Industry Report for DRHP

Focus Industry: Electrical & Electronic Components (Railways)

September 2025

Disclaimer

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Dun & Bradstreet has prepared this study in an independent and objective manner, and it has taken all reasonable care to ensure its accuracy and completeness. We believe that this study presents a true and fair view of the industry within the limitations of, among others, secondary statistics, and research, and it does not purport to be exhaustive. The results that can be or are derived from these findings are based on certain assumptions and parameters/conditions. As such, a blanket, generic use of the derived results or the methodology is not encouraged.

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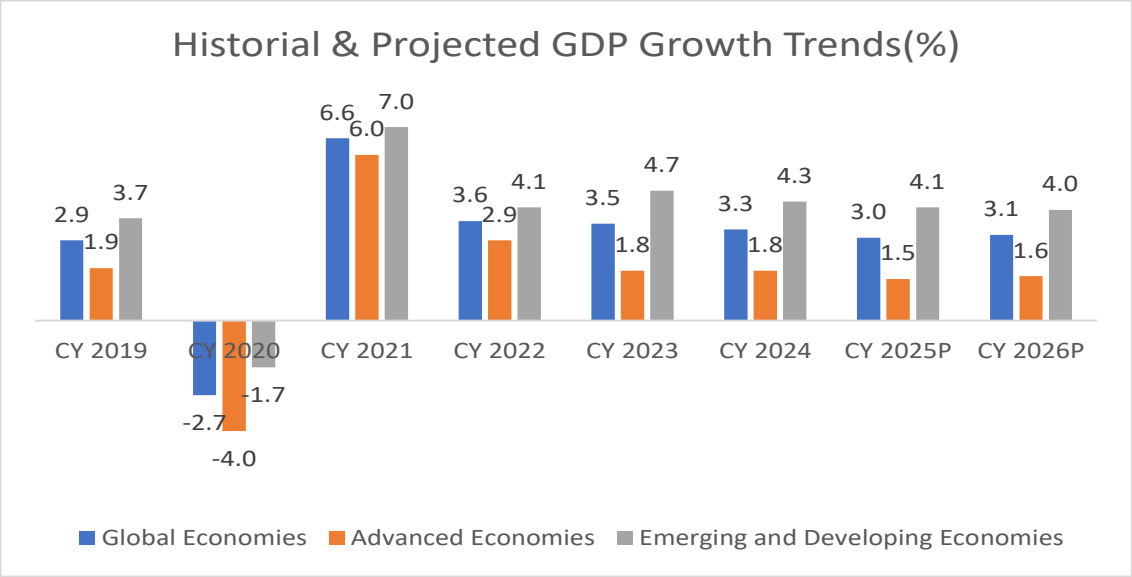
Global Macroeconomic Scenario

Global Economic Overview

The global economy, which recorded GDP growth at 3.3% in CY 2024, is expected to show resilience at 3.0% in CY 2025. This marks the slowest expansion since 2020 and reflects a -0.3%point downgrade from January 2025 forecast. Moreover, the projection for CY 2026 has also reduced to 3.1%. This slowdown is majorly attributed due to numerous factors such as high inflation in many economies despite central bank effort to curb inflation, continuing energy market volatility driven by geopolitical tensions particularly in Ukraine and Middle East, and the re-election of Donald Trump as US President extended uncertainty around the trade policies as well as overall global economic growth. High inflation and rising borrowing costs affected the private consumption on one hand while fiscal consolidation impacted the government consumption on the other hand. As a result, global GDP growth is projected to slow down from 3.3% in CY 2024 to 3.0% in CY 2025.



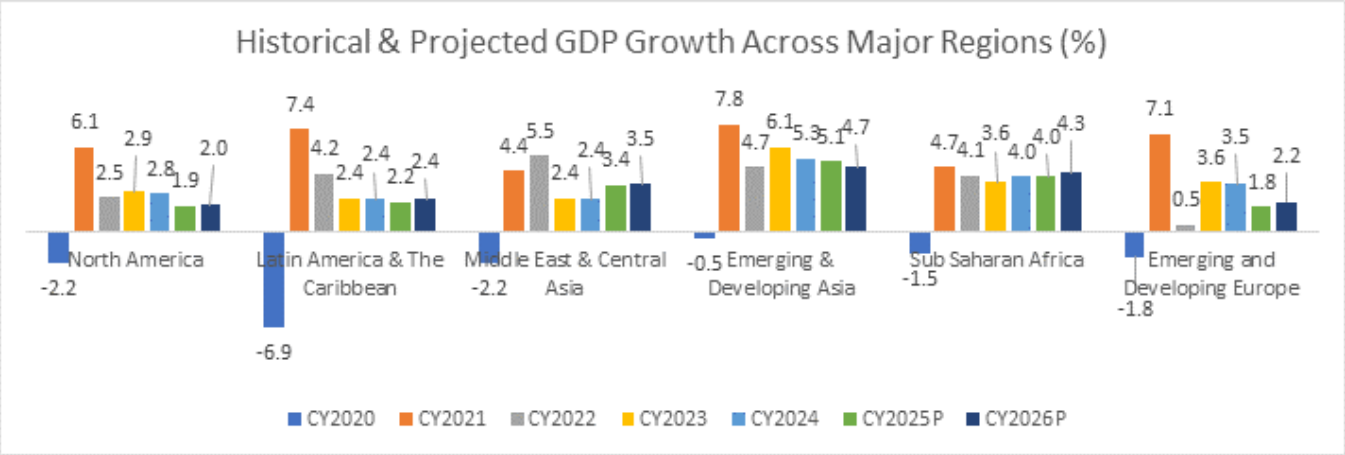
Source – IMF Global GDP Forecast Release July 2025

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

Historical and Projected GDP Growth

GDP growth across major regions exhibited a mixed trend between 2022-23, with GDP growth in many regions including North America, Emerging and Developing Asia, and Emerging and Developing Europe slowing further in 2024. In 2025, GDP growth rate in Emerging and Developing Asia (India, China, Indonesia, Malaysia, etc.) is expected to moderate further to 5.1% from 5.3% in the previous year, while in the North

America, it is expected to moderate to 1.9% in CY 2025 from 2.8% in CY 2024. Similarly in Emerging and Developing Europe is expected to moderate further to 1.8% from 3.5% in the previous year.



Source-IMF World Economic Outlook July 2025 update.

Except Middle East & Central Asia, all other regions like Emerging and Developing Asia, Emerging and Developing Europe, Latin America & The Caribbean, Sub Saharan Africa and North America, are expected to record a moderation in GDP growth rate in CY 2025 as compared to CY 2024. Further, growth in the United States is expected to come down at 1.9% in CY 2025 from 2.8% in CY 2024 due to lagged effects of monetary policy tightening, gradual fiscal tightening, and a softening in labour markets slowing aggregate demand.

Global Economic Outlook

The global macroeconomic environment remains shaped by divergent regional trends and continued geopolitical and policymaking uncertainties. A wave of new U.S. tariffs, mostly effective from August 7, has shaken markets and raised costs for global trade. On August 1, the U.S. announced higher tariff rates for countries from which it imports goods, with most of the rates effective from August 7. A 15% rate will act as a baseline floor for countries with which the U.S. has a trade deficit; a 10% rate applies for those with which the U.S. has a trade surplus. However, there are some countries that are subject to higher U.S. tariffs.

In North America, the United States continues to engage in trade negotiations with multiple countries and has announced plans to introduce sector-specific tariffs, targeting industries such as copper and pharmaceuticals. However, talks with Canada have stalled, despite Canada's decision to withdraw its Digital Services Tax in an effort to ease tensions. As a result, the U.S. imposed a 35% tariff on Canadian goods that do not meet USMCA compliance standards, effective August 1. This move has further strained bilateral relations and added complexity to the regional trade landscape.

By August 7, the U.S. had announced increased tariffs of 15-50% on Asian economies, with most rates around 20%. Although these tariffs are lower than the levels announced in April, they remain higher than those

applied to most Western counterparts, impacting exporters such as Taiwan Region (20%) and India (25%, with the U.S. saying this could rise to 50% at the end of August). Moreover, On July 28, the US imposed a 15% tariff on most EU imports under a new trade agreement, impacting Nordic countries such as Denmark, Finland, and Sweden. Key exemptions include aircraft parts and semiconductor equipment, while steel and aluminum continue to face 50% tariffs.

Tariffs and their unpredictable application have weighed on consumer and business sentiment, sunk global stock markets, raised recession risks, and made a global slowdown more likely. Our latest Global Business Optimism Insights report for indicates a further decline in business optimism as firms continue to grapple with trade-related policy uncertainty and its broader economic implications. Export-driven sectors reported sharp declines in optimism. Financial risk perceptions remain elevated as businesses contend with high borrowing costs and persistent inflation expectations. More broadly, the uncertainty is reflected in delayed capital expenditure and a pullback in hiring.

Tariffs have begun to exert pressure on central banks by contributing to inflationary pressures and increasing financial market volatility. Central banks are adjusting forward guidance and policy frameworks and may begin to consider the likelihood of softer growth being a bigger priority than high inflation by starting to cut interest rates to support economies. For businesses, this uncertainty translates into unpredictable cost structures, fluctuating credit availability, and the management of operational costs through diversified supply networks.

The latest Dun & Bradstreet Global Business Optimism Insights report reveals a further decline in business optimism, though at a more moderate pace than in the prior quarter, as businesses continued to grapple with trade-related policy uncertainty and its broader economic implications. Export-driven sectors such as automotives, electricals, and metals saw sharp declines in optimism, particularly in the U.S., Mexico, South Korea, and Japan, where rising tariffs and shifting trade policies have fueled cost pressures and demand volatility. Financial risk perceptions remain elevated.

Global Growth Projection

At broader level, the global economy is expected to experience a slowdown in 2025, with GDP growth projected to decline to 3.0%, down from 3.3% in 2024. This deceleration reflects persistent inflationary pressure, geopolitical uncertainties and tightened monetary policies. However, a sightly recovery is anticipated in 2026, with growth projected to improve to 3.1%. Global inflation is expected to decline steadily, to 4.2% in 2025 and to 3.6% in 2026. Inflation is projected to converge back to the target earlier in advanced economies, reaching 2.2% in 2026, whereas in emerging market and developing economies, it is anticipated to decrease to 4.6% during the same period. Trade tariffs function as a supply shock for the countries imposing them, leading to a decrease in productivity and an increase in unit costs. Countries subject to tariffs experience a negative demand shock as export demand declines, placing downward pressure on prices. In each scenario, trade uncertainty introduces an additional layer of demand shock since businesses and households react by delaying investment and spending, and this impact could be intensified by stricter

financial conditions and heightened exchange rate volatility. Moreover, Global trade growth is expected to slow down in 2025 to 1.7%. This forecast reflects increased tariff restrictions affecting trade flows and, to a lesser extent, the waning effects of cyclical factors that have underpinned the recent rise in goods trade. Geopolitical tensions as seen in the past such as the wars in Ukraine and the Middle East could exacerbate inflation volatility, particularly in energy and agricultural commodities.

India Macroeconomic Analysis

India emerged as one of the fastest growth economies amongst the leading advanced economies and emerging economies. In CY 2024, even amidst geopolitical uncertainties, particularly those affecting global energy and commodity markets, India continues to remain one of the fastest growing economies in the world and is expected to grow by 6.4% in CY 2025.

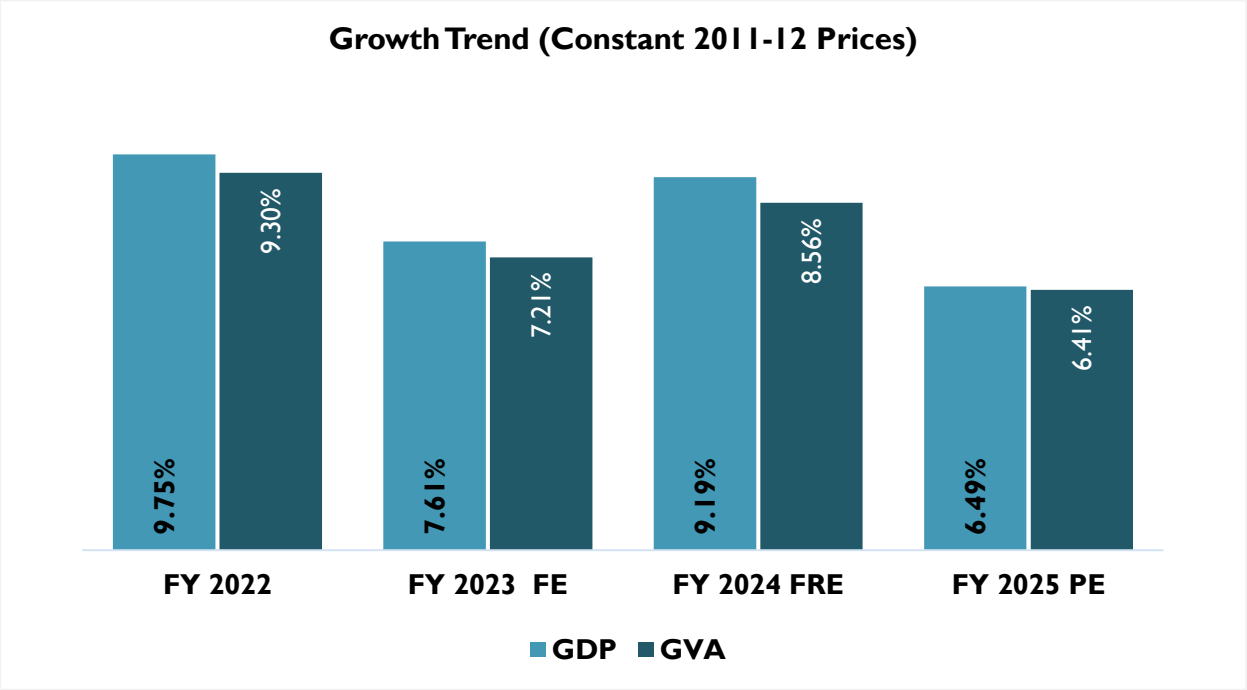
Country	CY 2020	CY 2021	CY 2022	CY 2023	CY 2024	CY 2025 P	CY 2026 P
India	–5.8%	9.7%	7.6%	9.2%	6.5%	6.4%	6.4%
China	2.3%	8.6%	3.1%	5.4%	5.0%	4.8%	4.2%
United States	-2.2%	6.1%	2.5%	2.9%	2.8%	1.9%	2.0%
Japan	-4.2%	2.7%	0.9%	1.4%	0.2%	0.7%	0.5%
United Kingdom	-10.3%	8.6%	4.8%	0.4%	1.1%	1.2%	1.4%
Russia	-2.7%	5.9%	-1.4%	4.1%	4.3%	0.9%	1.0%

Source: World Economic Outlook, July 2025

The Government stepped spending on infrastructure projects to boost the economic growth had a positive impact on economic growth. The capital expenditure of the central government increased by average 26.52% during FY 2023-FY 2024 which slowed to 7.27% in FY 2025 which is expected to translate in moderating GDP growth of 6.4% in CY2025. In the Union Budget 2025-2026, the government announced INR 11.21 billion capex on infrastructure (10.12% higher than previous year revised estimates) coupled with INR 1.5 trillion in interest-free loans to states. This has provided much-needed confidence to the private sector, and in turn, expected to attract the private investment.

Historical GDP and GVA Growth trend

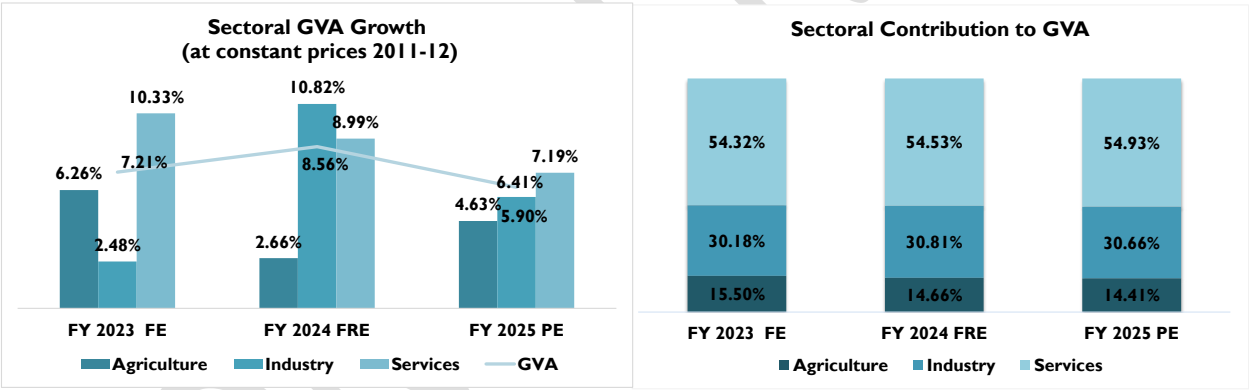
As per the latest estimates, India's GDP at constant prices is estimated to grow to INR 187.96 trillion in FY 2025 (Provisional Estimates) with the real GDP growth rates estimated to be 6.5% for FY 2025. Similarly, real Gross Value Added (GVA) growth stood is estimated to have moderated to 6.4% in FY 2025. Even amidst global economic uncertainties, India's economy exhibited resilience supported by robust consumption and government spending.



Source: Ministry of Statistics & Programme Implementation (MOSPI), National Account Statistics: FY2025.

FE is Final Estimates, FRE is First Revised Estimate and PE is Provisional Estimates

Sectoral Contribution to GVA and annual growth trend



Source: Ministry of Statistics & Programme Implementation (MOSPI)

FE is Final Estimates, FRE is First Revised Estimate and PE is Provisional Estimates

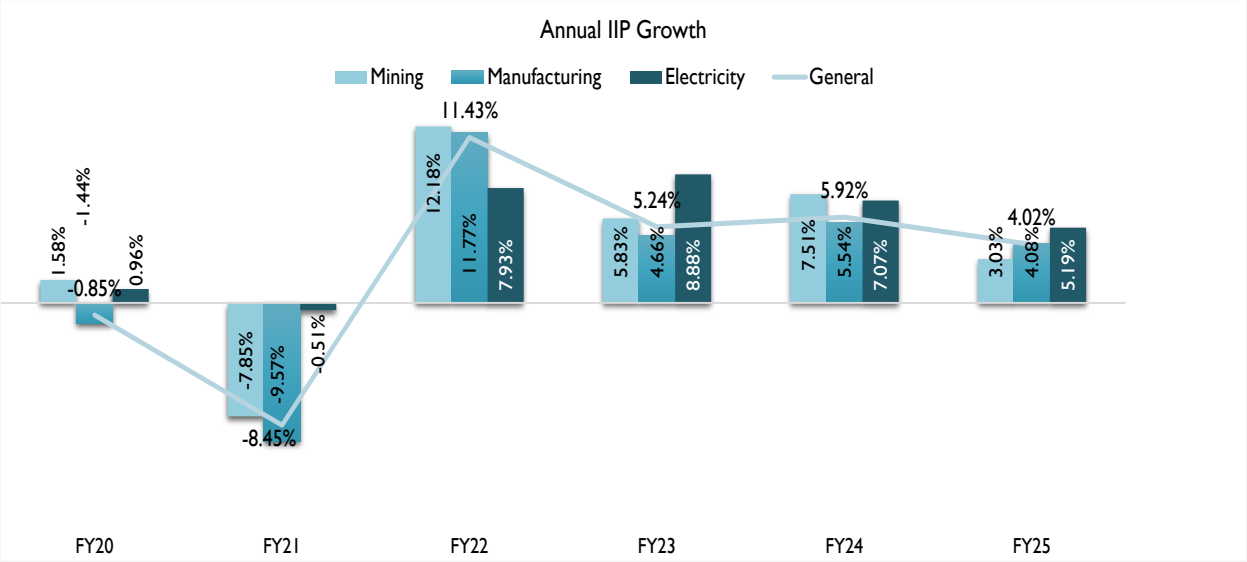
Sectoral analysis of GVA reveals that the industrial sector experienced a moderation in FY 2025, recording a 5.90% y-o-y growth against 10.82% year-on-year growth in FY 2024. Within the industrial sector, growth moderated across sub sector with mining, manufacturing, and construction activities growing by 2.69%, 4.52%, and 9.35% respectively in FY 2025, compared to 3.21%, 12.30%, and 10.41% in FY 2024. Growth in the utilities sector too moderated to 6.03% in FY 2025 from 8.64% in the previous year. The industrial sector's contribution to GVA moderated marginally from 30.81% in FY 2024 to 30.66% in FY 2025.

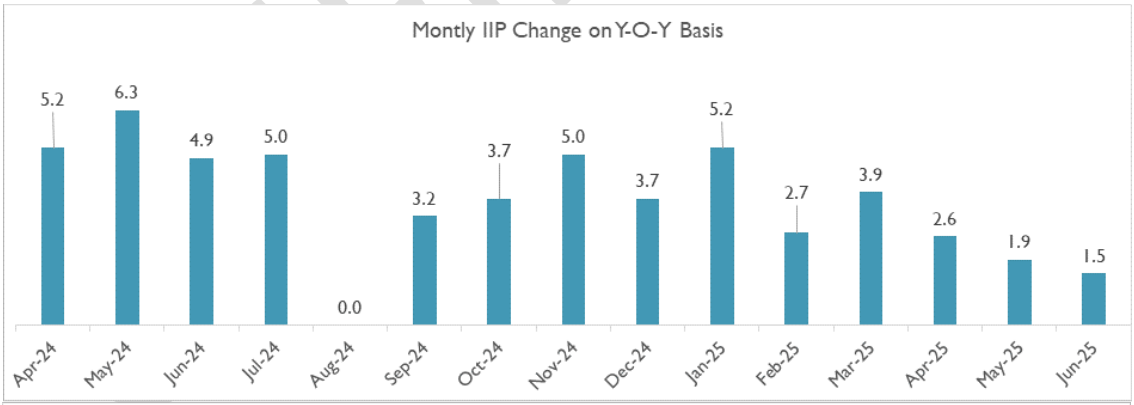
The services sector continued to be the main driver of economic growth, although its pace moderated. It expanded by 7.19% in FY 2025 from 8.99% in FY 2024. The services sector retained its position as the largest contributor to GVA, rising from 54.32% in FY 2023 to 54.53% in FY 2024, with a further increase to 54.93% in FY 2025.

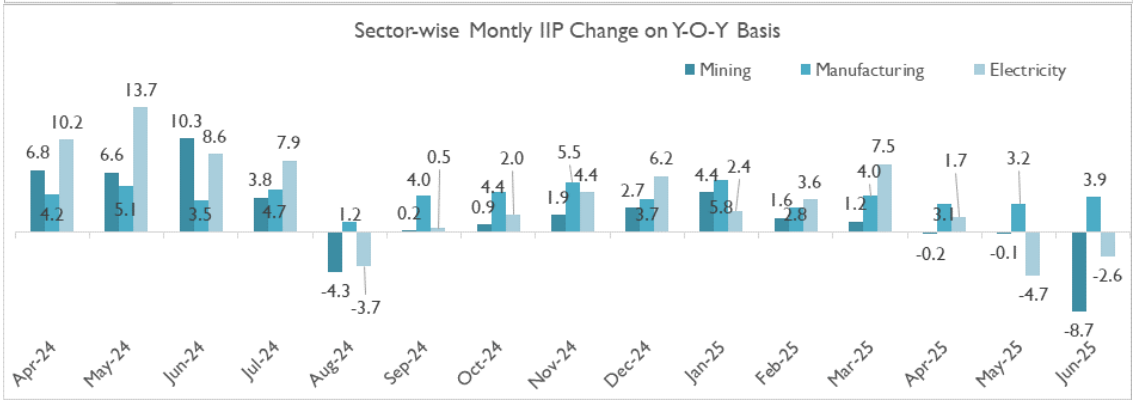
The agriculture sector saw an acceleration, with growth increasing from 2.66% in FY 2024 to 4.63% in FY 2025. However, its contribution to GVA declined marginally from 14.66% in FY 2024 to 14.41% in FY 2025. Overall, Gross Value Added (GVA) growth moderated to 6.41% in FY 2025 from 8.56% in FY 2024

Annual & Monthly IIP Growth

Industrial sector performance as measured by IIP index exhibited moderation in FY 2025, recording a 4.02% y-o-y growth against 5.92% increase in the previous year. The manufacturing index showed moderation and grew by 4.08% in FY 2025 against 5.54% in FY 2024. Mining sector index too moderated and exhibited a growth of 3.03% in FY 2025 against 7.51% in the previous years while the Electricity sector Index, also witnessed moderation of 5.19% in FY 2025 against 7.07% in the previous year.





