN 1.0

- Under this phase, 5 airline companies were awarded 128 flight routes to 70 airports (including 36 newly made operational airports).

UDAN 2.0

- In 2018, the Ministry of Civil Aviation announced 73 underserved and unserved airports.
- For the first time, helipads were also connected under phase 2 of the UDAN scheme.

UDAN 3.0

- Inclusion of Tourism Routes under UDAN 3 in coordination with the Ministry of Tourism.
- Inclusion of seaplanes for connecting water aerodromes.
- Bringing in a number of routes in the North-East region under the ambit of UDAN.

UDAN 4.0

- In 2020, 78 new routes were approved under the 4th round of RCS-UDAN to further enhance the connectivity to remote & regional areas of the country.
- Kavaratti, Agatti, and Minicoy islands of Lakshadweep will be connected by the new routes of UDAN 4.0

UDAN 4.1

- The UDAN 4.1 focuses on connecting smaller airports, along with special helicopter and seaplane routes. Some new routes have been proposed under the Sagarmala seaplane services.

- **Krishi Udan**

This scheme was launched by the Ministry of Civil Aviation in August 2020, on international and national routes to assist farmers in transporting agricultural products so that it improves their value realization. Krishi UDAN 2.0 was introduced in 2023 that builds upon RCS-UDAN by specifically focusing on promoting air cargo movement of agricultural products. It provides financial incentives to airlines and cargo operators to transport perishables, high-value agricultural commodities, and Agri-exports from underserved airports. The scheme primarily covers 25 airports focusing on North Eastern, Hilly and Tribal region besides 33 airports in other regions/areas. The Krishi UDAN 2.0 will be implemented at 53 airports across the country mainly focusing on Northeast and tribal regions and is likely to benefit farmer, freight forwarders and Airlines. This scheme aims to reduce post-harvest losses, improve market access for farmers, and boost agricultural exports.

- **National Monetization Pipeline (NMP)**

The NMP, announced in 2021, identifies 25 AAI airports for asset monetization through various modalities like public-private partnerships (PPPs). This aims to attract private investments into airport infrastructure development and expansion, accelerating growth and reducing the burden on public finances.

- **National Air Sports Policy (NASP)**

NASP was launched in 2022, aims to make India a major aviation sports hub by creating a safe, affordable, accessible, and sustainable ecosystem for various air sports activities. It seeks to establish dedicated air sports zones, provide training facilities and equipment, and promote competitions and events. NASP is expected to boost tourism, create new job opportunities, and attract investments in the aviation sports sector.

- **Nabh (NextGen airports for Bharat)**

Soaring passenger demand has spurred the Indian government to take decisive action in expanding its aviation infrastructure. The ambitious Nabh Nirman initiative, meaning "NextGen airports for Bharat," lays the groundwork for a fivefold growth in passenger traffic, aiming to handle a billion trips annually. This audacious plan prioritizes fair land acquisition, comprehensive master plans integrating airport and regional development, and ensuring balanced economic benefits for all stakeholders.

- **Encouragement to FDI**

The government has allowed 100% FDI under automatic rule for greenfield projects, whereas 74% FDI is allowed under automatic route for brownfield projects. 100% FDI is allowed under automatic route in scheduled air transport service, regional air transport service and domestic scheduled passenger airline. FDI over 49% would require government approval.

- **Budget Announcements**

The Union Budget 2024-25 takes decisive strides towards strengthening India's aviation landscape. A hefty Rs. 3,224.67 crore has been allocated to the Ministry of Civil Aviation, fuelling initiatives like reviving 50 dormant airfields – a mix of airports, heliports, water aerodromes, and advanced landing grounds – to boost regional connectivity. This follows the continued commitment to the RCS-UDAN scheme, receiving Rs. 601 crores in the previous budget. Furthermore, recognizing the crucial role of synergy between the Central and State Governments, the Minister of Civil Aviation has called for collaborative efforts to develop 16 new airports across five states - Madhya Pradesh, Chhattisgarh, Uttar Pradesh, Rajasthan, and Maharashtra – furthering the vision of seamless connectivity embodied by PM-Gati Shakti. Additionally, the PLI Scheme for Drones and Drone Components witnessed significant progress in FY23, with approximately Rs. 30 crores disbursed to beneficiaries, propelling India's burgeoning drone ecosystem.