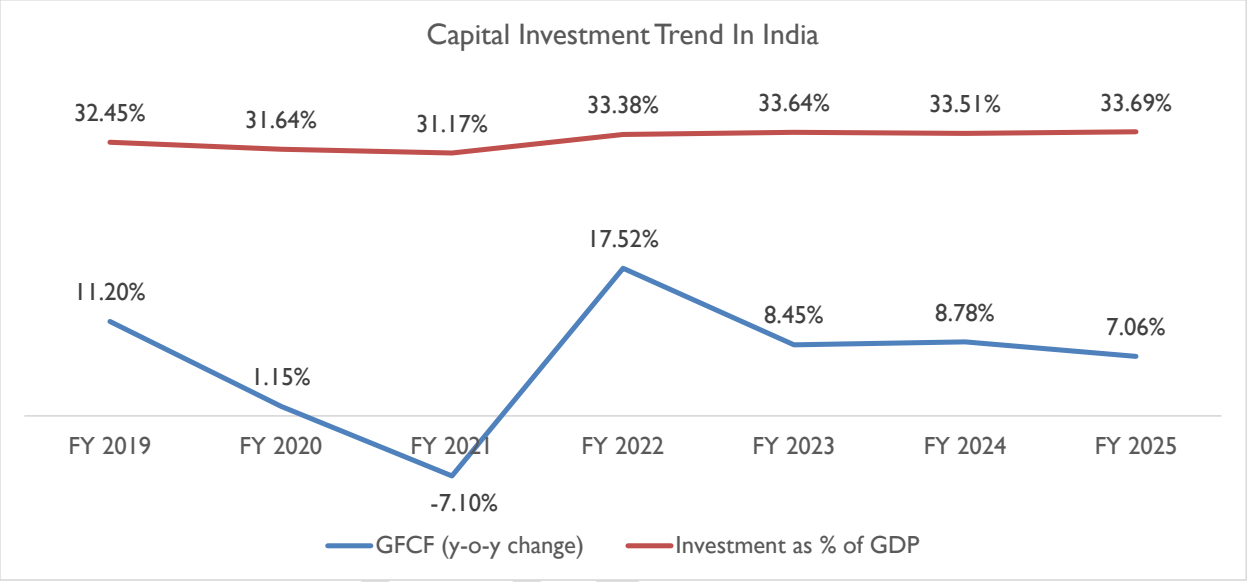


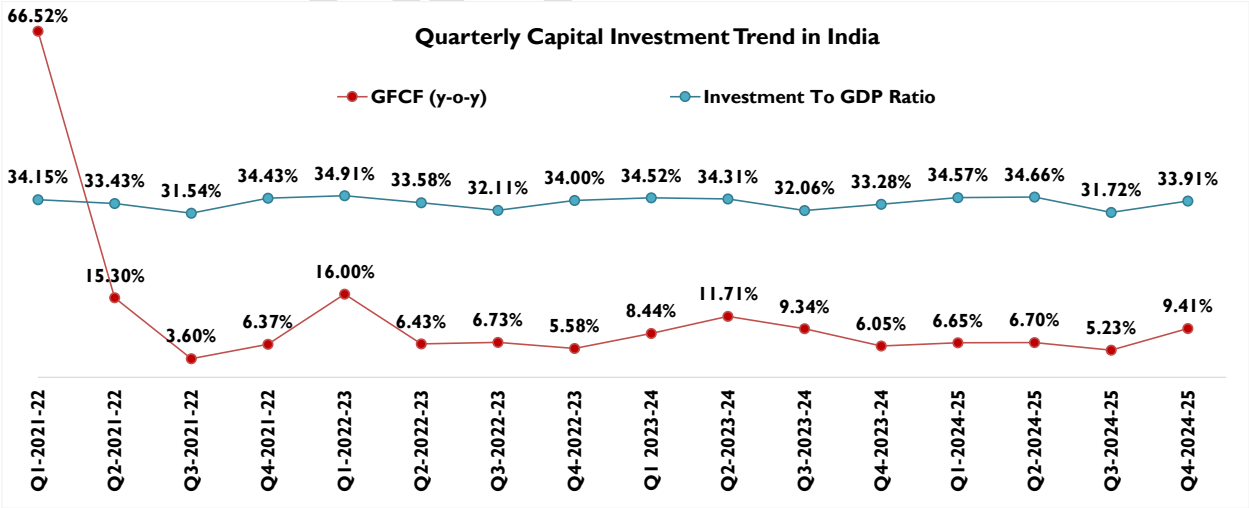
Source: Ministry of Statistics & Programme Implementation (MOSPI)

The IIP growth rate for the month of June 2025 is 1.5% which was 1.9% in the month of May 2025. The growth rates of the three sectors, Mining, Manufacturing and Electricity for the month of May 2025 are (-)8.7%, 3.9% and (-)2.6% respectively.

Annual and Quarterly: Investment & Consumption Scenario

Other major indicators such as Gross fixed capital formation (GFCF), a measure of investments, has shown fluctuation during FY 2025 as it registered 7.06% year-on-year growth against 8.78% yearly growth in FY 2024, taking the GFCF to GDP ratio measured to 33.69%.



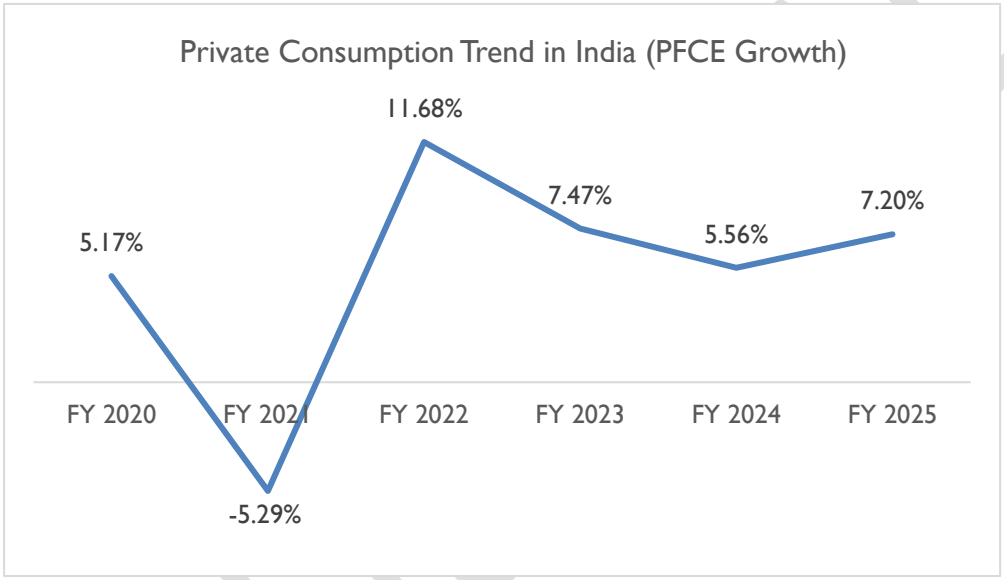


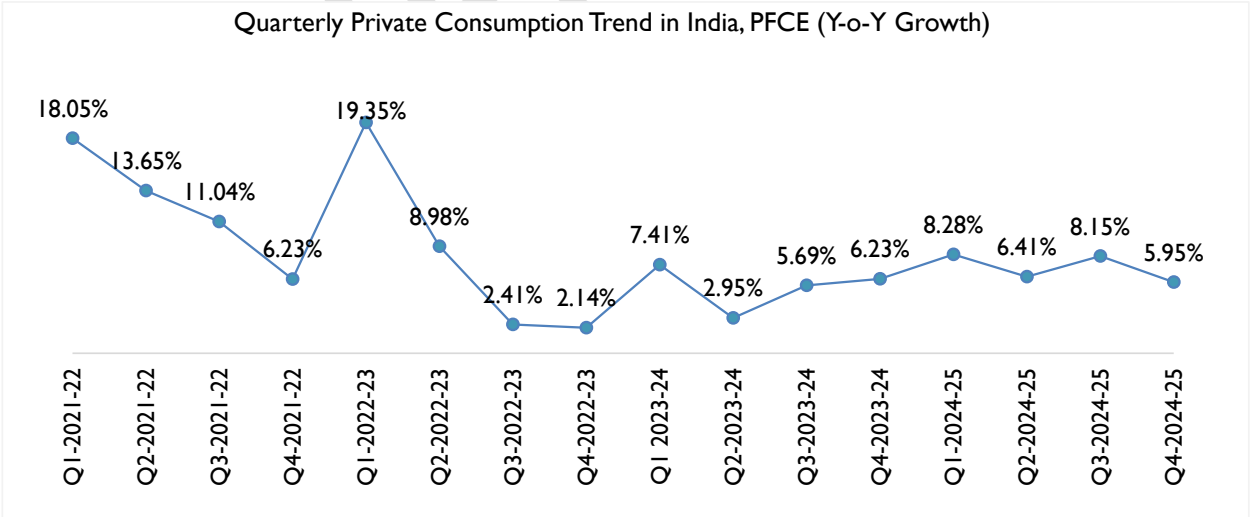
Source: Ministry of Statistics & Programme Implementation (MOSPI)

On quarterly basis, GFCF exhibited a fluctuating trend in quarterly growth over the previous year same quarter. In FY 2024, the growth rate moderated to 6.05% in March quarter against the previous two quarter as government went slow on capital spending amidst the 2024 general election while it observed an

improvement in Q1 FY 2025 by growing at 6.65% against 6.05% in the previous quarter and moderated in the subsequent two quarter. On yearly basis, the growth rate remained lower compared to the same quarter in the previous year during FY 2025. The GFCF to GDP ratio measured 33.91% in Q4 FY 2025.

Private Consumption Scenario





Sources: MOSPI

Private Final Expenditure (PFCE) a realistic proxy to gauge household spending, observed growth in FY 2025 as compared to FY 2024. However, quarterly data indicated some improvement in the current fiscal as the growth rate improved over the corresponding period in the last fiscal.

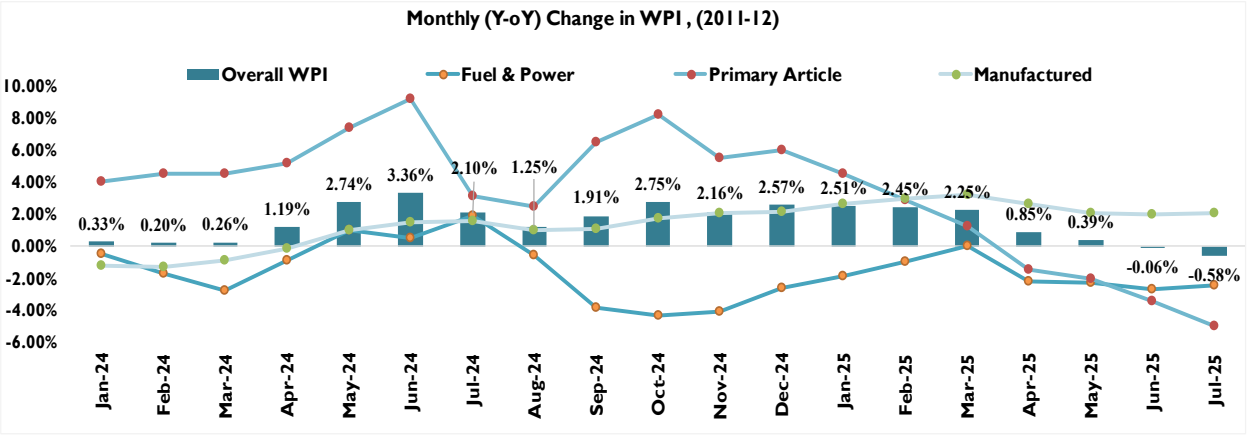
Inflation Scenario

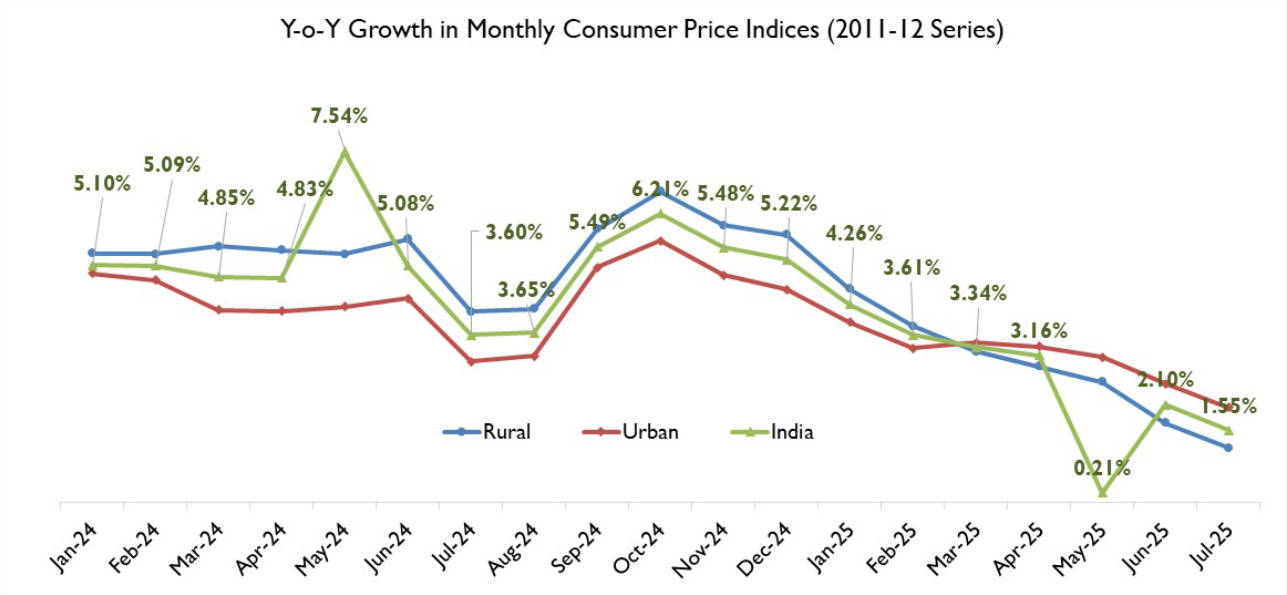
The inflation rate based on India's Wholesale Price Index (WPI) exhibited significant fluctuations across different sectors from January 2024 to July 2025. The annual rate of inflation based on All India Wholesale Price Index (WPI) number is (-) 0.58% (provisional) for the month of July, 2025 (over July, 2024). Negative rate of inflation in July 2025 is primarily due to increase in prices of manufacture of food products, electricity, other manufacturing, chemicals and chemical products, manufacture of other transport equipment and non-food articles etc.

By July 2025, Primary Articles (Weight 22.62%), - The index for this major group increased by 1.18 % from 185.8 (provisional) for the month of June 2025 to 188.0 (provisional) in July, 2025. Price of Crude Petroleum & Natural Gas (2.56%), non-food articles (2.11%) and food articles (0.96%) increased in July, 2025 as compared to June, 2025. The price of minerals (-1.08%) decreased in July, 2025 as compared to June, 2025.

Moreover, power & fuel, the index for this major group increased by 1.12% from 143.0 (provisional) for the month of June, 2025 to 144.6 (provisional) in July, 2025. The price of mineral oils (1.98%) increased in July, 2025 as compared to June, 2025. Price of coal (-0.44%) and electricity (-0.36%) decreased in July, 2025 as compared to June, 2025.

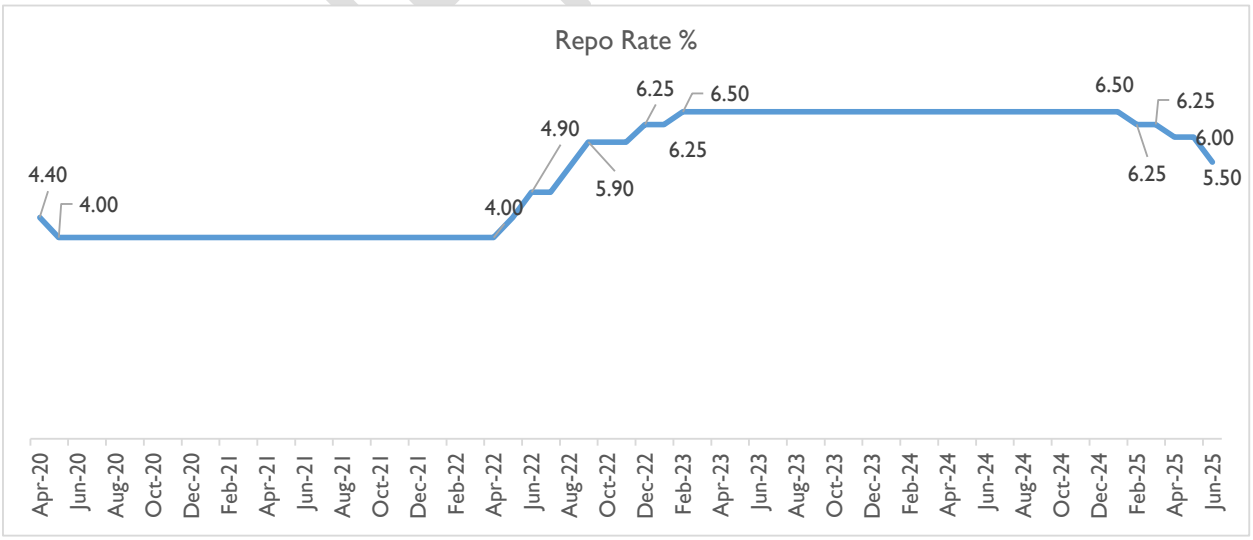
Furthermore, Manufactured Products (Weight 64.23%), The index for this major group declined by 0.14% from 144.8 (provisional) for the month of June, 2025to 144.6 (provisional) in July, 2025. Out of the 22 NIC two-digit groups for manufactured products, 9 groups witnessed an increase in prices, 9 groups witnessed a decrease in prices and 4 groups witnessed no change in prices. Some of the important groups that showed month-over-month increase in prices were other manufacturing; other transport equipment; motor vehicles, trailers and semi-trailers; other non-metallic mineral products and furniture etc. Some of the groups that witnessed a decrease in prices were manufacture of basic metals; fabricated metal products, except machinery and equipment; food products; chemicals and chemical products and paper and paper products etc in July, 2025 as compared to June, 2025.





Source: MOSPI, Office of Economic Advisor

Retail inflation rate (as measured by the Consumer Price Index) in India showed notable fluctuations between January 2024 and July2025. Overall, the national CPI inflation rate moderated to 1.55% by July 2025, indicating a gradual easing of inflationary pressures across both rural and urban areas. Rural CPI inflation peaked at 6.68% in October 2024, declining to 1.18% in July 2025. Urban CPI inflation followed a similar trend, rising to 5.62% in October 2024 and then dropping to 2.05% in July 2025. CPI measured above 6.00% tolerance limit of the central bank since July 2023. As a part of an anti-inflationary measure, the RBI has hiked the repo rate by 250 bps since May 2022 and 8 Feb 2023 while it held the rate steady at 6.50 % till January 2025. On 6th June 2025, RBI reduced the repo rate by 50 basis points which currently stands at 5.50%.



Sources: CMIE Economic Outlook

Growth Outlook

The Union Budget 2025-26 has laid the foundation for sustained growth by balancing demand stimulation, investment promotion and inclusive development. Inflation level is reaching within the central bank's target; the RBI may pursue further monetary easing that will support growth. The medium-term outlook is bright,

fueled by the emphasis on physical and digital infrastructure spending. With a focus on stimulating demand, driving investment and ensuring inclusive development, the budget introduces measures such as tax relief, increased infrastructure spending and incentives for manufacturing and clean energy. These initiatives aim to accelerate growth while maintaining fiscal discipline, reinforcing India's long-term economic resilience. The expansion of tax relief i.e zero tax liability for individuals earning up to INR 12 lacs annually under the new tax regime is expected to strengthen household finances and, consequently, boost consumption.

The external sector remains resilient, and key external vulnerability indicators continue to improve. However, tariff-related uncertainty is likely to weigh on exports and investment, prompting us to cut our CY26 GDP growth forecast to 6.4%.

Overview of Electrical & Electronic Equipment in Railway Locomotives

India's railway sector, being one of the largest and busiest in the world, has seen significant advancements in the adoption of electrical and electronic equipment to enhance locomotive performance, safety, and operational efficiency. With the increasing electrification of the railway network, the focus has shifted toward advanced electrical and electronic systems in railway locomotives.

Railway locomotives are vehicles that provide the motive power for trains. Indian locomotives are designed to handle diverse terrain, weather conditions, and varying operational requirements, such as passenger transport, freight movement, and high-speed rail operations.

Brief Overview on Locomotive Electrical Systems: Qualitative Insights on Key Components and their Role

First Train on electric traction started on 1500 V DC System from Bombay Victoria Terminus to Kurla Harbour on 3rd Feb 1925. This was the turning point in development of Railways and growth of sub-urban transport system for Mumbai City as also for other metropolitan cities. Madras was second metro city to get electric traction in Southern Railway on 11th May 1931. Up to Independence, India had only 388 km of electrified tracks.

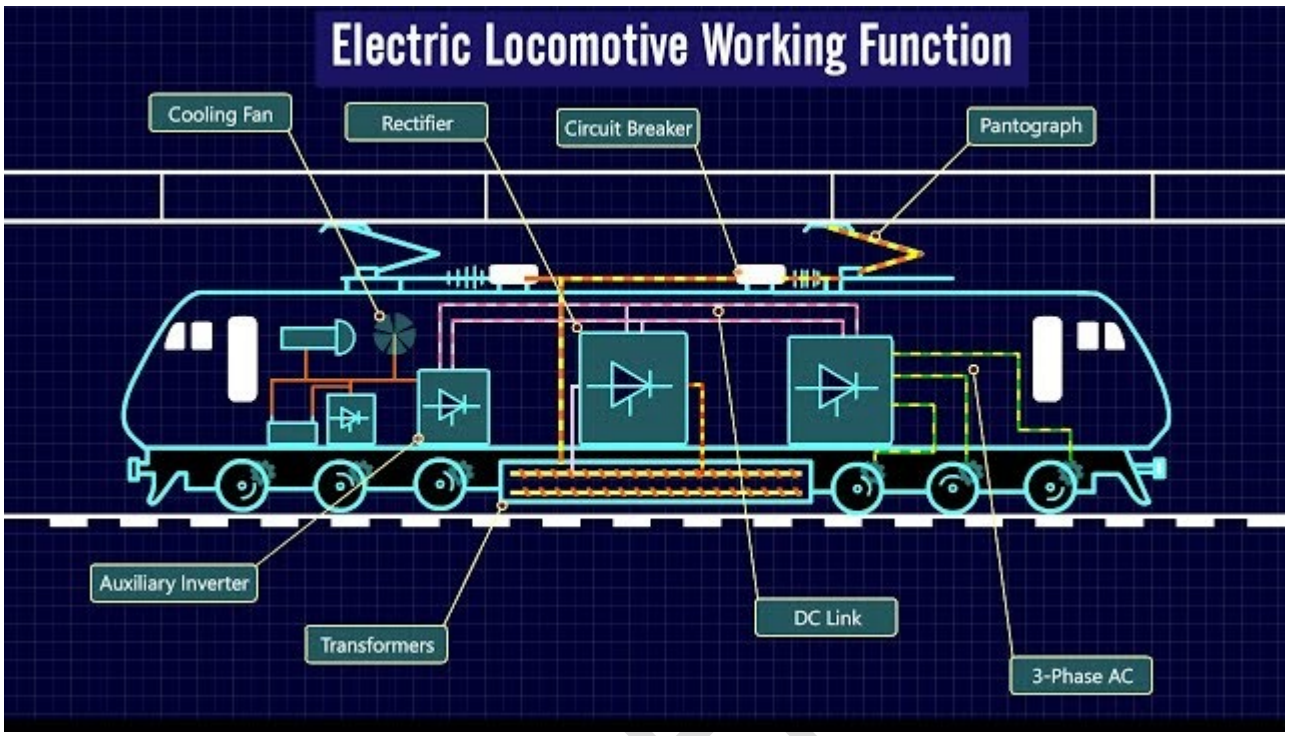
History of Electric Locomotives

Sr. No.	Class of Loco	Year of Manufacturing	Horsepower	Technology
DC Locomotives				
1	WCM1	1954	3170	English Electric
2	WCM2	1956	2810	English Electric
3	WCM3	1957	2460	English Electric
4	WCM4	1960	3290	Hitachi
5	WCM5	1961	3700	CLW
6	WCM6	1996	5000	CLW
7	WCG1	1925	2400	Swiss Loco works
8	WCG2	1970	1640	CLW
AC/DC Locos				
9	WCAM1	1975	3640(AC)	CLW

			2930(DC)	
10	WCAM2	1995	4720(AC) 3780(DC)	CLW
11	WCAM3	1997	5000(AC) 4600(DC)	BHEL
AC Locos				
12	WAM1	1959	2870	KM-KRUPP-SFAC
13	WAM2	1960	2790	Mitsubishi
14	WAM3	1964	2790	Mitsubishi
15	WAM4	1970	3640	Mitsubishi
16	WAP1	1980	3760	CLW
17	WAP3	1987	3760	CLW
18	WAP4	1994	5000	CLW
19	WAP5	1993	6000	ABB
20	WAP6	1998	5000	CLW
21	WAP7	2000	6350	CLW
22	WAG1	1963	2900	SNCF
23	WAG2	1964	3180	Hitachi/ Mitsubishi
24	WAG3	1965	3150	Europe
25	WAG4	1966	3150	CLW
26	WAG5	1984	3900	CLW/BHEL
27	WAG6	1987	6000	ASEA
28	WAG7	1992	5000	CLW
29	WAG9	1996	6000	ABB/CLW

30	WAG9H	2006	6000	CLW

Source: Elocos Railnet



Source: Google Photos

A driving force that causes propulsion of a vehicle is referred to as a traction system. The traction system is of two different types: Nonelectric Traction System and Electric Traction System.

Non-Electric Traction System

The traction system that doesn't use electricity at any stage of a vehicle movement is referred to as a non-electric traction system. Such a traction system is used in steam locomotives, IC engines, and in the maglev trains (high -speed trains).

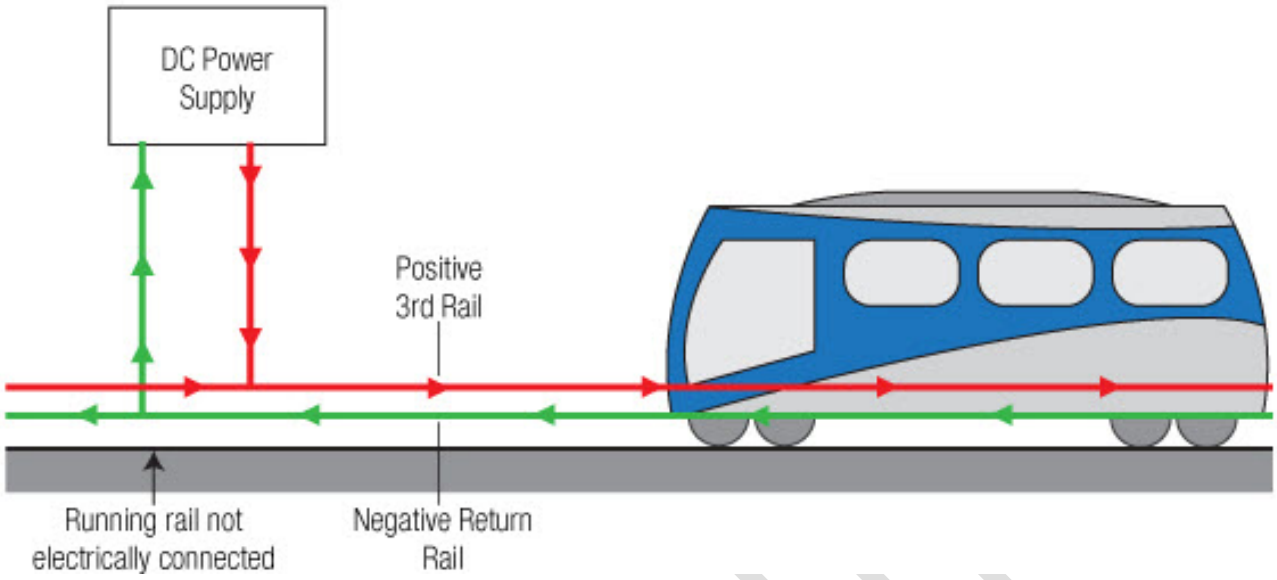
Electric Traction System

The traction system that uses electricity in all stages or some stages of a vehicle movement is referred to as an electric traction system.

The three main types of electric traction systems that exist are as follows:

1. Direct Current (DC) Electrification System
2. Alternating Current (AC) Electrification System
3. Composite System

1. Direct Current (DC) Electrification System



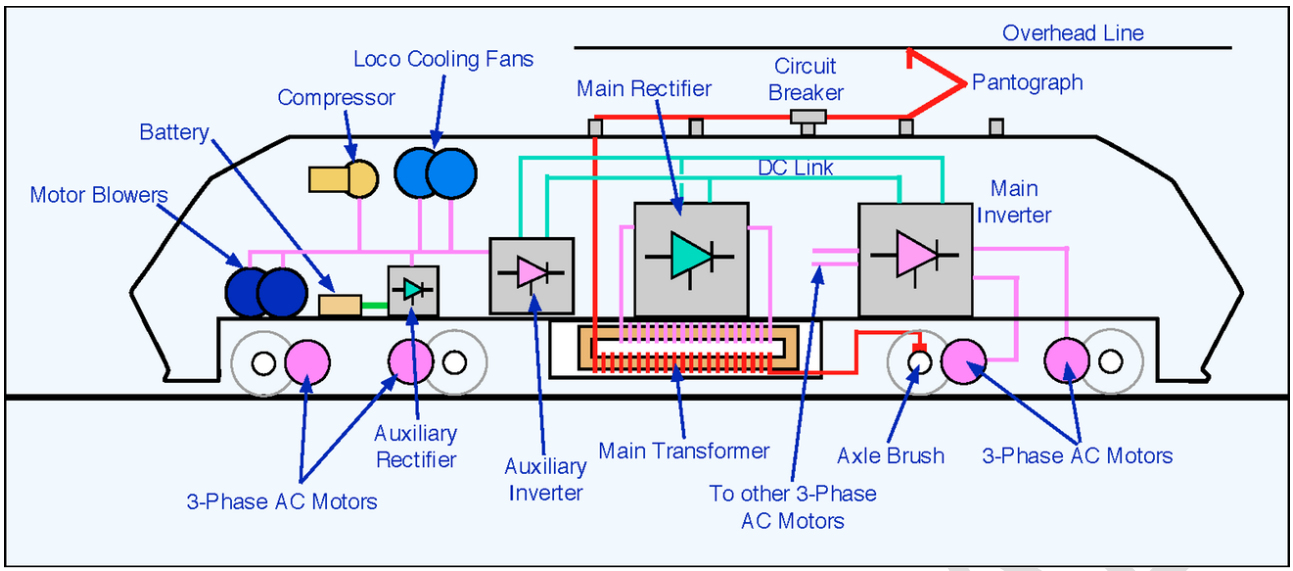
Source: The Railway Technical Website

The choice of selecting DC electrification system encompasses many advantages, such as space and weight considerations, rapid acceleration and braking of DC electric motors, less cost compared to AC systems, less energy consumption and others.

The DC Electrification System plays a crucial role in supplying direct current to locomotives, typically through overhead wires or third rails, enabling efficient power conversion into mechanical energy. DC systems require simpler, lower-voltage infrastructure, making them ideal for urban or suburban networks. They support regenerative braking, improving energy efficiency, and provide smoother control and acceleration for both passenger and freight trains. Key components like rectifiers and traction motors are designed for reliable performance with minimal maintenance, as DC systems have fewer wear-prone parts compared to AC systems, making them cost-effective for certain routes.

2. Alternating Current (AC) Electrification System

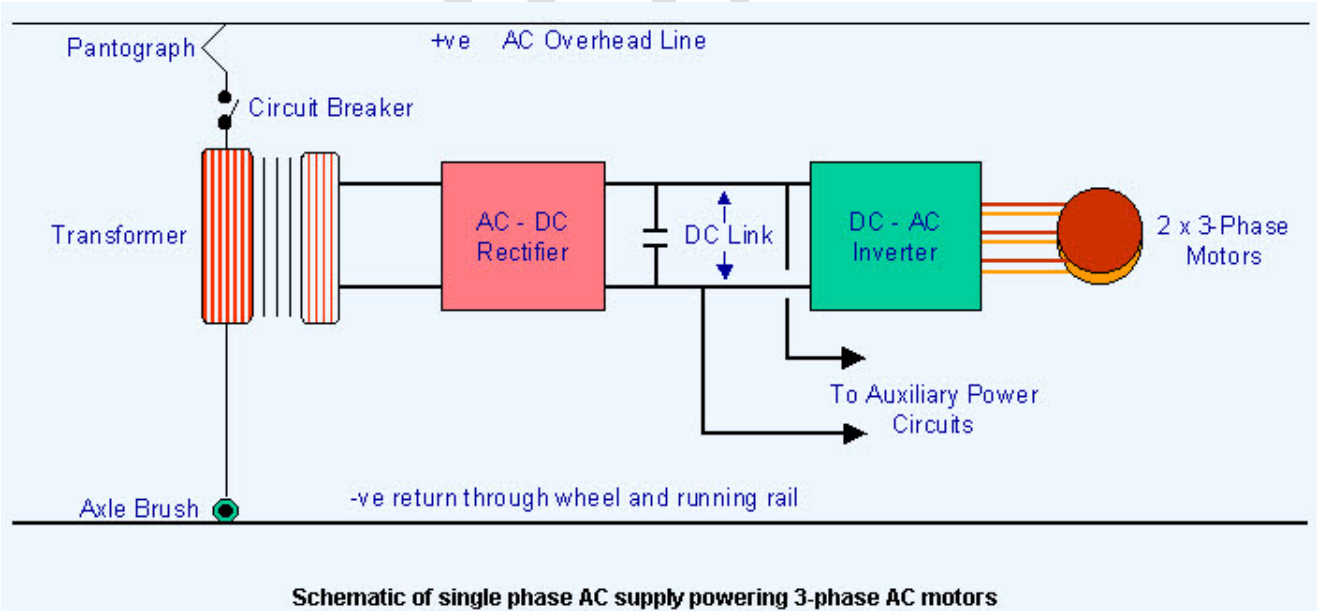
The AC traction system has gained widespread popularity due to several advantages, including the easy generation and transformation of AC power, efficient control of AC motors, and reduced need for substations. Additionally, it uses lightweight overhead catenaries to transfer high-voltage, low-current electricity, making the system more efficient and cost-effective for modern railway operations.



Source: The Railway Technical Website

This diagram shows an AC electric locomotive, collecting power from an overhead line. The red lines on the diagram indicate the single-phase AC circuit, the green lines the DC circuits and the purple lines the 3-phase AC circuits. A locomotive using DC traction current is similar, except that there is no single phase AC circuit or transformer. The current passes directly from the pantograph (or shoe) to the main and auxiliary inverters.

3. Composite System



Schematic of single phase AC supply powering 3-phase AC motors

Source: The Railway Technical Website

The Composite System in railway electrification combines the benefits of both DC and AC systems. There are two main types: the Single-Phase to Three-Phase (Kando) system and the Single-Phase to DC system. In the Kando system, a single overhead line carries a 16kV, 50Hz single-phase supply, which is then stepped down and converted into a three-phase supply of the same frequency within the locomotive using

transformers and converters. This approach leverages the advantages of both high-voltage transmission and efficient in-locomotive power conversion for enhanced performance and operational flexibility.

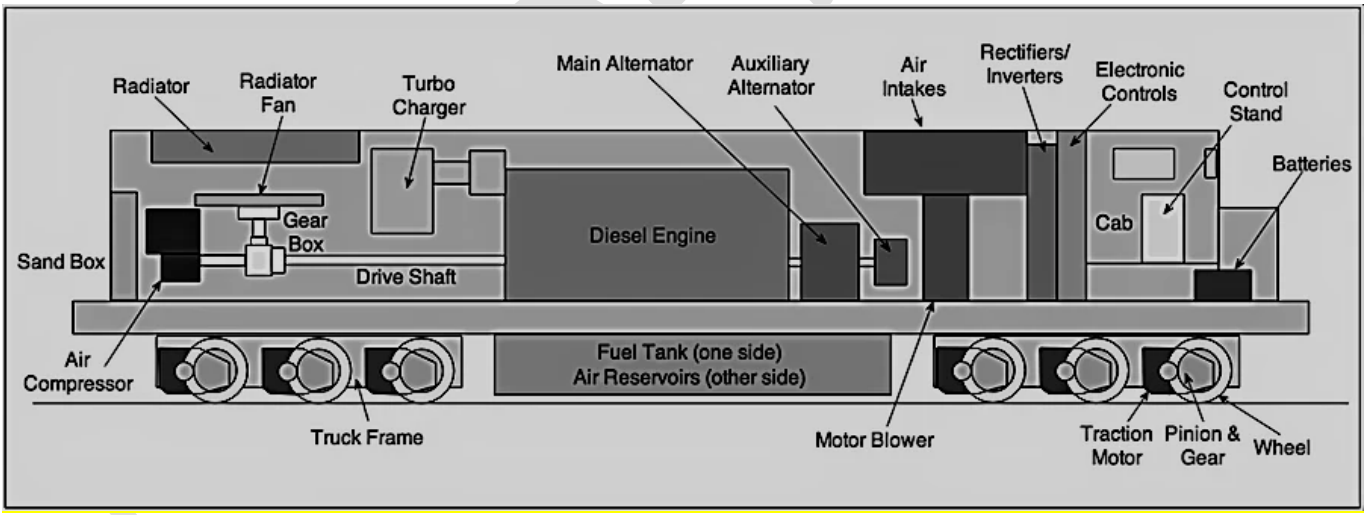
Key Components in Locomotive Electrical Systems and their Role

An electric locomotive is powered by electricity, which is drawn from overhead lines, a third rail, or on-board energy storage systems such as batteries or supercapacitors. Unlike traditional diesel or steam engines, electric locomotives rely on electricity to drive trains, enhancing efficiency and sustainability.

The process begins when the pantograph, a metal device mounted on the locomotive, makes contact with the overhead wire, allowing electricity to flow into the locomotive. This electricity is then transmitted to a transformer, which steps down the voltage to a level suitable for use within the locomotive. The lower-voltage electricity is supplied to electric traction motors, which drive the wheels and propel the locomotive forward. Additionally, energy can be stored in batteries, allowing for improved energy management and operational flexibility.

This system offers numerous benefits, including reduced carbon emissions, lower operational costs, and the ability to integrate renewable energy sources, positioning electric locomotives as a key component of modern, sustainable railway transportation.

Key Components in Locomotive:



The locomotive electrical system is a complex network of electrical parts that power and control the various systems of a locomotive. These components enable the locomotive to draw power from the main power source or from an auxiliary power source. It also helps the locomotive to move along the track and adjust the speed according to the conditions.

Electric locos derive tractive effort from Traction Motors which are usually placed in the bogie of the locomotive. Usually, one motor is provided per axle but in some older generation of locos two axles were driven by a single Traction Motor also.

However apart from Traction Motors, many other motors and equipment's are provided in electric locos. These motors are collectively known as the Auxiliaries.

Electric Locomotive comprising of the following parts:

a) Transformer (including Tap-Changer)

b) Rectifier
c) Smoothing Reactor
d) Traction Motors
e) Main Starting Resistances (in DC Traction on Dual Power Locos only)
f) Dynamic Braking Resistance Cooling Blower

The motors are the primary source of power for the locomotive. They provide the force that moves the wheels and other parts of the locomotive. Generators are responsible for converting mechanical energy from the motors into electrical energy. Rectifiers are used to convert alternating current (AC) from the generator into direct current (DC) that is used to power the motors and other systems. Controllers are responsible for regulating the power output of the motors and other components. Transformers are used to step down electrical voltages to the correct levels for use in the locomotive. Finally, wiring is used to connect the various components of the locomotive together and provide a safe and reliable connection.

Components of a Typical Locomotive Electrical System:

Electric Motors are the primary source of power for a locomotive. These motors are connected to the axle through a series of gears, allowing the engine to generate torque to move the vehicle. Electric motors require a certain amount of electrical current to operate, so the system must include devices to regulate the flow of electricity.

Generators produce the electricity that powers the motors. Generators are typically connected to the axle and spin as the locomotive moves, thus producing the necessary electricity. Generators must be connected to the engine to provide a steady flow of electricity, and the engine must be regulated to ensure that the generators produce the right amount of electricity.

Transformer is a crucial component in electric locomotives. It receives high-voltage AC power from the overhead lines and steps it down to a lower voltage, suitable for powering the locomotive's traction motors, auxiliary systems, and other electrical components.

Pantograph, a critical component of electric locomotives, is a V-shaped metal arm mounted on the roof. It maintains contact with the overhead catenary wire, collecting electrical power and delivering it to the locomotive. The pantograph's ability to move up and down ensures continuous power supply during operation.

The components of the locomotive electrical system work together to provide the engine with the necessary power to move the vehicle. By regulating the flow of electricity and the speed of the locomotive, these components help ensure that the engine runs smoothly and efficiently.

Traction Motors are the heart of electric locomotives, converting electrical energy into mechanical energy. These motors, typically DC or AC types, generate the torque needed to drive the locomotive wheels through gears or drive shafts, enabling acceleration and deceleration.

Inverter is used in locomotives with AC traction motors to convert DC power into AC power for motor operation. The inverter ensures that the electric motor receives the correct type of power needed for efficient operation and allows for precise speed control by adjusting the frequency and amplitude of the AC current supplied to the motors.

The **Control Systems**, often based on microprocessors, manage the overall operation of the locomotive, including speed control, braking, and system diagnostics. These systems monitor sensors throughout the locomotive to ensure optimal performance, automatically adjusting power to the traction motors, regulating braking, and maintaining safety systems. The control system ensures that all components work in harmony for smooth and safe operations.

Circuit Breakers and protection devices are critical for ensuring the safety of the electrical system by preventing damage caused by overloads, short circuits, or other electrical faults. These protection devices automatically disconnect electrical circuits when they detect faults, minimizing the risk of damage to the locomotive's electrical components and preventing dangerous situations.

Battery Storage in a locomotive provide an on-board energy storage solution for backup power and supply electricity for non-traction needs when the main power supply is unavailable. Batteries are essential for powering systems such as lighting, air conditioning, control panels, and emergency braking. They also allow for smoother operation during regenerative braking, where energy is stored and reused.

Types of Electronics Used in Locomotives:

The integration of advanced electronics in locomotives is becoming increasingly critical, as railroads modernize. These systems empower train engineers to efficiently monitor and control locomotive performance, leading to enhanced operational efficiency, safety, and reliability. The key electronic systems in modern locomotives optimize performance by leveraging real-time data and sophisticated controls, ensuring peak functionality and minimizing operational disruptions.

Microprocessors or Electronic Control Units (ECUs) are at the core of these systems, which oversee and regulate various locomotive functions. These units collect data from multiple sensors to monitor and manage vital components such as the engine and braking systems, facilitating optimal operation and performance.

Communication Systems in locomotives enable seamless interaction between engineers, other locomotives, and dispatchers. These systems support real-time messaging and coordination, helping to streamline train operations and address any technical issues swiftly. They also monitor the health of the locomotive, providing alerts when maintenance or repairs are required.

Navigation Systems further enhance safety and efficiency by guiding engineers in route selection and alignment. Utilizing GPS and other sensors, these systems provide real-time information on terrain, obstacles, and potential hazards. They also track the locomotive's speed, direction, and location, enabling engineers to make data-driven decisions to ensure safe and efficient train operations.

By incorporating these electronic systems, locomotives are better equipped to meet the demands of modern rail operations, ensuring safer, more efficient, and reliable performance.

Locomotive production scenario in Indian railways

The growing need for locomotive production in India is driven by rising freight demands, government initiatives aimed at enhancing logistics infrastructure, and a commitment to modernization within Indian Railways. The locomotive production scenario in Indian Railways for FY25 reflects a robust strategy aimed at increasing capacity and enhancing service efficiency. With ambitious targets for both locomotives and coaches, coupled with plans for exports, Indian Railways is poised to strengthen its operational capabilities significantly while contributing to economic growth and modernization within the transportation sector. Indian Railways has increased its locomotive production target for FY25 by 27%, aiming to produce 1,500 locomotives. This marks a substantial rise from the previous fiscal year, where the target was 1,180 locomotives. Additionally, according to the media reports, 1,300 WAG 9H locomotives will be made annually in FY26 and FY27, while 200 units of the WAP 7 variant will be manufactured every year in this period. Besides locomotives, the production plan for 50 Amrit Bharat trains has also been approved for FY25. This will mean production of 1,230 coaches at the production units of the railways.

India is set to begin exporting locomotives in 2025, marking a significant step towards establishing itself as a global locomotive manufacturing hub. This initiative aligns with the Indian government's "Make in India" and "Make for the World" initiatives, which are part of the broader Atmanirbhar Bharat vision aimed at boosting domestic manufacturing and enhancing global competitiveness. For instance, Wabtec Locomotive, a joint venture between Indian Railways and Wabtec Corporation, will commence exports of its Evolution Series ES43ACmi locomotives to an African customer in 2025. These locomotives will be manufactured at the company's Marhowra plant in Bihar. The ES43ACmi boasts a 4,500 HP Evolution Series engine, renowned for its fuel efficiency and proven performance in challenging high-temperature environments. The Marhowra plant's foray into global exports of standard-gauge locomotives will not only expand the local supplier network but also foster long-term job creation, thereby contributing significantly to the Indian economy. By aligning with national initiatives aimed at boosting local production and enhancing global competitiveness, India is poised to become a significant player in the international locomotive market, fostering economic growth in the process.