- **Skill Development Initiatives**

The government actively supports skill development programs for various aviation and airport professions through institutions like the Airports Authority of India Training Academy (AAI-TA) and the Rajiv Gandhi National Institute of Aviation (RGNIAM). These programs aim to address the existing skill gap and ensure an adequate workforce for the growing aviation sector.

These government schemes and initiatives contribute significantly to the growth and development of India's aviation and airport sector, making it a key driver of economic progress and creating new opportunities for employment and investment.

- **Sustainable Aviation Practices**

The Government has taken various steps to promote sustainable aviation practices and to reduce greenhouse gas emissions from aviation sector. DGCA has adopted the guidelines for environmental protection developed by the International Civil Aviation Organization (ICAO) through its Standards and Recommended Practices (SARPs) and issued it in the form of Civil Aviation Regulations (CARs). To realise the goals of decarbonisation of Aviation Sector, Ministry of Petroleum and Natural Gas (MoP&NG) has constituted a Bio-Aviation Turbine Fuel (ATF) Programme Committee to take forward the Bio-ATF programme in the country to promote use of clean fuels.

Ministry of Civil Aviation has written to the operators of all the brownfield airports with scheduled operations and developers of the upcoming greenfield airports advising them to work towards achieving 'Carbon Neutrality' and 'Net Zero', to get accreditation by Airports Council International (ACI/ISO 14064 through empanelled verifiers) and to adopt carbon mitigation measures as well as carbon management plans.

Airports Authority of India has taken initiatives such as Energy Intensity Data publication aimed at reducing energy intensity for existing as well as upcoming airport projects. A training module has also been created as a part of induction training programme for Air Traffic controllers to sensitise them towards carbon neutrality.

16.23. Emergency Credit Line Guarantee Scheme (ECLGS)

The Emergency Credit Line Guarantee Scheme (ECLGS) was introduced as part of the Atma Nirbhar Bharat Package in 2020 to support businesses, including MSMEs, in meeting their operational liabilities and resuming operations amid the COVID-19 crisis. The scheme provides Member Lending Institutions (MLIs) with a 100% guarantee against losses incurred due to non-repayment of the ECLGS funding by borrowers.

Initially set to expire in March 2022, the ECLGS was extended until March 2023, following an announcement in the Union Budget 2022-23 by Finance Minister Nirmala Sitharaman. Considering the significant portion of non-fund-based credit in the civil aviation sector, eligible borrowers were allowed to avail up to 50% of their highest total fund and non-fund-based credit outstanding, with a cap of Rs. 400 crore per borrower.

Recognizing the importance of a robust civil aviation sector for economic development, the Department of Financial Services (DFS) under the Ministry of Finance modified ECLGS to enhance the maximum loan amount eligibility for airlines under ECLGS 3.0. Airlines can avail up to 100% of their fund-based or non-fund-based loan outstanding as of the reference dates, or Rs. 1,500 crore, whichever is lower. Of this, Rs. 500 crores will be based on equity contribution by the owners.

16.24. Open air service agreement (ASA) policy

Air Service Agreements (ASA) encompass provisions regarding the number of flights, capacity, landing points, and codeshare agreements. India has entered into Air Service Agreements with 116 countries. Under these bilateral agreements, designated foreign airlines are permitted to operate to and from specific points in India, as outlined in the agreements. Similarly, designated Indian carriers can operate to and from international airports covered by these bilateral ASAs.

Under NCAP 2016, Policy for utilisation of bilateral rights are as follows:

Open Sky ASA: According to the National Civil Aviation Policy 2016, the Government of India intends to establish 'Open Sky' Air Service Agreements with SAARC countries and nations located entirely beyond a 5000 km radius from New Delhi, on a reciprocal basis. This agreement will permit unlimited flights beyond the current bilateral rights directly to and from major airports in India as designated by the Government from time to time. However, the points of call at other airports covered under existing Air Service Agreements will remain valid until they are renegotiated.

16.25. Government announcements for MRO hub creation in India

The government has introduced a new Maintenance, Repair, and Overhaul (MRO) policy with the goal of establishing India

as a global MRO hub, servicing 90% of Indian carriers' MRO needs by 2040. MRO services are divided into four main segments: Line maintenance, Component maintenance, Engine maintenance, and Airframe heavy maintenance and modification, with Engine maintenance and APU accounting for 60% of total MRO expenditure.
To boost MRO activities for aircraft and helicopters within the country, the ministry has identified eight airports to attract investments for setting up MRO facilities. These airports are located in Begumpet (Telangana), Bhopal (Madhya Pradesh), Chennai (Tamil Nadu), Chandigarh, Delhi, Juhu (Maharashtra), Kolkata (West Bengal), and Tirupati (Andhra Pradesh).
Key features of the new MRO policy to attract investments include:

- Land leasing at airports through an open tender process.
- GST rate for domestic MRO services reduced from 18% to 5%.
- Land allotment for MRO facilities extended to 30 years, up from the previous 3-5 years.
- Lease rents determined through a bidding process, replacing the current practice of fixed rates by the Airports Authority of India (AAI). Rental escalation is set at 15% every three years whereas earlier rates was between 7.5-10%.

16.26. Relaxation in FDI thresholds for brownfield and greenfield airports in India

The Government of India continues to take various measures to enhance the civil aviation sector's attractiveness and develop it as a significant contributor to the national economy. In line with this, the GoI has given 'in-principle' approval for the establishment of 21 Greenfield Airports across the country.

Presently, eight Greenfield airports, including Shirdi in Maharashtra, Durgapur in West Bengal, Pakyong in Sikkim, Kannur in Kerala, Orvakal in Andhra Pradesh, Kalaburagi in Karnataka, Sindhudurg in Maharashtra, and Kushinagar in Uttar Pradesh, have commenced operations.

Additionally, the government has allowed 100% Foreign Direct Investment (FDI) in Greenfield and existing airport projects, as well as in specified sectors such as Air Transport Services, Ground Handling Services, Maintenance and Repair Organizations, Flying Training Organisations (FTOs), and technical training institutions, subject to sectoral regulations and conditions specified in the FDI Policy.

16.27. National Logistics policy 2022

The government has launched the National Logistics Policy (NLP) 2022 with the aim of achieving quick last-mile delivery and addressing transport-related challenges. The policy seeks to halve logistics costs to align with global benchmarks by 2030, reducing the cost from 14-18% of GDP to the global best practice of 8%.

Key areas of focus for the policy include process re-engineering, digitisation, and multi-modal transport. This initiative is crucial as high logistics costs negatively impact the competitiveness of domestic goods in the international market. The need for a national logistics policy has been recognized due to the comparatively high logistics costs in India compared to other developed economies.

16.28. Digital initiative by airports

The Digi Yatra Foundation, comprising five shareholders—AAI, BIAL, CIAL, DIAL, and GHIAL—has been established to drive this initiative. Considering the growth projections for Indian aviation, the Ministry of Civil Aviation has launched the Digi Yatra (DY) programme to revolutionize air travel in the country. This initiative goes beyond the conventional approach of expanding airport infrastructure to handle more passengers. Instead, it aims to provide a seamless, hassle-free, and paperless journey experience through advanced identity management and facial recognition technology. Passengers will be automatically processed at various checkpoints, such as entry points, security checks, and aircraft boarding, using facial recognition systems. Additionally, this will enable self-bag drop and check-in by identifying passengers and recalling their data via facial recognition. The DY programme will facilitate paperless travel and eliminate the need for multiple identity checks, thereby boosting operational efficiency and potentially increasing airport handling capacities.

Digital transformation at airports is not only about adopting new technologies but also about updating processes and services to enhance the experience for all stakeholders, including airport operators, airlines, passengers, customers, security, customs, concessionaires, and ground handlers. The goal is to leverage new technologies to improve safety and security while streamlining business processes.

16.29. Outlook of Airports Sector in India

The outlook of Indian Aviation Sector is underpinned by the growth by becoming third largest aviation market globally after USA and China. India saw a 15% YoY increase in total air passengers handled at Indian airports reaching 37.6 crore in FY24. It is expected to be one of the fastest growing domestic air passenger markets over the next decade.