Overview of current locomotive & rolling stock infrastructure in Indian railways

India's locomotive production is a significant component of its railway infrastructure, with several key manufacturing units contributing to the nation's rolling stock. Here's an overview of the major locomotive production facilities and their recent outputs:

a) Banaras Locomotive Works (BLW), Varanasi:
Production Achievement: In the fiscal year 2023-24, BLW manufactured a record 475 locomotives, surpassing its target of 460. This includes 470 electric locomotives for Indian Railways and five diesel locomotives for domestic customers.

b) Chittaranjan Locomotive Works (CLW), West Bengal:
Production Capacity: CLW is recognized as one of the world's largest locomotive manufacturers. In the fiscal year 2019-20, it produced 431 locomotives.

c) Electric Locomotive Factory (ELF), Madhepura, Bihar:
Joint Venture: A collaboration between Alstom SA (74% equity) and the Ministry of Railways (26% equity).

d) Production Milestones: By March 2023, the factory delivered its 300th high-power WAG-12B locomotive. The project aims to produce a total of 800 such locomotives over 11 years.

e) Production Targets:
Future Plans: For the fiscal year 2024-25, Indian Railways has set an ambitious target to produce 1,500 locomotives, marking a 27% increase from the previous year. This includes 1,240 WAG-9H freight locomotives and 260 WAP-7 passenger locomotives.

These production facilities play a crucial role in supporting and expanding India's railway network, ensuring the availability of modern and efficient locomotives for both freight and passenger services.

As of January 19, 2025, Indian Railways has made significant strides in increasing its locomotive production capacity. Here's a detailed overview based on the latest data and trusted sources:

Current Locomotive Production Targets

a) Increased Production Goals:

Indian Railways has raised its locomotive production target for the fiscal year 2025 (FY25) by 27%, setting a goal to produce 1,500 locomotives. This includes:

- 1,240 WAG 9H freight locomotives.
- 260 WAP 7 passenger locomotives.

b) Stability in Production Plans:

The production target is expected to remain stable at 1,500 units annually until FY27. This includes plans for:

- 1,300 WAG 9H locomotives each year in FY26 and FY27.
- 200 units of the WAP 7 variant annually during the same period.

c) Coaches Production:

In addition to locomotives, Indian Railways plans to produce 8,145 coaches in FY25, which marks an increase from the previous fiscal year's target of 6,560 coaches. This includes:

- Production of 50 Amrit Bharat trains, translating to 1,230 coaches.
- Manufacturing of 5,688 Linke Hofmann Busch (LHB) coaches, with most produced at the Modern Coach Factory in Raebareli.

Strategic Initiatives and Investments

a) Government Budget Allocations:

- The budget for rolling stock has been set at approximately ₹54,113 crore for FY24-25, which is an increase from previous allocations. This budget is expected to focus on modernizing and expanding the railway network.
- The upcoming Railway Budget for FY26 is anticipated to allocate a substantial portion towards new trains, upgraded stations, and modern infrastructure.

b) Export Initiatives:

- Indian Railways plans to start exporting locomotives in 2025 through its joint venture with Wabtec at the Marhowra plant in Bihar. The plant is expected to supply Evolution Series ES43ACmi locomotives to global customers, marking India's entry into the international locomotive market.

c) Focus on Freight Services:

- The increase in locomotive production is part of a broader strategy to enhance freight train services in response to rising demand. This aligns with the government's goals for economic growth and infrastructure development.

Technological Advancements:

a) Modern Locomotive Development:

- There is a strong emphasis on investing in modern locomotives such as the WAG-12 series for improved power generation and operational efficiency.
- The introduction of advanced technologies like electric traction systems and automated controls is expected to enhance performance across the fleet.

b) Infrastructure Enhancements:

- Indian Railways has committed to upgrading existing infrastructure and expanding its network by adding new lines, gauge conversions, and electrification projects.

Innovations In Rolling Stock

The introduction of the Vande Bharat Express, in 2019, was a major feat achieved by IR in terms of indigenisation. However, with continuous upgrades over the years, IR has launched multiple variants of this train, including the Vande Bharat Express 2.0, 20-coach Vande Bharat Express and Vande Metro (Namo Bharat Rapid Rail). Further, the first prototype of the Vande Bharat Sleeper train has been rolled out for field trials by the Research Designs and Standards Organisation (RDSO) in December 2024, while the first look of the Vande Cargo was unveiled in September 2024. In addition to the Vande Bharat Express, the Amrit Bharat Express was launched in January 2024.

In line with the railways' goal of achieving net zero carbon emissions by 2030, the final trial for India's first hydrogen train will take place during January-March 2025. The design for this train has been completed and it will consist of eight passenger coaches, with the capacity to carry more than 2,600 passengers on a single journey, and three coaches for storing hydrogen cylinders. Recently, a toy model of this train was launched at the RDSO stadium in Lucknow in November 2024. Currently, Germany is the only country with operational hydrogen trains, running a two-coach model. The operationalisation of these indigenously

developed hydrogen trains can create significant opportunities for India, in terms of first-mover advantage, further facilitating the country's exports.

Domestic Manufacturing of Components

Amid disruptions in global supply chains due to recent geopolitical shocks, IR has adopted a proactive approach towards strengthening domestic capacity. Local sourcing of railway components plays a key role in building resilient domestic supply chains, ensuring smoother operations within the sector. Around 80-85% of the components for Vande Bharat trains have been sourced from domestic suppliers. Telangana became home to India's largest private rail manufacturing in June. With an expenditure of Rs 1,000 crore, the private rail coach manufacturing can produce 500 coaches and 50 locomotives per year. It will produce all sorts of railway rolling stock, including as coaches, train sets, locomotives, metro trains, and monorails. Further, with the aim of reducing import dependency on forged wheels (from Ukraine and China) while simultaneously boosting exports, IR acquired a forged wheel plant from Rashtriya Ispat Nigam Limited in Raebareli, Uttar Pradesh, for around Rs 23 billion. This initiative not only reduces India's reliance on foreign technology but also enhances its manufacturing capabilities.

Domestic private players in the railways component manufacturing industry have stepped up to utilise this opportunity. For example, in September 2024, Jindal Stainless Limited provided IR with high-strength 301LN (low carbon, nitrogen alloyed) grade austenitic stainless steel to produce Vande Bharat Sleeper train coaches. Further, in July 2024, Vishvas Power Engineering Services Limited despatched a total of two 2×25 kV AC traction system transformers to IR. These are the first indigenously manufactured two-phase transformers that have been transported to the states of Bihar and Jharkhand.

With India being an ideal investment destination, offering lower interest rates and higher returns on investment, global players have also announced their plans to set up component manufacturing facilities. Alstom Holdings is planning to manufacture large batteries that can power Vande Bharat and Vande Metro train services for railway traction parts in India by 2025. Initially, the batteries will be imported from France, but the company aims to manufacture indigenous cells in India gradually. Meanwhile, CJSC Transmashholding is planning to develop several facilities for train and component manufacturing in India to meet their domestic requirements.

Integrated Rail Technologies

The advancements in IR's fleet and components have given a boost to technology adoption in the sector. With newer and faster trains getting launched, their safety has become paramount. IR is currently in the process of upgrading the indigenously developed automatic train protection system Kavach, from Kavach 3.2 to Kavach 4.0, in their existing fleet. The newer variants, such as Vande Sleeper and Vande Metro, will be launched with the upgraded Kavach version. In December 2024, IR announced plans to implement an integrated track monitoring system (ITMS) across all its railway zones, at an investment of approximately Rs 1.8 billion, to enhance track safety. The ITMS features contactless track monitoring through laser sensors, high-speed cameras, light detecting and ranging technology, and other advanced tools.

IR has also implemented a live monitoring system in the northern part of West Bengal to increase train safety and prevent accidents. Further, in line with this system, it has also launched helmet cameras. These cameras will help in recording and monitoring the train's parts, such as wheels and bearings, that are in motion.

IR is working on developing AI-based robots for monitoring its railway tracks, to ensure the safety and better operation of trains. These robots will be able to detect track issues such as rail cracks, water on tracks, petrol clips and fishplates, etc., and can further report real-time data of the same to the railway staff. Further, in June 2024, IR awarded a contract to Sensonic IN India Private Limited for the deployment of an advanced elephant detection system, also known as the Gajraj system, on East Coast Railway (ECoR) routes.

Increase In Collaborations

In recent years, the railway sector has seen an increase in partnerships between private players and IR. This is expected to foster innovation and positively impact the sector's net exports. A key example is Taural India Private Limited partnering with IR to provide aluminium casting solutions for the Amrit Bharat Express train. The aluminium gear cases manufactured by the company led to the replacement of imported aluminium casting elements from Germany. Further, Uniproducts India Limited has collaborated with the Integral Coach Factory (ICF), Chennai, to provide sound and thermal insulation materials for the Vande Bharat Express project.

In addition, the consortium of Ramkrishna Forgings Limited and Titagarh Rail Systems Limited is likely to start the manufacturing of forged wheels for Vande Bharat trains by July 2025. The facility will have a total annual production capacity of 250,000 units, which includes 80,000 to be used in India and the rest for export.

Private players in India partnering with foreign companies for railway component manufacturing has gained significant momentum in recent years. This collaboration is driven by the need to modernize and expand India's railway infrastructure, enhance domestic manufacturing capabilities, and leverage advanced technologies. For instance, AT Railway, a subsidiary of Amber Enterprises India Ltd., has partnered with South Korea's Yujin Machinery Ltd. to form a joint venture focused on designing and manufacturing key railway components such as driving gears, couplers, and pantographs. With AT Railway holding the majority stake, the collaboration strengthens domestic manufacturing capabilities and aligns with India's 'Make in India' and 'Atmanirbhar Bharat' initiatives, while gaining access to advanced technology and expertise from Yujin Machinery Ltd.

Strategic Vision

The indigenisation of IR is crucial for achieving cost effectiveness, since locally manufactured components reduce procurement and maintenance costs. Moreover, the push for local manufacturing will lead to innovation and skill development through research, development and training within the railway sector. In line with this, the sector is placing significant emphasis on high-speed rail initiatives. IR has commenced manufacturing its indigenous bullet train, which is being developed on the Vande Bharat platform. The ICF at Chennai is responsible for developing the train's design.

With the development of a more futuristic approach and advanced technology, private players in India are experimenting with hyperloop technology. For instance, TuTr Hyperloop Private Limited, in partnership with the Chennai Unified Metropolitan Transport Authority, has completed the construction of India's first Hyperloop test track, stretching 410 metres. In December 2024, TuTr Hyperloop successfully conducted initial trials of the technology at a speed of 100-150 km per hour. The project is located at the discovery campus of IIT Madras in Thaiyur, Chennai.

The shift towards self-reliance in the railways aligns with the broader goal of "Atmanirbhar Bharat", which was highlighted by the Indian government to bolster the domestic economy, generate employment and enhance technological capabilities.

Locomotive addition pattern by Indian railways: Analysis of past trend

The locomotive production and addition pattern in Indian Railways has shown a consistent trend of increasing capacity to meet growing transportation demands. With record production levels achieved in recent years and ambitious targets set for the future, Indian Railways is well-positioned to enhance its operational efficiency while contributing to environmental goals.

The landscape of electric locomotive production in India is characterized by a combination of domestic manufacturing capabilities through Indian Railways (Chittaranjan Locomotive Works (CLW), Banaras Locomotive Works (BLW), Madhepura Electric Loco Factory, Patiala Locomotive Works (PLW)) and partnerships with global leaders like Alstom and Siemens.

Previous Achievements:

According to Railway Ministry data, India's annual electric locomotive production has increased more than threefold between 2009-10 and 2022-23, rising from 246 to more than 1,200 units.

Banaras Locomotive Works (BLW) achieved a remarkable milestone by producing 475 locomotives, exceeding the target set by the Railway Board for the 2023-24 financial year. Of these, BLW manufactured 470 electric locomotives for Indian Railways and 5 diesel locomotives for domestic customers. It has set a notable achievement in locomotive manufacturing by achieving the highest-ever monthly electric locomotive production in January 2024. With an impressive display of dedication, hard work, and efficiency, BLW's team produced 55 electric locomotives within just 26 working days, averaging more than 2 locomotives per day.

Here are past Three years data for Locomotives produced by major players working under IR:

Company	2021-22	2022-23	2023-24
Chittaranjan Locomotive Works (CLW)	486	436	580
Banaras Locomotive Works (BLW)	367	346	420
Patiala Locomotive Works (PLW)	116	198	180
Total	**969**	**980**	**1180**

Source: Ministry of Railways

Accelerate Skills to meet the Demand:

BLW employees and executives rose to the challenge by acquiring new skills and reorganising the shop floor, machines, jigs and fixtures and planning processes for the production of electric locomotives. The result of this process is that a record of production of 55 electric locomotives was set in just one month, while diesel locomotives are also manufactured from the same assembly line for export and non-railway customers.

Aspect	2021-2022	2022-2023	2023-2024
Total Locomotives Produced	~900+	980	~1,200 (target of 1,500 for FY 2024-25)
Diesel Locomotives	~10% of total output	Minimal, mainly for exports	Few units produced for niche uses
Chittaranjan Locomotive Works (CLW) Contribution	486 electric locomotives	436 electric locomotives	Estimated ~500 units
Banaras Locomotive Works (BLW) Contribution	Transition to electric locomotives	300+ electric locomotives	400+ electric locomotives production plan
Patiala Locomotive Works (PLW) Contribution	Smaller contribution (~116 units)	198 electric locomotives	180+ production plan
Electric Freight Locomotives	Large production share (WAG series)	Dominated by WAG series locomotives	Expansion with WAG-9 and WAG-12 models
Electric Passenger Locomotives	WAP series models introduced gradually	Substantial production of WAP-7 models	Continued emphasis on WAP-7 models
Diesel Locomotives for Export	Small output, specific for exports	Limited export production (to Sri Lanka, Bangladesh)	Continued limited export focus
Sustainability Focus	Initial steps toward sustainability	Increased emphasis on electrification	Push for 100% electrification by 2030

Electrification Milestones	Steady progress in electrification	85% of total broad-gauge routes electrified	Over 90% broad-gauge electrification
Technological Advancements	Upgraded electric locomotive designs	Enhanced safety and performance features	Focus on high-power (12,000 HP) locomotives
Production Capacity Utilization	Moderate, transitioning too electric	High-capacity utilization at major units	Peak utilization with record output

Source: Indian Railways

Key Observations Across Years:

1. 2021-22:
    - Focus on transitioning production units toward electric locomotives.
    - Diesel locomotives still had a presence, primarily for exports.
    - CLW led production, with ~431 electric locomotives delivered.
2. 2022-23:
    - Record-breaking production of 785 electric locomotives by January 2023.
    - Significant contributions from BLW (286 units) and PLW (155 units).
    - Reflects enhanced production capabilities and the increasing focus on electrification.
3. 2023-24:
    - Targeted production of 1,200 locomotives (1,250 estimated achieved).
    - BLW reported its highest-ever production, manufacturing 475 locomotives.
    - Continued dominance of WAG-9 and WAP-7 electric locomotives for freight and passenger operations.
    - Steady movement toward 100% electrification, nearing 90% coverage of broad-gauge routes.

Future Projections (2024-25 and further):

- Indian Railways targets 1,500 locomotives for FY 2024-25.
- Focus on high-capacity freight locomotives (WAG-12) and modern passenger engines.

Continued phasing out of diesel locomotives, except for niche and export markets.

Key Demand Drivers

Insight on railway locomotive capacity expansion plans & its impact.

Indian Railways is undergoing significant capacity expansion in its locomotive production and overall railway infrastructure.

Current Capacity Expansion Plans:

- Increased Production Targets: Indian Railways has set a target to produce 1,500 locomotives for the fiscal year 2025 (FY25), an increase of 27% from previous years. The production plan is expected to remain stable at 1,500 units annually until FY27, with plans to manufacture 1,300 WAG 9H locomotives and 200 WAP 7 units each year during this period.

- Coaches Production: Alongside locomotives, Indian Railways aims to produce 8,145 coaches in FY25, which marks an increase from the previous production target of 6,560 coaches in FY24. This includes:
  - 50 Amrit Bharat trains, translating to approximately 1,230 coaches.
  - Production of 5,688 Linke Hofmann Busch (LHB) coaches, with a focus on safety and comfort improvements.

- Infrastructure Investments: The budget for rolling stock has been set at approximately ₹54,113 crore for FY25, which is an increase from previous allocations. The upcoming budget for FY26 is expected to allocate further resources towards expanding locomotive capacity and modernizing infrastructure.

Impact of Capacity Expansion Plans:

- Economic Growth and Job Creation: The expansion of locomotive production is expected to create jobs in manufacturing and associated sectors. Increased production will require skilled labour and may lead to the establishment of new manufacturing facilities.

- Enhanced Freight Capacity: With a focus on producing more freight locomotives (WAG 9H), Indian Railways aims to improve its freight capacity significantly. This is crucial as freight traffic is projected to grow due to increased demand from various sectors.

- Improved Passenger Services: The introduction of more passenger locomotives (WAP 7) will enhance service frequency and reduce travel times for passengers. The addition of modern trains like Vande Bharat will further improve the overall travel experience.

- Sustainability Initiatives: Indian Railways is focusing on sustainability through electrification and the introduction of hydrogen trains. The operationalization of hydrogen trains is expected in early 2025, aligning with India's goal of achieving net-zero carbon emissions by 2030.

- Technological Advancements: Investments in advanced technologies such as AI for operational efficiency and the Kavach safety system will enhance safety and reliability across the network. The modernization efforts are expected to streamline operations and reduce delays.

- Export Opportunities: Indian Railways plans to begin exporting locomotives in 2025, marking a significant step towards establishing India as a global player in locomotive manufacturing 7. This could open up new revenue streams and enhance India's position in international markets.

- High-speed rail and infrastructure developments: A notable project includes the high-speed rail corridor between Mumbai and Ahmedabad, currently under construction at a cost of ₹1.08 lakh crore. Once completed, it will reduce travel time to just two hours, with trains running at speeds of up to 320 km/h. The Dedicated Freight Corridor, spanning over 3,300 km, is also being developed to enhance freight efficiency and decongest passenger lines.
  Indian Railways has completed 15,861 km of track doubling since fiscal 2016, further boosting network capacity. Additionally, 82 Vande Bharat and eight Tejas Express trains are operational, while 144 locomotives have been equipped with Kavach, an indigenous automatic train protection system.

- Station Modernisation and Digital Advancements: The Amrit Bharat Station Scheme aims to redevelop 553 railway stations across the country, with ₹1 lakh crore allocated for the project. Improvements include enhanced waiting areas, digital ticketing systems, and green buildings. Indian Railways has also installed free Wi-Fi at over 6,000 stations and introduced a next-generation e-ticketing system capable of processing 26,000 tickets per minute.

Initiatives by Indian Railways to Modernize its Locomotive & Rolling Stock, and Its Impact

Indian Railways is actively implementing several initiatives aimed at modernizing its locomotive and rolling stock. These initiatives are designed to enhance passenger services, improve operational efficiency, and ensure safety across the railway network. Below is a detailed description of these initiatives along with their anticipated impacts.

a) Locomotive Expansion Plans

- Indian Railways has implemented a long-term plan to acquire new technology, including 12,000 HP electric locomotives and 9,000 HP electric locomotives for freight operations.

b) Replacement of Older Coaches with LHB Coaches

- **Description**: Indian Railways has been systematically replacing older Integral Coach Factory (ICF) coaches with Linke-Hofmann-Busch (LHB) coaches since April 2018. LHB coaches are designed for enhanced safety and passenger comfort, featuring better crashworthiness and modern amenities.

- **Impact**: The transition to LHB coaches is expected to significantly improve passenger safety and comfort, potentially increasing ridership and customer satisfaction. The LHB design allows for higher speeds and better stability, which contributes to a more reliable service.

c) Introduction of Advanced Rolling Stock

- **Description**: The deployment of Vande Bharat trains represents a major leap in technology and comfort for Indian Railways. These trains come equipped with modern amenities such as GPS-based passenger information systems, Wi-Fi, bio-toilets, and upgraded interiors. The Vande Bharat sleeper trains are also in the final stages of testing and certification.

- **Impact**: Vande Bharat trains are expected to reduce travel times significantly while providing a more comfortable travel experience. This modernization aims to attract more passengers and enhance the overall perception of rail travel in India.

d) Electrification Initiatives

- **Description**: Indian Railways has made significant progress in electrifying its network, with approximately **97% of broad-gauge tracks** now electrified. This initiative reduces dependence on fossil fuels and enhances operational efficiency. Moreover, between 2014 and 2023, Indian Railways has invested approximately ₹43,346 crore in electrification efforts, with an additional ₹8,070 crore allocated for the fiscal year 2023-24.

- **Impact**: Electrification leads to lower operational costs and reduced carbon emissions, contributing to India's sustainability goals. It also allows for faster train speeds and improved reliability in service delivery.

e) Safety Enhancements through the Kavach System

- **Description**: The Kavach system is an automatic train protection system being implemented across the railway network to prevent accidents due to signal failures or human errors. However, progress has been slow; as of FY24, only **1,445 km** of the railway network is equipped with the system.

- **Impact**: Enhanced safety measures through the Kavach system are expected to reduce the number of accidents significantly, thereby improving public confidence in rail travel as a safe mode of transportation.

f) Investment in Infrastructure

- **Description**: The budget for rolling stock has been set at approximately ₹54,113 crore for FY25, which includes investments in new locomotives, upgrading existing infrastructure, and enhancing safety features.

- **Impact**: Increased funding will facilitate comprehensive upgrades across the railway network, improving service reliability and capacity. This investment is critical for meeting growing passenger demands.

g) Indigenization Efforts

- **Description**: To reduce dependence on foreign suppliers, Indian Railways is focusing on manufacturing equipment domestically. Collaborations with private manufacturers aim to enhance technological capabilities within India.

- **Impact**: Indigenization supports local industries while ensuring that technology transfer occurs within the country. This fosters innovation and helps build a self-reliant railway ecosystem.

h) Deployment of Smart Technologies

- **Description**: The integration of AI-driven operations and Internet of Things (IoT) applications is transforming how Indian Railways operates. This includes real-time monitoring systems for trains and track conditions.

- **Impact**: Smart technologies can lead to improved maintenance schedules, better resource allocation, enhanced operational efficiency, and reduced delays.

Anticipated Impacts of Indian Railways' Modernization Initiatives

As Indian Railways embarks on extensive modernization initiatives, the anticipated impacts can be categorized into several key areas, including passenger experience, safety, operational efficiency, economic growth, and environmental sustainability. Below is a detailed description of these impacts based on the latest developments and trends.

a) Enhanced Passenger Experience

- **Modern Amenities:** The introduction of advanced trains like Vande Bharat has revolutionized passenger travel with features such as automatic sliding doors, GPS-based passenger information systems, and bio-toilets. These enhancements are designed to make journeys more comfortable and efficient.

- **Digital Innovations:** The implementation of digital ticketing systems, QR codes, and real-time tracking apps has streamlined the booking process and improved accessibility. Passengers can now book tickets online, check train statuses in real time, and enjoy Wi-Fi services at major stations.

- **Customer-Centric Services:** Initiatives such as the redesign of passenger coaches to meet international standards enhance safety and comfort. Features like emergency talk-back systems and infotainment options further improve the overall travel experience.

b) Increased Safety

- **Technological Upgrades:** The adoption of the Kavach automatic train protection system aims to minimize human errors and enhance operational safety. This system helps prevent accidents due to signal failures or over-speeding.

- **Infrastructure Improvements:** The elimination of manned level crossings on critical routes enhances safety by reducing the risk of collisions. Additionally, CCTV installations and improved lighting at stations bolster security for passengers.

- **Modern Signaling Systems:** Upgrading signaling systems to include European Train Control System (ETCS) improves safety by ensuring that trains adhere to speed limits compatible with signaling permits.

c) Operational Efficiency

- **Electrification Benefits:** With approximately 97% of broad gauge tracks electrified, Indian Railways is expected to see lower operational costs and increased train speeds. Electrification also reduces reliance on diesel fuel, contributing to cost savings.

- **Predictive Maintenance:** The use of AI and IoT technologies for predictive maintenance allows for real-time monitoring of train conditions, leading to optimized maintenance schedules and reduced downtime.