The outlook for the aviation industry in India is stable, driven by rising domestic and international traffic, increasing per capita income, disposable income, and a growing middle-class population. Infrastructure development at major airports and favourable government policies are also significant contributors. As disposable income rises, individuals are expected to spend more on travel and tourism, boosting air travel demand. The anticipated growth in trade and freight activities will further drive the industry's expansion, necessitating efficient air cargo services. Government initiatives such as infrastructure development and supportive policies are crucial in creating a favourable environment for industry growth.

The Indian government has announced plans to revive 50 aircraft landing sites, including airports, helicopter pads, water aerodromes, and advanced landing grounds, aiming to enhance regional air connectivity. The UDAN scheme focuses on stimulating regional connectivity, The number of operational airports has doubled from 74 in 2014 to 157 in 2024, with a vision to expand to 350-400 by 2047. Over 1.44 crore passengers have benefited from more than 2.8 lakh flights. This highlights the UDAN scheme's success in making air travel affordable and widely accessible supported by a budget allocation of Rs 601 crores. Additionally, the NABH Nirman initiative aims to expand airport capacity significantly. Despite these efforts, infrastructure constraints, including congestion at major airports, pose challenges. The Indian government is aiming to leverage Public-Private Partnership (PPP) models to modernize and expand airport infrastructure, with a target of having 24 airports under PPP by 2025. Investor-friendly FDI policies and increased PPP participation are expected to attract investments, supporting the industry's long-term prospects. However, continued investment in modernization and addressing issues like land acquisition delays and ATF price volatility are critical for sustained growth.

16.30. Adani Portfolio

Adani Enterprises, part of the Adani Group, has made significant strides in the airport business in India. Adani Airports has taken over the management and operation of six major airports in India: Ahmedabad (Sardar Vallabhbhai Patel International Airport), Mangaluru (Mangalore International Airport), Lucknow (Chaudhary Charan Singh International Airport), Jaipur (Jaipur International Airport), Guwahati (Lokpriya Gopinath Bordoloi International Airport), Thiruvananthapuram (Trivandrum International Airport). The acquisition of these airports is part of Adani's strategy to become a significant player in the Indian aviation sector. Additionally, Adani Enterprises acquired a controlling stake in Mumbai International Airport Limited (MIAL), which also includes the upcoming Navi Mumbai International Airport. Adani Enterprise is second largest airport operator in India after GMR Group. In FY25, Adani Group saw passenger traffic of 6.3% (94.4 million) in India and Air Traffic and Cargo Freight at 5.0% (6,23,796) and 7.8% (1088.6thousand tons) respectively.

The airports under Adani's management are situated in economically diverse and significant states. Gujarat (Ahmedabad) recorded a GDP of Rs. 2.20 lakh crore in FY25, Karnataka (Mangaluru) stood at Rs. 2.50 lakh crore, Uttar Pradesh (Lucknow) at Rs. 2.55 lakh crore, Rajasthan (Jaipur) at Rs. 1.53 lakh crore, Assam (Guwahati) at Rs. 0.57 lakh crore, and Kerala (Thiruvananthapuram) at Rs. 1.15 lakh crore.

Table 57: Comparison by market share with other private airport operators

The Adani Enterprises owned airports rank second across operational parameters among PPP/ JVC airports.

FY24	Adani Enterprises	GMR Group	BIAL
Passenger	24%	28%	10%
ATM	22%	25%	9%
Cargo	30%	34%	13%

Source: AAI, CareEdge Research

Table 58: Positioning of Adani Airports holding limited airports on passenger traffic across years

Pax traffic (domestic + International)	2018-19	2019-20	2020-21	2021-22	2022-23	2023-24	2024-25
Mumbai							
in million	48.8	45.9	11.1	21.7	43.9	52.8	55.1
Rank	2	2	2	2	2	2	2
Ahmedabad							
in million	11.2	11.4	3.6	5.7	10.1	11.7	13.4
Rank	7	7	7	7	7	7	7
Lucknow							
in million	5.5	5.4	2.4	3.3	5.2	6.2	6.4
Rank	12	12	12	12	11	11	11
Mangalore							
in million	2.2	1.9	0.6	1.0	1.8	2.0	2.3
Rank	29	29	29	29	29	30	30
Jaipur							
in million	5.5	5.0	1.9	2.9	4.8	5.5	6.0
Rank	13	13	13	13	13	13	13
Guwahati							
in million	5.7	5.5	2.2	3.2	5.1	6.0	6.1
Rank	11	11	11	11	12	12	12
Trivandrum							
in million	4.4	3.9	0.9	1.7	3.5	4.4	4.8
Rank	15	15	15	15	18	16	14

Note: Rank is based on pan-India airports
Source: AAI, CareEdge Research

Table 59: Positioning of Adani Airports holding limited airports on freight traffic across years

Freight traffic (domestic + International)	2018-19	2019-20	2020-21	2021-22	2022-23	2023-24	2024-25
Mumbai							
in Tons	963460	863782	592966	770953	776934	822963	889,900
Rank	2	2	2	2	2	2	2
Ahmedabad							
in Tons	101731	103741	60749	90634	92337	106906	103,051
Rank	7	7	7	7	7	7	7
Lucknow							
in Tons	6111	14882	9968	14942	15840	20984	22,102
Rank	14	14	14	14	13	10	10
Mangalore							
in Tons	3287	4605	2186	3521	3815	2175	2,213
Rank	31	31	31	31	35	38	38
Jaipur							
in Tons	18513	17499	12204	14180	16441	19420	21,762
Rank	13	13	13	13	12	11	11
Guwahati							
in Tons	23840	21270	15951	21858	22823	18851	26,607
Rank	12	12	12	12	10	12	12
Trivandrum							
in Tons	25167	25511	14799	16579	15206	18392	23,033
Rank	11	11	11	11	11	13	13

Note: Rank is based on pan-India airports

Source: AAI, CareEdge Research

Table 60:Positioning of Adani Airports holding limited airports on air traffic movement across years

Air traffic movements (Domestic + International)	2018-19	2019-20	2020-21	2021-22	2022-23	2023-24	2024-25
Mumbai							
in Numbers	321263	304675	115864	186186	290387	324986	330,063
Rank	2	2	2	2	2	2	1
Ahmedabad							
in Numbers	78412	84577	40209	51157	80026	87025	101,119

Air traffic movements (Domestic + International)	2018-19	2019-20	2020-21	2021-22	2022-23	2023-24	2024-25
Rank	7	7	7	7	7	7	7
Lucknow							
in Numbers	41752	38494	22954	30005	42276	45549	49,662
Rank	13	13	13	13	12	11	12
Mangalore							
in Numbers	19365	15685	6664	9980	14382	15042	16,763
Rank	32	32	32	32	34	31	30
Jaipur							
in Numbers	46185	39484	18933	27157	41156	44863	48,407
Rank	12	12	12	12	13	12	13
Guwahati							
in Numbers	50488	45539	23442	33557	45909	46148	45,984
Rank	11	11	11	11	11	11	11
Trivandrum							
in Numbers	33093	28842	9313	15356	24594	30141	31,798
Rank	15	15	15	15	20	16	16

Note: Rank is based on pan-India airports
Source: AAI, CareEdge Research

Adani Group airports are city airports located adjacent to and well connected with large cities with easy access by bus, taxi, automobile and other public transportation modes. This has contributed to traffic at the airports being relatively resilient to the effects of seasonality and economic cycles affecting specific regions and tourism traffic. The Ahmedabad Airport is located approximately nine kms from Ahmedabad city and is the seventh largest airport in India in terms of passenger traffic, air traffic movement and freight traffic. Uttar Pradesh capital Lucknow in which the airport is located is the largest state in terms of population in India. The Mumbai airport is the second largest airport in India in terms of passenger traffic, air traffic movement and freight traffic.

As a result of Adani's acquisition and sustained efforts currently and in the past, airports have been recognized by several industry observers and have earned following Airport Service Quality ("ASQ") ratings.

ASQ Ratings of Adani Airports:

Airport	Pre-acquisition (March 2020)	Post-acquisition (March 31, 2025)
Ahmedabad	4.87	5.00
Mangalore	4.75	4.96
Lucknow	4.92	5.00
Jaipur	4.47	4.96
Guwahati	4.90	4.88
Thiruvananthapuram	4.95	4.89
Mumbai	4.98	5.00

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About:

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