- **Improved Freight Operations:** With the introduction of dedicated freight corridors (DFCs), the efficiency of freight transport is expected to increase significantly. This will facilitate faster movement of goods across the country.

d) Economic Growth

- **Job Creation:** The expansion of manufacturing capabilities and infrastructure development is likely to create jobs within the railway sector as well as in associated industries. Increased production targets for locomotives and coaches will require skilled labor.

- **Boosting Local Economies:** Enhanced rail connectivity can stimulate regional economies by improving access to markets, thereby facilitating trade and commerce. This is particularly important for remote areas that rely on rail transport for goods movement.

- **Increased Tourism:** The introduction of premium trains on tourism routes is expected to boost tourism revenues by providing better connectivity to popular destinations.

e) Environmental Sustainability

- **Reduction in Carbon Footprint:** Electrification and the shift towards cleaner technologies align with India's commitment to reducing carbon emissions. By promoting electric trains over diesel-powered ones, Indian Railways contributes significantly to sustainability goals.

- **Solar Power Initiatives:** Indian Railways is exploring solar power generation along its tracks, which will not only reduce energy costs but also promote renewable energy usage within its operations.

- **Water Conservation Measures:** New train designs include water-saving toilets that minimize water usage without compromising hygiene standards.

Regulatory Landscape

Regulatory / Policy Framework Governing the Industry.

- The Ministry of Electronics & Information Technology (MeitY) notified the "Electronics and Information Technology Goods (Requirement for Compulsory Registration) Order, 2012" on October 3, 2012. This order will be superseded by the "Electronics and Information Technology Goods (Requirement of Compulsory Registration) Order, 2021."
- As per the Order, no person shall manufacture or store for sale, import, sell or distribute goods which do not conform to the Indian Standard specified in the Order. Manufacturers of these products are required to apply for registration from the Bureau of Indian Standards (BIS) after getting their product tested from BIS-recognized labs.
- Bureau of Indian Standards (BIS) then registers the manufacturers under its registration scheme who are permitted to declare that their articles conform to the Indian Standard (s). The registered manufacturers are then allowed to use the Standard Mark notified by the Bureau.
- The development of the supply chain is essential for the manufacturing of electronic products with higher domestic value addition. The vision of National Policy on Electronics 2019 (NPE 2019) is to position India as a global hub for Electronics System Design and Manufacturing (ESDM) by encouraging and driving capabilities in the country for developing core components, including chipsets, and creating an enabling environment for the industry to compete globally.
- Electronic components are the basic building blocks for the electronics industry and entail maximum value addition. Therefore, a vibrant electronic components manufacturing ecosystem is vital for the overall long-term and sustainable growth of electronics manufacturing in India and essential to achieving net positive Balance of Payments (BoP).
- The Scheme for Promotion of Manufacturing of Electronic Components and Semiconductors (SPECS) notified vide Gazette Notification No.CG-DL-E-01042020-218992 dated 1st April 2020, will help offset the disability for domestic manufacturing of electronic components and semiconductors to strengthen the electronics manufacturing ecosystem in the country.
- The scheme will provide a financial incentive of 25% on capital expenditure for the identified list of electronic goods that comprise the downstream value chain of electronic products, i.e., electronic components, semiconductor/ display fabrication units, ATMP units, specialized sub-assemblies, and capital goods for manufacture of aforesaid goods, all of which involve high value-added manufacturing.
- The Scheme will apply to investments in new units and expansion of capacity/ modernization and diversification of existing units. Application under the Scheme can be made by any entity registered in India.
- The capital expenditure will be the total expenditure in plant, machinery, equipment, associated utilities, and technology, including for Research & Development (R&D).

- The Scheme is open for applications initially for 3 years from the date of its notification. Incentives under the Scheme will be applicable from the date of acknowledgment of the application. The incentives will be available for investments made within 5 years from the date of acknowledgment of application.
- The Scheme will be implemented through a nodal agency which will act as Project Management Agency (PMA) and be responsible for providing secretarial, managerial, and implementation support and carrying out other responsibilities as assigned by MeitY from time to time.
- Indian Railways Policy Circular No. 7 (Opening of Sections and Sanction of Sectional Speed on Indian Railways)
    - Tracks on Indian Railways are certified for varying speeds by competent levels, including CRS. Rolling stocks are designed for different speeds, and RDSO and Zonal Railways seek approval from the Railway Board for any design infringements against the IRSOD (Indian Railways Schedule of Dimensions).
    - To open a new line for traffic, use electric motive power on an existing line, or commission a line after gauge conversion, follow the rules and procedures outlined in the "Railways (Opening For Public Carriage Of Passengers) (Amendment), Rules, 2005".
    - New railway lines can be created in several ways: by extending current tracks, adding new tracks alongside existing ones (like double or triple tracks), or converting existing tracks to a different gauge. Additionally, existing lines can be upgraded to use electric traction instead of traditional fuel-based engines.

Policy initiatives /Government incentives designed to promote the industry activity

Currently, India is undergoing a digital revolution leading to a surge in the consumption of electronic devices in India. This growth is mainly attributed to the increasing middle-class population, rising disposable incomes, and declining electronics prices in the country.

- Major Government initiatives such as 'Digital India', 'Make in India', and supportive policies including a favourable FDI Policy for electronics manufacturing have simplified the process of setting up manufacturing units in India.
- The Union Budget 2023-24 allocated INR 16,549 crore (USD 2 Bn) for the Ministry of Electronics and Information Technology, which is nearly 40% higher on year.
- The government-allocated investment of INR 8,803 crore (USD 1.06 Bn) has been made under the scheme for the promotion of manufacturing of electronic components and semiconductors.
- The PLI scheme for large-scale electronics manufacturing has attracted an incremental investment of INR 8,390 crore (USD 1.01 Bn) in June 2024.
- India committed to reach USD 300 Bn worth of electronics manufacturing and exports by 2025-26. Artificial Intelligence is expected to add USD 967 Bn to the Indian economy by 2035 and USD 450–500 Bn to India's GDP by 2025, accounting for 10% of the country's USD 5 Tn GDP target.
- The Government is promoting the development of Electronics Manufacturing Clusters (EMCs) throughout the Country to provide world-class infrastructure and facilities. India is home to considerable talent for electronic chip design and embedded software.
- Exports of electronic goods stood at USD 2,009 Mn in September 2022. The Government of India aims to make Electronics Goods amongst India's 2-3 top-ranking exports by 2026. Electronic goods exports are expected to increase from the projected USD 15 Bn in 2021-22 to USD 120 billion by 2026. Moreover, post-COVID, The Government of India aims to increase India's contribution by around USD 400 billion Bn worth of electronics goods including exports worth USD 120 Bn, which would account for 9-10% of the overall global value chains, from the current supply potential of 1-2%.
- Production-linked scheme (PLI) for large-scale electronics manufacturing (including mobiles) has seen investments worth INR 6,887 crore (USD 833 Mn) (till June 2023), already surpassing the target for FY24 which was INR 5,488 crore (USD 664.4 Mn).
- India's electronics sector is set to harness USD 7 Bn untapped revenue by 2035 via circular business model and policy pathways, industry stakeholders said. Current commitments and targets set the projected market size for these circular models at USD 13 Bn in 2035.
- The Ministry of Electronics and IT (MeitY) announced the exchange of signing of a Memorandum of Understanding (MoU) between the Centre for Nano Science and Engineering (CeNSE) at the Indian Institute of Science (IISc), Bengaluru, and Lam Research India at the SemiconIndia in Gandhinagar.
- India Semiconductor Mission organized a three-day SemiconIndia 2023 Conference in July 2023 with the theme 'Catalysing India's Semiconductor Ecosystem' in Gandhinagar, Gujarat. In March 2023, the

Government approved the setting up of the Electronics Manufacturing Cluster (EMC) at Hubli-Dharwad in Karnataka, worth INR 180 crore (USD 22 Mn) and is expected to create about 18,000 jobs.

- The Indian startup ecosystem has experienced a surge over the years, due to rapid technological advancements, increasing internet penetration, growing digital infrastructure, rising startup culture, government initiatives like Digital India, Make in India, and Startup India, as well as a large pool of skilled workforce.
- India has witnessed an exceptional surge in the creation and funding of startups as the country has solidified its position as a major global center for innovation and businesses. However, securing adequate funding remains a significant task for startups, often leading to survival challenges.
- Indian Railways has made a significant stride in fostering innovation through collaboration with startups and businesses. On June 13, 2022, the Ministry of Railways launched the "Startups for Railways" initiative. This project aims to leverage cutting-edge technologies developed by Indian startups, MSMEs, innovators, and entrepreneurs to enhance operational efficiency and safety within the Indian Railways network. The initiative focuses on addressing issues related to quality, reliability, and maintainability. Under this policy, startups, MSMEs, innovators, and entrepreneurs will retain sole ownership of the intellectual property rights (IPR) generated during the course of the project.
- The inaugural Future Skills Summit was organized by the Ministry of Electronics and Information Technology (MeitY) in collaboration with the National Institute of Electronics and IT (NIELIT) in Guwahati on February 15, 2024.
- Voltas announced plans of INR 400 crore (USD 50.10 Mn) capex under the PLI scheme to manufacture components for white goods in May 2022.
- Ministry of Electronics & Information Technology (MeitY) has announced the “Scheme for Promotion of Semiconductor Ecosystem” in India with a massive outlay of INR 76,000 crore (USD 9.48 Bn) in 2022.
- As per the Union Budget 2022-23, the Ministry of Electronics and Information Technology (MeitY) has been allocated Rs. 14,300 crore (USD 1.73 Bn).
- In the allocated budget, revenue expenditure allocation is INR 13,911.99 crore (USD 1.8 Bn) and capital expenditure allocation is INR 388.01 crore (USD 50.4 Mn).
- About 80% of the Production-Linked Incentive scheme (PLI) encourages manufacturing in the country, which covers 14 industries and has a total investment of INR. 3 lakh crore (USD 38.99 Bn) is concentrated in only three sectors: electronics, automobiles, and solar panel production.
- The government allows 100% FDI in the ESDM sector through an automatic route to attract investments, including original equipment manufacturers (OEMs) and integrated device manufacturers (IDMs). The government has set a target to get ~ INR 18,000 crore (USD 2.4 Bn) investments in the electronics manufacturing segment by 2021-22.

- In May 2021, the cabinet, chaired by Prime Minister Mr. Narendra Modi, approved a proposal by the Department of Heavy Industries and Public Enterprises to implement the production-linked incentive (PLI) scheme 'National Programme on Advanced Chemistry Cell (ACC) Battery Storage' to achieve manufacturing capacity of 50 GWh (Giga Watt Hour) of ACC and 5 GWh of 'Niche' ACC, with an outlay of INR 18,100 crore (USD 2.47 Bn).
- On November 11, 2020, the Union Cabinet approved the production-linked incentive (PLI) scheme in 10 key sectors (including electronics and white goods) to boost India's manufacturing capabilities, and exports and promote the 'Atmanirbhar Bharat' initiative.
- The Electronics Sector Skills Council of India (ESSCI) aims to facilitate a world-class ecosystem for developing a future-ready workforce in the Electronics System Design & Manufacturing Sector. Its mission is to become a global leader in skill development in Electronics by aligning to the product lifecycle – Design, Manufacturing & Service through blended Skilling, R&D, Innovation & adoption of state-of-the-art technologies to reach the masses and lead to the growth of the ESDM sector.
- India Electronics and Semiconductor Association (IESA) acts as a trusted knowledge partner to the Central & State Governments helping device policies & incentives for the ESDM industry to help attract investments into India. To promote technology solutions to positively impact the lives of 1.3 Bn Indian citizens is a key aim of IESA, which it achieves by bridging the gap between academia & industry to bring innovations faster to market.

Energy Efficiency Policy for Indian Railway: With increasing electric locomotives, the demand for electricity by the railways will also be seen growing rapidly. As the railways pursue higher electrification targets, its power requirements are expected to grow from 4000 MW in 2012 to around 15000 MW in 203210.

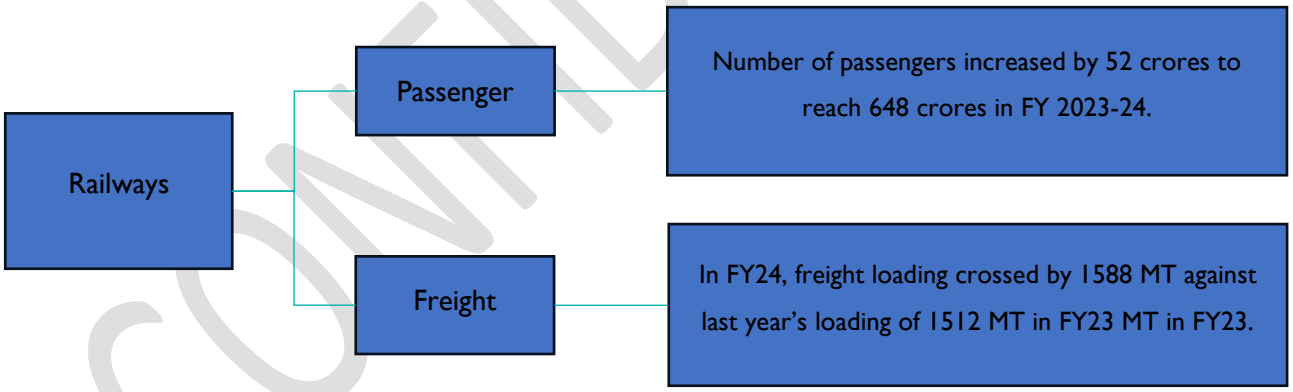
- Energy efficiency measures in Workshops, Production units, Locomotives including use of VFD drives, energy efficient motors, etc.:
    - Installation of energy efficient motors and pumps, VFDs for cranes, pulleys and other variable loads need to be done.
    - VFDs are to be installed to achieve energy savings wherever part load conditions occur.
    - Total cost of ownership of the equipment will be considered for procurement.
- Guidelines have been issued for provision of energy saving mode on three phase locomotives wherein power supply to Oil Cooling Blower (OCB), Traction Motor Blower (TMB) and Scavenge Traction Motor Blower (ScTMB) will be switched off through software logic.
- Use of energy efficient Brushless Direct Current (BLDC) motor fans in coaches and buildings.
- Production Units have completely switched over to production of energy efficient three-phase electric locomotives with regenerative braking features.
- Railways has introduced Insulated-Gate Bipolar Transistor (IGBT) based 3-phase propulsion system with regenerative braking in Electrical Multiple Unit (EMU) trains, Mainline Electrical Multiple Unit (MEMU), Kolkata Metro rakes and Vande Bharat Trains to conserve energy during the operations.

Railway Infrastructure in India

India boasts the fourth-largest railway system globally, behind only the US, Russia, and China. Indian Railways are a mode of land transport for bulky goods and passengers over long distances. The railway gauges vary in different countries and are roughly classified as broad (more than 1.5 m), standard (1.44 m), meter gauge (1 m), and smaller gauge. With a vast network spanning over 126,366 km of tracks and over 7,335 stations, Indian Railways is a crucial mode of transportation for millions.

Railways in India: Achievements and Goals

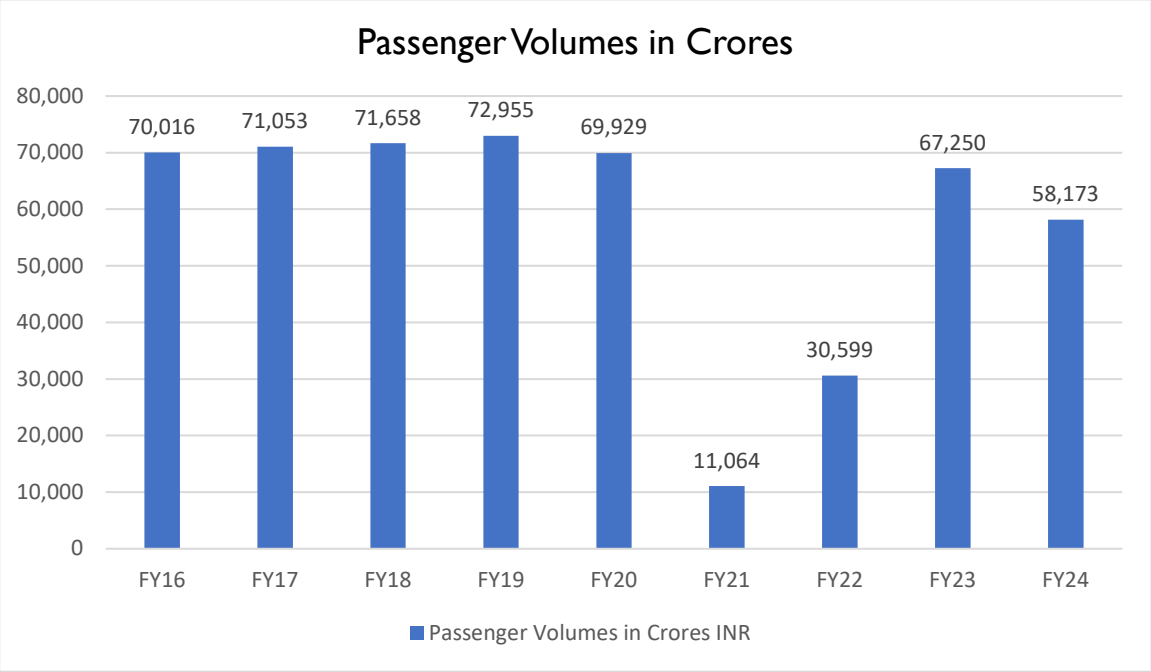
- **Origin:** Railway was first introduced in 1853, from Bombay to Thane during the Governor Generalship of Lord Dalhousie.
- **Global Status:** India ranks 4th globally in railway infrastructure, trailing only the US, Russia, and China.
- **Railways Infrastructure:** Indian Railways encompasses 126,366 km of track and 7,335 stations.
    1. Track Development: During 2022-23, 5,243 km of track was laid, with a record daily average of 14.4 km.
    2. Daily Operations: include 13,523 passenger trains and 9,146 freight trains daily.
    3. Freight loading: reached a record high of 1,512 MT in 2022-23, with a target of 2,024 MT by 2024.



- **Growth in Passenger Volumes and Revenue Generated Through Passenger Trains:**

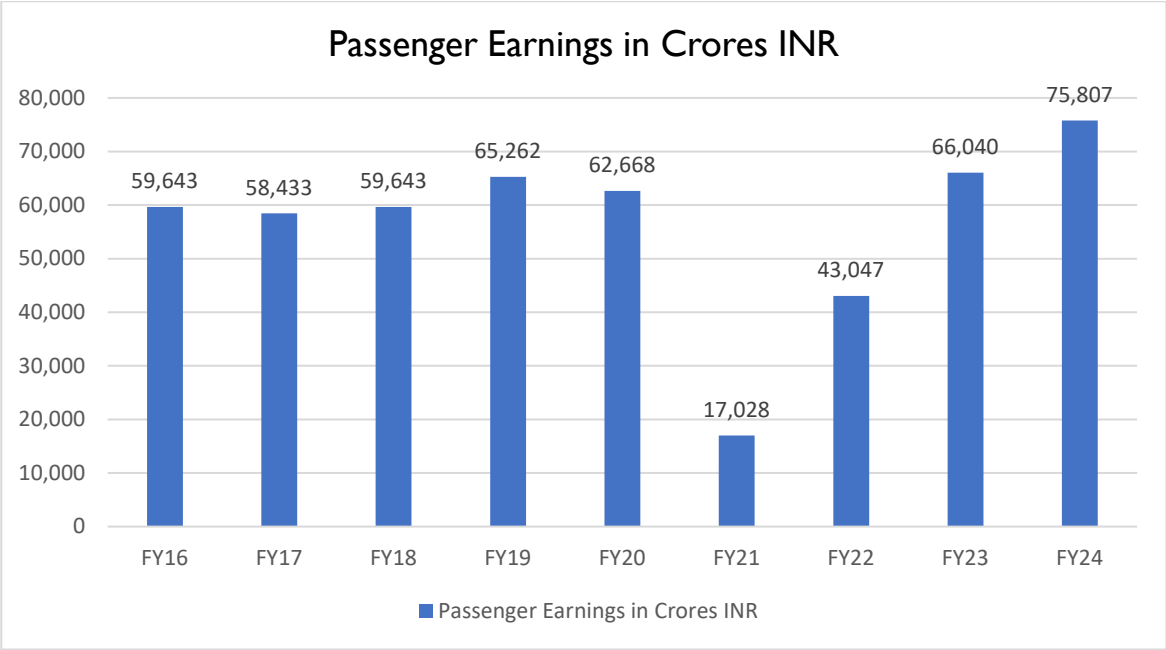
The Indian Railways derives the majority of its passenger revenue, approximately 96% in 2023-24, from non-suburban traffic, primarily through long-distance trains. Passenger traffic is projected to grow at an annualized rate of 2% between 2013-14 and 2023-24. For the financial year 2022-23, the Railways is estimated to generate 69% of its internal revenue from freight operations and 24% from passenger traffic, with the remaining 7% coming from miscellaneous sources such as parcel services, coaching receipts, and platform ticket sales. Passenger services are estimated to contribute 26% of the total traffic revenue, amounting to INR 69,720 crores (USD 8.4 billion). Additionally, passenger traffic is expected to grow by 11% compared to the revised estimates for 2022-23. The total number of passengers who traveled during 2023-24 was 648 crores, reflecting an increase of 52 crores compared to the figures for the same period

of the previous year. Passenger volumes are anticipated to increase gradually as the post-pandemic recovery continues. To enhance passenger convenience, Indian Railways announced plans in April 2021 to introduce new trains, including four Shatabdi Express trains and a special Duronto Express train.



Trends in passenger volumes (in Crores INR)

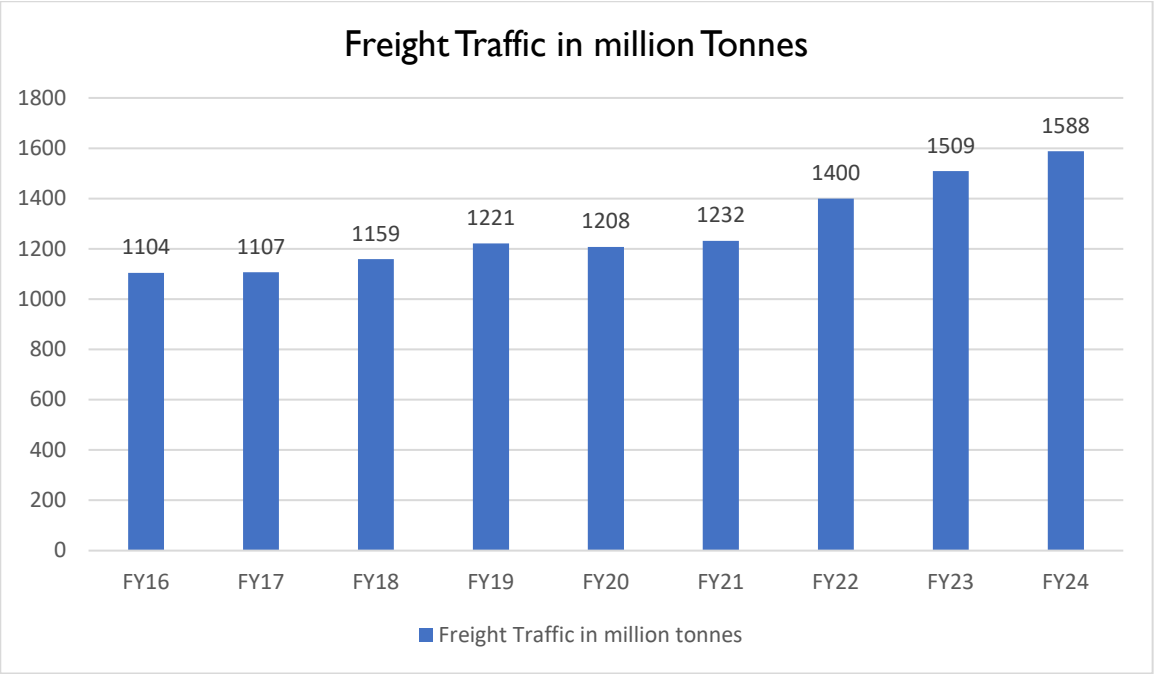
- During the fiscal year 2023-24, Indian Railways reported a total passenger revenue of INR 75,807 crores (USD 8.75 billion), marking a 14% increase from INR 66,040 crores (USD 7.62 billion) recorded during the same period in the previous year.
- For the period April 1 to January 31, 2023, revenue generated from the reserved passenger segment amounted to INR 41,930 crores (USD 5.1 billion), while revenue from the unreserved passenger segment stood at INR 11,510 crores (USD 1.4 billion).



Passenger Earnings (in Crores INR)

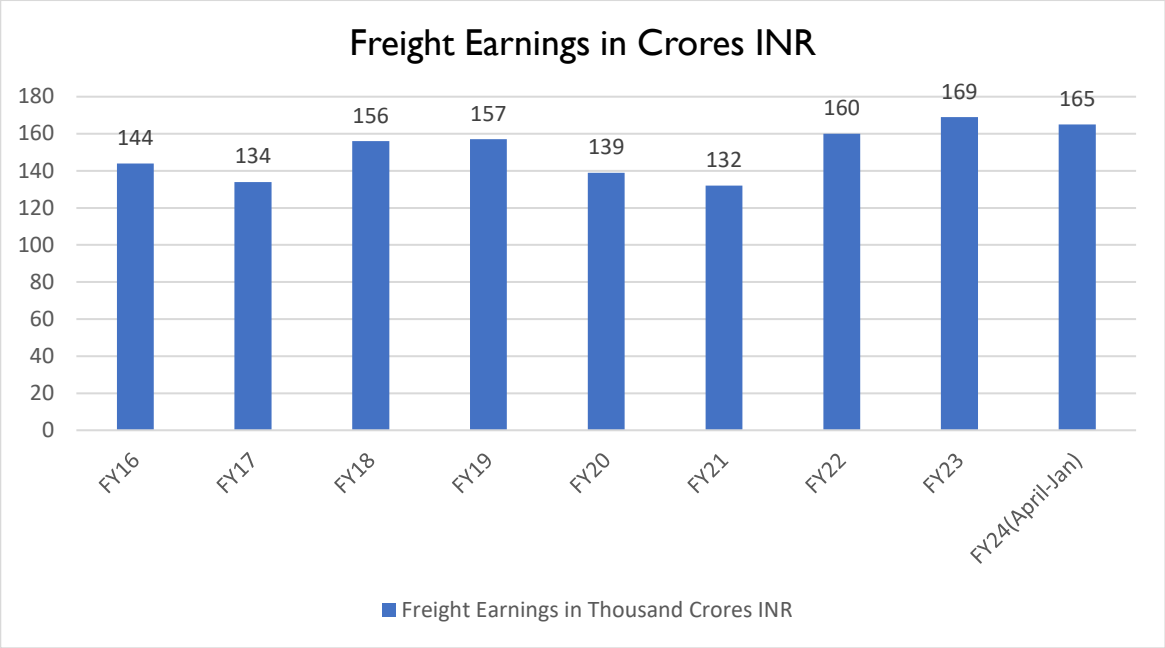
- **Growth in Freight and Revenue Generated Through Freight Trains:**

  In FY24, Indian Railways achieved a record freight loading of 1,588 million tonnes (MT), surpassing the previous best of 1,509 MT in FY23 by 82 MT. The Railways has set an ambitious target of achieving 3,000 MT by 2030. From April to February of FY24, freight loading reached 1,434.03 MT, reflecting an increase of 66.51 MT compared to the same period last year. During this period, freight revenue increased by INR 6,468 crores (USD 778 million) compared to the previous year. As of January 31, 2023, a total route length of 1,724 km—comprising 861 km of the Eastern Dedicated Freight Corridor (EDFC) and 863 km of the Western Dedicated Freight Corridor (WDFC)—has been commissioned, out of the planned total of 2,843 km. Freight traffic is projected to grow significantly in the medium to long term, driven by favorable policy measures and increased participation from both domestic and international private players. In FY23, the North Western Railway recorded the highest growth in freight earnings at INR 6,839.93 crores (USD 832.39 million), representing a 30.82% increase over the previous year's earnings of INR 5,228.13 crores (USD 636.3 million). Freight loading also rose to 32.69 million tonnes, a 10.07% increase compared to the 29.70 million tonnes loaded in the prior year.



Freight Traffic (in Million Tonnes)

- In June 2024, Indian Railways recorded a freight loading of 135.46 million tonnes. On a cumulative basis, from April 2023 to January 2024, railway freight earnings amounted to INR 1,65,490 crores (USD 19.1 billion), compared to INR 1,69,390 crores (USD 19.5 billion) in the previous year, reflecting a 2.5% improvement year-over-year.



Freight Earnings (in Thousand Crores INR)

- "Hungry For Cargo", IR has made sustained efforts to improve the ease of doing business and improve the service delivery at competitive prices, resulting in new traffic coming to railways from both conventional and non-conventional commodity streams. The customer-centric approach and work of Business Development Units backed up by agile policymaking helped Railways towards this landmark achievement.

- **High-speed Rail Project**: The Mumbai-Ahmedabad high-speed rail project, with an estimated cost of INR 1,18,437 crores (USD 14.27 billion), is currently underway.
- **Railway Electrification:** Indian Railways aims to achieve complete electrification by 2023, which is expected to result in annual savings of INR 12,873 crores (USD 1.55 billion).
    1. Over 61,813 km of Broad-Gauge network has been electrified, advancing towards 100% electrification.
    2. Significant progress has been made in railway electrification, with 38,650 km achieved by Oct 2023.
- **Wi-Fi:** It has been installed at 6,089 railway stations nationwide.
- **Green Initiatives:** More than 1,000 stations have been solarized to support green initiatives.
- **Safety System:** Automatic Block Signaling (ABS) has been implemented along 3,946 route km.
    1. Kavach, a safety system, covers 1,465 route km and 139 locomotives across several states.
- **Vande Bharat Trains and Gati Shakti Cargo terminals:** Plans include manufacturing 400 Vande Bharat Trains and developing 100 PM Gati Shakti Cargo terminals in the next three years.
- **Gauge Conversions:** From 2014 to 2022, 1,544 km of new lines, gauge conversions, and doubling projects have been commissioned, showing a significant increase compared to the previous period.

1. 18 Zones[1]: The Indian Railways has been divided into 18 zones: Northern Railway (Largest), North Eastern Railway, Northeast Frontier Railway (Smallest), Eastern Railway, South Eastern Railway, etc.

Railway zone	Code	Zone quarters	Route Length (Kms)	Number of stations	Railway Divisions
Central Railway	CR	Mumbai CSMT	4,102	612	Mumbai, Bhusawal, Pune, Solapur, Nagpur CR
East Central Railway	ECR	Hajipur	3,628	800	Danapur, Dhanbad, Pt Deen Dayal Upadhyaya, Samastipur, Sonpur
East Coast Railway	ECoR	Bhubaneswar	2,204	342	Khurda Road, Sambalpur, Rayagada

[1] https://unacademy.com/content/railway-exam/study-material/general-awareness/short-note-on-complete-and-updated-list-of-railway-zones-in-india/

Eastern Railway	ER	Fairlie Place, Kolkata	2,414	576	Howrah, Sealdah, Asansol, Malda
Konkan Railway	KR	Navi Mumbai	741	67	Karwar, Ratnagiri
North Central Railway	NCR	Prayagraj	3,151	435	Prayagraj, Agra, Jhansi
North Eastern Railway	NER	Gorakhpur	3,667	537	Izzatnagar, Lucknow NER, Varanasi
North Western Railway	NWR	Jaipur	5,459	663	Jaipur, Ajmer, Bikaner, Jodhpur
Northeast Frontier Railway	NFR	Maligaon, Guwahati	3,948	753	Alipurduar, Katihar, Rangiya, Lumding, Tinsukia
Northern Railway	NR	Delhi	6,968	1142	Delhi, Ambala, Firozpur, Lucknow NR, Moradabad
South Central Railway	SCR	Secunderabad Junction	3,127	883	Secunderabad, Hyderabad, Nanded
South Coast Railway	SCoR	Visakhapatnam	3,496		Waltair, Vijayawada, Guntur, Guntakal
South East Central Railway	SECR	Bilaspur	2,447	358	Bilaspur, Raipur, Nagpur SEC
South Eastern Railway	SER	Garden Reach, Kolkata	2,631	353	Adra, Chakradharpur, Kharagpur, Ranchi

South Western Railway	SWR	Hubballi	3,566	456	Hubballi, Bengaluru, Mysuru
Southern Railway	SR	Chennai Central	5,079	890	Chennai, Tiruchirappalli, Madurai, Palakkad, Salem, Thiruvananthapuram
West Central Railway	WCR	Jabalpur	2,965	372	Jabalpur, Bhopal, Kota
Western Railway	WR	Mumbai (Churchgate)	6,182	1046	Mumbai WR, Ratlam, Ahmedabad, Rajkot, Bhavnagar, Vadodara

In the entire Indian Railway system, Kolkata has the highest number of zonal headquarters, comprising the eastern zone, southeastern zone, and Kolkata Metro Railway.

Following are the major railway zones in India:

a) Central Railway Zone

The central railway zone was one of the largest railway zones. The Central Railway zone comprises some areas of the southern part of Uttar Pradesh and a significant portion of Madhya Pradesh. The zone was established on 5th November 1951 by merging the Scindia State Railway, Nizam state railway, Dholpur railways, Great Indian Peninsula Railway, and Wardha Coal state railway.

Although it was the largest railway zone, it was renamed, and a few of its divisions were given to the others in April 2003. Currently, the Central Railway zone has five different divisions under its authority, with its headquarters at the Chhatrapati Shivaji Terminus, Mumbai. At present, the state of Maharashtra, the North-Eastern Part of Karnataka, and the southern part of Madhya Pradesh fall under its authority.

b) Northern Railway

The Northern Railway was established back in 1859 and was later added to the official list of the railway zones in India on 14th April 1952. Currently, it is one of India's oldest and largest railway zones, which provides services in the state of Himachal Pradesh, Uttarakhand, Haryana, Punjab, and a few parts of Uttar Pradesh. It also operates in the union territories of the Indian government, mainly Delhi, Jammu and Kashmir, and Chandigarh. The Northern Railway zone is headquartered in New Delhi at Baroda House. Moreover, it has a railway network of 6,807 kilometres.

c) Konkan Railway

The Konkan railway began its operation on 20th March 1993. The train was operated between Mangalore and Udupi. Due to a few accidents in its initial working days, the Konkan railway highly promoted

advanced technologies in its operations, such as sky bus, roll-on/roll-off service (commonly known as the RORO service) and anti-collision devices.

The headquarters of the Konkan Railway is at CBD Belapur, which is located in Navi Mumbai. One of the interesting facts about the Konkan railway is that with just one track of 756.24 km, it covers 69 railway stations.

d) 18th Railway zone: South Coast Railway zone

The South Coast Railway zone is the 18th railway zone of the Indian railway which was introduced in the year 2019 by Piyush Goyal, the railway minister during the period. The zone has Guntur, Guntakal, Vijayawada, and Waltair divisions under it and is headquartered in Visakhapatnam.

2. **100% FDI:** is allowed in railway infrastructure under the automatic route.

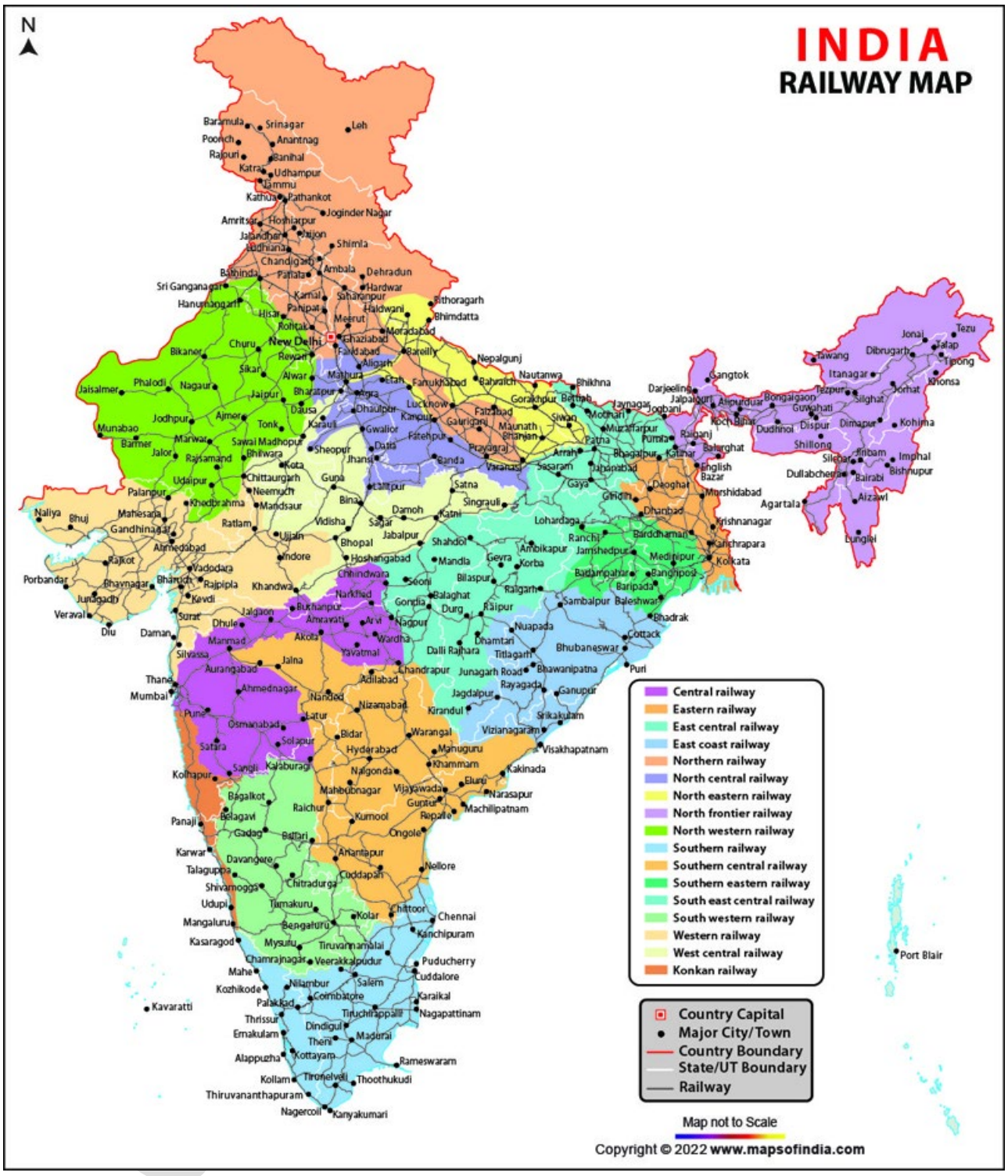
3. **Classification based on the width of track:** Broad gauge (1.676 metres), Metre gauge (1m) and Narrow gauge (0.762m or 0.610m; generally confined to hilly areas)

4. **Indian Railways has two UNESCO World Heritage Sites:**
   a) The Chhatrapati Shivaji Maharaj Terminus, Mumbai (2004)

   b) The Mountain Railways of India (1999, 2005, 2008): Darjeeling Himalayan Railway, Nilgiri Mountain Railway, Kalka-Shimla Railway.

- **Railway Infrastructure Projects in India:**

1. Dedicated Freight Corridors (DFCs):
   a) Eastern DFC (EDFC): 1,856 km long from Ludhiana (Punjab) to Dankuni (West Bengal); Covers Punjab, Haryana, Uttar Pradesh, Bihar, Jharkhand and West Bengal.
   b) Western DFC (WDFC): 1,504 km long from Dadri (UP) to Jawaharlal Nehru Port (Maharashtra); Covers Haryana, Rajasthan, Gujarat, Maharashtra and Uttar Pradesh.



India Railway Map

Diamond Quadrilateral Project: The Diamond Quadrilateral is an Indian Railways project to establish a high-speed rail network that will connect the four mega cities of India, viz. Delhi, Mumbai, Kolkata and Chennai.

a) Delhi-Mumbai
b) Mumbai-Chennai
c) Chennai-Kolkata
d) Kolkata-Delhi

Key Features of the Diamond Quadrilateral

- High-Speed Rail Network: Trains capable of speeds up to 300-350 km/h, significantly reducing travel time between these cities.
- Connectivity: Links four of India's largest cities, which are also major economic and cultural hubs. Improves accessibility to tier-2 and tier-3 cities along the corridor.
- Modern Infrastructure: Advanced railway technology, signaling systems, and electrification to ensure safety and efficiency. Integration with existing rail networks to maximize coverage.

Benefits of the Diamond Quadrilateral

- Economic Growth: Enhances trade and business by improving connectivity between industrial and commercial centres. Supports regional development and boosts employment during construction and operation.
- Reduced Travel Time: High-speed trains significantly cut travel times compared to conventional rail and road transport.
- Example: Travel between Mumbai and Delhi could be reduced to 4-5 hours compared to 16+ hours by conventional rail.
- Environmentally Friendly: Promotes a shift from road and air travel to rail, reducing carbon emissions and fuel consumption.
- Boost to Tourism: Easier access to cultural and historical landmarks across India, promoting domestic and international tourism.
- Technological Advancement: Adoption of cutting-edge rail technology brings innovation and skill development to India.

Current Status

- The Diamond Quadrilateral project is in its planning and development stages. The government has initiated feasibility studies for several routes, and the Mumbai-Ahmedabad High-Speed Rail Corridor, India's first bullet train project, is considered a precursor and part of this broader initiative.

Challenges

- Cost: High-speed rail projects require significant investment in infrastructure, technology, and land acquisition.

- Land Acquisition: Acquiring land for dedicated corridors often faces delays due to administrative and legal hurdles.

Coordination: Collaboration between multiple states and agencies is essential but challenging.

Signaling & Electrification Infrastructure

a) **Signaling Infrastructure:**[2]

Indian Railways has undertaken significant advancements in signalling and telecommunications to modernize train control, enhance operational safety, and improve overall efficiency. These efforts reflect the organization's commitment to creating a robust and technologically advanced railway network.

- **Modern Signalling Systems**

Indian Railways is making significant progress in upgrading its signalling systems. As of October 31, 2023, Automatic Block Signalling (ABS), which enhances platform utilization and reduces train delays, has been installed across 4,111 route kilometers. Additionally, ABS has been approved for six sections in Bengaluru, covering 639 km at a cost of INR874 crores. To further modernize the network, Indian Railways is replacing outdated electro-mechanical systems with advanced electronic route relay devices, investing INR1,00,000 crores to implement these changes.

- **Accident Reduction Initiatives**

The introduction of advanced safety measures has significantly reduced train accidents, from an average of 171 per annum (2004-14) to 71 per annum (2014-23). Key initiatives include:

1) Electrical/Electronic Interlocking Systems: Installed at 6,589 stations by June 30, 2024, to centralize the operation of points and signals, minimizing human error.
2) Interlocking of Level Crossing Gates: Enhanced safety at 11,048 level crossing gates as of June 30, 2024.
3) Complete Track Circuiting: Implemented at 6,609 stations, allowing electrical verification of track occupancy.
4) Axle Counters: Introduced on 6,079 block sections to automate train clearance and minimize manual intervention.

- **Indigenous Automatic Train Protection System**

The Kavach Automatic Train Protection (ATP) system, developed by the Research Designs and Standards Organisation, is a significant milestone in ensuring train safety. Kavach assists loco pilots by automatically applying brakes in case of emergencies and maintaining safe operation during adverse weather conditions. Key highlights include:

1) Adopted as India's national ATP system in July 2020.

[2] https://pib.gov.in/PressNoteDetails.aspx?NoteId=151988&ModuleId=3&reg=3&lang=1

2) Deployment across 1,465 route kilometers and 144 locomotives by July 24, 2024.
3) Projects such as the Mumbai-Ratlam route (735 km) and Delhi-Mumbai corridor are targeted for completion by 2025.
4) The annual installation capacity of Kavach has increased to 2,500 km, aiming to cover 5,000 km by 2026.

- **Communication Modernization**

  To modernize communication networks, the Indian government approved a INR25,000 crore (USD3.43 billion) plan in June 2021 to adopt 4G technology for railway stations. Additionally, a project for a Long-Term Evolution (LTE) Mobile Train Radio Communication system covering 34,803 route kilometers has been initiated to improve safety and operational efficiency.

- **Real-Time Train Tracking**

  The Real-Time Train Information System (RTIS), an indigenous IoT-based solution, has been installed on 8,700 locomotives, covering 60% of the operational fleet. This system enables real-time tracking of train location and speed, facilitating efficient train operations.

- **Safety Fund and Investments**

  The Rashtriya Rail Sanraksha Kosh (RRSK), established in 2017-18 with an initial allocation of INR 1,00,000 crores, aims to replace, renew, and upgrade critical safety assets. By 2021-22, INR 1,08,000 crores had been utilized under this fund. Recognizing its significance, the government extended the RRSK for another five years in 2022-23, with an additional allocation of INR 45,000 crores. This fund supports essential projects such as:

  1) Track renewals and upgrades.
  2) Bridge maintenance and modernization.
  3) Signalling system improvements.

- **Additional Safety Enhancements**
  1) Emergency Systems: Emergency talk-back and alarm systems are now integrated into Vande Bharat train sets.
  2) CCTV Installation: Over 9,572 coaches, including all Vande Bharat Express coaches, are equipped with CCTV cameras to enhance security.
  3) Fog Safety Devices: GPS-based fog safety devices assist loco pilots in low visibility areas.
  4) Ultrasonic Flaw Detection: Regular rail testing identifies and replaces defective tracks.
  5) Track Monitoring Systems: A web-based system for track asset monitoring and maintenance has been implemented.

b) **Electrification Infrastructure:**[3]

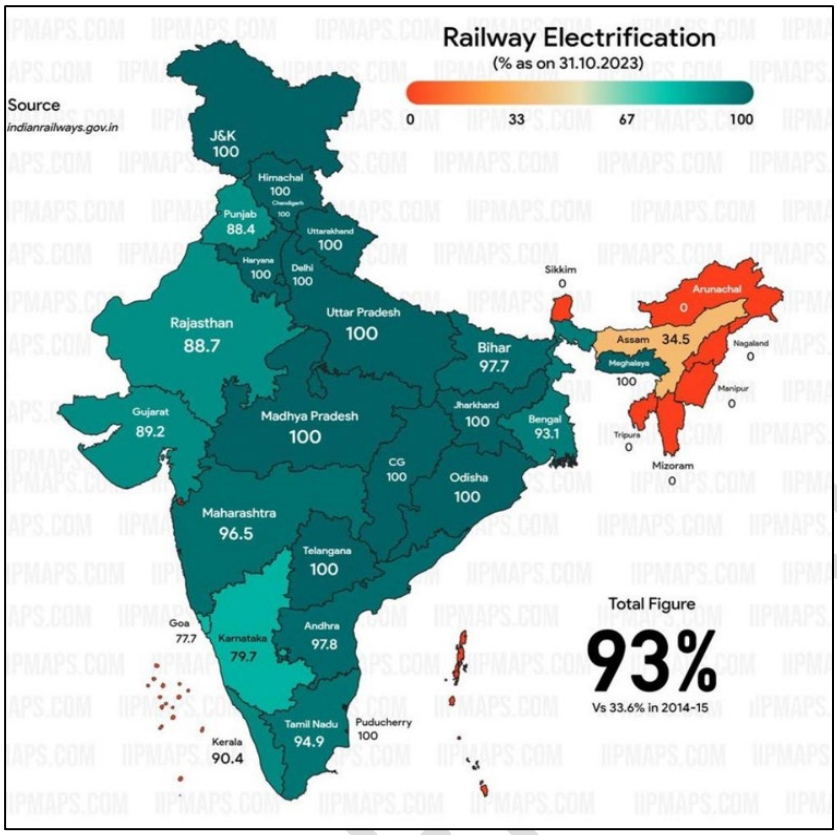
Indian Railway has plant to convert its infrastructure from 1x25 to 2x25 KV to facilitate the capacity augmentation to meet the growing demand of additional trains on existing track and specialty for running the Vande Bharat Trains. The total investment in upgradation of their existing system is INR 1 trillion which would be spent by the Indian Railway in the next 5-7 years.

- **Renewable Energy Initiatives**
  1) Indian Railways set a target to install 1,000 MW of solar power plants and 200 MW of wind power plants by 2022-23.
  2) As of now, 204.82 MW of renewable energy has been installed, comprising 101.42 MW of solar power and 103.4 MW of wind power.
- **Progress in Electrification**
  1) In CY 2023, Indian Railways electrified 6,577 Route Kilometers (RKMs), raising the total electrification of the broad-gauge network to 93.83%, or 65,556 RKMs.
  2) The target is to achieve 100% electrification of all broad-gauge routes by 2024, with 45,881 km electrified and the remaining 18,808 km under progress.
  3) Approximately INR 21,000 crore (USD 2.8 billion) is estimated to complete the electrification of the remaining routes.
  4) The electrification drive has seen rapid progress, achieving a 5x increase in electrification between 2014 and 2021 compared to 2007–2014.
- **93% of the Indian rail network is electrified by 2023**[4]

[3] https://www.ibef.org/industry/indian-railways

[4] Indian Railways.gov.in
https://www.reddit.com/r/trains/comments/18gjqvx/indian_rail_minister_claims_countrys_rail_network/

Electrified network by state (broad gauge only) as of 31 October 2023 (%)



- **International Collaboration**
  1) In November 2019, Indian Railways partnered with Madhepura Electric Locomotive Pvt. Ltd. (MELPL), a joint venture with France-based Alstom, to manufacture 800 electric locomotives for freight services.
- **New Services and Programs**
  1) The government launched Mission Raftaar in August 2022, aiming to:
     a) Double the average speed of freight trains.
     b) Increase the average speed of superfast/mail/express trains by 25 kmph.
  2) In September 2021, Indian Railways initiated rail-based tourism, leasing and selling railway coaches to private players.
  3) Under the National Rail Plan, Vision 2024, Indian Railways plans to:
     a) Implement multitrack congested routes.
     b) Achieve 100% electrification.
     c) Upgrade speeds to 160 kmph on the Delhi-Howrah and Delhi-Mumbai routes.
     d) Upgrade speeds to 130 kmph on other golden quadrilateral/golden diagonal (GQ/GD) routes.
     e) Eliminate all level crossings on the GQ/GD routes by 2024.
- **Modernization of Services**
  1) By January 31, 2024, 41 Vande Bharat trains were operational, connecting various states via broad-gauge electrified routes.
  2) In February 2021, Indian Railways upgraded the rake of the Agartala-Anand Vihar Terminal Special Rajdhani Express with Tejas Sleeper coaches to enhance passenger experience.
- **Decarbonization Efforts**

1) On June 14, 2023, the Government of India signed an MoU with USAID/India to assist Indian Railways in achieving Net Zero Carbon Emission by 2030.
2) Indian Railways has been collaborating with public sector enterprises to expedite electrification as part of its decarbonization strategy.
3) A record 6,015 RKMs were electrified in 2020-21, marking the highest-ever electrification of sections in a single year.

Railway track modernization initiatives

In the quest to Vikasit Bharat 2047, Indian Railways continued its transformative journey in the year 2024, paving the way for a new era of modernization and progress. With a strong focus on meeting world class travel experience, boosting freight efficiency, and adopting advanced technologies, the Railways has solidified its role as a catalyst for national growth. Modern stations, state-of-the-art trains, and innovative safety systems are reshaping the landscape of rail travel. Committed to sustainability, the Railways is steadily moving towards greener operations while driving economic development through extensive infrastructure upgrades and capacity building. This year has reaffirmed its vision of becoming a world-class transportation network, blending tradition with innovation to meet the needs of a dynamic and evolving nation.[5]

Insight on railway capex spending on track infrastructure (expansion & upgradation)[6]

Indian Railways has made significant capital investments to modernize its track infrastructure, focusing on expansion, upgradation, and sustainability:

1) Infrastructure Expansion: As of April 2024, Indian Railways is managing 488 projects, including 187 new lines, 40 gauge conversions, and 261 doubling projects spanning a total of 44,488 km, with a projected cost of INR 7.44 lakh crore (USD 89.4 billion). Approximately 12,045 km of these projects have been commissioned, with an expenditure of INR 2.92 lakh crore (USD 35.1 billion).
2) Electrification: Efforts to electrify all broad-gauge routes by March 2024 have seen over 96.99% electrification (64,421 km), significantly reducing carbon emissions.
3) High-Speed Rail Projects: Indian Railways is constructing 508 km of high-speed tracks, including the Mumbai-Ahmedabad corridor, and has planned seven additional corridors costing INR1.47 lakh crore (USD 17 billion).
4) Track Upgradation: Heavier section, high-tensile strength rails (52 kg/60 kg, 90 UTS) are replacing older rails to handle increased traffic loads and speeds. In FY24, Indian Railways laid 5,100 km of new tracks and commissioned 1,752 km.
5) Specialized Freight Lines: Dedicated Freight Corridors (DFC) on the Eastern and Western routes improve freight efficiency while decongesting passenger lines.

[5] https://pib.gov.in/PressReleaseIframePage.aspx?PRID=2088668
[6] https://www.ibef.org/industry/indian-railways

Key policy initiatives / measures

Indian Railways has implemented strategic policies to ensure efficient and safe track modernization:

- Track Renewals and Maintenance: Modern materials, ultrasonic flaw detection (USFD) technology, and advanced welding techniques are used to replace and maintain tracks, improving safety and durability.
- Electrification in Mission Mode: Aimed at decarbonization, electrification initiatives achieved the highest-ever section coverage of 6,015 route kilometers in 2020-21.
- Elimination of Unmanned Level Crossings: All UMLCs on broad-gauge routes were removed by January 2019, significantly reducing accidents.
- Elimination of level crossings: IR has been working towards elimination of manned level crossings, which are prone to accidents. Efforts are made to incorporate underpasses and overpasses instead. This often leads to an increase in project cost and development timelines. But since it reduces accidents and casualties, this mechanism has been adopted.7
- Bridge Modernization: Comprehensive inspections, rehabilitation, and strengthening projects ensure structural safety for increasing traffic loads and speeds.
- Web-Based Asset Monitoring: Digital systems for real-time track monitoring support preventive maintenance and efficient resource allocation.
- Fire and Safety Measures: Modern trainsets like Vande Bharat are equipped with fire detection, suppression systems, and emergency talk-back mechanisms.
- Dedicated Freight Corridors (DFC): These projects improve freight capacity and reduce congestion, with 90% of the 3,260 km DFC network operational as of 2024.
- High-Speed Corridors: Upgraded tracks on key routes enable speeds of 130-160 kmph, with future plans for semi-high-speed and high-speed rail corridors.
- National Rail Plan (Vision 2024): The plan focuses on multitracking congested routes, 100% electrification, and eliminating level crossings on key routes by 2024.
- Rashtriya Rail Sanraksha Kosh (RRSK): Established in 2017-18 with an initial corpus of INR 1,00,000 crores, this fund supports critical safety asset upgrades, including tracks and bridges. In 2022-23, it was extended with an additional allocation of INR 4,500 crores.
- Public-Private Partnerships (PPP): To attract private investment, a PPP model allows for commercial use of space above platforms and tracks with up to 40% viability gap funding.
- Achievements and Impact
- Electrification increased fivefold between 2014 and 2021 compared to 2007-2014.
- The completion of high-capacity projects during the COVID-19 lockdown included upgrades to 514 km of railways and new port connectivity lines.

[7] https://www.assocham.org/uploads/files/Modernisation%20of%20Railways%20for%20Viksit%20Bharat.pdf

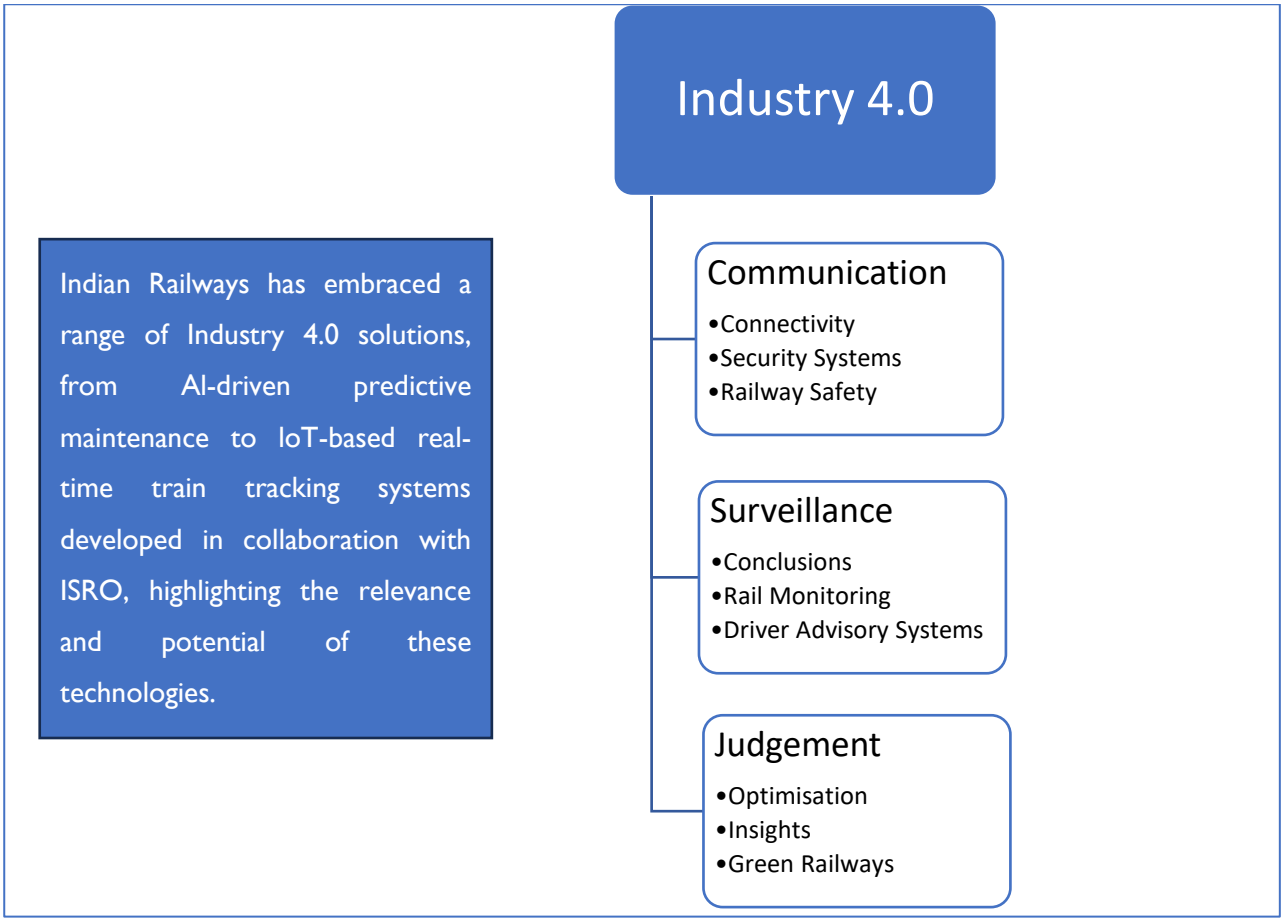
- Biodegradable infrastructure, such as bio-toilets in 79,269 passenger coaches, prevents daily excreta fall on tracks, enhancing hygiene and sustainability.

Indian Railways continues to modernize its tracks and associated infrastructure to meet growing passenger and freight demands, with a strong focus on safety, sustainability, and operational efficiency.

Technology Development in Track & Signaling Infrastructure

Indian Railways is accelerating its digital transformation to become smarter, enhance its operational efficiencies, and deliver an unparalleled experience to passengers. Smart Railways harness the integration of advanced technologies to create a more intelligent, connected, and data-driven rail network with the goal to provide a more convenient and sustainable travel experience for passengers. Smart railways are transforming the transportation landscape by integrating advanced technologies to improve safety, efficiency, and passenger experience. Digital signaling and train control systems enhance traffic management and operational safety, while IoT-enabled sensors continuously monitor tracks, equipment, and passenger activities, enabling real-time data collection and analysis. Predictive maintenance, powered by data analytics, reduces downtime and prevents equipment failures by addressing issues proactively. Smart ticketing systems, including RFID technology, mobile applications, and contactless payment options, streamline travel, and automated trains ensure efficient and error-free operations.

Passenger convenience and safety are prioritized with features like real-time updates via mobile apps and robust surveillance systems, including CCTV and facial recognition technology. Data-driven optimization enhances resource utilization and scheduling efficiency, while green technologies such as regenerative braking, energy-efficient systems, and renewable energy integration support environmental sustainability. Furthermore, seamless intermodal connectivity ensures efficient integration with other transportation modes like buses, trams, and metros, creating a unified and sustainable transportation ecosystem.



Industry 4.0 and IoT: The Building Blocks of the Future

Industry 4.0, powered by technologies like IoT, cloud computing, and AI, is poised to revolutionize Indian Railways by addressing growing operational demands. IoT enables real-time data processing and seamless communication across assets like trains, signals, and locomotives, optimizing existing systems. The integration of cyber-physical systems (CPS) enhances performance through improved coordination and failure prediction, while big data analytics generates actionable insights for maintenance, asset management, and schedule optimization. IoT fosters interoperability for smooth communication across the railway ecosystem, decentralizes decision-making to reduce human error, and enables smart systems like signaling to operate autonomously in real-time. Predictive and prescriptive analytics ensure proactive maintenance and performance optimization, while edge computing reduces latency by processing data near its source, enhancing responsiveness in critical areas such as safety and signaling. These advancements are essential building blocks for the future of Indian Railways.

Emerging Smart Technology /Other Features Making Their Way into Railway Track & Management Infrastructure

Indian Railways is embracing a range of smart technologies to enhance its track and signaling infrastructure, focusing on operational efficiency, safety, and sustainability. Key developments include:

1) **Smart Yards:**[8] Indian Railways is developing "Smart Yards" equipped with automated systems for predictive maintenance of freight wagons. These yards will use technologies such as Hot Box Detectors and Wheel Profile Recorders to identify potential issues like hot axles or defective wheels before they result in operational failures.
   - Implementation of Smart Yard:

   In the first phase, Indian Railways will convert 40 identified yards into Smart Yards.

   COFMOW, a unit of Indian Railways, has been assigned the responsibility for overseeing the Smart Yards project.
2) **Bidirectional Signaling:**[9] The introduction of bidirectional signaling systems enhances safety and optimizes traffic flow. This technology allows trains to operate in both directions on the same track, increasing capacity and reducing delays. The unidirectional track is transformed into a bidirectional system, with special block reversal procedures and dynamic adjustments in the Direction of Traffic (DOT) based on scheduling needs to ensure safety.

   For example, when a train needs to change direction, the control centre reverses the direction of traffic within the relevant blocks. This ensures that trains can safely travel in the opposite direction without conflicting with other trains on the track.
3) **On-board Condition Monitoring Systems (OBCMS):**[10] These systems are installed on rolling stock to detect onboard faults or vibrations, providing real-time data that helps in preventive maintenance and enhances safety. The predictive nature of the OBCMS enhances safety and reliability by providing early warnings for potential issues like wheel flats, bearing failures, and track deterioration, thereby reducing the likelihood of accidents. This proactive approach also drives cost efficiency by extending overhaul intervals, enabling timely and cost-effective maintenance, and minimizing operational downtime and in-service breakdown costs. Additionally, the system optimizes asset utilization by offering advanced condition insights, which streamline maintenance planning, reduce disruptions, and maximize time-in-service for rolling stock.

   Hitachi Rail India is transforming railway operations with its state-of-the-art On-board Condition Monitoring System (OBCMS) for rolling stock. Deployed in 100 LHB Smart Coaches of Indian Railways, the system utilizes Hitachi Rail - Perpetuum's advanced sensors to monitor critical components such as wheels, bearings, ride quality, and track conditions, covering an extensive network of 8,600 kilometers. By combining artificial intelligence with advanced analytical tools, the

[8] https://metrorailnews.in/train-technology/
[9] https://social-innovation.hitachi/en-in/knowledge-hub/techverse/smart-railways/
[10] https://social-innovation.hitachi/en-in/knowledge-hub/techverse/smart-railways/

OBCMS detects onboard faults and vibrations, delivering high reliability, reduced maintenance requirements, and increased rolling stock availability.

4) **Integrated Communication-Based Train Control (ICBTC):**[11] Integrated Communication-Based Train Control (ICBTC) is an advanced signaling system that builds upon the principles of Communications-Based Train Control (CBTC). This system is designed to improve the safety, efficiency, and capacity of railway operations. ICBTC combines various subsystems and technologies into a cohesive framework, integrating train control, supervision, and management functions. This integration allows for more efficient operations, improved safety, and enhanced communication across the entire railway network.

   Key features of ICBTC: The Integrated Communication-Based Train Control (ICBTC) system revolutionizes railway operations with uninterrupted, high-capacity bidirectional communication between trains and trackside equipment. This real-time data exchange eliminates reliance on traditional fixed block signaling, enhancing operational precision. ICBTC integrates multiple functionalities such as Automatic Train Protection (ATP), Automatic Train Operation (ATO), and Automatic Train Supervision (ATS), ensuring seamless coordination across the railway system. Safety is prioritized through ATP, which monitors train movements and conditions to prevent collisions and maintain safe operations by automatically adjusting train speeds and spacing. Additionally, the system employs Moving Block Technology for dynamic headway management, enabling trains to operate closer together. This reduces intervals between trains, significantly increasing rail line capacity without requiring additional infrastructure.

5) **Kavach System:** Kavach is an Automatic Train Protection (ATP) system developed by the Research Designs and Standards Organization (RDSO) for Indian Railways. Certified to Safety Integrity Level 4 (SIL-4), Kavach is a pivotal component of the Train Collision Avoidance System (TCAS) project, initiated in 2012 to eliminate train collisions across India's rail network. Currently operating on version 3.2, Kavach is slated for an upgrade to version 4.0 to expand its capabilities. Version 3.2 received certification in 2021, with deployment commencing in late 2022 on high-traffic routes such as Delhi-Mumbai and Delhi-Howrah.

   Kavach is a cutting-edge safety and operational efficiency system designed to revolutionize railway operations. It incorporates features such as automatic braking to prevent collisions, automated whistling at level crossings, and real-time movement authority updates for seamless train operations. The system's SOS emergency stop feature and inter-locomotive communication enhance coordination and mitigate risks. Kavach also offers robust safety functionalities, including Signal Passed at Danger (SPAD) detection, collision avoidance through automatic braking, and adverse weather adaptation by providing hazard warnings in challenging conditions like fog. Together, these functionalities ensure safer, more efficient, and reliable railway operations.

[11] https://metrorailnews.in/train-technology/

Insight on Digital Transformation Initiatives in Railways

Indian Railways is undergoing a significant digital transformation aimed at enhancing passenger experience and operational efficiency:

1) **Smart Railways Initiative:** The Smart Railways initiative focuses on creating a connected and data-driven rail network. This includes the integration of advanced technologies like electronic interlocking, autonomous operations, and on-board monitoring systems to improve service delivery.

2) **Future Rail India[12]:** Federation of Indian Chambers of Commerce and Industry (FICCI) had organized "Future Rail India 2024: accelerating towards Viksit Bharat, 5th edition of Smart Railways Conclave" on Friday, 26th July 2024. The 5th edition of Smart Railways Conclave aimed to propel Indian railways into a new era of technological sophistication, innovation and self-reliability. It encompassed a comprehensive agenda that shall address modernization of track infrastructure, railway electrification, the application of advanced technologies, and the enhancement of freight and passenger services. The conclave was to bring together esteemed government representatives, sector experts, and industry stakeholders to discuss strategies for enhancing efficiency, safety, and environmental sustainability in the railway sector. The program was held to serve as a crucial platform for stakeholders within the railway ecosystem to share insights, establish collaborations, and delve into the latest advancements in the industry. Participants had benefit significantly from discussions centered on optimizing travel and cargo transport, as well as examining the impact of cutting-edge trains and station developments on passenger experiences.

3) **Leveraging AI for security, passenger safety and avoiding train mishaps:[13]** The Namo Bharat trains by the National Capital Region Transport Corporation (NCRTC), launched in October 2023, leverage AI for numerous purposes. These trains, which are a part of the country's first regional rapid transit system (RRTS), use an AI-enabled security system to detect any unlawful activities. Further, the baggage scanners installed use AI-enabled tools such as a dual view generator x-ray baggage inspection system. Using this, images of both the upper and lower parts of the bag passing through the scanner appear on the screen and the AI system automatically identifies the restricted/prohibited items and alerts the operator leading to heightened security.

   Moreover, the train systems analyze real-time data and use AI algorithms to adjust train schedules and accommodate unforeseen disruptions or changes in passenger demand. This leads to a reduction in waiting times and improves punctuality. AI is also being used to forecast occupancy levels, guiding passengers out of high peaks, giving operators higher visibility on passenger distribution in trains and stations, and helping anticipate and control passenger density in real time.

[12] https://www.ficci.in/event_details/27187

[13] https://community.nasscom.in/communities/digital-transformation/treading-tech-track-5-key-modernization-initiatives railways#:~:text=Technologies%20like%20artificial%20intelligence%20(AI,undertaken%20to%20strengthen%20cybersecurity%20infrastructure.

Another interesting application of the technology has been development of an AI-based software called 'Gajraj' by Indian Railways that aims to prevent rising incidents of elephant and train collisions. The software uses and optical fibre cable (OFC) and triggers alerts upon detecting any questionable movement within 200 metres of the railway tracks. It identifies signal disruptions as signs of movement alongside the railway tracks and creates variations in the optical signals carried by the OFC, signalling a potential threat. The software has been successfully tested in Assam and is set to be deployed across 700 km of elephant corridors in multiple states including West Bengal, Odisha, Jharkhand, Assam, Kerala and certain parts of Chhattisgarh and Tamil Nadu.

4) **Supporting digital transformation through RailCloud:** The Indian Railways has its own cloud computing platform called RailCloud that provides scalable and flexible IT infrastructure to support digital transformation initiatives within the organization. It can accommodate extensive data and applications on the same server space and allows scaling up and down of storage space as and when required. The cloud platform helps streamline passenger services, including ticketing, inquiries, onboard services, and meal orders etc and leverages advanced software for real-time train monitoring and performance analysis.

Investment to Modernise Railways: The Indian Railways has committed nearly ₹180 crore to deploy Integrated Track Management System (ITMS) vehicles across all 17 railway zones. Presently, seven ITMS vehicles are operational, with plans to introduce 10 more. Each unit, costing approximately ₹18 crore, represents a significant financial investment in infrastructure modernisation. Ashwini Vaishnaw, the railway minister, highlighted that the deployment of ITMS aligns with Indian Railways' broader modernisation objectives. These efforts mark a critical step toward revolutionising track maintenance and enhancing passenger safety. The initiative also showcased the Road-Cum-Rail Inspection Vehicle (RCRIV), a pioneering tool designed for continuous track recording. Together, ITMS and RCRIV aim to set new benchmarks in railway safety and operational efficiency. With ITMS deployment planned across all railway zones, Indian Railways is advancing towards a future shaped by technological excellence. This initiative not only prioritises passenger safety but also underscores India's commitment to innovation and modernisation. By incorporating advanced technologies like ITMS, Indian Railways reaffirms its dedication to building a safer, more efficient, and reliable railway network.

Competitive Landscape

Analysis of key factors shaping competition in the sector

1) Technological Advancements

Staying on top of technological advancements in the electrical components and electronics sector is crucial. The latest developments in smart devices, the Internet of Things (IoT), and automation technologies can revolutionize the industry. For manufacturers catering to Indian Railways, incorporating these advancements can lead to more efficient and reliable systems. For instance:

a) IoT-enabled sensors can provide real-time monitoring of railway equipment, enhancing safety and maintenance efficiency.
b) Automation technologies can streamline operations, reduce manual labor, and minimize human errors.
c) Artificial Intelligence (AI) can be used for predictive maintenance, analyzing data from various sensors to predict potential failures before they occur.

2) Government Policies and Initiatives

Government policies and initiatives play a significant role in shaping the competitive landscape. The Indian government's "Make in India" initiative encourages domestic manufacturing by providing incentives and support to local businesses. Additionally, the National Electronics Policy aims to make India a global hub for electronics system design and manufacturing (ESDM). These policies create a competitive environment where manufacturers must:

a) Comply with regulatory standards set by the government and Indian Railways.
b) Leverage government support to enhance their capabilities, such as financial incentives, subsidies, and tax benefits.
c) Collaborate with government agencies to stay updated on the latest regulations and policies, ensuring compliance and securing contracts.

3) Supply Chain Dynamics

Efficient supply chain management is essential to remain competitive in this sector. Manufacturers must ensure the timely availability of raw materials and components, manage logistics effectively, and control costs. Key strategies include:

a) Diversifying suppliers to reduce dependency on a single source and mitigate risks of supply chain disruptions.
b) Implementing just-in-time (JIT) inventory management to minimize inventory costs while ensuring materials are available when needed.
c) Investing in supply chain technologies such as blockchain for transparency and traceability, and AI for demand forecasting and optimization.

4) Quality and Reliability

Quality and reliability are paramount for components used in railway systems. Manufacturers must adhere to stringent safety and performance standards set by Indian Railways. This involves:

a) Rigorous testing and certification processes to ensure products can withstand the harsh conditions and demands of railway operations.
b) Continuous improvement practices such as Six Sigma and Total Quality Management (TQM) to maintain high standards.
c) Regular audits and inspections to ensure ongoing compliance with quality standards.

5) Certifications and Standards

Indian Railways mandates high-quality standards for all components used in its operations. Manufacturers must obtain relevant certifications such as ISO 9001:2015 and approvals from the Railway Design Standards Organization (RDSO). Additionally, adhering to global standards like EN 50155, which focuses on electronic equipment used on rolling stock, can provide a competitive edge. Key aspects include:

a) Understanding and meeting certification requirements to ensure products are accepted by Indian Railways.
b) Maintaining documentation and records to demonstrate compliance during audits.
c) Investing in certification and compliance training for employees to stay updated on the latest standards.

6) Cost Competitiveness

Competitive pricing is vital to winning contracts from Indian Railways. Manufacturers need to strike a balance between cost efficiency and quality. Strategies to achieve this include:

a) Adopting lean manufacturing techniques to minimize waste and optimize resource use.
b) Leveraging economies of scale by increasing production volume to reduce per-unit costs.
c) Utilizing cost-effective materials and processes while ensuring they meet quality standards.

7) Customization and Flexibility

The ability to customize products to meet specific requirements of Indian Railways can provide a significant competitive edge. This involves:

a) Flexible design and production processes that allow for quick adjustments to meet unique project needs.
b) Collaboration with Indian Railways to understand their specifications and requirements thoroughly.
c) Offering modular solutions that can be easily adapted or expanded based on changing needs.

8) After-Sales Service and Support

Robust after-sales service and support are critical for maintaining customer satisfaction and loyalty. Manufacturers who provide comprehensive service solutions can differentiate themselves from competitors. Key aspects include:

a) Offering maintenance and repair services to ensure the longevity and optimal performance of components.

b) Providing technical support and training to help Indian Railways staff operate and maintain the equipment effectively.

c) Establishing a responsive customer service system to address any issues or concerns promptly.

Profiling of Peer Companies Profile

Autometers Alliance Ltd.

Section	Details
Overview	
Name	Autometers Alliance Limited
Industry	Electrical components and Electronics
Establishment Year	1995
Headquarters	Noida, Uttar Pradesh
Regional Presence	Noida, Uttar Pradesh
Manufacturing Locations & Production	Noida, Uttar Pradesh
Products	1. **Power Conditioning** (Static Converter LGBT Based 180kva, Auxiliary Converter GTO Based 3 × 100kva, Auxiliary Converter LGBT Based 3 × 130 KVA, Hotel Load Converter LGBT Based 2 × 500 KVA, Underslung Converter LGBT Based 25 KVA SGC, Underslung Converter LGBT Based 25kva Hog, SMPS Battery Charger 6.5 Kw, Battery Charger 30 KWPRE-Cooling, SMPS Battery Charger 4.5kw +2.5kw, Underslung Converter 5 Kw, Underslung Converter 50kva, Underslung Converter 100kva) 2. **Traction Switchgear** (Vacuum Circuit Breaker, Earthing Switch, 25kv Single Pole Primary Voltage Transformer, Protection Relay, General Purpose Relay, Master Controller, Key Multiplier, Auxiliary Supply Control Panel, Auxiliary Supply Panel, Control Supply Panel (Sb1, Sb2), Filter Cubicle, Circular Connectors Traction Grade, D Type Connectors Traction Grade, Contactors Electro-Magnetic, Contactors Electro-Pneumatic) 3. **Data Acquisition & Control Device** (Pulse Generator Opto Electronic, Active Speed Sensor, Tachograph System Diesel Locomotive And Dmus, Tachograph System, Primary Current Sensor, Hotel Load Current Sensor, Aspirating Smoke Detector System, Driver Display Unit, Diagnostics Terminal, Event Recorder, Vigilance Control Device, Fire Detector Equipment) 4. Audio and Display Systems 5. **Escalators**: Uninterruptible Power Supplies
Financial Performance	
Revenue	2023: INR 326.80 CR; 2022: INR 223.89 CR
PBDITA & PAT (and margins)	PAT 2023: 43.35 Crores (13.26% margin)
Customer Base and Market Segments	

Key Customers (Industry-wise)	• Indian Railway • Industrial Sector

HMTD Engineering Pvt. Ltd.:

Section	Details
Overview	
Name	HMTD Engineering Pvt. Ltd.
Industry	Engineering and Manufacturing
Establishment Year	1981
Headquarters	Taloja, Navi Mumbai, Maharashtra
Regional Presence	Taloja, Navi Mumbai, Maharashtra
Manufacturing Locations & Production	Navi Mumbai
Products	• Brushless Alternators 25kw & 4.5kw, PM Alternator 30kw With Controller. • Regulators (RRU) 25kw & 4.5 kw Or Regulator 25kw & 4.5 kw • Motors (BLDC Axle Flux 1kw to 1000kw With Controller) (BLDC Radial Flux 1kw to 500kw with Controller) • Power Factor Correction Equipment (For Electricity Board & For Traction Application) • Renewable Energy Products (Wind Mill Application & Hydro Power low head Application 10kw to 1000kw).
Financial Performance	
Revenue	2023: INR 12.62 CR
PBDITA & PAT (and margins)	PAT 2021: INR 0.22 CR - 1.71 % 2020: INR 1.71 CR - 4.99 %
Customer Base and Market Segments	
Key Customers (Industry-wise)	• Renewable Energy Companies • Industrial and Manufacturing Sector • OEMs (Original Equipment Manufacturers)

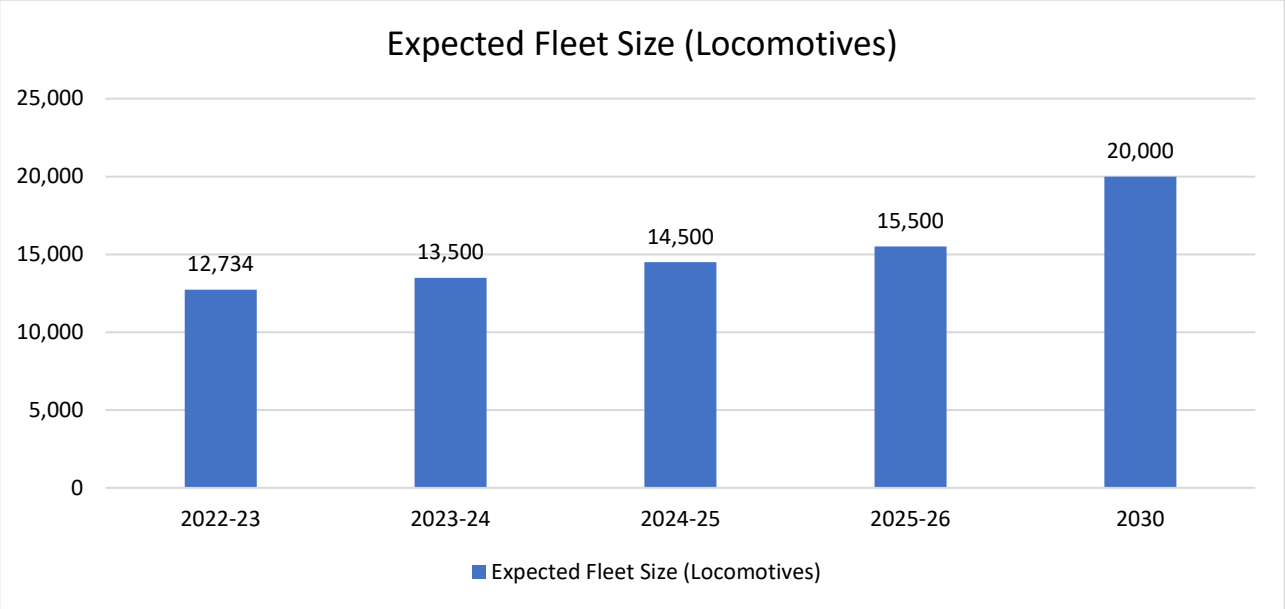
Hind Rectifiers:

Section	Details
Overview	
Name	Hind Rectifiers Limited
Industry	Electrical Equipment and Power Electronics
Establishment Year	1958
Headquarters	Mumbai, Maharashtra, India
Regional Presence	NA
Manufacturing Locations & Production	Mumbai, Maharashtra Sinnar, Nashik, Maharashtra Satpur, Nashik, Maharashtra
Products	• Railway Products:- Traction and auxiliary transformers IGBT propulsion systems On-board DC rectifiers and auxiliary converters Traction motors Safety and protection electronics HVAC systems for rolling stock. • Industrial Products:- Electrostatic precipitators High-current rectifiers Power quality improvement solutions Special rectifiers.
Financial Performance	
Revenue	2024: INR 545 CR, 2023: INR 378 CR, 2022: INR 392 CR.
Raw material & other key operating cost	
PBDITA & PAT (and margins)	PBIDTA: 8.9% PAT: RS 5.1 Crore
Customer Base and Market Segments	
Key Customers (Industry-wise)	• Railway Sector • Industrial Sector • Renewable Energy

Growth Forecast

The expected growth in the Indian Railway locomotive fleet is influenced by various government initiatives aimed at modernization, increased production targets, and strategic investments.

Expected growth in Indian Railway locomotive fleet in past and upcoming years:



Current Fleet and Production Capacity

- Existing Fleet: As of January 2025, Indian Railways operates approximately 10,238 electric locomotives and 4,543 diesel locomotives. This fleet supports both passenger and freight services across a vast network of over 67,000 km of electrified tracks.

Production Units:

Indian Railways has several production units dedicated to manufacturing locomotives, including:

- Chittaranjan Locomotive Works (CLW)
- Banaras Locomotive Works (BLW)
- Patiala Locomotive Works (PLW)

These units have ramped up production capabilities to meet increasing demands.

- Growth Projections

Increased Production Targets: For the fiscal year 2025, Indian Railways has increased its locomotive production target by 27%, aiming to produce 1,500 locomotives. This includes:

- 1,240 WAG 9H freight locomotives.
- 260 WAP 7 passenger locomotives.

The production plan is set to remain stable until FY27, with plans to produce 1,300 WAG 9H locomotives annually from FY26 onwards.

- Future Production Plans: The overall coach production target for FY25 has been revised upward to 8,145 coaches, which includes the production of Vande Bharat and Amrit Bharat variants. This reflects a commitment to enhancing passenger services alongside freight capabilities.

Government Initiatives

- Budget Allocations: The budget for capital expenditure has significantly increased from ₹500 billion in 2013-14 to ₹2.4 trillion in 2023-24. A substantial portion is allocated for new rolling stock and fleet modernization. The Railway Budget for 2025 is expected to focus on modernizing the fleet with new technologies and expanding the railway network through initiatives like the Kavach safety system and additional Vande Bharat trains.

- Public-Private Partnerships (PPP): Collaborations with private entities like GE Transportation aim to modernize the fleet with the introduction of fuel-efficient Evolution Series locomotives. GE plans to supply 1,000 locomotives by 2025 under this initiative.

- Dedicated Freight Corridors (DFC): The development of dedicated freight corridors is expected to enhance freight capacity significantly, necessitating an increase in freight-specific locomotives.

Technological Advancements

- Electrification Efforts: Indian Railways aims for complete electrification of its network by early 2025, which will further enhance operational efficiency and reduce reliance on diesel locomotives.

  Introduction of Advanced Technologies: There are plans for introducing hydrogen-powered trains and expanding the Vande Bharat fleet, which will contribute to sustainable rail transport solutions.

Key Factors Impacting Future Growth in the Industry

1. **Demand for Urban Transport:**
   - There is a rapid increase in demand for urban mass transportation systems in the country. Several metro rail projects are in progress to improve connectivity within cities.
   - In May 2021, the Government of India and European Investment Bank (EIB) signed a finance contract for the second tranche of US$ 182.30 million for the Pune Metro Rail project.

2. **M-Ticketing and E-Ticketing:**
   - The Centre is working to upgrade the online passenger ticket booking system of the Indian Railway Catering and Tourism Corporation (IRCTC) to ensure that it can handle more demand.

3. **International Investment:**
   - In November 2019, Indian Railways entered into procurement cum maintenance agreement with Madhepura Electric Locomotive Pvt Ltd. (MELPL), a joint venture of Indian Railways and France-based Alstom to manufacture 800 electric locomotives for freight service.

4. **Travel Insurance Scheme:**
   - Railways rolled out its insurance scheme for passengers, under which they can buy a premium of 1.52 cents while booking a ticket to get an insurance cover of up to US$ 1.5 thousand.

5. **Semi High-Speed Train Projects:**
   - IR intends to look for cost effective options to increase speed to 160-200 km per hour on existing routes such as Delhi-Chandigarh and Delhi-Agra.
   - In June 2021, the Central Government approved to implement a 235-km semi high-speed rail corridor between Pune and Nashik in Maharashtra. The project will be built at a cost of Rs. 16,039 crore (US$ 2.20 billion).

6. **Bullet Trains:**
   - The accomplishment of building 100 kilometres of viaducts was made possible by the installation of 40-meter long 'full span box girders' and 'segmental girders'.
   - For the upcoming Mumbai-Ahmedabad bullet train project, 24 bullet train sets are planned to be acquired from Japanese companies through tendering process.
   - The estimated value of the project is US$ 14.52 billion, which will reduce the duration of the journey by 2 hours. Construction of the corridor is expected to be completed by 2023.

7. **High-Speed Trains Projects:**
   - In July 2023, India is constructing 508 km of high-speed tracks and 174 km supporting semi-high speeds near Tughlakabad-Agra Cantonment.
   - Indian Railway has planned to build 7 high-speed rail corridors to provide faster rail connectivity across the country at a cost of US$ 17 million.

8. **New Services/Programmes Launched:**
   - In August 2022, the government launched Mission Raftaar for speed enhancement and to achieve a target of doubling average speed of freight trains and increasing the average speed of superfast /mail/express trains by 25 kmph.
   - In September 2021, Indian Railways started rail-based tourism by leasing or selling railway coaches to private players.
   - The Indian Railway launched the National Rail Plan, Vision 2024, to accelerate implementation of critical projects, such as multitrack congested routes, achieve 100% electrification, upgrade the speed to 160 kmph on Delhi-Howrah and Delhi-Mumbai routes, upgrade the speed to 130 kmph on all other golden quadrilateral-golden diagonal (GQ/GD) routes and eliminate all level crossings on the GQ/GD route, by 2024.

9. **Security Protocols and Procedures:**
   - The Indian Railways reviewed its security, crowd management and enforcement to meet the COVID-19 protocols as the footfalls are likely to increase ahead of the festive season. The new mandate includes the field officers to conduct intensive awareness campaigns among passengers on guidelines issued by the Railway administration to prevent outbreaks in trains and at stations.
   - A new campaign 'Meri Saheli' was launched to provide safety to female passengers and effectively respond to any security-related issues faced or seen by female passengers. This initiative is two-pronged and will also aim to curb human trafficking of women and children.

10. **Enhanced Safety Features:**
    - To suit the new requirements of passengers amidst the COVID-19, the temperature and air-circulation settings in AC train coaches have been modified by the Indian Railways.
    - In November 2020, Indian Railways developed anti-COVID-19 coach to prevent the spread of coronavirus. This anti-COVID-19 coach has handsfree water tanks and flushes; copper-coated handles and locks.

11. **Scheduling Amendments:**

- Furthering the revenue maximisation agenda, special trains will have 10-30% higher ticket prices including a special surcharge.

12. Budget Allocation:

- Under the Interim Budget 2024-25, capital outlay of Rs. 2.52 lakh crore (US$ 30.3 billion) has been allocated to the Ministry of Railways, which is the highest ever outlay and about ten times the outlay made in 2013-14.

13. Hospital Management Information System:

- HMIS has been synchronized with various other digital initiatives of Indian Railway like Unique Medical ID, IPASS and ARPAN etc. and is capable of further such integrations as per need. Digitization of health data which is accessible through unique medical ID (UMID) of Railway healthcare beneficiaries is going to make the healthcare services hassle free and transparent. Patient can take OPD appointment by scanning the QR code through HMIS app. This will bring improvement in patient care and patient services to approximately 10 million Railway health beneficiaries.

14. New Railway Projects:

- With a view to improve rail connectivity and ease travel for commuters, the Union Cabinet approved seven projects for Ministry of Railways in August 2023 at a cost of around Rs. 32,500 crore (US$ 3.93 billion). Spanning 35 districts in nine States -Uttar Pradesh, Bihar, Telangana, Andhra Pradesh, Maharashtra, Gujarat, Odisha, Jharkhand, and West Bengal, the projects will add 2,339 km to the existing network.
- As of April 2022, a total of 452 railway projects of total length 49,323 km costing approx. Rs. 7.33 lakh crore (US$ 87.92 billion) are in different stages of planning/ sanction/ execution across Indian Railways.
- Over 342 railway projects have been mapped on the Gati Shakti GIS platform developed by BISAG-N.

Threat & Challenges

The ongoing electrification and modernization of railways present both challenges and opportunities for electrical component manufacturers. From developing energy-efficient and maintenance-free components to addressing new demands like electrification, smart grids, and green technologies, the industry requires manufacturers to innovate continuously. Success lies in balancing the cost of innovation with market demands and proactively adapting to global trends in electrification and sustainability.

Analysis of Major Threats & Challenges Impacting the industry

a) Electrification of Railways

- Details: With global efforts to reduce carbon emissions, railways are transitioning to electrified systems, increasing demand for specialized electrical components such as traction systems, inverters, and transformers.
- Challenges: Adapting products for higher energy efficiency and sustainability. Retrofitting existing diesel-based systems with electrical alternatives.
- Impact: The shift to electrification creates a significant opportunity for manufacturers but also demands considerable R&D investment.

b) Stringent Government Regulations and Standards

- Details: Governments enforce strict regulations to ensure safety, reliability, and environmental sustainability in railway systems. Standards like EN 50155, IEC 62236, and IEC 61373 govern electronic components for rolling stock.
- Challenges: Compliance with diverse regulations across different countries and regions. Costly and time-intensive certification and testing processes.
- Impact: Failing to meet these standards can result in market exclusion, fines, or reputational damage, requiring manufacturers to allocate resources to regulatory compliance teams.

c) **Policy-Driven Procurement Requirements**

- Details: Government-backed rail projects often require manufacturers to meet specific procurement guidelines, such as:
  - Localization mandates: Manufacturing a percentage of components domestically.
  - Sustainability goals: Using eco-friendly materials and processes.
- Challenges: Establishing local manufacturing facilities or partnerships. Navigating bureaucratic hurdles to participate in government tenders.
- Impact: Complying with such requirements can increase costs and operational complexity, particularly for international manufacturers entering new markets.

d) Electromagnetic Interference (EMI) and Noise Compliance

- Details: With the proliferation of electronic devices and systems in railways, managing EMI and ensuring noise compliance is critical to prevent signal disruptions or failures.
- Challenges: Designing components that meet stringent EMI standards. Preventing interference between various onboard and trackside systems.
- Impact: Manufacturers must invest in advanced shielding and filtering technologies, which can increase production complexity.

e) Urban Rail Expansion and Electrification

- Details: With the expansion of metro systems, light rail, and suburban networks, the demand for compact, lightweight, and high-efficiency electrical components is on the rise. Urban rail systems often require components to fit within tight spatial constraints while meeting high reliability standards.
- Challenges: Designing miniaturized components without compromising performance. Addressing the challenges of high-frequency use in densely populated areas.
- Impact: Manufacturers must tailor solutions for urban rail projects while balancing cost and durability.

f) Uncertain Project Timelines and Funding Delays

- Details: Government-funded railway projects are often delayed due to budget constraints, political changes, or economic instability. These uncertainties can disrupt supply chains and revenue forecasts.
- Challenges: Managing production schedules and inventories in the face of delays. Maintaining liquidity and cash flow during long project gestation periods.
- Impact: Delays in government projects can lead to idle resources, reduced profitability, and strained supplier relationships.

Company Profile

IC Electricals Company Pvt Ltd:

Section	Details
Overview	
Name	IC Electricals Company Pvt Ltd
Industry	Electrical components and Electronics
Establishment Year	2005
Headquarters	Delhi, India
Regional Presence	1. Bahadarabad, Haridwar-Uttarakhand 2. Delhi
Manufacturing Locations & Production	Bahadarabad, Haridwar-Uttarakhand
Products	• Brushless Alternator-(25 KW Brushless Alternator, 4.5 KW Brushless Alternator) • Microprocessor Based Fault • Rectifier Regulator Unit 4.5 and 25kw • Electronic Rectifire Regulator Unit with UVC • Regulated Battery Chargers for Coaches and Locomotives • Micro Processor Based Control and Fault Diagnostic System • Auxillary AC Motors for Locomotives • Blowers with AC Motors for Locomotives • Vigilance Control Device System for Locomotives • Passenger Information System for Coaches & Train Set • Auto Engine Start Stop System with Auxiliary Power Unit for Diesel Electric Locomotives • Fuel saving through APU system • Coach Power Information Unit 30KW PMA
Financial Performance	
Revenue from Operations	2025: INR 12,188.59 Lakhs 2024: INR 9,924.92 Lakhs;
PBDITA & PAT (and margins)	PAT 2025: 914.27 lakhs (7.5% margin)
Customer Base and Market Segments	
Key Customers (Industry-wise)	• Indian Railway

Note: consolidated Financial are considered